Edited evidence

a basic step in determining working techniques is an understanding of the proper stone for toolmaking & reconciling the relationship of techniques to material.

I. The study and evaluation of lithic materials is of prime importance not only when interpreting manufacturing techniques, but should also be included in determining typology. The material used has a direct bearing on methods of manufacture and could even have restricted the toolmaker in the final control of thinness and flaking uniformity. Further, a working knowledge of the stone to be flaked is essential for the knapper, as any variation in its quality requires a different method of treatment by the worker. No two materials are exactly alike and, therefore, although the worker's techniques may vary the basic principles of manufacture remain the ~~same~~ constant.

What are lithic materials? Ideal lithic materials are kinds of stone with the necessary properties of texture, elasticity and flexibility. They must be relatively free of flaws, cracks and inclusions so they will withstand the proper amount of shock and force necessary to detach a flake of a predetermined dimension. ~~This~~ My definition of lithic material is based on my ~~own~~ experience in making stone tools. and should not be confused with the mineralogists definition, which has reference to and does not pigeonhole materials unc

My purpose in this paper is to describe and explain what materials are used in the toolmaking industry, to resolve what stone is adaptable for flaking a flint worker needs, and to point out some of the working problems related to material that confront a flintknapper. When subjected to the proper amount of force, applied on a properly prepared platform, portions of the stone can be removed producing flakes with a very sharp cutting edge. The following text will endeavor to further explain man's ability to control the size, thickness, width and length of flakes thus detached. When one is able to control the four dimensions - thickness, width, length and curve when removing a flake, he can then produce almost any tool he may need. However, the platform prepared on coarse material will collapse more readily than that fabricated on finer textured material. Generally,

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the coarser the stone texture, the tougher and the more difficult it is to work. The tougher the stone, the more difficult it becomes to remove regular and uniform flakes. The character of the stone is also important, i.e., bedding planes, inclusions, incipient cracks and internal stresses, etc. These will be discussed more fully in a later analysis of individual materials. But a stoneworker must be concerned with texture and character of material. While color and transparency will produce a more colorful and beautiful tool, they are not necessary properties of good lithic materials.

I would like to point out the differences in the multiple types of lithic materials. Each source of stone has certain attributes of which the worker is aware. For example, when Dr. Francois Bordes and the writer were doing some experimental flint working at the University of California in Berkeley, materials for our project were from many and diverse locations, i.e., Southern France, Northern France, Indiana, California (2 locations), Oregon and Idaho, representing seven widely separated sources. After a week of working, the materials were almost entirely utilized and the resulting array of flakes was mingled in one big heap. Yet, if any single flake had been given us, and this happened, we could identify its origin without error. The point I am trying to emphasize is that after the toolmaker has worked with a given material, he will be able to identify its peculiar properties. Other features to be examined are: texture lustre, surface character (rind or cortex) color, transparency, sound, flexibility, sharpness of the removed flakes and perhaps most important is the amount of resistance to the necessary force required for detaching a flake. The degree of lustre is used as a visual guide by flakers to regulate the amount of force necessary to remove a flake of a given dimension & is one of the most useful attributes for determining workability. The variations of lustre include glassy, waxy, greasy, satiny to dull, matt, flat, sugary, fine crystalline, medium crystalline, coarse crystalline and sandy.

The refractive index also may serve to determine the degree of fineness or coarseness of material,

II. Most sources of lithic materials produce a material that is identifiable through special qualities recognized by the stoneworker. He must, when choosing material, determine the homogeneity of the mass and appraise the texture and lustre of the stone and fit the size of the rough material to what he wants in a finished tool. The myriad of bright colors are desirable, but color in most instances, does not indicate workability of stone. In making an appraisal of the flint-like materials to determine their workability, one may first tap the stone lightly to prevent bruising and listen to the sound of the tapping.

a quick & pretty good field test of material is to drag the fingernail across a freshly flaked surface. If the fingernail moves easily across the surface the material is, generally, fine-grained; if it hangs up or drags - then I generally find the material to be coarse-grained.

Often I have heard reference being made to a large thick biface, irregularly surface-flaked, as "crude heavy biface" or "crude percussion work", whereas in reality, the worker was a skilled craftsman to have produced any type of tool considering the material he had to work with. I have also heard this same reference being made to pressure work on poor material whereas the presence of any control at all denoted a skilled craftsman. A stone knapper will always relate the quality of workmanship to the material.

Certain materials will allow the platform to collapse - leaving a dull edge - while others haven't sufficient strength or flexibility to permit making a long thin flake, thereby causing multiple hinge and step-fractures. Personally, I cannot do the fine type of controlled pressure flaking on coarse-grained materials that I can achieve with finer, more closely-grained stone and, from the few collections I have been able to study, I have noted this same type of material restriction. Therefore, I reiterate that we must consider material in our analysis of tools, our explanation of type, and the study of technology.

Poor material showing skilled and controlled surface techniques does indicate good workmanship. Good quality material skillfully worked also denotes good workmanship. When we do find poor work on quality stone then I think it is safe to assume we are viewing poor workmanship, unless we find, on inspection, that the worker was merely preforming good material which was later to receive the refined techniques.

When hunting suitable material in the field, I find the most satisfactory method of testing is to drag your fingernail across a freshly flaked surface to determine its qualities. If the fingernail moves easily across the surface, I can assume the material is finely-grained. If it hangs up or drags, then I presume the material to be coarse-grained. If the stone gives off a dull sound, one can expect undetectable cracks, fissures and planes of weakness. However, if the stone has a sharp ring, the chances are good that the material will be of working quality. One may then remove a test-flake, or cleave the stone to examine it further. If this shows the material to be free of crystal pockets, foreign deposits and shows the right lustre, then the worker assumes the stone will lend itself well to the manufacturing of an artifact. The final outcome will, of course, depend on the skill of the worker.

Some material is still available in certain alluvial deposits with new exposures. In these deposits of cobbles, one may identify, by examining the surface texture of the individual stones, the material that will best lend itself to flaking. If one is not familiar with the nature of the stone then appraisal will be more difficult and testing of each cobble would be necessary. Water-worn cobbles lose a great deal of their identity as a result of pounding and rolling in the water. However, this rolling and pounding, fortunately, gives a clue to the workability of the stone. The projections and irregular edges receive the greatest portion of the impacts and each time the stone bumps against another cobble, a distinctive bruise is produced. Upon examination, one will find that, in reality, each bruise is a cone. Some are obvious, others are visable circular scars just under the surface. If one examines a well-used glass marble, he will readily see the type of scars I am referring to. It is this type of a scarred surface that is so important in determining the materials usefulness to the stone flaker. The multitude of cones is superimposed at random and intersect one another. Under certain conditions, moisture will enter the incipient circular cracks then at low temperature freeze and loosen the portions of stone between the cones. The surface then is similar to what we laughingly call "goose bumps" or a multitude of little exposed cones. This cone-covered scarred surface is reminiscent of the surface of the moon. The recessed or concave protected areas often receive a polish from being burnished without shock against one another and do not have cones. By these types of surfaces, one is able to identify the cobble that has the desirable working properties.

As a source of material, surface finds are easier to secure than material which must be dug. In most areas of this kind, a person will find a few broken tools made from this material. From the size of the broken tools, the aboriginal stoneworker had uncanny ability to find the best and most colorful quality in massive form. Today, usually a deposit of this kind yields only pieces under six inches in diameter, and finding a nodule as large as a basketball is a rare event as the bubbles in the molten lava must have burst or risen to the surface before the lava solidified. Occasionally, fissures and cracks will fill with agate, chalcedony and jasper and when they weather out they are in large tabular pieces ideally suited for the making of large bifacial tools. Some of the silica minerals deposited in the cracks and crevasses will form tabular pieces of usable material that is of ideal thickness for making thin knives and projectile points, ~~since~~ thus this ~~eliminates~~ eliminating percussion preforming.

When such material is available, one may complete the tool by the use of pressure alone. In some instances, when this thin material was used, the entire surface was not removed by the pressure retouch. When this happened, and a flat portion of the original surface on each side of a bifacial implement remained, it could be diagnostic in determining the source of the material. However, the source of material is difficult to determine on a finished bifacial artifact if all of the original surface is removed. The flakes discarded by the workman are then of more value in determining the location source of the material than the finished artifact. Sometimes the dorsal side of ~~some of~~ the flakes will show the natural surface of the material ~~and the surface will show the natural cortex of the material~~ and this will, in most cases, indicate whether it was quarried, secured from alluvial deposits, veins or weathered from the surface.

When I hunt for material, I look for a stone with the following qualities: ~~cleavage~~ fracture in any direction, lacking grain or cleavage plain, breakage with a sharp edge. To be useful such a stone must be of some size and have good strength. The silica minerals that I have used in my experiments to reproduce prehistoric tools are similar, or the same, as prehistoric stoneworkers. Because my home has been in Idaho, I have had to gather the major portion of my experimental materials from the West with small quantities being given and sent to me from other parts of the United States and abroad. This has given me the advantage of living in a sparsely populated area where lithic materials were fairly abundant, but ~~I have had~~ the disadvantage of not being able to study enough collections to permit viewing and comparing a larger array of materials used by the aboriginals. During the many years that I have roamed the deserts in search of material, I always found, upon discovery of a source of good rock, that ancient man had been there before me and had quarried out the same material for his tools. Further, it always seemed that the massive material they ~~left behind~~ rejected I, too, discarded and for the same reasons, i.e. imperfections in the stone, flaws, fractures, too granular, crystal pockets, etc. Finding an undisturbed source of good material suitable for tools has been a problem for me since I first started my experiments. The first materials I used for fabrication were the rejects and cast-offs of the Indians. The disadvantage of using cast-offs was the irregularity of the flakes and the short supply. Somehow I could never seem to find massive material that quite matched the flakes and cast-offs of the campground. Because of this, I became suspicious of Paleo-man altering some of the flint-like materials. From this deduction and further experimenting, I found their secret of altering lithic materials by the thermal treatment (Crabtree & Butler).

But, in the beginning, I only knew that I was attracted to their cast-off flakes because of the change in color, the shiny lustre and the ease with which their discards worked. During these years, I have visited many sources of material and quarry sites and have yet to find one that was not previously visited and worked by ancient man. After taking what was left over, after centuries and millenia use by prehistoric man, I now have to contend with the present day hunters called "rockhounds".

~~III.~~ Particular materials present separate problems to the flintknapper. My experience with a range of workable stones has lead to some observations which may be useful to other flintknappers and archaeologists. In order to produce a good tool of quartz crystal, it must be oriented with an axis of the crystal, that is, the proposed artifact must be parallel to the flat side of one of the six sides of the crystal. When this is done, the applied force will move the flakes across the growth patterns thereby permitting more uniform flakes to be detached with the minimum of steps. If this procedure is followed, the result will be a thin, uniform artifact. When the artifact is made from a cross-section of the crystal, the resultant tool will have multiple step fractures because the growth patterns will not allow a long flake to be removed due to the intersection of so many cleavage planes of the growth pattern. The resulting artifact will be thick and ill-formed and no amount of skill can overcome the physical properties due to the weakness in the crystal planes of poorly oriented artifacts.

Quartzites & Silicified Sandstones

From a stoneworker's point of view, there are at least two types of quartzites - the metamorphosed sandstone and the silicified sandstone. They are not readily differentiated and defined by eye, but when flaking them one can detach a flake and find a marked difference in their workability.

The brecciated silica cemented variety is more desirable because it will allow long, thin, well-controlled flakes to be detached while the material composed of the rounded grains will not have as much flexibility. The brecciated and the rounded varieties respond readily to heat treatment if the matrix, or cementing medium, is chalcedony or a similar type of cryptocrystalline ~~mineral~~ silica. The most workable quartzite I found is the silicified sandstone from Hell Gap, Wyoming. ~~Metamorphic quartzite~~ Bull Quartz is one of the least desirable for making flaked tools, for the fracture is unreliable and the resulting tools are usually thick and ill-formed. Much skill is necessary to make even a very crude artifact from this material. The edges are usually dull and the surface covered with step-fractures.

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Flint-Like materials (copy from Page 45)

Some materials do not work equally well by percussion and pressure. Experience will serve as a guide and I can point to a recent example with ...

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flint. Outwardly, or by visual inspection, one flint may appear to be of the exact nature of that from a different site, yet when subjected to the percussion method of detaching flakes, it does not respond well, while for pressure work it will respond admirably. To cite an example: Recent correspondence with Dr. Francois Bordes informed me that he had received a supply of flint from Sweden. To quote Dr. Bordes "This is beautiful flint to make blades, works also fine by pressure - untreated - but it is very difficult to work by percussion. A most paradoxical flint!" Dr. Bordes did not say if this material was freshly mined or surface, but he did indicate that he was going to subject this flint to the thermal treatment and see what results he would get after the heating. It is common knowledge that when lumps of flint containing water are exposed to the elements they will be in no way as workable as freshly mined masses removed from below the frost level. Continued exposure to sun and frost will naturally create expansion and contraction that will, ultimately, form cracks, planes of weakness and internal stresses that are undectable until one attempts to make a flaked tool. However, the smaller the pieces, the greater their ability to stand rapid changes of temperature. I find that the flakes detached by ancient man are as easily worked by pressure as the newly mined material. However, this factor may ~~pertain~~ be pertinent to only certain types of flint and much material still remains to be tested. It is true that coarser textured flints will allow more expansion and contraction than finer textured flints. After flint has been slowly heated and cooled, it has a much glassier texture which makes it easier to flake./ These experiments proved the amount of water flint will absorb is considerable and Mr. Kreigh (Melgaard) was of the opinion that freshly mined flint was more desirable and permitted more control than the surface variety.

To further illustrate the different varieties of flint, I might say that for our experiments at the University of California at Berkeley, Francois Bordes and I received some Harrison County Indiana flint through the courtesy of Dr. Raymond S. Baby of the Ohio State Museum. This material had weathered out of limestone and was marked with rust streaks as a result of being hit by plow and field tools in farm tilling. Yet, Bordes and I agree that it was one of the best flints in its natural state that we had ever worked, responding well to either the pressure or percussion method. We could see no reason to alter this material by using the thermal treatment. This flint must be of considerable age, as it had apparently laid on the surface since it weathered from the limestone of the area. This would, therefore, seem to substantiate my theory that one must consider each individual material separately rather than judge its workability according to whether it is freshly mined or surface, dehydrated or hydrated. Each of the many flint sources has its own character.

Good quality flint has most of the attributes necessary for the making of most flaked tool implements~~, especially when the cortex has been removed~~. Working on flint produces a flake with a sharp edge. This material has the quality of toughness, permits one to create a platform that will withstand the necessary pressure or percussion force without collapsing, thereby permitting a wide thin flake to be detached without breaking off short which causes step-fractures. Flint has a resistance to "end shock." That is, when the blades are removed from the core, the shock on the proximal end of the flake will be transmitted to the distal end of the flake, causing a rebound of the mass, resulting in a broken blade. This, I think, of as elasticity. The coarser-textured flints do not produce flakes with as sharp an edge as do the finer-textured flints. The edge of the flake can be only as sharp as the degree of micro-crystal size. For example, a non-crystalline material, such as obsidian and opal, when cleaved or a flake removed, will break to the last molécule or to a theoretical infinity, while flint will break to the last micro-crystal, producing an edge with a diminutive saw effect. A flesh wound made by the sharp edge of flint is slow to heal, as its coarse edge bruises and destroys the tissue cells, while obsidian and opal sever the cells and rapid healing can be expected. Generally, the flint cut will heal leaving a scar, while the opal and obsidian cuts will heal more rapidly and leave no scar.

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Opal- Amorphous

Opal is the most brittle of all the silica minerals, thin edges of opal can easily be flaked by the pressure of the fingernail. Opal with a rich display of colors is considered a precious gemstone but, because of its rarity, played little or no part in the toolmaking industry. Opal is not particularly satisfactory material for making large flaked stone implements. Because of its high water content, it is a very unstable stone and rapid temperature changes and exposure will result in dehydration, causing the material to crack and craze. However, opal freshly dug from below the frost line may be worked into small artifacts, if the work is done before the stone has a chance to dehydrate. Because of its non-crystalline structure, a quality which opal and obsidian have in common, opal breaks to a very sharp edge. It is this quality that allows a flake to terminate to the last molecule thereby producing an edge with greater sharpness than that of any metal razor or any other variety of ~~chalcedony~~ silica — see pg 65. In spite of its brittleness, opal is the most easily flaked of all materials, permitting very long minute flakes to be detached with a minimum of force. Its quality of elasticity allows the worker to guide and bend the flakes with less effort than is exerted on most other materials.

Obsidian

Obsidian has all the desirable qualities and properties necessary for making flaked stone tools and it must have been a time of much rejoicing among ancient toolmakers when a source of good obsidian was located. It requires less force to detach a flake from obsidian than from the cryptocrystalline silica minerals and it works equally well for the percussion or pressure methods. Its only drawback is its limited strength. The cryptocrystalline silica minerals are stronger and not as brittle as obsidian. However, the sharpness of the obsidian flakes more than compensate for the difference between the two materials. A great deal of the obsidian in the Yellowstone Park area contains spherulites, making it unsuitable working stone as one must first delete these imperfections and, therefore, only small tools can be produced. There is also a difference in the texture of various obsidians from the same site. The coarser-textured varieties have less strength and, therefore, are not as desirable as the more vitreous types. The age of the obsidian is also a factor in its workability— the older the obsidian, the more internal stresses and strains because the molecular structure is unbalanced by trying to regain a crystalline form, making the older material unpredictable for the manufacture of tools. This phenomena may be likened to old and new window glass. A glazier will sometimes refuse to cut old glass because of its brittleness. An example of this phenomenon in nature is evident in the obsidian found in pearlite beds. Often it is so brittle from internal stresses that one cannot remove the surface by grinding on a lapidary wheel without almost exploding the obsidian. Much of the pearlite is made up of the exfoliated obsidian. Areas producing this type of obsidian have the appearance of being an aboriginal workshop due to the exfoliated flakes. Some of the material will even resemble polyhedral cores due to the starch fractures caused by internal molecular pressures. However, this type of break is readily identifiable from those man-made, either by pressure or percussion. When I speak of old and new obsidian, I am making reference to the geological age and, at the present time, the age is only relative.

Gene Titmus, Henry Irwin and I did some toolmaking work at the Glass Butte and Burns, Oregon sites and became very aware of the additional amount of force required to detach a flake of similar size from a piece of Burns obsidian and the cobbles found at the Glass Butte site. When struck, the Burns obsidian has a resonance that is unnoticeable in the Glass Butte material. Until one is able to mentally calculate and compensate for this difference in toughness and homogeneity and allow for the difference in the force necessary to remove flakes of equal dimensions, it is difficult to change from the Burns material to the Glass Butte obsidian. Some of the sites from which I have obtained obsidian for experimental purposes are: the Island of Sacrifice near Vera Cruz, Mexico; Teotehuacan, Valley of Mexico; East of Magdelena, Mexico; San Blas, Mexico; Glass Butte, Oregon; Silver Lake, Oregon; Northwestern Nevada; near Cedarville, California; Coso Hot Springs near Little Lake, California; Glass Mountain northwest of Bishop, California; Fish Lake, Nevada; Clear Lake, California; Snowflake obsidian south of Salt Lake City, Utah; the Western slope of the Tetons, Idaho; Sweet, Idaho; and Owyhee County, Idaho.

Obsidian requires a different working technique than the cryptocrystalline varieties of silica mineral. When working obsidian, a softer hammerstone is used to prevent the shattering and collapse of the striking platform. It is also necessary to use more care in the preparation of the platforms to insure their withstanding the necessary pressure or percussion force. With obsidian, the shock must be dampened with more care and the force must be directed toward the center of the mass more carefully. Support is more critical and greater care must be exercised in holding the stone being worked. Because of the fragility of this material, a refinement of technique is necessary when one changes from flint-like materials to obsidian.

Pitchstone

Pitchstone is a variety of obsidian with a coarser texture. The edges of the flakes are not as sharp, the platforms crush more readily than do those on obsidian and a little more force is required to remove a flake. I believe pitchstone has a slightly different water content than does obsidian, but generally, the qualities are similar. Ignimbrite A fractured surface of ignimbrite will exhibit numerous imperfections. When a flake is being detached it intersects the small granules of impurities which create unequal resistance to the force necessary to detach a flake. These impurities leave a roughness on the flake. When ignimbrite is used for making stone tools, slightly different techniques must be used than those applied to obsidian. The edge strength is not as great as obsidian, so more care must be used in seating the pressure tool, and a stronger platform must be created. When percussion is used to detach flakes, the impact must be farther in from the leading edge to prevent it from crushing or causing a step fracture. Very fine narrow controlled precision flaking may be accomplished when one becomes accustomed to this material. Ignimbrite is quite plentiful in Southern Idaho and was apparently a favorite material for early man in this area. The greatest percent of the artifacts found here are made from this reconstituted tuff.

Basalt

The more finely textured basalts lend themselves well to pressure flaking. However, more force is required and a stronger platform is necessary to detach flakes than on obsidian and other vitreous materials. A greater amount of control must be exercised to make basalt pressure flakes of uniform dimensions. This is because of the increased amount of pressure necessary to detach a flake and at the same time prevent the flake from collapsing. One may expect the flakes to be much shorter and have more step fractures than when working a attrition - grinding & cracking of rocks

finer-textured material. Pressure flaked artifacts of basalt may be expected to be thick, unnotched or slightly notched, stemmed or lanceolate. In rare cases precision flaked tools with sharp edges may be found.

Rhyolite

When rhyolite is found with a minimum of phenocrysts, it can be a very satisfactory stone for the manufacture of flaked implements. The colors of rhyolite range from white to gray, pink, red and purple. The glassy rhyolites may be flaked by either percussion or pressure and well-controlled flakes may be detached. Fine quality rhyolite may be compared to good quality heat-treated jasper and chalcedony in degree of workability.

Andesites

Because of the wide range of constituents, textures and contained minerals the degrees of workability is relative to the homogeneity and texture of andesite.

~~Limestone~~

Limestone with a high silica content can be useful for making tools adaptable for rough usage and when a sharp edge is not necessary. Siliceous limestone is very difficult to pressure flake and most of the forming of the tool must be done by percussion. The nature of this material is comparable to basalt in workability, texture and toughness.

Metamorphosed Rock

Minerals resulting from metamorphism are only useful if they have the qualities necessary to make flakes that may be controlled by pressure and percussion. Slate has been a fairly common material used for tools and ornaments but they are usually finished by grinding. However, the initial shaping can be accomplished by using percussion and pressure.

~~IV.~~ Readers may wish to experiment for themselves and professionals may wish to have suitable classroom materials for instruction. Both purposes may be satisfied easily enough. It is not necessary to seek adequate natural materials from aboriginal quarries or from alluvial deposits. Suitable experimental

Glass

materials are close at hand. Glass has much the same properties as obsidian and it responds in an identical manner under the application of force. Both natural glass and manufactured glass are by far the best materials for studying fractures for they leave radical scars, fissures, undulations, the step and hinge fractures, the eraillures, the flake overlaps, the platforms and the bulbs of force well defined. The glasses will reveal much more of the mechanics of force used in manufacture than will more coarsely textured materials. Of much importance to the experimenter is the fact that glass requires much less working force than the cryptocrystalline silicas. Even the aboriginal people chose glass as a preferred material for glass tools have been found in some of the historical sites in the Americas, it was a favorite of the Australian ab-originies, and a great majority of the experiments done by Ishi were worked in glass. When one becomes familiar with a certain kind of glass and continues to use the same quality very satisfactory results may be obtained. If one cannot obtain the desired results when working with glass it would be useless to attempt to work with natural materials. One must keep in mind, however, that unless one is doing this work continually, the hands will become very tender until the muscles are hardened and callouses are formed.

Glass as an experimental material is easy to obtain in a variety of shapes, forms, colors and composition. An excellent source of supply in the archaeological sites of the future, i.e., the city dumpgrounds. Here may be found cold cream jars, pyrex jugs, broken plates and bromo bottles and a particularly satisfactory item old T. V. tubes. One should not delay too long, however, as our civilization is rapidly entering the age of plastics.

Porcelain

For the study of fracture and comparison with the natural coarser-textured stones, porcelain may be used as an experimental material for the fracture of porcelain is quite similar to some varieties of quartzite. However, it does not have the same toughness. Porcelain is also variable in quality suitable for flaking. That which has been fired at a high temperature is the best working material. Examples include discarded high voltage transmission line insulators and most porcelain bathroom fixtures. This material is very good for percussion practice work and better grades may even be pressure flaked.

Ice

Ice can be useful for classroom demonstration of the fracturing of flint-like materials and protects the participants from injury from flying pieces of natural material. Resins may be used by students to practice pressing off flakes and to simulate small cores, etc., for determining the nature of fracture. Starch has much the same character as resin and microblades may be removed with the tip of a lead pencil. Anthracite coal, cold tar and Gilsinite are also materials that can be used to show the mechanics of fracture. This list is incomplete and there are perhaps many other substances and compounds that can be used for laboratory demonstrations to show how certain solids react to applied force.

~~There are a number of things to be kept in mind whenever a flint worker examines raw material. A list of suitable materials based on the standard supply by (Dana [redacted]) and may be found in the appendix which follows this paper.~~

see page 91 for complete list by Crabtree

1. Color is an excellent aid in sorting the toolmakers debris. Certain distinctive colors afford a key to the points of origin of some minerals even though texture does not always remain the same.
2. The cortex of the stone should be examined for a clue to its usefulness as well as to its source. Cortex indicates the exterior surface of the mass before it has been shaped into a tool. Most materials have a natural surface layer that is sometimes sufficiently distinctive to be useful for identifying places of origin. Cortex is used to identify the natural or

unflaked surface of material useful for tool making. Examples are: the partly silicified surface or the incompletely mineralized exterior of nodules or masses of flint whether from chalk or limestone deposits. The bruised, abraided or naturally polished materials found in alluvium; glacial till or naturally transported deposits; surfaces retaining the impressions of cavities, voids, fissures, crevices and joints where silica-charged solutions may be deposited or the external surface impressions left by organic materials that have decomposed and their voids or casts replaced by siliceous materials.

3. Distribution of material in space with a greater distribution more likely it is that the material was of special value to flint workers.

4. Every effort should be made to examine deposits in place in order to identify the effects on the material of its mode of occurence.

5. Light transmission is an important identifying feature being useful in determining the colors by a transparency rather than a reflected light. If one will moisten a thin flake, or a thick one broken to a sharp edge - then hold it towards a bright light, he will be able to see the degree of translucency as well as the mineral structure. The wetting of the surface is also good to bring out the true color of the reflected light and, at the same time, aid in revealing the structure which may be characteristic of that particular material. It is often difficult to determine the difference between ignimbrite and obsidian in the field but upon holding a thin edge of a flake towards a bright light, the ignimbrite is generally opaque or has a very uneven distribution of coloring matter in the form of granules, while obsidian has a uniform distribution of color with different degrees of translucency.

6. Texture is the most important key to the workability of lithic materials as it indicates the degree of crystallization. Textures range from a very glassy or vitreous to the more granular rocks. This can indicate how much force is necessary to remove a flake, whether the material can be flaked by pressure or percussion, the sharpness of the edges, and whether flakes of uniform dimension can be detached without the platforms or the flake collapsing. The finer the texture, the greater the control in making flakes, blades and tools.

7. The edge character of a flake can denote how useful the material would be as a cutting implement, its degree of texture, the finer the texture the sharper the flake. Tools made of fine-textured materials are useful for cutting soft materials such as leather, flesh, cordage and other fibers. The finer-textured materials are also ideal for pressure flaking and where a sharp edge is needed for knives, blades and projectile points. For tools that will be subjected to rough usage, a material that has a coarse edge will be more satisfactory since it is tougher. The difference between a sharp and a coarse edge is the conversion of a cryptocrystalline silica mineral by the use of thermal treatment. For example, agate in its natural state has an irregular edge. This irregularity is the result of the size of the microcrystals. In its natural state, it has much toughness well suited for drills, perforators, scrapers and other tools where it is unnecessary to remove long regular flakes and the edge need not be extremely sharp but rather is designed to withstand twisting, shock and generally severe treatment. However, if a thin well-formed knife with a razor edge is needed, one can be made from the same piece of agate if it is first altered by the use of heat treatment from its original form to a material

that has a very sharp cutting edge and is easily pressure flaked.

8. Resistance to shock is one of the qualities of stone that only the stoneworker of the past and a few present day experimenters can fully appreciate. It is one of the paradoxical things that is not entirely understood. The resistance to end shock is more noticeable in the technique of removing blades from a core for one finds that certain materials can be compressed when struck by a hammerstone or a billet and will then expand without breaking the blade. Some materials do not have this resistance and, when a blow is delivered at the proximal end of the blade, there seems to be a transmission of force thereby causing breakage. At present, this resistance is confined to certain groups of materials and this is apparently due to the intertwining of the microcrystals of the cryptocrystalline group. The quality of toughness is directly associated with the resistance to shock and this quality prevents platforms that receive the impact of the blow from collapsing. Flint has this quality, but it is not found in volcanic glass. Toughness is the quality of flexibility without brittleness or yielding to force without breaking.

9. Elasticity is the property or ability to return to its original form when the force is released. It is this quality that is related to end shock - the ability to recover without fracturing.

10. Flexibility is a term meaning the quality to be bent or pliancy or not being stiff or brittle. It is this quality that allows a person to control and guide a flake over a curved surface. If it were not for this property of flexibility, there would be no convex or double-convex artifacts. Different materials have different degrees of flexibility. Heated cryptocrystalline minerals and volcanic glasses have this flexibility to a greater extent

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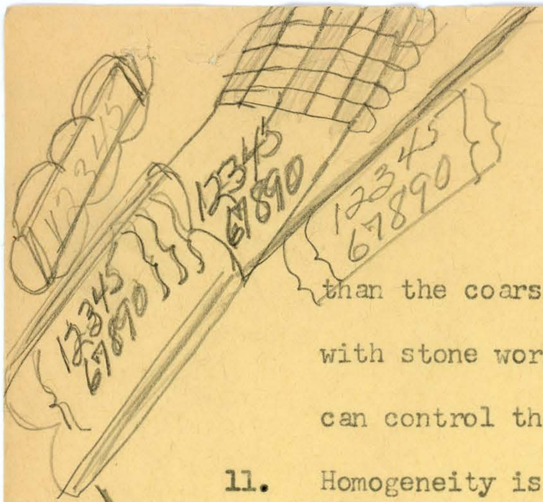

than the coarser-textured minerals. It is difficult for one familiar with stone working to fully understand this property, but a flintknapper can control the flexing to an amazing degree.

11. Homogeneity is a condition in which the composition and the physical state are uniform throughout. Consisting of identical or closely similar material which may be a single substance or a mixture whose proportions and properties do not vary.

12. Heat treatment — Specimens should be examined for evidence of heat treatment. Some of the character of heat treated artifacts has already been decribed in Crabtree & Butler(1964?). There will be additional information published at a later time.