types, but, in reality, there is no exact facsimile. There are duplicates in technological traits but there is no exact duplicate artifact. Like fingerprints, each is distinct and a mould of one artifact, no [illegible], and would not fit the mould of another. The elements involved in manufacture are not that sterotyped and the human margin of variation is too great. Analysis of flakes will show a greater consistency of form and attributes ~~for~~ as it is only necessary to consider one unit rather than the composite units that compose an artifact. It will be much easier for a student to separate flakes into different technological categories than to type artifacts if he considers the surface character of the artifact together with the form. Projectile point forms are probably the most consistent of the flaked artifact types, but they too vary with the whim and needs of the maker. While their dimensions are variable, their mode of manufacturing is generally constant. An outstanding and well-known example of the variation in form but consistency of technique ~~xrx~~ is the points found at the Bison Kill site excavated by Dr. Joe Ben Wheat (Olson-Chubbuck). This site yielded a large population of unbroken and mint-condition projectile points and was devoid of the discards and debitage usually found in zones of occupation. The flaking technique of these points was consistent and uniform, with only slight variations - yet they vary in size and form. Unfortunately, we do not have enough occurences of these finds for they are a fine example of what actually went to the field and they furnish much knowledge regarding technology and typeology. Because of their unique mode of manufacture and because they are in mint condition, a thorough analysis of this collection should resolve the consistency of flaking techniques and the variation of form and size.

Because of the nature of the material being worked and the human element of change and error involved, there are many characteristic variables and, therefore, stereotype of flakes and artifacts cannot be expected but we can look for consistency. Consistent differences reflecting minor and major changes in techniques of flake and blade removal can be noted when the flakes are separated into the stages of their taxonomy. Each stage will readily demonstrate the rhythm attained by the worker and then there will be a greater consistency of flake types. Categories, similarities, and like attributes will show the development of patterns which will denote the phases and stages of the part they played in the development of artifact types which will greatly assist in the interpretation of the cultural traits. Because of these slight variations and variables, the flakes should not be appraised individually but rather by the manifestations of their traits and techniques.

I recently had an opportunity to study collections at Idaho State University, Washington State University, University of Washington, University of British Columbia, University of Arizona, Univerisy of Colorado, National Museum at Victoria, Canada, Museum of Man at San Diego, California, Southwest Expedition Field School at Vernon, Arizona, Denver Museum of Natural History site at Kersey, Colorado, and the information xx gleaned from these collections has been most rewarding and emphasized the need for debitage analysis for numerous technological traits and techniques were represented. My personal rapid method of surveying flake assemblases was: (1) Separate the flake parts into categories of abberant, ill-formed, and broken material which would serve no functional purpose and not of the proper size for modification or artifact manufacture. Then isolate the unbroken flakes which are useable or may even show signs of function. (2) Flakes are then arranged in rows with the platforms on the proximal end facing the sorter for these ends provide the bulk of the information pertaining to technology. (3) Then the mid-sections and the distal end of the flakes are arranged in a like manner. (4) The proximal ends (those bearing the platform of applied force) are then regrouped by segregating those with like platform characteristics. These characteristics are further explained in this text.

Percussion flake assemblages fall into two classes - the debitage flakes from artifact manufacture and flakes and blades made either to be used freshly struck or to be modified into tool types characteristic to blades and flakes. It is not the intention of the writer to infer that there is a major cultural difference between debitage flake assemblages derived from artifacts percussioned by the core method and those derived from the modification of large flakes or blades. Both techniques can be used by a single group of people and it is only important to be able to recognize these techniques when they make their appearance. However, the core method is a wasteful technique and discards a greater amount of debitage than does the modification of a flake or blade. The use of the core as a source of blades or flakes is an indication of mans' first economy for it provides quantities of useable flakes either modified or unmodified, whereas the artifact made by the core method provides only a single tool and much waste material.

There are numerous types of flake specializations. Many now existing in collections have no terminology, yet they could have considerable diagnostic value in the interpretation of technological traits. At present, the only separation of flakes seems to be blade-like forms, yet there are numerous technological techniques and flake specializationsused to remove blades from cores. The term "blades" encompasses a vast array of flakes with parallel sides with "Their length being two times their width" (Francois Bordes, Les Eyzies Lithic Technology Conference, November, 1964). Individual analysis of such assemblages will readily demonstrate that they fall into two technological patterns which are distinctive to that group alone - the mode of manufacture and the refinement of production. One cannot separate flakes and blades according to whether their manufacture was by pressure or percussion but must evaluate the techniques and even then there will be a blending of form when shape alone is used to separate flakes and blades. Size should also be considered as both percussion and pressure flakes range fromthe diminutive to the more massive and it is not enough to assume that because a flake or blade is massive that it was produced by percussion. Consider the prismatic blades from Meso-America which may be as much as an inch wide and eight inches long and yet are made by pressure. These blades have a consistency in form with two or more scars running the longitudinal axis on the dorsal side, the result of previous blade removal. They are complete tools within themselves, or they can be altered into geometrics, microburins and other forms characteristic to blades. Their preparation and pressure removal represent a variety of technological traits (See Polyhedral Core Paper)

Old World blade forms are much the same in shape as the prismatic blades but undoubtedly various forms of percussion techniques - such as indirect percussion - were predominant in their making. Normally, blades are considered to be the result of a refined technique and of a definite form, however, some classify long narrow flakes with parallel and sub-parallel sides to be blades. There are specialized flakes removed by simple direct percussion that could technologically be blades but they lack the refinement of form which is the result of exacting core preparation and method of removal. So there can be no sharp lines of demarkation between the blade industry and indiscriminate blade making. The main differences are technological ones. Future study will, no doubt, indicate certain parallelisms and traditional traits in flake stone technology.

The very presence of cores in tool typeology is mute evidence of the importance of flake scar study. They are not considered a tool, (unless they show functional scars), but they are of prime importance in typeology for the express purpose of studying the scars and technological features to resolve the tool types of their flakes and blades. Debitage flakes can be equally important.

In the Americas, where we have a great absence of cores, it is not only recommended but almost imperative that we resolve the core techniques by analyzing and mentally if not actually reconstructing the cores from the flakes and blades if we are to ultimately postulate the ty of core with which they are compatible. Conceivably, a shortage of raw material forced the ancient stoneworker to reduce his core to a minute, unrecognizable or insignificant size, and it is possible that this same lack of stone prompted the modification of these exhausted cores into tools such as wedges, scrapers, and other cutting implements. No doubt pebble tool industries developed because materials larger than pebbles were not available. Even though we rightfully regard cores as basic in the study of the toolmaking industry, they represent only the residue of discard debitage to the prehistoric stoneworker. He was not concerned with their weight, beauty, or form, and he made no real attempt to keep them uniform other then that required to successfully remove a flake or blade of the desired width, thickness and length. To the stoneworker, the core was the nuclei, the waste product, and he had no thought for their regularity or uniformity. His efforts and aims were on the detaching of flakes and blades. But since his needed blade type required certain consistencies in flintknapping techniques, he ultimately produced a uniform core type. In other words, the design of the blade or the flake, which wax pertinent to different cultures, geographical areas and economies determined the type and design of the core. This, of course, is what makes core study so import and contemporaneous with the movement and age of man. It also points out the need for careful study of the debitage flakes and for core reconstruction when none of the cores are found at the site.

careful
w.P.S.

Cores may be derived from large tabular or primary flakes, sections or parts of nodular forms, or simply from parts of cobbles derived from alluvium. Populations of cores are usually limited to areas abundant in lithic materials for when materials had to be transported a great distance to the occupation zone, the core was normally consumed by flake and blade removal until there generally remained only a bare and unrecognizable remnant of the original piece of material. In this case, we must attempt to resolve the core type by relating the flakes. Flakes and bladeshave certain identifying characteristics such as the platform angles, curvature of the flake, depth of bulb of force, termination of the flake, etc. which make it possible to reconstruct the core to which they are pertinent. A previous study of aboriginal cores and flakes will help one to resolve core types from the flakes alone. Because the core was designed to produce flakes and blades and is, therefore, consumed in the process, the study of cores and their stages of development is usually difficult. Unless the aboriginal worker was interrupted and his unfinished work abandoned, or the core was ruined during manufacture, or unless he discarded the core because the removed blades were too small to suit his purpose, it is unlikely that the evolution of the core would remain. Therefore, at best, one must generally base his conclusions on the exhausted or malformed cores and flakes.

It israre, indeed, to find a great population of cores such as Francois Bordes found this year at Corbian (about 1000) of the Upper Perigordean (Personal communication, November 6, 1966). On the other hand, most literature shows great populations of flakes or blades with small proportions of cores (J. Radley and P. Mellers, 1964 Proceedings of the Prehistoric Society. A Mseolithic Structure at Deepcar, Yorkshire, England. 23,000 flakes and 17 cores were found)

The people who adapted the core and blade traditions most certainly recovered all flakes and blades which conform to their needs and, therefore, those found usually are aberrant, malformed or those which broke as they were removed from the core. Such populations of useable flakes, other than trimming, retouch and modification debitage, cannot be expected - other than an accidental occurrence - for the flakes were removed from the core for a functional purpose. It is from a reconstruction of these waste flakes and blade assemblages that the end product can be evaluated.

Before the experimenter starts to remove a flake from a core, he must understand that detachment is not accomplished by indiscriminant random blows, but is the result of a preconceived design of the flakes. Most literature which described the manufacture of stone tools speaks of the "impulvise blow". The student of Physics will immediately identify this word "Impulsive" with that of motions which take place quite suddenly; or, forces acting which are rapidly changing in magnitude and direction. However, this word also convey the interpretati of psychological use - a desire to act resulting from instantaneous judgments as to how to meet an emergency, and a lack of deliberation. For this reason, I think the term "impulsive blow" show be dropped from the literature when referring to stone tool manufacture. THE PAST ARTISANS IN NO WAY STRUCK IMPULSIVE BLOWS, AND ONLY AFTER CAREFUL PREPARATION OF SURFACES AND ANGLES, WAS THE BLOW DELIVERED WITH CONTROLLED, CALCULATED AND METICULOUS PRECISION. The worker must have control of muscular motor habits and must deliver the pressure or percussion force with extreme accuracy. Any carelessness or mis-calculations in detachment will result in a hinge or step fracture causing the artifact to be malformed or useless. The supbarb examples of aboriginal work reveal not a bag of tricks but an intensive knowledge of materials that lend themselves to stone toolmaking and a splendid display of mental and muscular coordination.

A flake and blade (specialized flake) industry represents specially formed flakes removed from cores - the flakes being used freshl struck or modified into artifacts. Blade making techniques are various and involve different types of core preparation from the simplest to the more refined. Blades can be used without modification or retouched by pressure flaking. Large flakes and blades are sometimes preformed by percussion into knives, projectile points, etc. When smaller flakes are to be modified into a projectile point, the flake is straightened by removing the bulb of applied force on the ventral side of the flake and by trimming the distal end of the flake/ on the ventral side until the longitudinal axis of the flake is straight. This is usually done by the pressure technique. Most pressure flakes are crushed during their removal and, therefore, will pass through the sifting screen at a dig. Cores which result from flake and blade making are sometimes utilize as core tools or can be reduced to useable flakes. Therefore, discarded well-defined cores cannot be expected unless there is an abundance of raw materials near at hand. An exception to this is the microblade cores of the Arctic. Some well-defined cores are found there for the worker removes microblades until they were so small there were practically no room to seat his tool and, therefore, he discarded his core. So, sometimes the very technique can determine whether or not cores were left at a site.

Flakes and blades are removed from a mass of material (core) by applying force at varying degrees of intensity and velocity mm at a specific angle on a definite and predetermined surface area. The surface receiving the applied force is known as a platform and its design has a direct bearing on the type of flake or blade removed from the core. The raw material sometimes determines the technique of flake and blade removal for the stone must respond to the application of force to detach, in any direction, portions of the material. This quality in material is known as isotropism. Flaking must include control of the width, length, and thickness of the flake; and the applied force must follow the desired direction of the worker.

The simplest core form is a piece of material bearing a flake scar. This embryonic stage of core development could go unrecognized but, nevertheless, it was able to provide substance for useable flakes. Most cores have more than one flake scar which are usually characterized by a negative bulb of force at the apex. The removed flake retains the platform and the bulb of force but the scar left on the core indicates the order of flake removal. When a cobble is severed by force delivered by a hammerstone, the portion bearing the bulb of force will be the flake part and the half bearing the negative bulbar scar will be the core. There is one exception to this rule and this is the absence of a bulb on either part of a severed cobble. This is accomplished by a special technique which results in the splitting of the cone of force. When the cone is split, both halves will have duplicate features. This special technique occurs rarely and is usually associated with pebble and cobble industries and core rejuvenation. Normally, the flake will be smaller than the core for the core must be heavier and more massive in order to provide sufficient inertia to remove the smaller flake.

Since both artifacts and cores bear flake scars, it is sometimes difficult to determine whether it is a core or a tool. For example: A chopping tool is the core remnant and, under certain conditions, could be mistaken for a core or vice versa. A case in point is the so-called cores from the Shoop site. These were identified by John Whitoff as exhausted cores and, in fact, could be confused as such. But, at the Les Eyzes conference, November, 1964, it was termed by both European and American archaeologists that they were "Piece Esquiellles". They are, in fact, a core tool but not an exhausted core. The normal conception of the core is a mass of material used for making blades and flak and the residue or remnant of thismass is the core. A notched projectile point couldn't look less like a core, yet a core it is. Exhausted cores, or cores which had the flaking operation either suspended or discontinued, were sometimes converted into hammerstones or used as functional tools such as pulping planes. Cores defined as having been used as a tool should be appraised very carefully before they are typed. The leading edges should be examined for wear patterns and functional scars for sometimes a similar surface is produced by the toolmaker when preparing platforms for subsequent flake removal. Grinding and removing the overhang left by the last series of flake~~s~~ removal are technological traits used in certain techniques and could be mistaken for functional scars or abrasions.

Core forms are endless, yet they play an important part as a diagnostic trait and they demonstrate many technological differences. When they are worked down to a small unfamiliar form, many are difficult to recognize as cores. Some sites are distinctive because there is a complete absence of cores, yet the flake discards indicate detachment from a core. Generally, this denotes a shortage of material and the worker's need to reduce the core to the last useable piece of material. In this case, flakes and blades will have to be evaluated and the core reconstructed from the diagnostic features which the flakes and blades reveal.

Since all mans' acts are by nature inquisitive with a natural and inborn urge or motivation, a relationship between the lithic techniques of primitive man and my experiments will have certain parallelisms. The methods I use and his techniques may not be concurrent but their counterparts may have a certain amount of similarity. Before I made my first eolith, I tried to remove useable flakes from a core by striking a piece of flint-like material with a small cobble. I used direct free-hand percussion which ~~which~~ resulted in battering and bruising and ultimate shattering of the piece of flint. My core was not even recognizable and the flakes lacked style and uniformity. However, several flakes in this shattered mass had sharp cutting edges and could have served as tool but they would not be recognized as such by an archaeologist. I continued using this method over a considerable period of time and occassionally would remove a few good flakes. By studying the conditions which accomplished this removal - such as the correct amount of force, the vector of striking angle, the character of the point of impact and the surface of the stone on the dorsal side of the flake - I could determine the conditions which produced a replica flake. But these conditions must be firmly resolved in the mind of the stoneworker before he becomes a good eolith maker. These first futile stoneworking attempts did, however, produce flakes and cores even though any refinement was sorely lacking. Since these first efforts some forty years ago to successfully remove a flake from a core, certain conclusions have been reached regarding the mechanical laws pertinent to isotropic materials and relating them to core types. When working isotropic material,its inherent nature causes definite patterns in flakes and cores. Upon appraisal, these characteristics may be related to various techniques and these techniques correspond to certain people in time and space.

To coherently explain cores and flakes one must understand what is happening when force is directed against a mass of flint-like materi Impulsively striking a stone mass will result in a shattering of the piece; but when force is properly applied against a flint-like mass, the objective piece will fracture. However, to successfully remove surplus material from an artifact, or to detach a flake or blade from a core, the worker must control the direction and amount of force. He must be able to terminate the force at a predetermined point and remove flakes of the desired shape and thickness. This is the basis for the many and diverse stoneworking techniques. To make cores, blades or tools, the worker must dominate the stone by being aware of and controlling its elastic limit and providing for future and subsequent flake detachments to be in accord. Allowing a flake to step or hinge fracture will ruin the core or artifact. But sometimes, in spite of the best of coordination, a failure will result from a slight miscalculation, an undetected flaw in the material, a crushed platform, the slightest angle change of either the artifactor the flaking implement and from the improper dampening of force. It is doubtful if there are any perfect examples of the more complex artifacts/ for the human margin of error prohibits fabrication of a perfect stone artifact. Even the classic examples of Danish and Egyptian work reveal slight miscalculations of the worker. This statement will probably meet with disagreement, however, minute examination of specimens will reveal minor flake scar distortions, or insignificant step-fractures. The making of flint tools is not the manifestation of a long line of ancestors, but is the result of each new generation trying to improve the product or to make it fit his particular need. In a short time, with an experienced teacher an apt and interested student can learn the basic techniques.

W.P.S. note - Maybe add para. from p. 58 and p. 86

Following is a list of points to be followed in flake analysis:

Following is a list of points to follow in flake analyses.

Cores 31

1. Material identif~~y~~ication
2. Texture of material
3. ✓ Material altered by thermal treatment
4. ✓ relation of material to flakes
5. ✓ The amount of applied force
6. ✓ The kinds of applied force
7. ✓ Methods of applying force

PERCUSSION List of flintknapping techniques

8. ✓ Throwing on anvil
9. ✓ Striking on anvil
10. ✓ Hammerstone (free hand)
11. ✓ Hammerstone (with rest)
12. Hammerstone (with rest and clamp)
13. ✓ Hammerstone (with rest , bipolar)
14. ✓ Hafted hammers (free hand)
15. ✓ Hafted Hammer (with rest)
16. ✓ Billetts or rods (freehand)
17. ✓ Billets (with punch)
18. ✓ Billets (with punch and rest0
19. ✓ Billets(with punch, rest and clamp)
20. ✓ Hammerstone with punch (free hand0

✓21.✓ Hammerstone with punch and rest ✓

✓22..Hammerstone with punch , rest and anvil CLAMP

✓23. Indirect (hammer ##d#re##) free hand

✓24.Indirect (hammer and rest)

✓25. Indirect with fixed punch

✓26. Pressure (free hand) Unhafted
27 p ressure (free hand) hafted

28 28. Pressure (with rest)

29 28.Pressure ~~with fixed punch~~ finger-held, Pressure"

30 29. Pressure with rest and clamp

31 30. Pressure with short crutch

32 31. Pressure with long crutch

33 32. pressure (notched tool)

Pressure
34 33. Lever and fulcrum

35 34. pressure ~~Finger held~~ with filed punch

36 35. Pressure on anvil

Resulting flake characteristics

37 36. Implement used to detach the flake

38 37. Size and weight of flake

39 { 38. Primary flakes (cortex)

38. Secondary flakes

40 39. Flakes with pronounced undulations or waves

missing 40. Flakes with little or no waves

(1) Material Identification:

A basic step in the appraisal of flake assemblages is an evaluation of the lithic material. Postulate how far the material is from its original source. What are its diagnostic qualities? How does it compare to materials from other well-known sources? How many varieties are represented in the occupation site? Sometimes the material source may be identified by the outside surfaces found on the dorsal side of the primary flakes. This natural surface may denote bruising, abradin and cratering which is typical of alluvium. Natural surface can give a clue to whether the material was quarried or it may show natural breaks of ledges, lodes, fault zones, bearing the mold markings of the vesicular cavity. Organic replacements will indicate that the material formed in sedimentary deposits. Concretions of flint will indicate the whereabouts of limestone and dolomite. These are but a few of the clues found on flakes which may indicate material occurrence and may aid in locating the source. Detailed studies of material which was used in the lithic industries holds much information regarding the movements of man through time and space for generally material bears inpurities which are characteristic to that material alone. (See materials paper) /Even though cultural tool forms are not in evide This type of study could ultimately aid in resolving mans transporting materials and the route of travel from their original source to their final destination.

(2) Texture of Material:

The texture of material is an important Consideration in [redacted] determining the quality of the modes of manufacturing. The quality of the artifacts and the manufacturing technique cannot exceed the quality of the material regardless of the knapper's skill. Lithic materials range from the glassy to the granulose, and the more granular varieties can result in inferior types of flakes and artifacts. Techniques must be adapted to materials. Fine definition of flake attributes are usually erased in the coarse-grained rocks because the platforms crush more easily and the flakes or blades will collapse before they terminate at the distal end of the core. Flakes of coarse material haven't the resistance to end shock and the worker must apply a greater amount of force to accomplish detachment. To successfully fracture coarse-grained material, it is necessary to use a hard hammerstone and direct percussion in order to concentrate the kinetic energy to a confined area. The more vitreous material increases the worker's ability to control the flakes and the cutting edge of such flakes will be much sharper. A decreased amount of force is required to remove a flake of equal area on fine-grained material for vitreaous material has elastic qualities which is not present in the granulose rocks and this allows the flakes to bend without breaking. This does not imply that coarse-grained materials are not important to the economy of many ethnic groups for they did play an important part. Sometimes they were even preferred to the more vitreous rocks because the flakes struck from coarse-textured rocks were more useful for certain functional needs. Such flakes serve admirably for sawing and carving, and for forming materials.of wood bone, antler, shell and soft stone.

Tool types for sawing can be fashioned more rapidly from coarse-grained material than from a vitreous stone because they give an edge that can be used freshly struck whereas the vitreous rock must be serrated to do similar work. A simple field test should be the actual flaking of questionable material before any final decisions are made regarding the workability of a particular mineral.

(3) Material altered by thermal treatment:

Certain siliceous materials will respond to an artificial vitrification by the application of heat. The change occurs upon the temperature being slowly raised to around four or five hundred and then slowly cooled. (Correction to Crabtree and Butler, Tebiwa, Vol 7,1964) The material will withstand considerably higher degrees of heat but the change actually starts taking place at the above noted temperatures. Different materials require different temperatures to effect the alterati and only experimenting will define the temperature and time needed to effect the change. All materials do not respond to the heat treatment. Successful alteration of materials is an exacting practice requiring a throrough knowledge of the material being altered. (Crabtree and Butler, Tebiwa, Vol. 7,1964) In order to determine if the material has been altered, one must look for a few identifying clues before making final judgement. For example: after heating, the original surface of the material remains unchanged and removal of a test flake will reveal a lusterous texture. To be positive of the thermal change, a flake of suspected material must be found which bears a flake scar on the dorsal side which still retains a little of the original textured material prior to heating. If the material has been altered, the ventral side of the removed flake will have a distinctive lusterous character pertinent to thermal treatment which is not present on the original surf But should a flake be detached from a treated core containing no original surface, it will be lusterous on both the dorsal and ventral surfaces. Few materials have natural vitreous luster, therefore the flake will be suspect but not reliable and no definite conclusions can be made on the alteration. Occassionally, abandoned heat-treated flakes are found which retain their original texture but examination may reveal small flake scars on the margins which show the change of luster. These small flake scars may be the result of the aboriginal testing the materia to see if the heat application was successful. A simple field test is removal of a small flake and subequently examining the scar to determine the difference in texture. If the material is heated over a long period of time, the trace minerals will be subject to oxidation causing yellows to become red and various other color changes, depending on what mineral impurities were present in the treated material. Flakes which are overheated result in crazing, potlidding, and occasionally complete disintegration. These are relatively infrequent considering the exacting control necessary to perform this alteration.

W. P. S. note - what about the reversal of heat treatment noted by Don.

(4) Relation of Material to Flakes:

The character of the flake has a direct relationship to the quality of material. Unlike the granular rocks, glassy rocks have attributes and characteristics which leave well-defined flake scars and this will greatly assist in flake analysis. The worker must conform both the tool and the technique to the material. A case in point is the relationship of applied force to materials. Removing flakes from tough, granular, tenacious material requires a greater amount of applied force than do the vitreous materials - therefore, the platform, or impact area, must conform with the velocity of force. As a rule, platforms on the proximal ends of flakes of tenacious material will be larger when simple direct percussion is applied with a hard hammerstone. Coarse-textured materials do not require the careful platform preparation which is necessary when working vitreous stone for the freeing, or isolation, of the platform in granular stone would reduce the amount of material which would receive the force and, therefore, the chance of platform collapse would increase.

Regardless of the worker's skill, the granular-textured material will not effect the refined artifact which can be made from vitreous material. But, conversely, the lack of skill can reduce high quality material to an inferior artifact.

(5) Amount of Applied Force:

The amount of applied force may be hypothecated by measuring the area on the ventral side of the flake, or on the flake scar, itself. The amount of force required to accomplish fracture is contingent on the type of material being worked. But, regardless of the quality of material used, the amount of force must be carefully controlled and the muscles of the worker must be conditioned to deliver the force to a predetermined area at the proper intensity and velocity. Because the amount of necessary force to sever or detach portions of material varies contingent on material and flake dimension, the ratio of force must be precisely calculated to fit the need. Analysis of artifacts will show that the last repititious series of flakes either from an artifact or a core were detached in a constant pattern and the applied force delivered in a uniform manner. Such a series of blades or flakes demonstrates the control and concentration of the mind directing the xx muscles to respond uniformly. Control of the applied force on ideal materials is one of the basic principles of flintknapping.

(6) Kinds of Applied Force:

Types and variable velocities of applied force (Pressure, Percussion, indirect percussion, etc) are the key to the development of indipendent techniques. The need and desire to make flakes of certain dimensions and form require applying force in different methods and at varying velocities whether by pressure or percussion. Force is transmitted to the material by incorporating several techniques such as percussion and pressure tool types, varying velocities of force, dampenin of force, angles at which force is applied and the method of material support. All have a direct bearing on the detached flake. Certain combinations of methods will make similar flakes but variation in techniques will make minor but consistent differences in the resulting flakes. These differences will be useful in separating pertinent cultural traits.

(7) Methods of Applying Force:

Methods of applying force fall into three major types:

1. Percussion
2. Indirect Percussion
3. Pressure
4. Pressure with the aid of percussion.

Still another, but untried, method is the Egyptian technique of pressing the percussor on the edge of the artifact and then striking both percussor and artifact against a wooden anvil. This, purpotedly, drove the retouch flake toward the anvil, thereby removing the retouch flake by bi-directional forces, a variation of the bipolar technique.

Methods of applying force are numerous and variable and the use of these methods results in a variety of flake forms and scars. There may be parallelisms of techniques which appear to duplicate and converge, yet minor and major features will be represented on the flake to a greater extent than on the flake scar. This is due to methods, materials types of force, and theimplements used to transmit the force. Force ranges from a very sharp impact to gradually applied pressure. Pressure requires greater energy than percussion for a blow delivered by percussion is increased by the instantenous conversion of potential energy to kinetic energy. Aboriginal man instinctively took advantage of this feature and concentrated stress and strain on the raw material by over-extending the elastic limits of the stone to the point of fracture. Experiments have shown that the amount of required force varies with each technique. A large hammer impelled at a decreased velocity can deliver the same amount of energy as a small hammerstone moving at high velocity. Using a large hammerstone at a lessened veloci decreases the shock and will prevent the shattering of the lithic material. Therefore, the use of a large hammerstone at slow velocities is only suitable for the more massive types of flake and blade removal. Decreasing the velocity of the large hammerstone uses potential energy
as a means of slowly applying force, of if you want to be very technical
of slowly applying force, or if you want to be very techni

it is a rapid application of pressure. However, it has the disadvantage of overcoming the inertia of the object being struck and propelling the objective piece. By changing the percussor from stone to a softer material such as antler, bone,wood,and soft stone, Potential energy can be used instead of Kinetic energy. The softer the percussor material, the greater must be the velocity of the blow. Flakes and flake scars made by the use of Kinetic and Potential energy bear diagnostic features pertinent to each which will be described under individual techniques.

(8) Throwing On An Anvil:

The initial toolmaker derived his flakes by percussion detachment. There are many percussion methods and techniques which produces flakes. The simplest - and probably the initial - method was by throwing a piece of flint-like material against a larger rock until it shattered and pieces were dislodged and then recovering the pieces which had a sharp cutting edge. But flakes produced in this manner will be irregular in form and will show evidence of shattering and it is inconceivable that any degree of control could be gained with this method. It does not allow selection of impact surface and the angles on the surface of the core cannot be predetermined. Further, the amount of force required to propel the core could not be related to the size of the detached flake, nor could contact be made with the anvil with any duplication or regularity. When this technique is used, both cores and flakes will contain strains and weaknesses which would render the largest portion of the material useless.

However, this method has recently been observed among the Australian aborigines by Dr. Norman Tindale. (South Australian Museum Vol 15, No. L, Oct., 1965) This cultural trait is characteristic to the Nakako and the Ngadadjara as well as the Pitjandjara of the Great Western desert. At the same time, Donald F. Thompson writes of his experience among the Bindibu and of their skillfully removing flakes from large blocks of material with smaller ones of the same stone - stri ing the flakes off, shaping these with the larger blocks either to a rough point or a sharp cutting edge. Such refinement has to be the result of long experience and a knowledge of the stone's behavior. He stated: "We watched men carefully examine and balance each block and with a few dexterous blows convert them into what was obviously sharp effective cutting tools". (Proceedings of the Preshistoric Society, 1964) According to Tindale, these are examples of embryonic and refined techniques being used at the same period of time and not separated by a great deal of geography.

Cores resulting from casting material lack regular form and have a battered and bruised surface and do not bear the flake scars which result when detachment is by applying force at a preconceived and planned point of impact. Also, flakes detached in this manner will have no consistency of form whereas Thompsons Bindibu people have cores and flake which show the selection of platforms and flakes removed in a regular manner plus the evidence of percussion tools.

(9) Striking on An Anvil:

Using the anvil as a percussor is just the reverse of the normal procedure of using a stone to strike the material to be worked. This technique involves holding the material to be worked in both hands and then striking it on a large stone which is partially immobilized by being buried in the soil - or at least secured in a manner to prevent its movement when struck by the core. This technique uses the maximum concentration of kinetic energy. Due to the mass and stability of the anvil and the velocity of the object being propelled, the energy and force is condensed into the material being worked. Because the core is not projected by the force - which is the case when the core is struck by another object - there is a greater concentration of forces. Force applied to isotropic material in this manner causes a distinctive break which is definitive by a lack of any bulbs of force. The bulb of force is part of a cone, usually well-defined by the radiation of the force. But this technique causes the cone to be sheared and bisected which is distinguished by the expanding circles of force making waves at the point of impact. These waves are much closer together than wehn the flak is removed with a hand-held hammerstone. I experimented with this technique by immobilizing a large cobble which had a natural ridge on the exposed surface. This ridge was used as the contact area for the isotrophic cobble to be cleaved. The cobble to be bisected was held in both hands and struck vertically on the anvil, which was a partly-buried tough, granulose, waterworn cobble. The flint-like material was cleaved in two equal pieces, each part having a flat surface at the poin of fracture and each piece was well suited for a core. This technique was well understood in Mexico and probably used to make the thin, flat, regular, uniform thickness, flakes which were used to make graduated rad of obsidian for neck ornaments. The surfaces of these ornaments bear th same type of rippling or force circles. ¶ But this technique requires considerable skill to deliver an accurate blow of the correct intensity and simultaneously calculate the correct striking angle. Angles may vary, depending on the desire of the worker and the proposed implement. Because the force is concentrated in such a restricted area, this technique is unsatisfactory for removing blades.

☆ W.P.S. note
what about Danish blades?

There are indications that a similar striking method was used to make Levallois Flakes, for the Levallois core is held in the hands and struck against an anvil stone. However, only the striking is similar, for a platform is prepared on the Levallois core and then the core is struck against the anvil but at a different angle to cause the platform on the core to contact the anvil. Levallois was not attempting to cleve the core, but only to remove one or possibly two specialized flakes. The platform on the Levallois core is established by preparing a ridge directly above the spot where the flake will be removed as the impact area. This provides for greater accuracy. Ridge is established by removing two or more flakes horizontal to the longitudinal axis at the top of the core which will produce a ridge from the dorsal side of the core to the ventral side. The ridge is isolated so it will contact the anvil when the core is struck and increase the accuracy of the blow. In order to make a Levallois flake, the cone of force must be isolated. The angle of the cone is calculated and the core struck against the anvil in such a manner that the cone will make the negative scar on the core. If the core is struck against the anvil in the proper manner, this technique will concentrate the force to such a degree that the Levallois flake will not flex and will be flat. This experiment requires proper preparation of the core and platform and practice and skill to regulate the intensity and velocity of the force. It also requires an abundance of material and it is wasteful when only one or two useable flakes are desired.

A small anvil is useful when making certain types of burin-like implements from flakes and blades. Two experiments in replicating this burin-type form are: Select the proper blade or flake with an existing flat on the lateral margin and, if none is available, a flake can be made flat by marginal retouch. The flattened edge will serve as the platform to be impacted on the edge of the anvil. The angle at which the edge of the flake is struck will determine the angle of the useable edge and will produce a simple burin. The flake can then be struck against the anvil a second time to make an angle burin but the striking angle of the flake must be changed to use the flat surface of the previously struck flake to serve as a striking platform. The removal of this second flake should leave a chisel edge on the burin. The angle of the chisel edge is contingent on the striking angle of the flake. Another method of producing a simple burin is to place the flat edge of the flake on the anvil and strike the flake with a small hammerstone to remove the second flake. However, this method usually dulls the tip of the burin. This burin technique is fast, but lacks control. Another method is to remove the burin spalls by the use of an antler, or suitable, pressure tool which will be described in detail under pressure techniques, but a quick explanation is to hold the objective piece in the left hand which is rested against the left knee, prepare a platform and remove the burin flake by pressure.

The anvil is also used to make simple chopper forms from cobbles, for the anvil concentrates the amount of force on the cobble and greatly assists in the fracture. It is difficult to remove flakes or cleve a spheroid cobble with a hammerstone but the anvil stone allows the worker to concentrate the force in a predetermined area and produce a fracture that will cleave the cobble or remove a flake. Once a flake has been removed or an angle created, then a hammerstone can be used efficiently. Evidence of this anvil technique was noted on material collected by

Dr. Charles Borden, University of British Columbia. Material collected from the high terraces above the Fraser River exhibited both flakes and cores made with great skill with the aid of the anvil. Some of the large primary flakes show superb control of this technique. It is unfortunate that the very useful anvil is difficult to recognize as a tool. This may be because it can be of any hard, durable stone of assorted shapes and sizes and only close examination of its surface would distinguish it from another similar stone.

While experimenting in replicating knives, or sawing devices, with the distinctive cortex backing, I made use of the anvil to remove flakes from one end of a quartzite cobble. Backed knives made of coarse granular material should possibly be called saws, because they are excellent for shaping and forming objects of antler, bone, wood, and soft stone, yet they are almost worthless for skinning or dressing game. The original texture of the aboriginal backed-saw indicated that its origin was a waterworn quartzite cobble. My first attempts to replicate backed-saws was with a hammerstone and simple direct percussion. I shattered three hammerstones without severing or removing a flake from the quartzite cobble, so I resorted to striking the cobble on an anvil. By using the anvil, a series of flakes were removed from the cobble which bore a strong resemblance to the backed saw-like implement. After these backed blades were removed from the cobble, the cobble core replicated the common chopper. It might be well to note that unless there is a sig of use on the chopper, it could very well be the core. By using this same technique on vitreous material, the backed flakes are duplicate but are suitable for a different function, such as skinning and other cutting purposes.

Another use for the anvil stone is for turning the edges of a bifacial flake stone artifact prior to thinning, either by direct percuss ion or pressure. The anvil serves a dual purpose for turning the edges of an artifact. After the edge of the artifact is turned, I abrade the edges by rubbing them on the surface of the anvil in order to make them more resistant to crushing. This marks the anvil with incised parallel markings rather than bruising which is characteristic of the normal anvil function. The anvil is also often used as a rest for other stoneworking techniques.

(10) Hammerstone, Free-hand

The hammerstone has, no doubt, endured as a flintknapping tool for the longest span of time in the history of mans' development. It is a tool which persisted through time and space until the advent of metal. Its only modification is usually the result of use alone. A hammerstone is selected to suit the technique for which it will be used. Some techniques demand that the hammerstone be of hard, tough material, while other require a soft stone. Weight and form of the hammerstone are variable and must conform to the technique. The hammerstone is used to cause the fracture of material in a predetermined manner. With the exception of pressure flaking, it is used for all phases of stone implement-making from the quarrying to the finished form. Two types of hand motion are used to project the hammerstone to the objective piece. One method is to propell the hammerstone in an arc pattern and the second striking pattern is in a straight line and each method demands a different manner of holding.

Straight Line Method:

Straight line means a direct blow with the line of propelled force being straight with no deviation of the path of flint. The hammerstone is weilded by propelling the arm forward in a thrusting movement to contact the objective piece away from the leading edge. By using the forearm and keeping the wrist rigid, the impetus of the hammerstone is converted to propulsive force. The hammerstone can be round or oviate and is held by the thumb and the first three fingers wit its base resting under the first or second knuckle.

The straight line motion is used when accuracy is not required an usually only to reduce larges masses of lithic material into workable pieces; or when the worker desires thick flakes and blades.

The hammerstone contacts the core back from the leading edge, for if the edge is struck with this motion, both platform and flake will crush. Flakes or blades that have been detached by the straight line percussion technique have distinctive marks at the proximal ends such as - the top of the flake or blade is thick with material flaring on either side of the truncated cone of percussion; the cone part is well-defined and there is usually an eraillure flake scar present on the bulb of percussion. Flakes removed in the straight line method show little or no refined platform preparation.

If it is necessary to use a hammerstone with a curved surface, then the contact surface of the percussor must be the center of this curv which will bear the functional scars. If an elongated hammerstone is used and its ends alternated, then use marks will show on either end. But if the hammerstone is ball-shaped, it may bear use scars over the entire surface.

Arc Method:

For this method, the hammerstone must be round and be held between the thumb and the first and second fingers; and both the forearm and the hand are propelled in an arc motion. The arc method is quite different than the straight line method for it strikes a glancing blow rather than a direct hit. This is due to the curve on the rounded hammerstone and because the path of flint is curved. The blow must be calculated, for the hammerstone must contact the artifact, or core, on its prepared edge. ~~Xhx~~ This type of blow ~~upon~~ prohibits the artifact or core, from receiving the full intensity and shock of the hammerstone. The arc motion gives a greater range of accuracy and because of the curved, or rounded, surface of the hammerstone and the curved path of flight, the intensity of the force is increased as the hammerstone conta and moves across the striking surface. Tolerance is proportionate to both the amount of curvature of the hammerstone and the magnitude of the arc propulsion. The arc technique permits the artifact to be moved into the path of flight of the hammerstone and, therefore, accurate contact on the designated point of impact. Shock to the artifact may be increased or lessened by the hammer of holding both the artifact and the hammerstone, i.e. by relaxing the hands or by making them more rigid. Practice intuition and "feel" permit the knapper to literally thrust the hammerstone into the artifact at the exact time of impact to detach a flake. This intuition and "feel" are attained only after considerable practice.

The arc method is much more accurate for removing flakes and blades from cores but is unsatisfactory for cleaving large masses of lithic material. The accuracy of the arc method can be controlled and, therefo the worker can prepare platforms by isolating projections of stone to receive the percussion force. The shape of the flakes or blades will depend on the contours of the surface prior to striking. Both the striking angle of the blow and the angle of the platform will determine the termination of the flake or blade.

Rippling, or shock waves, will be governed, in part, by the materia and the velocity and thickness of the flake. A hard hammerstone also magnifies the shock waves to a greater degree than a soft one.

Flakes, artifacts, and cores made by percussion with the hammerst free hand-held are variable in form and size. These deviations are the result of constant changes of conditions. However, various stages of artifact making may be identified by seperating flakes of similar or character and stressing the character of the proximal ends. Certain rhythms in the use of the hammerstone will disclose definite traits, patterns and techniques.

11. Hammerstone With Direct Rest:

The hammerstone is propelled in the same manner as described under No. 10, Hammerstone, Free Hand, but the objective piece (artifact or core) is artificially supported. Support can be accomplished in several ways (the ground, against the thigh, on wooden blocks or logs, or an anvil stone) but the simplest is placing the core, or artifact, on the ground with the contact edge exposed so the flakes may be freely detached without being driven into the ground. In this case, the ground serves as an anvil. Rests, or anvils, may be of many substances such as hard or soft stone, antler, bone, horn, or wood, depending on how muc resistance is required for a particular technique. Materials for the ~~re~~ rest are selected with regard to the lithic material being worked. For example: obsidian, because of its brittle nature, will require a wood anvil to prevent its unpredictible fracture. Quartzite, or granulose lithic materials which require more force for fracture, demand an anvil of dense, hard material such as an anvil stone, etc.

This method creats bi-directional forces, for the anvil will project force simultaneously when the hammerstone contacts the objective piece. The purpose of the anvil is twofold; it prevents any downward movement of the objective piece and, at thesame time, transmits force into the core or artifact. The striking pattern must allow the flake to detach without being obstructed by the support, otherwise there would be opposing forces between the anvil and the hammerstone and consequently only a crushing of the flake or blade. Properly executed, this technique diverts these forces from their path of contact and causes a shearing between the anvil and the hammerstone. Blades detached by this method are flatter than those made by the freehand technique because the lack of support in freehand holding allows movement of the core. Also flakes detached by this method will be de of compression rings radiating from their distal end but these rings will be present on the proximal end which receives the force from the hammerstone.

If the artifact is a biface, it is rested vertically on one lateral margin upon the anvil, with striki g on the opposite margine. This confines the shock between the anvil and the hammerstone which dampens the vibration to the distal ends of the artifact and flakes can be terminated and detached at the desired point without carrying across the width of the artifact and removing the opposite edge. Cores because of their greater mass are more resistant to shock and the flakes and blades will terminate to a feather edge without removing the distal end of the core.

w.p.s. note
what about
flat on the
thigh?

Using the anvil, or fixed rest, method efficiently requires considerable more skill and practice than the simple hand-holding method because two forces are created and, therefore, any miscalculation or neglect of this additional force will produce failure. When the artifact, or core, is hand-held, the use of the rest is an important aid to the knapper because it relieves the strain on the left hand (assuming the majority of knappers were right handed and weilded with the right hand and held with the left). Conversely, the lefthand performs considerable more work than does the right arm and hand for it must both support the core and properly manipulate its angles to successfully remove flakes. Also, the fingers of the left hand seek out the ridges and examine the underside of the object being worked and this must be by feel alone for the underside of the artifact is not visible to the worker. To retain this feel, the artifact must be kept in a fixed position and, therefore, the fingers are in almost continual motion. The left hand receivesfurther strain for it must counter the shock delivered by the hammerstone. Hand-holding provides for considerable more manoueverability and easeof manipulation than does the rest, but it is less accurate. There are advantages and disadvantages to both methods and their application depends on the desires of the worker and the tool formhe needs. The size of the objective piece is sometimes the deciding factor for when a small objectis struck it will be projected with the force of the blow more readily than one of greater size. When a small agate pebble,devoid of a flat surface or projection, is cleaved, it is more intractable and unyielding and because of the lack of flat striking area, it is impossible to repeatedly cleave these pebbles by the hand-held technique. Therefore, the worker must resort to the anvil or rest technique. This type of industry has been reported in the Wadi Halfa Sudan area by Wendorf and Shiner. (Personal Communication)

12. Hammerstone With Rest and Clamp

The use of the hammerstone with rest and clamp is much the same as described in No. 11 but with the additional aid of a holding devise. The clamp frees the left hand of its holding function and allows the worker considerable more freedom of movement. The holding medium may be either the feet and heels of the worker or a second person may assist in the holding. Feet andheel holding has been noted recently by Norman Tindale (Stone Implement Making among the Nakako, Ngadadjara and Pitjandjara of the Great Western Desert. From records of the South Australian Museum, Vol 15, No. 1, 6th Oct., 1965) Also thismethod of holding was noted by Donald F Thompson (pp 400-422 Proceedings of the Prehistoric Society for 1964, Vol. XXX)

When the feet are used as the holding medium, a certain amount of movement is still present and the striking area of the stone is restricted and limited because the worker must remain in a stationery, seated position and he cannot manipulate the working piece to allow for selection of platform surface. When a second person is used, there is till a small amount of movement of the objective piece, but it does allow for greater platform selection and manouverability of the worker and the artifact. However, further experiments with this method will be tried when I have a second person to assist who is familiar with this technique.

The aboriginal probably used numerous and varied holding devises but because of their perishable nature, little or no evidence remains. Some blades and unifacial and bifacial artifacts indicate that they were made by a combination of percussion and downward and outward pressure. This technique produces a tool which is flat on the ventral surface end termination of the flakes is a feathering out without adhering to the core or artifact. Also, the undulations on the blade and core lack definition. Examples are the Arctic Micro-blade industries, the Mexican Polyhedral cores, Hopwellian cores and many examples of percussion struck flat blades and flakes. These types of holding techniques are more commonly used in core and blade making than on bifacially flaked artifacts.

Stops and pegs are useful in restricting the movement of the artifact but they do not fully immobilize it and restrict movement in one direction only. The stops may be simply a depression in a log. The pegs may be driven into a log but providing a slight depression between them to allow clearance for the flakes being removed. This method is more useful for indirect than for direct percussion and it may also be used for pressure.

~~These~~ my experiments have made use of all varieties of clamps, vises, and holding devises. They have proven that no mechanical vise is as satisfactory as the primitive method of loosely binding two strips of wood with cordage at one end and inserting a mass of rock between the slats at the other end to provide leverage. The binding must be far enough back from the working end to allow for insertion of the core. The opposite ends of the wooden strips are then spread by moving the lever rock forward until sufficient pressure is attained to immobilize the core

The strips of wood may be of any section or length. This type of lever provides the maximum in clamping immobility. Besides being perishable, a vise of this type would be quite unrecognizable as a functional tool when it was dismantled. However, materials other than wood may be used to make a similar devise. When doing preforming work with massive material, I commonly add a large flat stone to the top of the clamp to provide greater weight and further immobilize the object.

13. Hammerstone (With Rest Bi-polar)

This technique is not to be confused with the anvil and rest method for each embodies a different set of mechanical problems.

The bi=polar technique is useful for certain phases of stone-working, such as cleaving a cobble and ________________ ______________ ____, but it will not produce a flake or blade with a bulb of force on the ventral side at each end. I have examined many collections but I have never seen a flake or blade with this technological trait and I fail to comprehend the laws of mechanics or force which could produce such an implement. If a nodule of flintlike material is placed on an anvil and then struck in a manner to detach a flake bearing a cone at both ends, the two simultaneous forces (from the percussor and the anvil) would be in direct opposition. Two opposing forces would create two opposing cones and their attempt to expand would exceed the elastic limitsof the material and, therefore, the mass would shatter without detaching a flake or blade. The opposing forces and the opposing cones would restrict the normal expansion of the cone; the two forces would compress and, therefore, the mass would shatter. The resulting debitage would be a mass of splinters roughly triangulate in section and having no definition of a bulbar scar. However, a cobble-like core could bear bulbar scars on both ends with the distal end of the flake scars having a common termination point on the same plane. However, this does not necessarily indicate that the flakes were removed simultaneously, but rather that they were detached by rotating the striking ends of the core. A core with this distinctive technological trait would show that the flakes were truncated by either a hinge or step fracture and expanded as they reached the point of termination. Also, the flakes from such a core would be unduly thick and the core face would be concave rather than convex.

Using a hammerstone with rest or anvil to support the objective piece is a technique involving the principals of force, motion, and the elasticity of solids. Absolute bi-polarity of forces applied to isotropic and homogeneous material is not useful for making flaked stone artifacts with any degree of control. To observe the behavior of forces in direct opposition, a simple experiment can be condusted.

Place a pebble of flint-like material in a machinist's vise and then subject the pebble to the forces of the tightened jaws of the vise until rupture occurs. The force exerted from each jaw of the vise will cause a cone of force to form at both poles of the pebble and as the pressure is increased, the elastic limits of the material will be exceeded and the piece will shatter. (For laboratory purposes, a glass marble can be substituted) When this experiment is altered to include percussion instead of pressure and an anvil is used instead of a vise, the results will be duplicate.

Therefore, the bi-polar technique must be changed to prohibit the opposition of forces and provide for the by-pass of the two movements. This causes a shearing and then the objective piece and the cones of force will be severed. The fracture and cone-severing which occur from the by-pass of forces does not produce a bulb of force because the plane of fractur does not involve using the angle of the cone for detachment. Force is directed slightly less then vertical to prevent their opposition. When the angle of the cone is used, the force must be directed at an angle which corresponds with that of the cone.

When cleaving the mass by the bi-polar technique, it is difficult to distinguish between the core and the flake as there is no bulb of percussion on either. The fracture surface is quite flat and the concentric rings of force are diminshed and very closely spaced. When shearing occurs, the apex of the compression rings is from only one pole and which pole will be determined by the dominant force and the contact points of the anvil or the percussor. Because of the irregularity and, therefore, difference in distribution of the mass, the end, or pole, with the greater mass will have greater resistance to the force and permit the fracture to start at the end with the least resistance. If the vertical axis between the anvil and the point of the hammerstone impact are tilted more then a few degrees, the bulb of force will be more conspicuous and will increase in prominence as the deviation from vertical is increased.

w.p.s. note
Parrish ?

My experiments with bi-polar flaking have shown that this technique is unsatisfactory for detaching blades or flakes the entire vertical length of the core. Attempts have been made to fabricate flakes and blades with a bulb of force on the ventral side at both the proximal and distal ends but have resulted in failure when using the bi-polar technique. Flakes and blades can, however, be produced with bulbs of force on opposite ends but the positive bulb of force will be on only the proximal end on the ventral side and the negative bulb of force will be at the distal end on the dorsal side.

Both the aboriginals and the writer have used a slight variation of the bi-polar technique to make right angle edges on blades and flakes to prepare a core prior to removing burin blades for notching blade edges, and for making and severing microburins. Several styles of flake and blade knives are backed by an abrupt retouch which is accomplished by placing the flake or blade on an anvil and then carefully striking the supported edge with a small pebble. (Small hammerstone) However, the blow is struck slightly less than vertical, which is not truly bi-polar, for the forces are not directly in opposition. Edges made by this technique have certain distinctive characteristics which will be described in more detail under flake and blade knives.

14. Hafted Hammers (Freehand)

Using the hafted hammer freehand has advantages and disadvantages over the unhafted hammerstone. The affixed handle increases the velocity of the blow which will be in porpotion to the length of the handle. The increased velocities gained by the handle are very important in freehand flaking of small artifacts which have insufficient weight or inertia. If the striking motion is slow, the artifact will be projected with the blow of the hammerstone. High velocity blows from the hafted hammer will permit the knapper to remove thin, wide flakes from the artifact and to feather them out at point of termination. Also the hafted hammer does not bruise the striking hand as readily as an unhafted hammerstone.

The disadvantage of the hafted hammerstone is that the slightest miscalculations in judging the point of impact on the artifact are magnified in porpotion to the length of the handle. Because of this factor, the knapper must seek handle-holding positions which will better enable him to use the tool with accuracy. I find that by placing the back of the left hand, which is holding the artifact against the inside of the knee aids in fixing the position of the artifact. The right hand then weilds the hafted hammer but the right elbow is held close to the body. This limits the movement necessary to deliver the blow of the hammer. This method is done in a sitting position on a low seat - or on the ground.

15. Hafted Hammer (With rest)

The hafted hammer is used in much the same way as in No. 14 except the object being worked is placed on a rest. The rest or anvil will aid in dampening the shock of the blow to the artifact but, because of the inaccuracy of this method, it is necessary to isolate the platforms.

Striking accuracy may be increased by constant practice which is true of most flint-working techniques. Using the rest will relieve the fatigue of the left hand and the flakes will be flatter and have feathered edges. This method is suitable for removing the distinctive side-struck flakes from tabular core pieces. Side-struck flakes expand rapidly as they near termination and bi-laterally remove the distal end of the core. Therefore, the distal end of the flake is bi-pointed and somewhat triangulate in longitudinal section.

The hafted hammer and rest may also be used to remove blades. Cores are designed with one or more ridges to limit the blades' expansion, for the shape of the flake or blade is largely controlled by the core surface. The size and weight, as well as the length of the handle, must be adapted to its functional performance.

16. Billets or Rods (Free-hand)

Using billets, rods of wood or antler - eitherhafted or unhafted - for removing flakes from bifacial tools offers many advantages over the hammerstone percussor. This baton-like percussor is held in the right hand and is normally swung in an arc-like path of movement rather than a straigh line to contact the objective piece in the left hand. The width of the proximal end of the flake will be the area contacted by the billet.

Velocity of the blow can be increased by grasping the baton at the far end and decreased by holding near the striking end. For several reasons, this implement can produce better results than the hammerstone. It permits a greater margin of error and miscalculation than the hammerstone will tolerate. Also, the billet imparts less shock to the artifact and it is easier to direct the path of flight and to vary the velocity of the blow. A novice can attain fair results with the billet even though the blows are not exact because the flint will slightly penetrate the wood billet and dampen the shock. Because of this dampening effect, poorly directed blows will not shatter the artifact and the novice can repeatedly strike the edge of the artifact without removing the desired flake. However, even though he is unaware of it, small bits of flint are being removed from the underside of the artifact on either side of the ridge (high part). This ridge, or high part, has more resistance because of its greater thickness. Repeated blows of the billet will eventually free the part of the edge which bears the ridge left from a previously removed flake - thereby making a platform and centering the ridge. Flakes removed by the wooden billet will naturally be thin, have a diffused bulb of percussion, a slight lip on the ventral side and will lack the sharp definition of the cone. The slight lip on the ventral side of the flake is due to the slight penetration of the edge of the flint into the billet and is more pronounced when using a wood billet then one made from antler. When the billet technique is used, the hardness of the wood will accentuate this diagnostic feature.

I first became aware of the wooden billet technique in the 1930's when assisting with a paleontological survey in the Walker Lake Region in Western Nevada with the late Dr. Reuben A. Stirton. While camped on the ranch of a Nevada pioneer, he told of the Piute Indians stealing the wooden spokes of the wagon and buggy wheels to use for making stone artifacts. This elderly man did not know how or why they used the wood but the Indians had told him of the wooden billet.Up until this time, I had used only the hammerstone for roughing out and preforming. But I tried using the broken handle of a prospector pick and was soon able to define the advantage of this type of percussor over the simple hammerstone. The Australian primitives also used a piece of hard wood to tap the flint-like material setin the ends of their throwing sticks - such was a common retouching or sharpening method. Others who have used the billet or baton in their experiments have been M. Leon Coutier, Professor A.S. Barnes, Andres Kreigh, L.S.B. Leakey, Jacques Tixier and Francois Bordes, who has attained perhaps the greatest control and understanding of the use of the billet.

The wooden billet is of little use for striking blades from a core and the antler billet is preferred. The striking end of the angler billet must be slightly rounded and the percussion blow must allow the curved part to contact the edge of the stone. As the billet becomes worn from use, it may be rotated to prevent its becoming flat and developing large facets.

By using this harder billet, thicker flakes may be removed with a single blow, however, because of this increased hardness, the antler billet requires that the worker be much more accurate in striking. To use the billet efficiently, one must first understand the fracture of flint-like materials. To get the desired flake dimensions, the worker must pre-establish surfaces prior to removing a flake and special attention must be given to the selection and preparation of the platform area.

Many flakes found in aboriginal sites indicate that they were removed by the billet technique but there seems to be a scarcity of aboriginal billets. Wood could not be expected to endure the ravages of tim but there should be evidence of the antler billet unless it was consumed through use. On page 193 of B.A.E. Bulletin # 60, W.H. Holmes, there is an illustration of four typical antler billets. The wear pattern on these four billets indicates that both ends were used for thinning and forming the artifact which was originally preformed with a hammerstone. In my experiments, I have used both ends of the antler billet and have a wear pattern duplicate to those illustrated. See Figure ________ for characteristic flakes removed by the use of the wood and antler billets.

There are two striking patterns when using the antler billet - the arc-like motion and the straight-line movement - and the choice depends on the length of the antler - whether it is a full section or a part section.

When just the section of antler is used, the straight line method is employed and the billet is held vertically and projected in a straight line to the point of impact - much the same as one would use a hammerstone in the straight line technique. This tool and technique is useful for detachin blades from a core for it dampens the shock normally created when using the hammerstone. Blades removed by the antler section in the straight line method will have a diffused bulb without the definition of the cone; a general absence of an eraillure flake scar; and a wide lateral platform. The definition of the compression rings will be less than those left from the hammerstone and more than those resulting from pressure. The antler section does not work well for the arc method.

When a longer piece of antler is used in an arc-like motion, the billet is grasped in the right hand as one would hold a club; the wrist is held immobile and the forearm supplies the force. The objective piece is held loosely on the four fingers of the left hand with the thumb exerting a slight pressure to hold the artifact in position. The blow is projected in a follow-through motion to the main body of the objective material. The novice should protect the left hand with a glove or pad until he has become experienced and adept with this technique. After this, the protection can be deleted for the bare fingers have the advantage of inspecting by "feel" the underside of the artifact.

When making a biface, the blow is directed from the tip toward the base and then the piece is rotated and the blow delivered from the base toward the tip. When this has produced a shape suitable for flaking, the artifact is turned so the striking area will be the edge and the blow is delivered from one marginal edge toward the opposite lateral margin.

There are several variations in me thods of holding and striking. One is to strike with the tip of the billet and at right angles to the ~~af~~ artifact. Another is to strike with the edge of the billet and change the holding position of the left hand to line up themarginal edge for proper contact. When the latter method is used, the objective piece is held parallel to the arc of the blow and the flakes are detached from the underside of the artifact between the first and second fingers of the left hand. This technique is also useful for thinning down a thick core tool. If flakes removed by this technique have the desired qualities, one can then remove additional flakes from the same margin. For the novice, it is recommended to keep the angle of the blow, the angle of the objective piece and the intensity of the blow constant. After the experimenter has practi and attained much skill, he will find it desirable to alternate flake removal from both sides from the same margin.

W.P.S. note

Maybe move this to the intro.

Each artifact presents a new set of problems and they must be delt with in slightly different manners and modification of the techniques. For instance if the artifact is not sufficiently thin, it may be desirable to terminate a flake in themiddle of the artifact by either a step or hinge fracture and then remove a flake from the opposite edge to meet th flake termination of the step or hinge fracture. Very thin bifacial tools may be made by this type of thinning. The thickness, length, and width of the flake will depend on how near or far from the marginal edge of the artifact the blow is hit. The length and width of the flake depends on the exterior surface of the artifact and the force intensity of the blow.

Flake termination is dependant on both the angle of holding the objective piece and the angle of striking. Different types of billet materials leave characteristic attributes on the platform area of the flake. The hardness or softness of the billet will leave characteristics which may help to identify the billet material. The softer the material, the greater the penetration of the flintlike material into the billet. Wooden billets will vary in hardness, depending on the type of wood used. Some of the exotic hard woods such as Mountain Mahogany, Sapodilla, and others will compare in hardness with the antler. The results of different materials with equal hardness will, therefore, be similar. The geographical area will be, in part, a deciding factor of materials used for billets for whether the materials be of hard woods, antler, horn, bone, or even stone, depends on the availability of material at the time of manufacture. Another consideration is the Genus of the antler bearing animals supplying the billet material. Those derived from the Caribou, Moose and Elk are considerably larger, heavier and more massive than the deer antler which allows the knapper to remove larger flakes.

The bone billet should also be mentioned in these experiments. I fou that the cannon bone of the horse, because of its shape and weight, is well adapted for a billet. But the bone billet will not survive making more than one or two medium sized artifacts because of the spongy nature of the ends. When these ends become unduly soft, it is impossible to remove any large number of flakes and when the spongy part is consumed, the remainder is very brittle and lacks strength due to the marrow cavity in the center. Fresh uncooked bone will withstand impacts much better then weathered or altered bone.

Both individual and traditional techniques of using the billet will be determined by an examination of the platform area of the flakes. Major and minor variations will depend on the manner of holding the artifact, the hardness or softness of the billet and the character of the surface prior to receiving the force of the blow. The salient bulb, i.e. one showing a conspicuous, well-defined cone part, is uncommon on flakes detached by the billet technique but is characteristic to the hammerstone. The softer billet leaves a slight overhanging lip directly beneath the platform. This curv on the platform part is the result of the billet contacting and penetrating the platform surface and pulling away the flake. Because the billet is soft and yielding, the cone is spread leaving a diffused bulb. Much of the flake character depends on the preparation of the platform. (See platforms)

Granular materials can also cause bulb diffusion. Since the billet is commonly used in the intermediate steps between hammerstone preforming and the final pressure flaking, the dorsal surface of the flakes will bear scars of the previous preforming. Billet flakes are usually rapidly expanding with feathered edges and an accentuated curve.

(17) Billets (With Punch)

This technique uses the billet to transmit force to an intermediate tool which will be called a punch. Using the punch as an intermediate tool not only permits the knapper to make knives, spears, and assorted unifacial and bifacial implements; but it is also useful for detaching blades from cores.

The punch is usually an uncurved antler tine or a rodlike piece of bone or a suitable antler part. By using an antler billet rather than a small stone, I found I could strike with increased velocity and greater accuracy. The proximal end of the intermediate tool which is to receive the blow from the billet is made flat and the distal end which is placed on the objective piece is slightly accuminated. Generally, the billet is of hard wood, antler, or bone. Its dimensions will depend on the type of work to be performed. A long billet will increase the velocity of the blow as opposed to a short one. The diameter and weight will determine the amount of force - the longer the diameter, the more force at even a reduced velocity.

The billet and punch technique permits the worker to accurately select the impact area which is not possible when using just the billet without the punch. This technique has been described by B.B. Redding in the American Naturalist, 13, No , 11 (1879) " Holding the piece of obsidian in the hollow of the left hand, he placed between the first and second fingers of the same hand, a split piece of deer horn, the straight edge of the split deer horn resting against about one-fourth of an inch of the edge of the obsidian; then with a small stone he, with his right hand, struck the other end of the split deer horn a sharp blow" But this method leaves much to be desired for the first and second fingers cannot apply sufficient pressure to provide good contact between the tip of the punch and the edge of the artifact.

This method is unduly cumbersom and it is hard to simultaneously manipulate both the angles of the punch and the artifact in the left hand and, at the same time, strike the punch with the right arm. It is difficult to hold an object larger than an arrowpoint and also the punch in the same hand. However, by slightly changing the style of holding, I found the method has some merit. By placing the artifact between either the knees or the heels, the punch may then be used with accuracy and satisfactory flakes can be detached. But for satisfactory results, the blow must be delivered with considerable velocity to prevent the artifact moving with the blow.

A variation of this technique requires two persons to do the work. One person holds either the punch or artifact and the second person delivers the blow. George Catlin describes this technique in"Last Rambles Amongst the Indians of the Rocky Mountains and the Andes" (New York D. Appleton and Co., 1867. "The master workman - seated on the ground - lays one of these flakes on the palm of his left hand, holding it firmly down with two or more fingers of the same hand and with his right hand, between the thumb and two forefingers, places his chisel (or punch) on the point that is to be broken off and a co-operator(a striker) sittin in front of him, with a mallet of very hard wood, strikes the chisel (or punch) on the upper end, flaking the flint off on the underside, below each projecting point that is struck". This indicates very close observation by Catlin, even defining the use of projections as platforms for seating the tip of the punch. This method is useful for thinning and finishing artifacts which have been previously preformed by direct percussion. The length and width of flakes is governed by the exterior surface of the artifact, the angle of the punch and the intensity of the blow. The size of the platform must be the same size as the contact point of the punch; and the cone part (bulb of ~~percussion~~ force) will be salient with good definition. This two man technique allows the striker freedom of working manipulation but for success the workers must coordinate their actions and synchronize punch placement with the blow. When the punch process has sufficiently thinned and formed the artifact to the stage where further work with this method would break the artifact - then a pressure technique is used to remove any irregularities and ridges left by the accentuated bulbs of percussion; straighten and sharpen the edges and make the artifact more uniform.

Flakes or blades detached by the punch will vary according to the type of artifact the worker needs. The character of the platform, the bulb of percussion, the dimension and termination of the flakes or blades will depend on the workers individual and traditional traits and the implement being formed. However, there will be a certain consistency and uniformity of flakes removed by this method; their major and minor deviations being a reflection of the particular type of manufacture.

To relate this technique to the flake or blade, one must examine the platform for pertinent characteristic~~s~~ features such as special platform preparation - grinding, isolation, angle, limited area and the distance of the platform from the leading edge of the artifact or core. Flakes will reveal that the punch was placed with precision, care and accuracy on an established platform which is not the case when direct free hand percussion is the technique.

(18) Billets with punch and Rest:

Using the billets with punch and rest is much the same as No. 17. Flakes or blades made by this technique will have a slightly less accentuated curve and some may be almost flat with little or no curve at their distal end. The anvil provides inertia and affords a means of immoblizing the working material which decreases the amount of force necessary to detach a flake or blade. The impact of the billet also causes the rest, or anvil, to exert force in an opposite direction, resulting in a shearing action of the material. This produces a flatter flake or blade and terminates them at a point just beyond the edge of the anvil which avoids compression of the material by the anvil and the force of the blow.

(19) Billets with punch, Rest and Clamp

This technique eliminates the need of a second person for holding. There is a variety of ways to secure the core or artifact - the simplest being for the worker to assume a sitting position and use his heeld to hold the objective piece. According to Dr. J. Desmond Clark, this method has been recently used by the Africans to make gun flints. (Personal communication) Dr. Clark has conducted numerous experiments on the function of Paleolithic implements(Page 120, Early Man ; Life Nature Library by F. Clark Howell)

Both the writer and Dr. Francois Bordes have conducted experiments with this punch, rest and clamp technique and found we had much greater control of flake removal than when we used simple direct perucssion. However, the feet allow the objective piece to move slightly and, therefore, it is difficult to exert downward pressure and still hold the objective piece firmly on the anvil. The slightest movement of the objective piece will cause the flake or blade to be malformed. Much preferred is a holding devise made from two lashed poles and a fulcrum which permits a minimum amount of movement and allows the worker to accurately remove blades and flakes. The clamp allows the worker to accurately place the tip of the intermediate tool, or punch, on a pre-selected platform area and both the vertical angle and the angle of fracture can be calculated. Then the velocity of the hammerstone or billet, which is relative to its weight, is calculated to comply with the size of the desired flake and the angle of the plane of fracture and the texture of the material.

The form of the flake or blade is controlled by its dorsal surface. Should the face of the core be flat, the blow will create an expanding flake, but if the core has a prepared longitudinal crest or ridge on the face, it will form a narrow flake or blade/

The billet with punch rest and clamp technique is used for making blades and for the refined percussion flaking of artifacts following direct percussion preforming and prior to final pressure retouch.

Characteristics of this technique can be found on the proximal or platform end of flakes and blades. The size of the platform area is governed by the size of the tip of the punch or by a special preparation which isolates the area contacted by the punch, which can then be smaller than the punch. The platform can be the natural cortex, an unmodified plane of fracture or a part that is concave as the result of removal of one or more flakes; or a crest left from the removal of a flake on either side of the crest; or it can be ground or polished. Should the platform be convex, it usually indicates that the platform was either isolated, ground or polished. The angle of the platform is variable depending on how the core was formed and is a significant factor in determining core types yet should be constant if a single technique was used. If the top of the core is prepared at a right angle to the long axis - then the platform of the flake or blade will have a corresponding angle. If less than a right angle, the platform will correspond to this angle. The angle of the platform on the flake is at right angles or less than a right angle to the longitudinal axis of the core. The apex of the angle begins at the dorsal side of the flake or blade and will never slant toward the dorsal side but rather toward the ventral side.

In general, flakes and blades made by the billet, punch and clamp technique are uniform; generally have small platforms; a salient bulb of percussion, and a general absence of eraillure flake scars - features not characteristic to an assemblage made by direct percussion.

Because of the use of the clamp, flakes and blades will be flatter; they can be controlled and, therefore, terminated by feathering at their distal end. Because of the decreased shock when using a billet, the ventral surface of the blade or flake is generally smooth and without well-defined pressure rings.