LITHIC ANALYSIS: CHIPPED STONE TOOLS AND WASTE FLAKES IN ARCHAEOLOGY

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The air was thick with the sweet smell of sage that hot Nevada afternoon in 1973, my first day of archaeological survey. We had huffed and puffed our way to the top of a windy ridge overlooking Big Smoky Valley. Our crew leader, Robert Bettinger, always ahead of the rest of us, paused at the crest of the hill. I caught up with him first. Looking down at the ground, he asked me if I saw “it.” Following his gaze, I saw dozens of small flecks, brilliant red against the parched earth. I bent down to pick one up and was surprised to find they were stone. I had thought they were flower petals! Nearby was a broken knife of the same material, its surface covered with neat symmetrical fractures as if someone had carved it from clay. In my hand I held the stone, hot from the noon sun, and ran my thumb over its undulating surface. I thought that I had never seen anything so beautiful. At that moment my future was charted for me.

Lithic analysis is the study of chipped stone tools and the waste flakes from their manufacture and maintenance. Stone tools and waste flakes form the largest class of archaeological data. They record the earliest instances of tool making by our ancestors (just over two million years ago) and are the bulk of the archaeological remains left behind by hunting and gathering peoples. They even continued to be an integral part of prehistoric technology after the introduction of metals. Flaked stones were used for the manufacture of projectile points (arrowheads and spear points, scrapers, engraving tools, knives, choppers, drills, and shredders; these tools were used to work leather, wood, bone, antler, and sinew to make clothing, bags, baskets, bows, amulets—to make all the necessities of life. Understandably, then, archaeologists have devoted a considerable amount of time to the study of stone tools.

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Is It a Tool?

Students frequently ask me to look at stones found in their fields that they think are spear points or scrapers or something else (I also get lots of petrified brains and hearts). Usually the students are right, but sometimes what they show me is just an unusually shaped rock. How does an archaeologist know what’s a tool and what’s just a broken rock?

Most of the time the answer is easy because the probability that a stone could naturally fracture into, for example, a projectile point is extremely small. But prehistoric people often fashioned tools expediently by quickly striking a few flakes off a handy cobble. How can we tell if such cobbles are tools? This issue is especially
important to archaeologists who try to determine when humans first arrived in the Americas.

All archaeologists agree that people were in the Americas by 11,200 years ago—they were the ones who fashioned Clovis spear points (see Figure 1). But some argue that people were here ear-

Figure 1
Three Stone Tools: A Clovis Spear Point, an Acheulian Hand Ax, and a Microblade Core
lier—fifty thousand or more years ago—based on the excavation of crudely fractured cobbles at a few localities, such as the Pedra Furada site in Brazil. The “tools” at this site’s earliest levels are simple quartzite cobbles from which a few flakes were removed; they look like crude chopping or cutting tools. While living peoples made frequent use of such tools, we also find fractured stones that look like tools along a river’s rapids where they were pounded against one another; at the base of cliffs where they shattered upon impact; in *alluvial fans*, the geologic deposits that form vast and deep skirts on mountain ranges where stones broke under pressure or in mudslides; or in glacial deposits where stones broke beneath the crushing force of a thick sheet of ice.

Pedra Furada is a cliffside rock shelter, far above which is a geologic deposit containing quartzite nodules; these nodules have been breaking off, tumbling down the cliff, shattering and rolling into the rock shelter for millenia. How do we know if the casually fractured stones in Pedra Furada’s early deposits were made by humans or by natural forces?

First, we can sometimes rule out natural processes by the kind of rock that was used to make tools. Through visual inspection or chemical analysis it is often possible to trace a rock to the geologic strata from which it came. If the tools occur in large numbers in a site located higher in elevation than the geologic strata, then there is a good chance that people brought them there (or, as archaeologist Dennis Stanford once said, there must have been one heck of a windstorm). Or if fractured stones are found in geologic deposits that were deposited with little force (e.g., pond sediments or a peat bog), Mother Nature cannot be blamed. But if the stone comes originally from a geologic strata “upslope” from where it is found (as at Pedra Furada), someplace from which the stone could have rolled down and into the site, or if the stone is found in a deposit that was (at least in times past) deposited violently, then it is less likely that the tools were created by people.

Second, if we knew how stones tend to break in nature, uninfluenced by people, then we might be able to say whether casually flaked cobbles in a site could or could not be products of nature. What do stones look like if they fracture naturally as they roll down rivers, bounce along in a mudflow, topple off cliffs, or are crushed by glacial ice? Archaeologists can simulate these situations by churning cobbles, water, and mud into cement mixers or by dropping rocks off a cliff. The results could provide “signatures” of the frequency of different kinds of broken rock in natural deposits, showing, for example, the percentage of the stones in a mudflow...
that have only one flake removed, the percentage that have two, or the percentage that have two flakes removed from the same edge.

Although more detailed studies need to be conducted, current experiments suggest that natural processes only rarely produce stones that look like those called stone tools at Pedra Furada. It seems that if Mother Nature breaks hundreds of thousands of rocks blindfolded, she will produce only one or two that look like casual tools. This means that if the archaeologist looks at enough broken rocks, he or she will certainly find a few that look like tools but that are probably not tools. If I only find three dozen rocks in a site, including artifacts and unmodified stones, and ten of these each have three or four flake scars, then there is a good chance that they were produced by humans. But at a site like Pedra Furada, where researchers recovered tens of thousands of broken rocks, only a few of which were thought to be tools, there is an infinitesimally small chance that these few pieces really are tools.¹

How Were Stone Tools Made and How Do Archaeologists Know?

The first stage in making a stone tool is selecting the right kind of stone. The kind of stones that prehistoric peoples preferred to use were primarily flint, chert, jasper, and obsidian. The reason is that when stones of these materials are struck they break with a con
coidal or glassy fracture that creates sharp edges and that gives the flintknapper control over flake removal. Quartz, quartzite, and fine-grained basalts were also used. Other kinds of rock can be flaked, but they can be awfully frustrating. Prehistoric peoples often visited the same locales to obtain stone, even transporting it long distances. Prehistoric quarries demonstrate this fact. At Spanish Diggings in Wyoming, for example, acres and acres of hill-sides are covered with a dense carpet of quartzite flakes and discarded tools and are pitted with deep holes where people excavated into solid rock, using only fire to loosen pieces and stout poles to wedge them out. Prehistoric peoples knew that stone on the surface had “dried out” (yes, rock can dry out) and would not flake as well as the buried “wet” rock.

Now our flintknapper has a piece of stone; how does he or she make it into a tool? There are many ways to flake stone, and they are differentiated primarily in terms of the degree of control the
flintknapper wishes to exercise over the size and shape of flakes removed. One could simply throw a hunk of stone against another and select suitable flakes from the resulting shatter. Most prehistoric peoples, however, preferred methods with a bit more control, such as direct percussion. Here one holds a stone, the core, and strikes it with the hammer. There are two kinds of hammers: hard hammers, normally fist-sized, slightly oblong cobbles (hammerstones), and soft hammers, antlers or hardwood batons, which permit a bit more control over the shape of flakes. With practice, you can learn how to strike a stone with just the right amount of force and at just the right angle to detach the kind of flake you want. Still greater control can be achieved by using indirect percussion, in which an antler punch is used in conjunction with a hard hammer to direct the force of the blow to a very small area on a core’s edge.

An unmodified flake was probably suitable for many prehistoric tasks, but often a tool had to be shaped. After removing a flake from a core, the flintknapper could continue to remove flakes from all margins and both sides of that flake. This results in a tool that is flaked on both sides and is therefore called a biface or a bifacial tool. The technique used for the final flaking of implements—to sharpen the edges of a knife or to put notches in an arrowhead—is pressure flaking. Here the tine of an antler or a pointed hard stone is used. Instead of striking the margin of the stone, the flintknapper removes flakes by pressing on the edge of the tool until a flake pops off the opposite side of the tool. To assist in this process, a tool’s edge is first ground with a flat cobble to roughen it up and provide the pressure flaker with a purchase on its edge. Bifacial tools can be of many different sizes, from large Acheulean hand axes (manufactured throughout much of the Old World some 1.7 to .5 million years ago) to projectile points smaller than a U.S. dime.

Sometimes prehistoric people found themselves with only small cobbles as the source of flakes for tools. In this case, they normally used the bipolar technique. Here the flintknapper holds a small cobble on an anvil or, if it is especially small, wraps grass around it to provide a “handle,” and then unceremoniously strikes it with a hammer stone. The result is often a shatter of flakes, most of which could not be further modified but which were useful for expedient tasks.

Finally, there are prismatic blades and microblades (see Figure 1). These are rectangular razor-bladelike tools that vary in size but are generally at least twice as long as they are wide. Large blades were removed from conical or cylindrical cores, while microblades were
often removed from small, wedge-shaped cores. Blades could be handheld and used for a variety of fine cutting or skilled carving tasks. They could also be set into slots carved into appropriately shaped bone, wood, or antler to form razor-edged spear points or long sickles. Blades were produced through indirect and direct percussion as well as pressure flaking. Sometimes the flintknapper used a *chest crutch*, a meter-long T-shaped pole, pointed at one end. The pointed end was placed on the edge of a cylindrical core, which was held in a wooden vice or between the flintknapper’s feet. The flintknapper then bent over, placing his or her chest on the top of the T-shaped pole, and with a quick motion downward drove off a flake. In my experience, this method works best if you weigh about two hundred pounds—otherwise you end up with nothing more than flint dust and bruised ribs.

It takes no time at all to learn the simplest of these methods of making stone tools, and a considerable amount of time to learn others. It helps if you have the skills of a sculptor because you have to be able to “see” the arrowhead in the lump of stone before you. Archaeologist Bruce Bradley, certainly one of the world’s finest living flintknappers, says that it takes about two years of practice to make an acceptable Clovis spear point (which entails the removal of one or more blades from the surface of a biface). If you wish to practice making stone tools, I would recommend apprenticing yourself to a flintknapper. Also, be sure to hold the stone you are working on in a thick leather pad to prevent flakes from being driven through your palm (you’ll know an extremely hard-core flintknapper by the number of band-aids on his or her hands), wear protective goggles to protect your eyes from flying slivers, and work in an open environment—eighteenth-century gunflint makers in England frequently died of silicosis, contracted from breathing flint dust for years on end.

Practicing making stone tools is the first step in learning how to recognize evidence of different stone tool manufacturing methods from archaeological data. Different manufacturing methods leave behind different kinds of traces besides the tools themselves. Blade production, for example, leaves behind a very distinctive core, one with narrow flake scars running along its long axis. Learning how to recognize different methods of stone tool production also requires learning how to recognize the different sorts of flakes each technique produces. Flintknapping is a messy activity; for every shaped tool a knapper produces he or she may leave hundreds of waste flakes behind. Sometimes these waste flakes are a clue as to what technique was being used. The kinds of tools
found in a site are certainly indicative of the reduction methods used, but the same tool can be made through different techniques. And although some tools were brought to a site fully manufactured, others were made on the spot and discarded, and still others might have been partially completed and then transported from the site. Understanding what stone tools have to tell us about prehistoric lives means understanding how tools are used across a landscape, not just at one location. And this means reconstructing stone tool technology not just from the tools themselves, but from the waste flakes left behind. This is not easy, for a given technique may produce more than one kind of flake. But experimental archaeology suggests that the different ways of manufacturing tools leave discernible patterns in their waste flakes.

Before going further we need to define a few terms (see Figure 2). A flake has two sides: Its dorsal side is the side that was outside the core and its ventral side is the side that was inside the core. The dorsal side is normally covered with flake scars, evidence of previous flake removals from the core. The dorsal side of the first flakes removed from a core, however, are covered with cortex or patina,
the weathered surface of the core. At the flake’s “top,” the point where the hammer stone or pressure flaker made contact with the core, is the *striking platform*; on the ventral surface of the flake just below the striking platform is a slight bulge, the *bulb of percussion*. The “bottom” of the flake has a *feather termination* if it comes to a thin, featherlike end, or a *step* or *hinge fracture* if the flake broke off the core abruptly. Archaeologists record all sorts of observations on flakes—length, width, thickness, platform width, platform depth, weight, platform angle, the number and directions of flake scars on the dorsal surface, the amount of cortex on the dorsal side, the kind of termination, the type of platform, and a range of other arcane measures.

Experimental replicative flintknapping suggests that these variables can be used to detect prehistoric flintknapping methods. To see how, consider the following scenario. Imagine a family of hunter-gatherers who spend some time one summer in a rock shelter. They have brought a number of spear points fashioned from a distinctive red chert. While at the shelter, these points are used in hunting, but also for cutting meat; some break and are reflaked and used to scrape hides. Needing to prepare willow branches to make baskets, a woman brings some small quartzite cobbles from a nearby stream and makes some flakes through percussion knapping; some of the cobbles are small and so she reduces them bipolarly. She uses the flakes for a day, then discards them. Meanwhile, some of the men decide that they do not have enough spear points for the next place they plan to inhabit, which is good hunting territory, and so they make a special trip to a quarry they know is two days’ journey away. Once there, they make some large bifaces of a brown chert—not wanting to bring back stone that contains flaws—and return home, where they work on them further. Some of these bifaces are heated in the family hearth, for these foragers know that chert often flakes better if it is baked for a while. After a month, the family leaves. The wind blows dust into the rock shelter, covering the flakes and tools left behind; time passes, and the site is left for the archaeologist to excavate.

Sorting the waste flakes and artifacts into three raw material categories, the archaeologist notices several patterns. In the red chert pile there are broken bits of bifacial spear points, some recycled into scrapers. The flakes in this pile are all very small and have no cortex on their dorsal surface but, for their size, they do have many dorsal scars. Their platforms are small and are covered with many facets, suggesting they were removed late in a tool’s “life.”
In the quartzite pile are many flakes with cortex on their dorsal surface, indicating that they entered the site as complete river cobbles. Looking more closely, we see primarily two kinds of flakes: some with wide or deep platforms with only one or two facets, and some with platforms completely crushed that also lack prominent bulbs of percussion—some of these are crushed at the end opposite the platform. Many of the flakes in both piles terminate in hinge or step fractures. The first pile represents simple percussion knapping while the second indicates bipolar reduction. There are regular cores and bipolar cores present, but no bifacial tools of quartzite. Finally, the pile of brown chert contains medium to large flakes with prominent bulbs of percussion, and platforms with only a few facets. There is no cortex on the dorsal surfaces, which are instead covered by a few previous flake scars. The flakes are generally thin, with unpronounced bulbs of percussion suggesting they were struck with a soft hammer. These flakes point to an early stage in the manufacture of bifaces.

An additional line of evidence the archaeologist could use at this site is refitting. If our archaeologist excavated most of the site, he or she could try to fit the flakes, cores, and tool fragments together, reconstructing the knapping sequence in reverse order. This is not easy; it takes hours and hours and is like trying to put together a 3-D jigsaw puzzle with half the pieces missing and no picture on the box. Some people are very good at it while others like me don’t have the patience. But it can be an extremely valuable addition to or confirmation of an analysis of waste flakes. Putting the quartzite flakes together, the archaeologist would see that some flakes refit back to cores and some to bipolar cores, forming entire river cobbles; he or she could probably see that some of the heated and unheated pieces of chert fit back together again (sometimes heat-treating completely changes a rock’s color and texture), and that many flakes of the red chert fit back together, forming the outside of a biface, but the biface itself is missing. A biface fragment recycled into a scraper may fit back to the rest of the discarded biface. Refitting can also trace the movement of items across a site—showing where different activities occurred—or it can even indicate whether a site was used more than once, whether natural factors affected the distribution of material in a site, or if there has been much vertical movement of artifacts in a buried site (caused by burrowing rodents, for example).

Returning to our analysis, we could interpret the patterns in the waste flakes and tools as indicating that the red chert entered the
rock shelter as completed bifaces that were then resharpened and occasionally recycled into scrapers. The quartzite flakes came from a source so close that no preliminary reduction was done at the quarrying location. Only expedient flake tools were produced from them, and small cobbles were reduced bipolarly. The brown chert was brought into the site after being initially reduced into large bifaces at the quarry; these were further worked into bifacial implements, perhaps spear points, but were generally not used as tools at the site—they were taken with the occupants to be used elsewhere.

In reality, analysis of tools and waste flakes is far more complex than the above example suggests. It is often difficult to sort raw materials, and postdeposition factors such as trampling can break flakes in ways that have nothing to do with flintknapping. The relationship between flake characteristics and knapping techniques is still not clear. Some archaeologists suggest that we look only at simple characteristics, such as the degree of flake completeness, or size grade distributions of flakes. Others advocate more complex approaches, preferring to measure many variables and crunch these through high-powered statistical routines to search for patterns. Personally, I am of the “less-is-more” school, but the jury is still out. Finally, stone tool analysis is inevitably complicated by the fact that tools, cores, and flakes could be changed into something completely different at any stage in their use-lives. While we often look upon stone tools romantically as artistic endeavors, I suspect they were just rocks to prehistoric peoples. A flintknapper could set out to make a biface, but if the stone broke along the way, as often happens, it might be turned into something else; bifaces can also be smashed bipolarly to produce small expedient flake tools, or points can break and be turned into scrapers. The past is never as neat and tidy as we would like it.

**WHAT WERE STONE TOOLS USED FOR?**

For many years archaeologists interpreted the function of stone tools based on a tool’s shape: Projectile points were used for hunting, scrapers for scraping, drills for drilling. But we now know that the shape of a tool does not always tell us its use. And shape tells us nothing about what simple unmodified flakes were used for
It makes sense that using stone tools on different materials will produce different kinds of wear on the tool. The Russian archaeologist Sergei Semenov initiated the microscopic study of use-wear in the 1950s. His method has since been refined by a number of archaeologists. This research entails experiments. Archaeologists make stone tools or flakes, record their unused edges under a microscope fitted with a camera, then use the tools to cut open animals (road kills, or zoo animals that died of natural causes), and cut or scrape hides, wood, antler, bone, etc. Using a tool on any of these materials leaves three major sorts of traces on its edge: microscopic edge chipping, striations, and polish. Chipping is the most obvious, and the harder the material involved the larger the chipping. Striations indicate the motion involved: Striations perpendicular to the tool edge point to a scraping motion while striations more parallel to the edge indicate a cutting or sawing motion. As the tool is used friction sends silica from both the tool and the material being worked into solution and builds up polishes that vary in luster, brightness, roughness, and pitting depending on the kind of material being worked. This polish can be seen beneath a microscope at x 200 to x 400, although some analysts advocate the use of lower powers—less than x 100. Experimental research demonstrates that polish of different degrees of luster, brightness, etc., can be attributed to some very specific materials: green bone, old bone, wood, hides, meat, etc.

Use-wear studies of stone tools have altered some of our ideas about prehistory by betraying archaeologists’ assumptions about stone tools. For example, George Odell argues that the bow and arrow came into use in the midwestern United States some 2,000 years before the long-accepted date of A.D. 1000 based on the presence of projectile use-wear on small triangular flakes—artifacts not typically labeled as projectile points. He also notes that many artifacts in the eastern United States traditionally labeled as projectile points bear no use-wear of having been employed as projectiles.

Use-wear has been a tremendous boon for archaeology but it is not without its limitations and difficulties. It is difficult to see some types of polish on certain types of stone; the method works best on cherts and flints (which have plenty of silica to form polishes). Also, since tools could be used for a variety of purposes, the analyst may only see the most recent use, or may not be able to decide what
kind of polish is present. It also takes some time for a tool to build up a polish. In fact, Douglas Bamforth argues that it takes about 30 minutes or 1,500 strokes of continuous use for a tool to build up a polish that is distinctive of the particular kind of material being worked. Many prehistoric tools were probably used for very quick tasks and use-wear on their edges tells us they were used, but nothing more. Although early claims of extreme accuracy in identifying the worked material have now been tempered, use-wear analysis remains an important part of the archaeologist’s tool chest.

**WHAT DO STONE TOOLS TELL US ABOUT PREHISTORIC LIVES?**

Stone tool production is a complex sequence of stone quarrying, manufacture, use, repair, recycling, scavenging, and discard. Many analysts focus on reconstructing the particular sequence at a specific site. Others, however, are more interested in what stone tool production has to say about prehistoric economy and society.

For example, several archaeologists argue that nomadic hunter-gatherers made greater use of bifacial implements than did sedentary peoples because the shape of bifacial implements allows them to be resharpened and the potential source of more flake tools than a simple core of similar weight. Thus, bifaces maximize the number of tools carried while minimizing the amount of stone carried—an obvious advantage for nomadic peoples. But not all prehistoric nomadic hunter-gatherers used bifaces: Where stone tool raw material is widely available, they used simple expedient flake tools. We have not as yet found any simple correlations between technology and other social, economic, or political variables.

The type of tool made is affected by four factors: material type, size, regional distribution, and function. Material type and size will constrain the types of tools that can be produced: If only small, grainy material is present, even an experienced flintknapper will not be able to produce blades or large bifaces. If raw material is rare, then some aspect of tool manufacture and use must respond to the fact that the tool supply will be difficult to replenish. The task at hand also directs a tool’s final form—you don’t make a scraper if what you need to do is kill a mastodon.

But it is not always easy to define which of these variables are at work. Microblades, for example, may be an alternative to bifaces
as a way to make efficient use of raw material, but they may also be a way to make efficient use of very small nodules (like bipolar knapping, but with much greater control). Then again, they may be a way to manufacture long, straight edges, as are needed, for example, to make a grass-harvesting sickle (a single blade, thirty centimeters to fifty centimeters long, would break far too easily for the effort it would take to manufacture one; microblades can be set into a slot in a wooden handle and if one of the blades breaks only the blade must be replaced, not the entire tool).

As yet there is no coherent body of theory that accounts for how stone tool production and use respond to changes in economic, social, or political behavior. In the Great Basin, for example, projectile points became smaller in size about 1,500 years ago. Earlier points were resharpened and recycled more frequently than later points. The later points probably came in with the introduction of the bow and arrow, but this does not account for why earlier points were larger and frequently resharpened. What might the change in technology have to say about changes in the role of hunting in Great Basin societies—a change from long-distance hunting to hunting that occurred only in the immediate vicinity of camp? a reduction in the amount of meat in the diet? a shift in the division of labor, the time men devote to hunting? Going back further in time, what does it mean that our early human ancestors’ stone tools, especially Acheulean hand axes (see Figure 1), were manufactured in a remarkably redundant fashion across entire continents for tens of thousands of generations (whereas later in time we see a diversity of stone tool manufacturing methods that are responsive to differences in raw material type, distribution, and tool function)? Perhaps this pattern is a clue to a fundamental qualitative difference in the reasoning abilities between ourselves and the maker of hand axes, *Homo erectus.*

**WHAT DOES THE FUTURE HOLD?**

One might think that since stone tools have been the focus of so much archaeological research, there would be little more that could be said about them, but this is not true. In fact, there is an enormous amount of work to be done. Use-wear analysis, while moving far in recent years, still needs further experimental work, and more accurate, more easily replicable methods of analysis (I must admit that when I look at photographs of different kinds of polish
they all look like the same blurry, mottled surface to me). We need far more replicative experiments to determine how to differentiate the various reduction techniques based on waste flakes. Few people today make even moderate use of stone tools, which were replaced long ago with traders’ goods, or tools manufactured from iron (car springs are a preferred raw material, in my experience). Nonetheless, ethnographic research with living peoples may still help point to the relationships between technology and behavior to help us develop ways to make inferences about prehistoric behavior from stone tool remains. Researchers interested in understanding the use of stone tools by our early human ancestors face an especially difficult barrier because these earliest of all stone tool users were neither biologically nor behaviorally similar to modern humans. In this area, one innovative approach implemented by paleoanthropologists Nicholas Toth and Kathy Schick has been to observe chimpanzees as they learn to make and use simple flake tools.10

Others are working on better ways to date stone tools. For many years archaeologists have been unable to date the many stone tools that are found on the surface of sites in arid parts of the world, where organic artifacts that could be dated through more conventional radiocarbon methods have long since disintegrated. Accelerator radiocarbon dating of organic residues trapped in a stone’s patina and cation-ratio dating of the patina itself are now being developed.11 Others are using a variety of methods to extract and identify blood residue from the cracks in tools, even tools that are thousands of years old.12 In sum, the field of lithic analysis still holds some distant horizons and uncharted territories. Stone tool studies will continue to play an important role in archaeology for many years to come. Sometimes, in fact, I feel as though I am back on that windy ridge in Nevada, looking for the first time at a scatter of red chert flakes.

NOTES


2. Small points are popularly known as “bird points” but there is no reason to think they were used for hunting birds. In fact, birds
were more usually hunted with bunts, and if an arrow was well placed (and especially if it was dipped in poison beforehand) a small arrowhead could still be used to kill game the size of bison or giraffes.

3. Heating siliceous rocks at 300°C to 400°C recrystallizes stone and improves its fracture qualities.


Suggested Readings


