# Hammerstones

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*Resumen*: Una parte de los procesos de talla líticos y de diversas actividades humanas básicas son los percutores de piedra, instrumentos muy poco estudiados, situación lamentable porque su análisis y clasificación proporcionaría a la arqueología información sobre una amplia gama de actividades prehistóricas, empezando con la producción y uso de instrumentos de piedra, que son más que simples rocas. En este artículo proponemos que las poblaciones mesoamericanas usaban millones de percutores de centenares de tipos y variedades, que comprendían desde la elaboración de lascas cortantes de obsidiana, hasta la construcción de los palacios de sus gobernantes. Cada tarea requirió de instrumentos apropiados y cada percutor tenía funciones específicas e incluso funciones múltiples, para actividades no especializadas que podrían deducirse por medio de sus propiedades físicas y huellas de uso o desgaste. Por ejemplo, un percutor para fabricar un cuchillo de pedernal tendría poca utilidad para esculpir la Piedra del Sol. Al respecto, se revisó la literatura especializada para identificar las propiedades físicas esenciales de los percutores y sus funciones óptimas.
*Palabras clave:* percutores de piedra, prehistoria, pedernal, obsidiana.

Abstract: In the history of the emergence of humankind, hammerstones were some of the first tools used by humans and the most frequent. In archaeology, hammerstones have the ironic distinction of being the oldest and most ubiquitous human tools on earth as well as some of the most infrequently studied. Because they are common and found everywhere, they are easy to ignore. We argue that important information can be inferred from hammerstones. They merit more archaeological attention than they have received thus far. To promote better studies, we describe different kinds of hammerstones and their properties, as reported in ethnographic accounts and for modern replication experiments. A major distinction is between hammerstones used to chip other stones into cutting tools and those used to sculpt coarser-grained stones by pecking to make things such as metates and shaped building stones. After this literature review, we summarize four case studies of hammerstones from Mesoamerican sites to show the range of hammerstone types and the utility of detailed studies of hammerstones.
*Keywords:* hammerstones, prehistoric, flint, obsidian.

*There is no implement more common among the relics of the stone age, none the uses of which have been less discussed by archaeologists, and none more deserving of thorough discussion.*

J. D. McGuire ( The Stone Hammer and its Various Uses, 1891)

Archimedes, the Greek philosopher-scientist of the third century BC, famously remarked, “Give me a place to stand, and I shall move the earth with a lever” (Mackay 1991:11). With the same modesty he could just as accurately have proclaimed, “with a hammer large enough I could cleave the earth.” Hammers, like levers and other simple machines, must be appropriate to the task at hand. The thousands of tasks performed by stone hammers in antiquity necessarily required just as many kinds of implements. Hammerstones may be the earth’s oldest tools. By any fair assessment of primitive technology, before the age of metals hammerstones were some of the most ubiquitous, useful, and diverse tools on the planet, as argued by Joseph D. McGuire over 120 years ago (epigraph). Scholarly recognition of hammerstones has not advanced much since. For most archaeologists all hammerstones are pretty much the same; to see one is to see them all. Analysts reduce diversity to singularity. This same taxonomic “lumping” robs hammerstones of explanatory value from the start. With such treatment no one should marvel that hammerstones are among the most undervalued artifacts from prehistory. This essay addresses the irony that these primary tools are rarely studied and even less understood.

Billions of secondary artifacts fabricated with hammerstones have been objects of study by dilettantes, antiquarians, prehistorians, and archaeologists since the fifteenth century, but the primary tools of production have not. One essay cannot redress centuries of neglect, but we can begin according hammerstones greater analytic importance. We propose functional distinctions among hammers to get things started. Our shared perspective comes from using hammerstones in experiments of various sorts as well as from analyzing hammerstones from archaeological sites and quarries in North America and Central America.

Not all hammerstones were created equal; no two are the same. Some archaeologists can distinguish well-worn hammerstones from unused cobbles, but most cannot distinguish types of hammerstones. It would advance matters if hammerstones were at least classified according to tasks performed, such as sculpting stone versus breaking flakes from cores, as proposed over a century ago (M'Guire 1891, 1892, 1893). Within classes, further distinctions could be made, such as separating hammerstones used for knapping chert from those used for obsidian, or those for sculpting from those for making axes or milling stones. Within general functional categories, other distinctions would be of interest. In quarry work, for example, different stages of the reduction process required hammerstones of different qualities (shapes and sizes), beginning with mining and preliminary processing down to final finishing of cores, bifaces, blanks, or flakes (see Crabtree and Gould 1970; Holmes 1919). Other characteristics of hammerstones crosscut classes, such as whether they were male or female, or for the right or left hands.

These last points are deliberately provocative. The category "female hammerstone" may appear a contradiction in terms. That many scholars might consider it so exposes a bias in archaeology. Hundreds of tasks undertaken in prehistory by women surely made use of stone hammers and pounders, so it should be possible to identify some female hammers.[1] Their identification, of course, presupposes that tasks hammerstones were used for can be identified. This is our principal proposal. Determining which tasks were male or female is a larger issue and separate matter. The gender bias we allude to arises from a gross simplification of hammerstone function, namely, the assumption they were used almost exclusively to chip stone tools, a presumed male activity.[2] In reality, knapping hammerstones may not have been the primary type of stone pounding tools at most archaeological sites, even for foraging societies. More appropriate classifications of hammerstones will be needed before scholars can begin to address such questions. Stone hammers were surely used by women and children as well as men, and just as certainly some users were left handed. Handedness should be identifiable for some hammers (see Holmes 1893). Whether such distinctions are worth making is a different matter (e.g., Schick and Toth 1993:140). The important point is that information of this sort is within the range of careful inference for some tools, given proper analysis. Issues of gendered and handed hammerstones may seem arcane, but the mere possibility that identifications at this level of specificity are possible exposes the shabby treatment accorded hammerstones by archaeologists in the Twentieth century and the poverty of current expectations. Hammerstones could provide a wealth of information on a range of activities if they were adequately studied. A recital of facts from archaeology and experiments could provide a basis for a functional typology of hammerstones, a task we take up in the second section. Before doing so we offer a digest of hammerstone verities derived from experiments and analyses of archaeological specimens, as interpreted by modern knappers.

## Banal Truths from Experiments

We start discussion with truths so self-evident they approach banality, at least for knappers. Our presentation attempts to bridge the gulf between practitioner expertise and the innocence of non-practitioners, much as any book teaching a craft would do. Many self-help manuals are available for those who wish to learn knapping. We start with their basic instruction and add to it. Fundamental facts of modern hammerstone use provide a foundation for identifying and understanding archaeological specimens. Scholars adept at using hammerstones will doubtless find deficiencies in our coverage. We encourage them to add to the following list of knapping insights. Our treatment of hammerstone facts is catechistic in organization, with numbered propositions followed by commentaries and vignettes to draw out implications relevant for archaeological analysis.

We reviewed a broad range of publications on knapping to extract insights listed here as propositions. Early studies distinguished natural hammerstones from formal stone pounders that were grooved or perforated (bored) for hafting, in the same manner as groundstone axes (see Evans 1872; Holmes 1896; M'Guire 1891, 1892, 1893; Wilson 1851). These formal, blunt-ended tools are called mauls; some may have been weapons. We limit attention here to informal or "natural" stone tools used to work other stones. We do not consider those used to process foodstuffs or other soft materials here; they are topics worthy of separate treatment. Clear definitions of "hammerstones" are elusive because hand-held pounding stones were used prehistorically in so many ways on

1 "But every man and woman in savagery needs a hammer, each in their several industries. The Indian women of North America with hammers of stone break dry wood for fires, crush bones to extract the marrow, pound dried meat into meal for pemmican, drive down pegs for setting the tent, beat the hides of animals to make them pliable. In this last operation they are imitated all over the tropical world by their sisters who hammer cloth of the bark of trees" (Mason 1895:53).

2 Among the Adaman Islanders, knapping was a female activity (see Mason 1895:137).

a wide range of materials. For stone tools and objects fabricated with hammerstones, the manufacturing process required the collision of two stones, one usually stationary and the other dynamic. The moving stone is generally the hammerstone – the stone through which force is applied to a passive workpiece.[3] Stationary stones are the pieces worked, such as cores or blanks. Sometimes a third stone is involved, another stationary stone that serves as an anvil or rest on which a workpiece is placed, as in bipolar percussion (see Crabtree 1972:40; Flenniken 1981). Force applied through hammerstones affects all stones brought into contact – hammer, workpiece, and anvil. Force of sufficient magnitude leaves marks on all three stones, an outcome which makes identifications of different kinds of hammerstones and anvils possible.

## I. Hammerstones are myriad and of different kinds.

Hammerstones come in a variety of shapes and sizes, with major distinctions based on tasks performed. Hammerstones were used to make other tools by chipping, pecking, battering, and dressing other stones. A fundamental insight from the earliest studies of hammerstones is that "chipping" hammers differed from "battering" hammers (Holmes 1896; M'Guire 1891). Both also differ from hammers for "pecking" and "dressing" stone (see Hayden 1987; Holmes 1919; Wilke and Quintero 1996). Chipping hammers are designed to break off flakes from flintlike rocks, those with a fine, homogeneous texture or matrix. M'Guire (1893:317) claimed that the "hand hammer used in chipping requires weight and hardness to facilitate the detaching of flakes, but any ordinary hard stone that may be readily held in the hand will answer the purpose." This is largely correct but spectacularly misleading.[4]

Hammers used to make "groundstone" implements have been called by many names, here represented by "pecking," "hammering," and "dressing" stones. Hard stones useful for tools but with granular textures unresponsive to flaking, such as granite or diorite, were worked by pulverizing and/or gouging away minute portions of the worked stone through a more gradual reduction process. Pecking hammers or "pics" have sharp edges or points that penetrate the surface of a workpiece and cut, shatter, and/or crush away small pieces of rock.[5] They resemble chopping tools, and they become blunt during use and have to be resharpened by chipping a new edge (Hayden 1987; Wilke and Quintero 1996). In contrast, battering hammers have flattish and broader surfaces. "The battering hammer is commonly a discoidal stone, having a rounded periphery, with a pit on each flat surface intended to hold the thumb and middle finger, whilst the index finger is placed on the periphery" (M'Guire 1893:318).[6] A blow with such a stone pulverizes the part of the worked piece it contacts and turns it to dust, and a minute portion of the hammerstone is likewise pulverized. Consequently, the hammerstone wears away and develops a flat spot or facet on the edge in contact. A discoidal shape for a hammerstone would be ideal because the tool could be constantly rotated to prevent formation of facets which could make the tool unusable. Stone hammers used to give a fine, uniform surface to a tool, or to "dress" the surface, are refined battering stones. The same techniques used to make a grinding stone were also used to "carve" stone sculptures (Holmes 1919; M'Guire 1893); see Figure 1. Depending on sculptural styles, special hammerstones and pics may have been needed to cut narrow grooves in a stone. "In stone-carving pointed tools are required where the spaces to be worked are narrow, size and weight depending on the available surface" (M'Guire 1892:170).

These last three techniques were involved in making groundstone and polished stone tools, with the

3 With an anvil technique a core is swung to contact a stationary hammerstone or "anvil" (see illustration in Crabtree 1972:35). A stone can be thrown against another in a missile method, an effective technique for breaking very large stones at quarries or roundish cobbles.

4 Most hard stones that fit comfortably in the hand indeed can be used to break flakes from cores, but more specialized hammerstones are required for making fine bifaces (flaked knives) (or removing flakes of pre-determined size and shape from a prepared flake core). The fact that early experimenters and even professional flintknappers from Brandon, England, could not duplicate the fine bifaces found archaeologically —then still considered a truly "lost art" (Mason 1895:132, 136-37)— may have had something to do with using inadequate tools ineptly. Even higher primates can learn to make flakes (Schick and Toth 1993), but only a master craftsperson can make some types of fine bifaces.

5 Pecking hammers do not have to be large stones. Halvor Skavlem in his earliest experiment used a chert flake to resharpen a broken aboriginal celt (Pond 1930:73). "Close examination showed that as he struck the broken celt with the piece of chert, bits of the chert flew off leaving many sharp edges. These sharp edges acted as so many tiny chisels which cut the crystals of the celt reducing them to dust and so gradually shaping the broken celt as desired"(Pond 1930:75).

6 The issue of finger grips or modification of stones for holding in the hand is important. We have heard many claims along these lines, especially for elongated hammerstones from the obsidian mines at Pachuca, Hidalgo, Mexico, but we have not seen any hammerstone that definitively shows a manufactured grip (see below). We have not examined the specimens illustrated and described by M'Guire. However, we have studied many flattish hammerstones that have slight indentations on both broad faces. The indentations on tools we have examined result from use of these stones as hammerstones and/or anvils in bipolar percussion, so they were multipurpose tools (cf. Flenniken 1981:figs. 13-20). If the indentations on the faces of the hammerstones described by M'Guire are smooth and polished, then his notion they were designed and made for gripping would be compelling. If they result from anvil work instead, these depressions should be rough and gouged as if pecked. The discoidal shapes he described make use of the entire circumference of the hammerstone, and, given their bilateral symmetry, these hammers could be used in either hand, a particularly useful trait for a battering hammer, given the number and rapidity of blows required in the process. One could switch hands periodically and continue working to rest one arm and then the other.

**Figure 1.** Rosemary Lieski flattening the surface of a boulder to make a bas-relief sculpture (July 2013).

final tasks consisting of abrasion and polishing. Stones of granular texture were sculpted by pounding away unwanted portions of workpieces. In terms of expended energy and effort, the hammering work involved was several orders of magnitude greater than that needed for chipping stone, and it also required different kinds of stone hammers. For example, one can shape a flint knife in less than 10 minutes with 50-100 well placed blows and flake removals, depending on the size and shape of the original workpiece. In contrast, making a polished axe by pecking and battering requires tens of thousands, or even hundreds of thousands of blows and 4 to 40 hours, depending on the raw material and size of the workpiece.[7] Based on extensive experience in trying to duplicate ancient tools M'Guire (1893:318) observed that for "battering" hammers, any stone harder than the one being fashioned would do. He further claimed that "With this hammer rapidity is essential, and the blow is ordinarily given to a broad surface, and no deliberation is necessary. Battered objects are numerous and vary greatly in size; consequently the hammer is found to vary likewise" (M'Guire 1893:318).

Knappers have long known that "groundstone" is generally a misnomer for this category of implements because the label implicates the final phase of production in which tools were ground into shape with the use of abrasive stones, called "whetstones" in early studies. For some small objects, grinding may have been the only technique involved, but for most tools, such as axes and milling stones, the worked material was first flaked, pecked, and battered into shape before any final grinding took place (for an excellent description, see Wilke and Quintero 1996). Sometimes, "battered" implements were given a fine but rough finish with "dressing" hammerstones, in lieu of being ground (see Wilke and Quintero 1996). Mesoamerican milling stones, the quintessential "groundstone" tools, were finely dressed in this manner, but not subsequently abraded or polished.[8] When the grinding surfaces of these implements became polished and slick as a consequence of use, they had to be "resharpened" (roughened) by pecking anew a rough surface with a hammerstone pic to restore the rough surface best for grinding (see Clark 1988:93).

Some hammerstones found archaeologically look like blocky, multifaceted cores on which most of the ridges from flake removals have been blunted or crushed (see below). These expended cores were used as pecking hammers but would also have worked as dressing hammers. In Mesoamerica, broken jade axes and other hard-stone tools were many times recycled and used as pecking tools.

Hammers used for final finishing work develop flattish working surfaces during use. The effective edge of the hammerstone, and the contact surface of the worked piece become mirror images of each other. It should be possible to match manufacturing traces on hammered pieces to the use traces on hammerstones; adequate study of hammerstones should focus on hammering marks (see González and Cuevas 1998). Surfaces resulting from pecking are rough and pocked from the gouging of the sharp edge of the hammerstones. Finishing work consists of removing the high spots of this pimply surface and creating a flatter surface.

**II. Hammerstones are relational tools.**

A basic insight from any kind of crafting is that tools must fit the task. Tools need to be suitable, and artisans need to know how to use them effectively and efficiency. In optimal conditions, the best tools for a task are used. In other cases, tasks are carried out with sub- optimal tools. For instance, most of us have used coins to turn a screw when a flathead screwdriver was unavailable, have opened a can with a knife when no can-opener was handy, or even used a rock to pound a nail. For tasks performed ad hoc there may not have been an optimal relation between expedient stone hammers and the material worked. However, for repetitive tasks we expect that special hammerstones

7 M'Guire (1892:167) described an experiment in making a celt from nephrite (a variant of jade) that took 55 hours and 10 minutes. At about 140 blows per minute, the work represented over 460,000 blows. He destroyed over 40 hammerstones before he found one tough enough to withstand the work and do the job. "With a single exception, none lasted more than ten minutes. The exception was a close-grained gray, quartzite, which … performed eight to ten hours' work."

8 In studies of stone artifacts in archaeological reports "groundstone" is usually accorded a broader meaning of "non-chipped-stone," rather than being confined to objects actually"ground" or "abraded."

would have been chosen for adequate and suitable work. This is what we mean by relational – the relation or correspondence between a tool and a task. A stronger way to say this is that the physical and technical parameters (technological imperatives) for the manufacture of a desired form from a given piece of stone determine which fabricating tools will be suitable and even optimal. A hammerstone used for pecking a jade cobble into a celt, for example, would be totally unsatisfactory for flaking an obsidian biface, and the hammers needed for the biface would not be up to the job of shaping the jade celt. Within a single industry, such as the chipped obsidian industry, different kinds of hammerstones were also needed. A hammerstone for making small percussion blades would not do for fracturing 10-pound flakes from a massive obsidian boulder.[9]

We propose that ancient artisans commonly used ends-means thinking and selected suitable tools to achieve desired ends. We further suggest that such teleological reasoning is appropriate for classifying different kinds of hammerstones – sorting them according to the tasks/ends they best served. In this regard, a hammerstone is half a pair, the positive of a missing negative, much in the manner of a flake and its flake scar on a core. Each hammerstone was meant for a task, or limited range of related tasks, and used for them.

### III. Hammerstone performance depends on natural properties and principles.

Knapping is practical physics in motion, so assessments of the properties of raw materials is an excellent place to start appreciating hammerstones. We accept the assumption that the laws of "nature" or physics, as they concern our planet, are constant. Obsidian, flint, granite, jade, quartzite, and all other stones "behaved" anciently under force and duress as they do today. More specifically, the way these stones fracture or crumble when stuck by stones of different sorts is constant. It follows that properties modern knappers find useful for hammerstones were likely also important anciently. Hammerstone properties were relational, so in controlled settings the raw material, size, and shape of hammerstones related to and were determined by manufacturing techniques and "the quality of material being worked and the stage of manufacture" (Crabtree 1972:9).

> All chipped implements show a special fracture; the weight of the hammer, its material, and its shape are all important elements to be considered; the intended implement must be struck with a certain weight and force and at a particular angle to accomplish the desired result. The quarry hammer of great weight must be used if it is desired to crush a large block of stone; the hand hammer, to reduce it still further. (M'Guire 1893:317)

Modern knappers have identified a suite of properties critical for hammerstones used for different tasks. Critical attributes include size, density, weight, hardness, toughness or tenacity (i.e., resistence to fracture), texture or grain, lack of flaws, overall shape, and shape of the working portion of the stone. Most commentary in the knapping literature concerns the properties of basic tools. Advice on how to choose suitable tools varies, depending on one's experience, local resources, and the techniques to be employed.

> Choosing a hammer stone requires some thought: the most desirable choice is usually a cobble that has a nicely rounded surface (to knock against the core) on at least one end or side and is fairly smooth over most of its surface, so it doesn't dig into the hand while flaking. Many times, the preferred hammers are slightly oblong or egg-shaped. The size of the hammer stone varies: for a pound-size core, the hammer is about the same size; for flaking a small cobble, the hammer stone is somewhat larger than the core; and for very large cores, the hammer tends to be smaller in order to be wielded in the hammering hand. Also, it's very important to avoid cobbles with obvious flaws or cracks in them, as they can shatter and cut the hammering hand. (All of these precepts were gained *not* from the armchair, but from the direct experience of experimental archaeology.) (Schick and Toth 1993:118, original emphasis)

Most discussion among knappers quite logically concerns stones used for knapping, or viable substitute materials for knapping hammerstones. A major distinction is between "hard" and "soft" stones. On its face, this distinction appears counter-intuitive to non-knappers because of the popular perception that all rocks are hard things. But some rocks are harder, more dense, and tougher than others.

> Choice of hammerstones depends upon the type of lithic material to be worked. Hard flint-like minerals require hard hammerstones. These should be of tough granular

9 Gene Titmus and Jeffrey Flenniken reduced a 300 pound obsidian boulder in 1980 at the Little Lake Knap-In with a large maul of basalt, a sub-optimal hammerstone but the only available that would do the job (see Figure 2; also *Flintknappers Exchange* 3 (3):5-7). For removing plates from a massive boulder the "weight of the hammerstone can vary considerably from more than the weight of the flake you propose to remove to about half its weight, although the larger the hammerstone the less hammerstone velocity is needed. What one should try to achieve is a slow gentle blow with follow-through that will start the flake crack at the platform and let the weight of the hammerstone complete the removal of the flake. Using a lighter weight hammerstone requires a blow of greater velocity, which sets up more shock and vibrations, and flake damage and breakage go hand-in-hand with increased hammerstone speed" (Titmus 1980:22).

**Figure 2.** Gene Titmus (left) and Jeff Flenniken (right) reducing a large obsidian cobble (Aug. 1984).

> stone and should be oval in shape. Waterworn cobbles from streambeds are a good source of hard hammerstones. Most knappers prefer softer hammerstones for working obsidian, although this material can also be worked with hard hammers. Non-crumbly sandstone and vesicular basalt are the best sources of softer hammerstones. (Hellweg 1984:31)

Choice of hammerstones depends on the raw material of workpieces, their sizes and shapes, and the desired final products of the work.

Flakes removed with different kinds of hammers can have different characteristics, mostly evident in their platform and bulbar attributes. Don Crabtree was of the opinion that "the hammerstone must be softer than the material being worked" (Crabtree and Swanson 1968:50); "the more vitreous the material, the softer the texture of the hammerstone" (ibid.). "The hardness or softness of the hammerstone controls the interval of contact between the percussor and the flint-like material, for the time of contact is proportionate to the yield and density of the percussor" (Crabtree 1972:9). Crabtree's comments concern chipping hammers and not pecking or battering hammers (Figure 3). Soft hammerstones for chipping yield results comparable to those of tools of antler or dense hardwoods.

> ... not only can soft stone (i.e., sandstone) duplicate each and every effect of the antler billet but ... for obsidian and glass, it is superior. All of the far Western obsidian knappers, those trained under Crabtree, Titmus, or Flenniken, know this, as do all my students. In fact, I demonstrated to my own satisfaction last summer in Sweden where I spent two months knapping massive, tough Danish flint daggers, that soft stone can duplicate practically any effect of antler, even on flint. (Callahan 1996:83)

A colossal caveat is worth mentioning at this point. Our emphasis is on hammerstones and their properties. A great deal depends, however, on the hands that wield these stones. Beginning students can destroy the most perfect hammerstone in the world through ineptness, hence the general knappers' rule of thumb not to allow novices to touch their best hammerstones. As with the auctioned ancient violin of poetic fame,

**Figure 3.** Don Crabtree knapping an obsidian core (Aug. 1979).

a "touch of a master's hand" makes all the difference in the performance of the instrument and, thus, its value. In a master's hands, such as those of Don Crabtree, Gene Titmus, Jeffrey Flenniken, Jacques Pelegrin, or Errett Callahan, even an unsuitable hammerstone could/can be made to perform exquisite work that novices could not approach with even the best tools and instruction. This is to admit that hammerstone utility is a variable with a range dependant on the knowledge and skill of the artisan. The human element vis-a-vis a particular task is huge. The usefulness of a hammerstone also changes throughout its career as it changes shape during use (see below). For example, with use a hard quartzite cobble will develop a crushed and flatter surface which will start to perform like a softer hammerstone, contacting a greater area of the workpiece and for a longer interval. Some stones have a softer cortical surface, and as that wears away during use, a tougher inner texture becomes exposed.

Size is an obvious critical variable familiar to most people who use hand tools. "As a general rule, the hammer should be lighter than the core it is striking, and the size of the hammer will also affect the size of the flake you can strike off" (Whittaker 1994:85, 87). "Hammerstone size is related to the dimensions of the flake being removed" (Crabtree 1967:61). Carpenters today would not use a sledge hammer to drive a finishing nail or a ball-peen hammer to set a railroad spike. Ancient peoples were equally practical in using the right size (dimensions, weight, density) of stone tool for the task at hand. "Hammerstones normally graduate in size from large to small as the flaking work progresses. Large, heavy hammerstones are necessary for the quarry work, smaller percussion tools being used as the artifact nears completion" (Crabtree 1967:62). "The same hammerstone can accommodate a considerable latitude in object piece size although the rule of thumb of using a hammer with the same mass as the object piece can keep a knapper out of trouble" (Patten 1980:17).

Most hammers described in knapping books are small and can be held in one hand. Some hammers found at quarries required two hands (see Figure 2; also, Hampton 1999:figs. 3, 7.4- 7.8; Hayden 1987:29-33, figs. 2.6-2.9; Holmes 1919:171, 217, figs. 55, 93). Some extremely large hammers for quarrying could have required more than one person. "There are many kinds of stone hammers, and they are of many sizes – from that of a walnut to the large mauls used in quarries, which were often heavier than a single individual could readily manage" (M'Guire 1891:301).

Other important characteristics are stone density and texture or grain. These relate to toughness and "tooth," a technical term for surface roughness. Hard sandstone cobbles used to work obsidian have "tooth" and actually grab or dig into the slick surface of a core rather than slide off. "A hammer with a gritty surface grabs hold of the edge of the stone so glancing blows can be effective instead of skidding off. Silicified sandstone grinding stones were commonly converted to hammers for this reason. Used properly, gritty hammers can work as well as other tools for percussion" (Patten 1999:29). Of interest here is the claim that a stone's texture affects the angles in which it can effectively be used. "Practically, the traction a hammer provides determines whether a knapper has to worry about the angle of impact. Hard hammers typically skid, so they work best when directed perpendicular to the platform surface. Knappers can and do change the platform angle, but that is not always easy or convenient" (Patten 2005:90).

"Hammerstones should ordinarily be of tougher, less brittle material than the core they are used on" (Whittaker 1994:87). "Stones that flake easily, like chert and obsidian, do not make the best hammerstones for knapping because each blow produces an incipient cone of percussion in the hammer as well as in the core, reducing the hammer, and occasionally flaking or shattering the hammer" (ibid.).[10] This generalization does not always hold. Chert hammerstones are common in Mesoamerica, and many were obviously used for knapping. We have even seen obsidian hammerstones that appear, based on their context, to have been used for knapping.

Hammerstone shape is significant at two different scales, first the overall form and dimensions of a stone, and second, the shape of individual sectors of the stone. Most authorities recommend rounded or oval cobbles as hammers for beginners.

> Stream-rounded pebbles and cobbles of less brittle stone make the best flaking hammers. A rounded egg or oval shape fits the hand well, balances nicely, and has a definite end to strike with. On a flatter, rounded stone you can use the edges. Different knappers prefer different shapes; all that really matters is the size and a convenient but definite point or spot on the hammerstone with which to strike. (Whittaker 1994:87)

We could call the definite point or spot on the hammer its *nose*. "The pointed (conical or bi- conical) ends of the hammerstone permit the worker to strike in a restricted area" (Crabtree 1967:69). Like other hand stones, hammerstones have to be of sizes and shapes that fit in the hand. As a percussion implement, it is also desirable for a hammerstone to have a salient portion that can contact a workpiece without pinching the hand or fingers between the hammer and workpiece. Knapping requires blows of proper force aimed with a hammerstone and at the proper angle, so a requirement is that at least one sector of a hammerstone be suitable for aiming.

The foregoing is generally true and constitutes standard advice for using a hammerstone. But it only applies to certain tactics or gestures. Crabtree developed another way of using hammerstones inspired by analysis of archaeological specimens which evinced "edge grinding" (Crabtree and Swanson 1968). It turns out the "ground" edges involved were not from grinding at all but were battered, worn surfaces from using the edges of these stones in knapping. Most knapping guides advise using the salient end of an ovate cobble as the point of impact. Crabtree's experiments demonstrated that the lateral edges of some hammerstones served as well (Figure 4). Clark and Woods prefer to use the flat faces of sandstone cobble hammerstones to achieve the same effect. If ancients used stones in this way it would be obvious from wear patterns on their hammerstones.

It is important to point out that these edge and face "ground" hammerstones operate on a different knapping principle or tactic than that of normal chipping hammers. Standard knapping is patterned after the practices of the Brandon gunflint knappers in which a pointed metal hammer was used to remove flint blades. The skill was in precision-striking, hitting a point on the core platform with the pointed tip of the tool. Using the nose of a cobble hammerstone to contact a core platform at a desired point set in from the edge of core rim is the same technique (Fig. 3). In contrast, using the edge or flat face of a hammerstone requires that one build the needed precision into workpiece instead of the hammer. The broad, flat part of the hammerstone contacts the prepared, salient part of the core at only one point (Fig. 4). This is done by what Patten (2005:76, 2012) describes as creating "offsets." Crabtree called them "isolated platforms." Woods and Clark use this technique to make

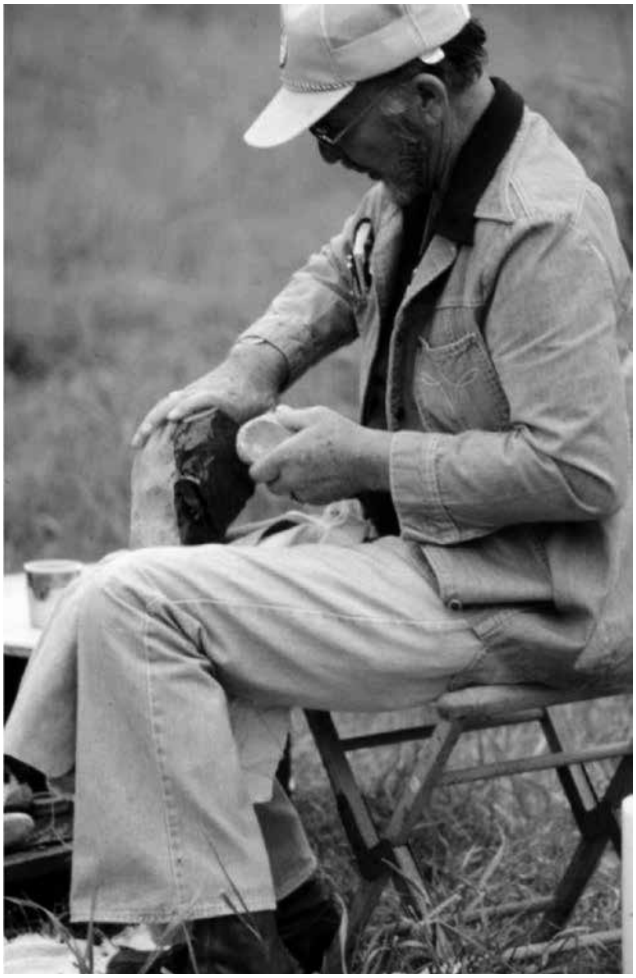

**Figure 4.** Don Crabtree using the edge of his hammerstone in knapping an obsidian core (June 1980).

**10** The propensity of flint or chert to break makes them excellent raw materials for pecking hammerstones. Expended chert cores and broken bifaces were used in Mesoamerica as hammerstone pics. The sharp edges and ridges of these recycled forms cut into the surfaces of workpieces, and because these hammers are brittle and easily fractured, some of their edges are partially self-sharpening.

blades as well as to thin bifaces, so the technique is not limited to blade-making (contra, Crabtree and Swanson 1968:52). Flakes and blades produced by this technique have extremely small platforms and generally diffuse bulbs of percussion (for a variant of this technique for broad bifaces, see Callahan 1982; Pelegrin 1981).

### IV. Hammerstones are selected for utility and performance

Consideration of hammerstone properties vis-a-vis desired knapping outcomes raises the issue of choice. An important distinction concerns ad hoc knapping activity and activities undertaken in more controlled and predictable situations. A cobble picked up and discarded after being used to knock a few flakes from another cobble does not interest us a much as stones selected to carry back to a base camp, village, town, or city for extended future use. Knapping requires long sequences of choices and decisions in how to shape stone tools, with the first choice being the selection of appropriate tools and raw materials. This occurs at least at two different levels: first, selecting hammerstones for possible general use and, second, picking out a hammer from all the stones in a toolkit for a particular task. Anticipation of future needs, based on experience and ability, determines the stones selected as candidate hammerstones.

Modern knappers have numerous hammerstones. Some knapping manuals recommend that one obtain about a half dozen stones of different sizes to start out.[11] Most serious knappers have hundreds. We recently visited a self-taught knapper in Mexico who had over a thousand hammerstones collected from the ancient quarry nearby (Sierra de las Navajas). Initial selection of potential hammerstones anticipates imagined future activities and thus involves expansive thoughts, at least in our case. We pick up rocks from all over the country to try out later as hammerstones. Some modern knappers cover a wider range of techniques than did ancient knappers and thus probably collect a much wider range of candidate hammerstones than did they. Ancient knappers had clearer notions of what they needed than do scientific knappers trying to rediscover the techniques these ancients learned growing up (Crabtree 1975). We have taken students to river beds to collect hammerstones, and then we have tried to teach them knapping with the very stones they chose. After just a little bit of experience, the students begin to appreciate differences in hammerstones and start to regret having picked up lousy stones and having left the good ones in the gravel bed. The stones selected for one's toolkit set the parameters for future choices. During knapping one chooses a tool deemed best for the immediate task from among the collection of tools at hand. It may not be the best possible tool or even the best in the toolkit, but it should be suitable.

Discussion of stone properties concerned principles of uniformitarianism. Our consideration of hammerstone selection embraces assumptions of culture and rationality. We presume that recent humanity is of one piece; ancient peoples were at least as intelligent and rational as we, if not more so. Culturally, we accept the proposition that people knew their own world. As Otis T. Mason (1895:121) argued in his classic study of technology, ancient peoples were "good lithologists."

> They found out where this material abounded under the best conditions to be worked. They planned methods and invented apparatus for mining and quarrying it. They transported the material for long distances, half shaped it in their quarries to reduce the weight, made treaties with hostile tribes to secure the right to visit the coveted spot, and bartered the choicest of their own productions with fortunate possessors of the coveted material. ...But savage man's knowledge of lithology did not stop with his acquaintance with materials. The qualities of the substances were known to him, both as to working and to using. He could tell you how each kind of mineral ought to be worked, and how it would do its work after it was put into shape. An examination of his workshops demonstrates that he understood cleavage and granular structure and the idiosyncracies of each stone. (ibid.)

Scholars have rightly emphasized the raw materials processed to make other tools, but a basic part of ancient lithic knowledge must also have been how to select suitable hammerstones for tasks planned or anticipated. Early studies viewed hammerstones as everywhere available, as if any stone would serve the purpose, and this attitude still predominates in archaeological analysis. A few swings at a core with an inferior hammerstone would suffice to correct this misconception for any still holding this view.

> Selection of a hammerstone was not accomplished by indiscriminately picking up the first cobble or rounded boulder that was available, as the broken and utilized percussion tools found in a quarry would lead one to believe. Percussion tools used for mining, or tool making, are usually of tough, granular stone which has good

11 "Everyone has favorite hammerstones and antler billets that they have learned to work with. I personally use a heavy quartzite hammerstone (800 grams) for initial shaping of large flint nodules, and smaller hammerstones (250-350 grams) for finishing bifaces and making dartpoints from thick flakes. Since force applied is a function of weight and velocity, each person finds percussors that fit his own abilities. Experiments should be made to find hammerstones best suited to the individual, and to the particular material being worked" (Patterson 1978:11).

> resistance to shock and abrasion. For mining, they range in size from three inches in diameter to as much as twelve and fourteen inches in diameter and they weighed from one and a half to as much as twenty to thirty pounds. (Crabtree 1967:61)

> Choosing the proper hardness of hammerstone requires both common sense and experience. Generally, the hardest stone hammers are used for quarrying, or to work tough stone. As more fragile stones are encountered, it is better to try softer hammers such as limestone or sandstone. After prolonged use, a hammerstone becomes pitted enough to soften the impact, no matter how hard the hammer. When flaking delicate stone, it may help to use a hammerstone that has been softened from use. (Patten 1999:28-29)

Selection and choice imply a field of operation. One chooses from among alternatives, and this may not include the best possible outcome, thus our distinction between suitable tools and optimal tools. Some regions were poor in lithic resources, and people had to make do with the best of a poor lot. Studies of hammerstones and their uses need to done against the lithic landscape available to the peoples whose tools are being analyzed. Studies of artifacts brings the hypothetical down to earth, and one can determine what kinds of stones were selected from among those available and how each was used. Gauging prehistoric parameters of choice is a difficult matter that requires some practical field geology and knowledge of lithic resources for a locale or region. Viewing each hammerstone as a bundle of properties, an analyst can determine what properties were selected from those available.

In some ethnographic cases, informant testimony details vital qualities of desired stone hammers. Brian Hayden (1987) described the manufacture of metates (milling stones) in western Guatemala. Ramon, Hayden's informant, was one of the last artisans left at the time who had experience using stone tools. For Ramon, selection involved suitable stones, both for blanks for making milling stones and for pecking the blanks into shape. For the hammerstone pics,

> Ramon tested potential boulders for a number of important qualities. Testing for flaws was achieved by tapping specimens lightly and listening to the "ring" of the rock. Chips were removed to test the flaking quality, coarseness, and internal homogeneity of prospective pics. Once a sharp edge was created, it often was tested for penetration and durability by indenting some nearby vesicular boulders. Sharpness was tested by running finger tips along edges. Specimens were further tested for adequate grip and for porosity by wetting freshly exposed surfaces. (Hayden 1987:25)

In this case the stone to be quarried and harder stones suitable for hammerstones were found in the same river bed and vicinity. At many obsidian quarries we have visited, suitable hammerstones had to be brought in from elsewhere.

**V. There are different ways to use the same hammerstone.**

Hammerstone selection actually involves a third level of choice, that of deciding what part of the tool to use, and in what way. We touched on this topic in arguing that the nose of a hammer could be used, as could its lateral edges and flat faces (Figs. 2-4). These comments concern hammerstones in their relatively pristine state, a passing condition. Knapping affects hammerstones as well as workpieces. Depending on the knapping technique, shape modification from use included ablation (gradual loss of the surface), loss of mass, and spalling. More importantly, the shape of the rounded or convex point that contacts the workpiece becomes flattened, as alluded to by Crabtree (1967:69): "Should the hammerstone be used for thinning and striking as on the edge of a bifacial artifact, facets will develop on the tool from wear, for as one edge becomes worn, the hammerstone must be turned to expose new striking surfaces of the tool."

Different parts of a hammerstone can be used, and the same parts can be used differently by changing one's grip or swing, to name the most obvious human variables. One of the startling facts brought back to mind each time we attempt to teach knapping to novices is that they do not know how to hold hammerstones or deploy them. After years of experience hammerstone use seems so natural and obvious to us that it is good to be reminded from time to time that it is neither. Hammerstone grip determines which part of a tool is exposed and available for contact with a workpiece, and the levels of precision of the impact possible. Most newcomers pick up a cobble and seat it firmly in their palm, holding it tightly, with the fingers and thumb wrapped around it like a baby octopus strangling a baseball. With such a grip there is generally little clearance between the hammerstone's nose and the ends of the fingers, so the hammerstone is hard to aim, and many a finger gets smashed in attempting to do so. We do not encourage such mayhem nor revel in its consequences. Students watch us work before they start knapping, but they fail to perceive details, such as how we hold a stone with our fingers in a loose grip, or how we swing it with a relaxed wrist and elbow. Self-inflicted pain heightens perceptions and makes learners more focused. "To get the most out of the hammer it should be soft but durable to avoid shock, have a gritty texture to promote pulling and have a curved surface to facilitate predictable contact. In addition to physical characteristics of the hammer, a loose grip on delivery of the blow is critical to the success of this technique" (Patten 1980:17).

Swinging a hammerstone is more difficult than it looks. Counting from finger tips to shoulder, a normal human adult has six joints or hinge points potentially involved in swinging a hammerstone. The motion has more complexity than a golf swing and is just as important for each swing – at least for knapping or chipping. For some pecking work, some working motions are not as critical until the final stage of manufacture involving fine details. There are many ways to swing a chipping hammer, with the important things being angle and force of the blow to a workpiece. These relate to tool mass and hammerstone velocity. Novices who palm their hammerstones also tend to swing them with excessive force, as if they had just one blow to club to death a beast carrying off their only child. Others swing hammerstones with a petite karate chop, trying to withdraw the blow as soon as contact is made – rather than carrying through with the swing to remove flakes. It is worth pointing out that the power grip of a palmed hammerstone can be effective in pecking work, but it also causes more trauma to the hand than does a tool held with the fingers in a precision grip (see below).

Holding and swinging hammerstones properly takes some practice and experience. For any given stone appropriate grips can vary, depending on what part(s) of the stone one wants to put in play, and this depends on the task at hand. The immediate task also affects the swing, angle of blow, and force applied. These variables are well understood by knappers and become so automatic that they become unconscious actions. Crabtree (1967:69) gives a typical example: "Blows delivered by the hammerstone for thinning purposes are struck in a different manner than those delivered for blade or wide flake removal." It is worth noting that for any particular grip a hammerstone had a leading and a trailing end and an inside and an outside face. These change with shifts in grip, if a hammerstone is rotated from end to end in the hand or flipped from one face to the other.

We have couched discussion of hammerstone use as "task" related. This requires clarification. The overall goal of making a tool or tools from a given workpiece dictates the work required to transform it into a desired form or forms – whether by chipping, pecking, battering, and/or dressing. The overall process includes many sub-routines and tasks, such as removing cortex or knocking off a protruding part of a workpiece, such as a hinge fracture on an obsidian core. This is to admit that a desired outcome of a hammerstone stroke dictates the optimal blow. Hammerstone use is all about goals and intentionality, and these have to be adjusted, sometimes on the fly, to compensate for, or adjust for, undesired outcomes, whatever their cause. Sometimes workpieces were discarded and the artisan started over with another. In other cases, hammerstones broke and had to be replaced.

Two lessons in hammerstone use were impressed on Clark's memory at the second Maya Lithic Conference held in San Antonio, Texas, in October of 1982 (see Hester and Shafer 1991). There he met and watched J. B. Sollberger (Solly) replicate Maya chert axes. The greatest difficulty of the technique is the final (tranchet) blow to the wide end of a thick biface. This blow removes a flake that curls around the bit like an orange peel and leaves a broad scar as one of the two faces of the finished bit. Setting up this flake is complicated. After chipping the angles of this bit properly on several bifaces, Solly marked with magic marker the path of the final "orange peel" flake, both its lateral margins and length, and the flake came off as predicted. Many knappers remove potential, marked flakes in public demonstrations, but it never fails to amaze bystanders that knappers can imagine specific flakes precisely and make the imagined a reality. Some knappers work so fast that onlookers fail to perceive any rhyme or reason in their work, but in knapping each blow matters. Once Solly's demonstration was over, he allowed Clark to try his hand at working a chert piece, and with his hammerstone. Clark could not get anything to work. Solly came up with the idea that a problem might be that his hammerstones were left-handed and Clark was trying to use them right-handed, and without success. Change to a pristine stone resolved Clark's knapping difficulties and allowed him to remove an orange peel flake on a biface Solly had set up. Before this time, Clark never thought of hammerstones as having handedness.

Analysis of Solly's well-used hammerstones should reveal their handedness, and the same should apply to Crabtree's and Titmus's well used right-handed hammerstones, to name some hammerstones available for study.[12] Of course, any hammerstones of known use will do. To our knowledge, detailed studies have not been done of the tools used by modern knappers and correlated to their idiosyncratic knapping motions. Such studies need to be done before the use-wear traces on prehistoric specimens can be interpreted at this level of detail. In the meantime, enough is known to start with better analyses of archaeological artifacts. As with left and right golf clubs, one should be able to determine handedness by evaluating the relationship

12 Flintknapping tools of Don Crabtree and Gene Titmus are part of the research collections of the Herrett Museum of the College of Southern Idaho, located in Twin Falls.

of club heads to handles. For well-used hammerstones the equivalent analysis would be to determine the worn parts of tools in relation to grips used. Faceting on the hammerstone will indicate the angle of blow, and when related to the grip, should indicate handedness.[13] A proposal is illustrated in Figure 5.

## VI. Hammerstones develop distinctive wear patterns from use

A few minutes of holding Solly's hammerstone incorrectly was enough to realize that hammerstones wear away in predictable ways, depending on how they are used. We cannot emphasize this point strongly enough. Determinations of past uses and functions of hammerstones must come from a general appraisal of their natural properties as well as from specific evidence of their human or cultural modifications from use. It makes a difference if a hammer weighs two pounds, twenty pounds, or 10 ounces. It makes a difference if it is of hard rather than soft stone. And it makes a very significant difference how much it is worn, where it is worn, and the characteristics of the worn portions of the tool. "The wear pattern on percussors can be of diagnostic value in interpreting techniques. The position and depth of the wear pattern, striations, bruising and battering aid in reconstructing the manner in which the percussor was held, the way the blow was delivered and the probable stage of manufacture" (Crabtree 1972:9).

Individual wear patterns from use become consistent with consistent use. They reveal how hammerstones were held and used. Different kinds of hammerstones develop different kinds of wear. Any kind of consistent contact with workpieces can leave a trace. Whittaker (1994:87) observes that "Hammerstones quickly develop distinctive wear patterns, as each blow crushes a bit of the stone. If you use a hammer long enough, it will also become polished where your fingers grip it." Not all hammerstones are of a texture that would take a polish, but even without specific evidence of where fingers gripped a stone, it should be possible to determine a grip by charting the bruised and battered parts of a stone in relation to pristine portions.

Consistent use of the ends of hammerstones with the left or right hands wears them away as mirror images of each other. Mike Johnson (1978:3) published the schematic shown in Figure 5 which indicates that hammerstones used in the same way with different hands develop flat facets and wear patterns that are the inverse image of each other. In his words, "During the past five years I have noticed a distinctive wear pattern, or [planing], developing on my hammerstones. It appears to be a direct result of my right handed percussion technique. Using my left hand, I have produced a similar but distinctly opposite wear pattern" (Johnson 1978:3).[14] The pattern shows that each of his hammerstones had two working ends, and each end was used in two ways by turning the hammer in the hand to work the nose from each side. When anchoring a workpiece with the left hand on the left leg (seated knapping position), a hammerstone used in the right hand requires that the right arm swing across the body to make contact with the workpiece (Figure 6). In this working position, the most common in modern knapping, the right arm becomes the hypotenuse of a right triangle (from a birds' eye view, triangle formed by the torso [base], the left arm or leg [side of triangle] and the left arm as hypotenuse). Reversing roles and holding the hammerstone in the left hand and workpiece on the right leg reverses the right triangle. The two knapping strokes (or hypotenuses of these inverse triangles) are nearly perpendicular to each other, so use wear on hammerstones used in opposite hands should be distinctive, depending on the precise positioning of workpieces. The wear is particularly apparent in the ridge formed between the flat faces on opposite faces for each end. For right-handed hammers, the crest or keel slants, from top to bottom, to the right. For left- handed hammers, the slant is to the left (Figure 7).

"The wear pattern on some percussors reveals that they were used for pecking rather than for flake removal" (Crabtree 1972:9). This should be an easy distinction to make for hammerstones since pecking requires a sharp edge or pointed edge and tools made from hard, tough rock. Perhaps no analyst would confuse a pecking hammer with a chipping hammer. Much more likely would be to confuse pecking hammers with choppers. "The [chipped] bevelled hammerstones shown to have been so important in the production of millstones ... may resemble choppers but should not be confused with these artifacts merely because of similarity in form" (Wilke and Quintero 1996:258). The pecking hammer will have cutting edges that show extreme blunting from use on stone (see Hayden 1987) whereas choppers for less resistant materials, such as wood, will show a different kind of wear.

Hammers used to batter and dress groundstone artifacts are another matter, however. They develop

13 In evaluating "grip" we assume a constancy of human hand anatomy and opposable thumbs. O. W. "Bud" Hampton's (1999:22-23, figs. 1.15-1.16) account of the axe-makers among the Dani of highland Irian Jaya provides some food for thought. One of their cultural practices is to sacrifice fingers (by removal), so some of the knappers are missing a finger or two. Working with fewer digits does not appear to have affected their work.

14 We verified Johnson's observations by using bars of soap as super-soft "hammerstones" to speed up the appearance of wear patterns. Rather than take five years to wear down a stone, we took five minutes and simulated the wear for both right and left hammerstones.

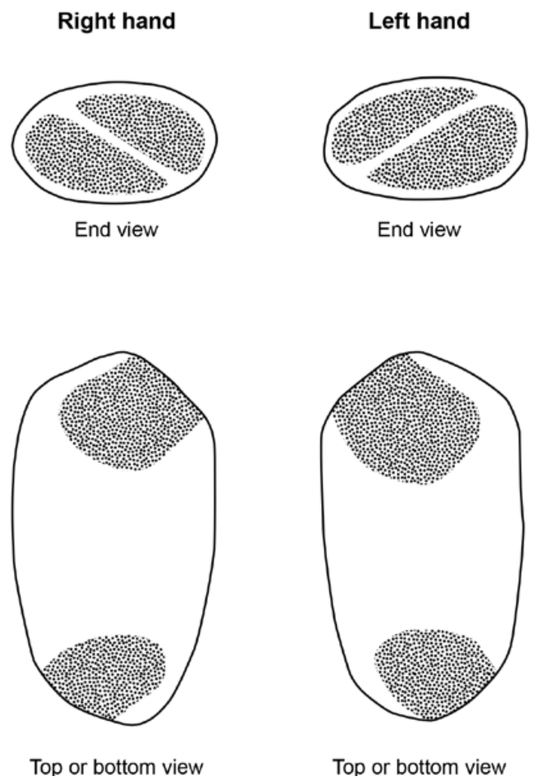


**Figure 5.** Facets on left-handed and right-handed hammerstones (adapted from Johnson 1980:3, fig. 2).

**Figure 6** Gene Titmus knapping obsidian; note the angle of hammerstone use (Aug. 1997).

**Figure 7** Jim Woods knapping a large obsidian biface (July 2013) using the edge of his hammerstone. Resting the work piece on his right leg changes the hammerstone angle.

flat and regular surfaces and can mimic forms used in chipping. But this is to consider hammerstones hypothetically. Archaeological specimens come from specific contexts and should be interpreted from this point of view. What objects were made and used at a site, and what tasks were performed? Which of these tasks required stone hammers? If no knapping occurred at a site, hammerstones found there that look like chipping hammers probably were used for different purposes. Analyses of hammerstone properties and wear patterns can only take one part of the way to a plausible conclusion. Hammerstones need to be studied in the context of artifacts found in co-association.

**VII. Hammerstones wear out or break.**

"Hammerstones wear out and break, so you will want to have several, of different sizes, before you begin" (Whittaker 1994:87). This wise counsel points to the problem of replacement and the need for multiple stones, rather than the need for a range of hammerstones for different tasks. In lieu of breakage, it is difficult to determine when a hammerstone reaches a point of marginal utility when it cannot be used to remove one more flakes or strike one more blow. The longer the use, the more developed wear patterns become. Hence, well-used hammerstones provide the best evidence for how they were used. In this regard, like any other flaked stone, hammerstones do not break randomly unless they have internal flaws or are fractured by fire. Patterns of hammerstone breakage are a significant clue to past use, as are flakes which spall from hammerstones during use. More commonly, mass removed from hammerstones are dust- size particles from crushing rather than flakes.

Crabtree used some of his favorite hammerstones so long he wore them down to pebble size.[15] He is shown using these tools in his many instructional films, so it will be possible to relate the wear patterns on his tools to specifics of his technique, a study we hope to undertake. Lithic specialists are familiar with reduction sequences which show the transformation of raw materials into final forms and discarded byproducts. Hammerstones and other tools used to work stone also go through logical reduction sequences and changes in shape. Generally, hammerstone transformation is so gradual that not much is made of it. Hayden (1987:figs, 2.24-2.33) illustrates the transformations of hammerstone pics used in milling stone production in western Guatemala. These tools go through rather rapid changes because they have to be resharpened frequently, and the pecking process involves thousands of blows per hour. Knapping stones also wear down, and changes in the micro-morphology of their contact points may make them unserviceable (i.e., from a curved to a flat surface). Renewed use-life can be instilled in such stones by reshaping their working edges by pecking and battering.

Kathy Schick and Nicholas Toth make a plausible proposal for the round stones or "bolos" found at early man sites. Based on observations made from some simple experiments, they propose that bolo stones were well-used hammerstones.

> We found that after approximately four hours of percussion these quartz hammers assumed a remarkably spherical shape *without any necessary intent or predetermination.* After four hours of use as a hammerstone, an angular chunk of quartz was transformed into a virtually perfect spheroid, just by being used as a hammer stone. (1993:133, original emphasis)

The illustration accompanying this text (Schick and Toth 1993:132) shows the sequential transformations of chunky quartz into the spheroid form. Figure 8 shows hammerstones from southern Mexico which demonstrate the same principle, in this case with exhausted chert cores being used as pecking hammers. Hammerstones used for chipping and battering also undergo morphological changes. Some adjustments a knapper makes while knapping may be triggered by changes to his/her hammerstone. A flake spalling from the hammer may not make a hammerstone useless but may affect how it can subsequently be used. More often, the changes are to hammerstone curvature of the active area. These sometimes can be corrected, but reshaping the nose of a hammerstone may not be worth the effort. Much would depend on the availability of suitable replacement hammerstones. A spherical hammer is an ideal form because every sector of its surface is equally useable and useful, and it can be used in either hand. As noted, it is a form that results naturally from a certain style of hammerstone use.[16]

Considering our own knapping, Pastrana, Woods, and Clark work mostly with obsidian, and Patten works principally with chert and flint. The best hammerstones for working obsidian, in our experience,

**15** In thinking about the use-wear and severe shrinkage of Crabtree's hammerstones, Woods realizes that he never pushes his hammerstone to the same degree. He discards worn hammers long before they reach this condition. For his part, Patten quickly tosses any hammerstone that develops a flaw to prevent using it again later. A damaged hammerstone is an unreliable tool that can cause problems in knapping, so best get rid of damaged tools and reduce chances of knapping problems.

**16** When he first started knapping, Woods selected hammerstones which were as spherical as possible, the more symmetrical the better. Today his technique has evolved to using the flat surfaces of hammerstones, so he does not even have a spherical hammerstone in his regular toolkit. When he takes students to collect hammerstones they usually look for round and symmetrical specimens. This shape seems to be the "default" choice for novices

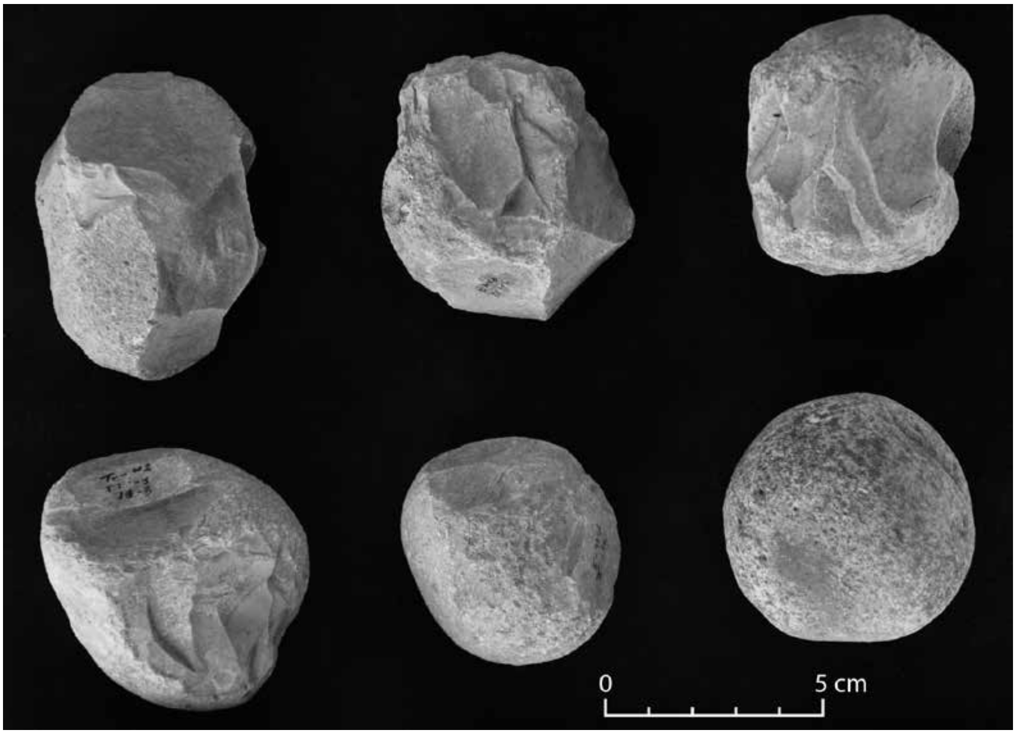


**Figure 8.** Hammerstones from El Cerrito, Chiapas, Mexico, representing sequential morphological transformations of exhausted flake cores used as hammers.

come from the Wood River of Sun Valley, Idaho. These are obdurate, fine grained sandstone cobbles, the best having a gray color. These stones are harder and of a different color on the inside; the gray exterior appears to be a weathered surface only about 5 mm thick. When the gray exterior of these stones wears away and exposes their bluish interior, they have become fundamentally transformed and have to be used for a different purpose or discarded. They become harder hammerstones with less tooth.

## VIII. Most stone working requires more than one size or type of hammerstone

This basic point has been made in conjunction with other propositions but deserves mention in its own right. For a given system of production, there can be a suite of hammerstones (and other tools) related to stages of production for a single tool form, ranging from large hammerstones for mining to small stones for retouch or for fine finishing of a pecked tool. "The forming of the artifact from the initial break of the raw material to the finished tool usually requires several stages of manufacture and the use of several different kinds of fabricators" (Crabtree 1972:7).

> Percussion tools seen at quarries include ovate, discoidal, lenticular, cylindrical, spherical, conical, and biconical shapes. These tools are found in many sizes. Various hammerstone types are designed to fit certain phases in making artifacts or to suit certain types of mining operations. Their shape was governed by the manner in which they were held and the specific type of work they were to do. The ovate, spherical, conical or biconical tools were used to restrict the force of a blow to a confined area. (Crabtree 1967:60)

For some knapping techniques and desired products the reduction process and staging involves a shift from stone percussors to those of organic materials such as bone, antler, or wood. Hammerstones were not the only tools used to chip stone.

## IX. Hammerstone use can cause bodily harm

Most manuals on flintknapping advise the use of protective goggles, clothes, and gloves given dangers inherent in breaking or shattering sharp stone. Compared to flying glass shards or roiling clouds of obsidian dust, hammerstones appear virtually harmless; even so, they have their dangers. As noted, good candidate stones to be used as hammers should be free of flaws lest the stone break to pieces in one's hand and cause lacerations.

Pecking hammers, and the work they do, appear to be inherently more harmful to the human body than chipping hammers, mostly because pecking requires thousands of times more blows, and harder blows, so the incessant hammering takes its toll. Also, the hammers have sharp edges. Phil Wilke and Leslie Quintero (1996:258) bring this out in their study of milling stone manufacture: "the hand that wields the hammerstone in the course of millstone production is subjected to a great deal of trauma. This trauma occurs in all stages of production, but it may be worse in dressing millstones to their final configuration because smaller hammerstones that have a tendency to become well-seated in the palm of the hand are used for prolonged periods."

Their observation makes the important points that hammerstone size, weight, and grip make a significant different in possible trauma. What they did not say is that after months of replicating milling stones Wilke developed a bone spur on his right index finger that had to be surgically removed, and he also experienced problems with his circulation and was unable to knap for over a year. As he explains matters (personal communication, 2012),

> The thing that stood out most clearly is that the hammers we used seated fully in the hand when doing the pecking, and the repeated impact in the same place had a cumulative effect. I could not peck effectively, and Leslie could not either, if the hammer was held loosely in the fingers [i.e., the grip for chipping hammers]. [The battering hammer] had to find its place and stay there, hour after hour. I also recall numbness in my fingers on the hand that held the hammer/pecking stone. The fingers got cold in cold weather and turned white when cold. I attributed that to damage to the circulation.

Hayden's dalliance with millstone production was of only a few minutes duration but still was sufficient to reward him with some ill effects.

> Aside from the sheer force required to manipulate and carry large blocks of stone, using heavy stone tools with bare hands can result in cuts and serious blistering. This is one reason that so much care is taken to choose pics with appropriate grips and to blunt sharp edges. During the course of the roughing out stage I attempted a little participant observation, using one of the stone pics to chip away at a small protuberance. Within five minutes blisters began to appear, and within another minute they began to tear open. This stands in marked contrast to the four hours that Ramon spent using stone tools that day. (Hayden 1987:34)

Hayden also observed that "repeated shock from the impacts involved in this type of work creates serious bone trauma and abnormal growth in the hand bones of some individuals, according to recent experiments in pecking techniques" (Hayden 1987:35). This was the case with Wilke and Quintero's experiments. It bears mentioning that experience with hammerstone trauma in ancient times would have factored into any subsequent selection and use of hammerstones.

## X. Hammerstones are exchanged

This proposition may come as a shock to most archaeologists because hammerstones are not even considered worthy of study. Why would anyone exchange stones found everywhere on the landscape? Framing the question satirically in this fashion supplies its own answer by exposing inappropriate assumptions. Stones suitable for various kinds of hammerstones were not ubiquitous, so artisans had to make special trips to procure them or obtain suitable stones through trade. We just mentioned the famous sandstone cobbles from Sun Valley; good hammerstones of this material have been given to knappers all around the world.[17] It helped that the Crabtree-Flenniken flintknapping school was located near this hammerstone source for over a decade, so the fame of these stones is now widespread. Shipping boxes of hammerstones to city-dwellers is one thing, but what of ancient peoples who had ready access to river gravels?

Sven Nilsson (1868) was the first scholar formally to identify hammerstones as special tools. He recognized them as such because they looked just like tools he used when he taught himself how to make flint tools. One of his fundamental insights concerns potential exchange. "I am of [the] opinion that all hammer-stones, without exception, were portable, and that the savage was in the habit of carrying them with him while hunting" (Nilsson 1868:11). Hammerstones must have been part of the toolkits of many mobile peoples, meaning that hammerstones have been taking day trips for thousands of years. Movement of hammers from sources to other destinations does not mean, of course, that hammerstones were exchanged rather than being procured by people who visited the sources. On the other hand, it does not rule out simple exchange. That the concept of hammerstone exchange may be hard to accept can be chalked up to prejudice. Hammerstones are still viewed by many archaeologists as valueless tools everywhere available and easily replaceable. They are rarely accorded much space in artifact reports.

Some of us treasure hammerstones obtained over 30 years ago. We have favorite hammerstones which have worn out, but we keep them around anyway. As

17 The modern exchange of knapping materials is a topic worthy of study in its own right. Crabtree received raw materials from all over, and he and Jacques Tixier famously swapped Oregon obsidian for French flint so each could become proficient in the techniques of the other, using the same materials (Clark 2012). Clark and Woods have plate glass, flint, and obsidian nodules that came the stockpiles of Crabtree, Titmus, and Flenniken. Clark has one of Crabtree's knapping tools he got from Titmus, and half of his Sun Valley hammerstones were given to him by Woods. Woods has a large hammerstone used repeatedly by Titmus to section large obsidian boulders. It was carried by Titmus on numerous trips to Glass Buttes, Oregon, over a 30 year period to help process large nodules of obsidian. It is now about half its original size. Archaeologists focus on the distribution and exchange of raw materials. It would be well to broaden coverage to include stones used for hammers as well.

noted, Crabtree used some of his sandstone hammers until they were so small he could hardly hold them. Our hammerstones relate to knapping for fun and science rather than to subsistence or livelihood, so our attitude towards our tools may differ significantly from those of ancient artisans towards their tools. Some prehistoric circumstances concerned high levels of production with an entailed critical and serious need for reliable and serviceable tools. We expect that artisans involved in these enterprises made special efforts to assemble good toolkits for the long term. We have visited many obsidian quarries and have seen hammerstones that were obviously brought into these locales to process the obsidian. The hammerstones are strangers to the local geology. In rare circumstances, mother nature provided good stones for hammers near obsidian outcrops, but this appears the exception rather than the rule.

We have definite evidence for Mesoamerica that rocks used for abrading stones in lapidary industries, and even sands for polishing, were exchanged over long distances (Clark 1988:161). Early documentary sources confirm the exchange of these rustic materials. We suggest that hammerstones may have been other pedestrian materials exchanged as well, at least within regions.

### XI. Hammerstones were sometimes cached at quarries

One of the obvious cases of hammerstone movement in prehistoric times was of artisans bringing them to quarries because suitable stone for good hammers were not available nearby. A logical implication of this behavior is that stones brought to a place to work stone ought to be left there for future use rather than being carried back and forth (cf. footnote 17). A good option would be to conceal or cache these tools in a place where others would not find them so they would be available to those who made the effort to haul them in. Woods observed workmen caching tools for this purpose during his research in the lowland jungle of northern Guatemala (Clark and Woods 2013). The metate worker described by Hayden engaged in this same practice.

> When leaving a blank at the quarry or riverbed was necessary, careful precautions were taken to cache the stones. Ramon had found one such cached metate, clearly of a Colonial or preconquest style, and he stated that he, too, sometimes cached blocks or boulders of potentially usable stone. Hammers, chisels, and other tools were cached at the workshop sites, as well. Cached objects occasionally were lost because workers forgot where they had hidden them. In fact, Ramon had lost one set of chisels in this fashion. He also had unearthed at least one cache of 15 two-handed pics, and another of stone pics, axes, and hoes, from which the wooden handles had rotted away. (Hayden 1987:26)

Clark found a cache of hammerstones at a small obsidian quarry in Michoacan, Mexico. While traveling along a new stretch of highway from Toluca to Morelia in January 1996 he came to a place where the road went through an obsidian outcrop (Kilometer 292). He stopped at this spot and walked up hill on a rough road cut by a bulldozer and found evidence of a blade workshop. Exposed in the scraped road cut was a cache of five soft hammerstones made of dense rhyolite, one elongate and the others oval or spheroid in shape (see Figure 9). The find substantiates the idea of cached quarry tools and shows the association of specific kinds of hammerstones. Each hammer is of a different size and shape, with the whole collection indicating a toolkit for a related series of tasks, such as known in modern knapping. Given their small sizes,

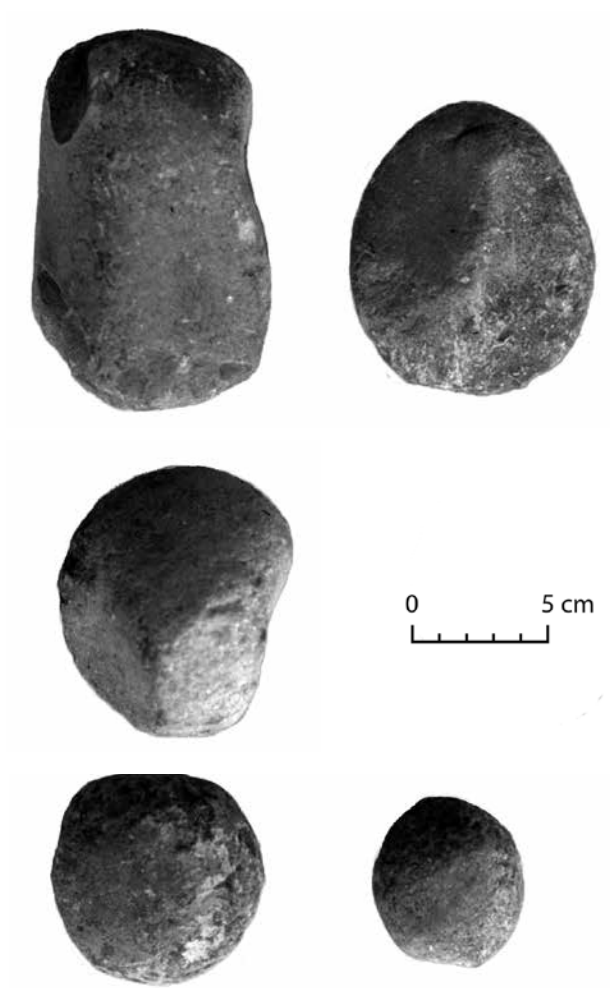


**Figure 9.** Hammerstones from a cache from Michoacan, Mexico (near Highway Marker 292).

they appear to have been for core preparation and reduction rather than for mining.

A wide variety of hammerstones have been reported from obsidian quarries, beginning with William Henry Holmes's (1900a, b, 1919) work at Hidalgo, Mexico. It is clear that the hammerstones illustrated by Holmes were used to flake obsidian, but it is not clear which ones related to others because the hammerstones were found randomly dispersed in the obsidian waste heaps and not as groups. More recent exploitation of the Sierra de las Navajas obsidian mines to make items for the thriving tourist industry has cut away at the mountainside and exposed some ancient vertical mine shafts and their lateral tunnels. Some very large hammerstones and pics have been found at the bottoms of these mine shafts. These tools were used for digging out and extracting obsidian nodules. These tools appear to have been left in place for subsequent use.

To our knowledge, in Mesoamerica no hammerstone cache has been reported outside of quarries, and few hammerstones are reported in burials or offerings. The absence of these tools in ceremonial or memorial contexts at habitation sites could be evidence that, by and large, ancient Mesoamericans did not accord much more value to hammerstones than do most modern analysts. This is an issue in cultural perceptions meriting more research.

## Classification of Hammerstones

Preceding discussion mentions different classes and types of hammerstones but, in reality, we have only considered a small range of stones used prehistorically to hammer other rocks. We restricted attention to "natural" stones with clear traces of hammering marks, thereby excluding, on the one hand, pecked and polished stone hammers and mauls shaped to be hafted and, on the other hand, natural stones that saw very little use. Many stones used to process non-lithic materials in times past may belong to the latter category of expedient tools. These distinctions of classes of stone tools represent the upper levels of a classification system. Information presented above provides a basis for finer distinctions.

Space limitations preclude presentation of a full classification of hammerstones here, but we consider briefly a few examples from Mexico that cover a wide range of variation. Classification of hammerstones needs to be keyed to local cultures whose tools they were, and to the regional geologies involved. Postulates presented above provide a basis for devising many different typologies. We recommend a functional typology. When it comes to hammerstones, "technology" is an ambiguous term because mostly "natural" hammers were involved. Hammerstones were used for different purposes, and we propose these purposes be used to distinguish among kinds and types, to the degree that the ancient purpose a tool can be determined. Distinctions among functions to which we refer are technological functions, with hammerstones being used to make different classes of stone tools by different techniques. Approaches to these issues are apparent in four case studies. The locations of sites mentioned are shown in Figure 10.

**Stone Tools from Sierra de las Navajas**

Archaeological studies of stone tools in Mesoamerica began at the Sierra de las Navajas obsidian mines in Pachuca, Hidalgo, in the 1860s (Tyler 1861), and some of these early studies paid attention to the hammerstones found mixed in with the acres of heaped-up knapping waste (Holmes 1900a, b, 1919). Given the fame of these mines, and the high-quality, translucent green obsidian exported from them, it is not surprising that some attention has been accorded to the production of saleable goods from these mines and to hammerstones, the principal production tools found there. This obsidian source has been exploited for over 3000 years, and it continues to be more so than ever by modern lapidaries who sell trinkets to tourists.

Sierra de las Navajas, as the name implies, is famous for its blades or knives, so most of the hammerstones found there have been associated, at least implicitly, with the manufacture of percussion blades and blade cores. This supposition may eventually prove to have been the case, but the question has yet to be addressed adequately, and the situation at the mines is more complicated than originally thought. Known products made at the mines include blade cores, biface blanks, bifaces, scrapers, eccentrics, and small beads or sequins (Pastrana 1981, 1988, 1990, 1991, 1993, 1994a, b, 1997, 1998, 2000; Pastrana and Cruz 1991; Pastrana and Domínguez 2009; Pastrana and Fournier 1998). Different peoples worked the mines over its centuries of operation, and these included different products and working techniques – and likely tools. Most hammerstones illustrated in past publications relate to the final pre-Columbian and immediately post-Columbian exploitation of the mines by the Aztecs. The same applies to the hammerstones shown in Figure 11. A group shot of hammerstones is not the way to publish these tools in a formal report, but we include the image here to illustrate the range of sizes and shapes of the full hammerstone assemblage.

Hammerstone forms include spheres, disks, cylinders, and split examples of all of them. These tools are made of fine-grained basalt, rhyolite, and *toba* (welded tuft), with rhyolite being the most common material for hammerstones. The chopper-like forms of


**Figure 10** Map showing the locations of the sites mentioned in the text.

**Figure 11.** Sierra de las Navajas hammerstones.

basalt were probably for working soft stone, or wood, or even for excavating vertical mine shafts or lateral tunnels. This is to admit that some of these tools may not be hammerstones (even though associated with tons of knapping debris) but cutting tools for making wooden tools used in other mining activities. Distinguishing between choppers for working wood and sharp hammerstones for sculpting stone will have to be determined based on wear patterns, a study yet to be performed. The largest hammerstones at this obsidian source have been found at the bottoms of vertical mine shafts, in situ, rather than in the heaps of obsidian waste flakes and chunks on the surface. These large hammerstones were clearly used in freeing obsidian nodules from their matrix of soft ash. These hammerstones and/or digging tools were apparently left in place for easy access and were subsequently buried when open shafts were filled in with knapping refuse.

The long, cylindrical hammerstones shown in Figures 11-13 were probably used for basic processing of nodules and for preforming blade cores. These hammerstones vary mostly in length and degree of wear. They obviously were reduced in length through use. Segments broken from them became small discoidal hammerstones. With some nearly pristine examples of cylindrical hammerstones, it is clear that they were chipped and pecked into their basic form, so these were not natural forms selected from river cobbles but were produced forms (see Figures 12 and 13). The same may be true of some of the smaller hammerstones as well. An unknown percentage of the small hammerstones, both discoidal and spherical, may have been used in the production of bifaces and scrapers. Even smaller stones appear to have been abrading tools for removing overhang from cores (Figure 14). The undulating surfaces of the mid-shaft sections of some cylindrical hammerstones may also have been used for this purpose, thereby creating the irregular, shallow grooves partially encircling these stones (Figure 13). These modifications do not look like grooves for hafting these hammerstones; they are more like the concave surfaces on the small abrading stones. The shallow grooves are not purposely carved finger grips, although they may have helped in holding these tools. The numerous striations associated with these irregular grooves parallel the long axis of the cylindrical hammerstones and, thus, are perpendicular to the partial circumferential grooves on the tools' midsections. There is no evidence that these shallow grooves were pecked into these hammerstones. This wear is evidence of versatile tools used for knapping and abrading the rims or edges of cores to remove overhang. Obsidian cores and large flakes and blades from Sierra de las Navajas show the removal of overhang and thus substantiate this postulated use of hammerstones.

Identifying the specific functions of the Sierra de las Navajas hammerstones, or at least bracketing their probable functions, still remains to be done. We will do this through a detailed study of wear patterns and comparisons of these to wear produced on experimental tools used to manufacture products known to have

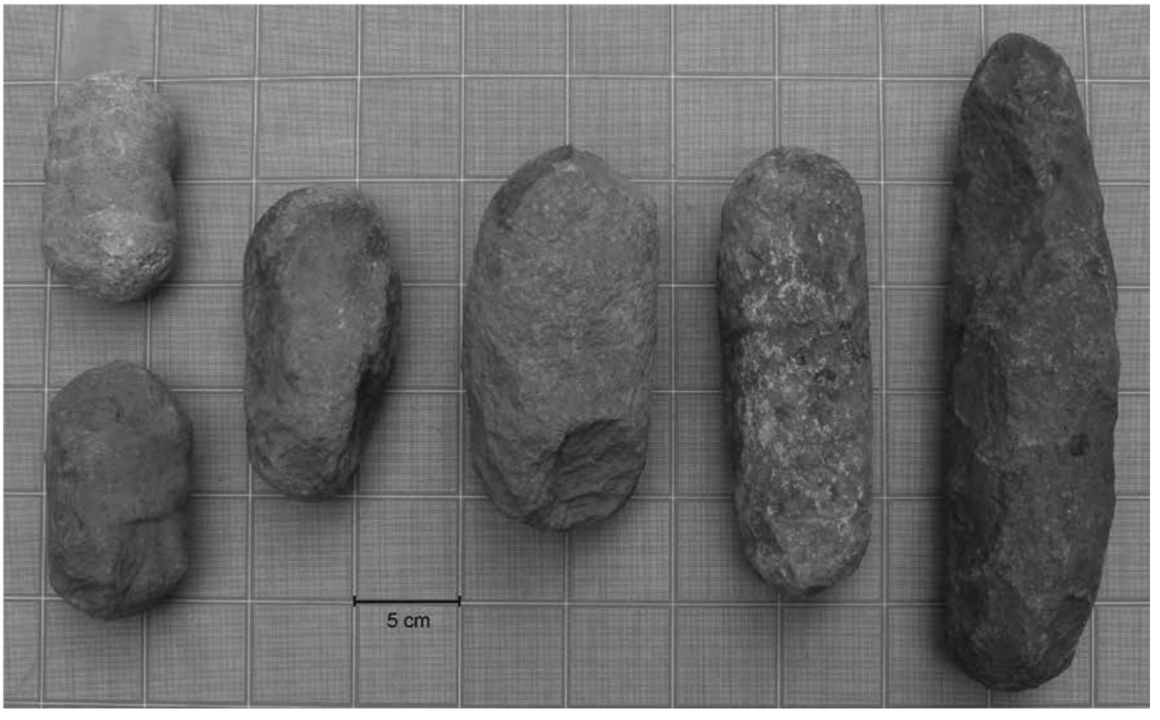


**Figure 12.** Cylindrical hammerstones from the Sierra de las Navajas obsidian mines.

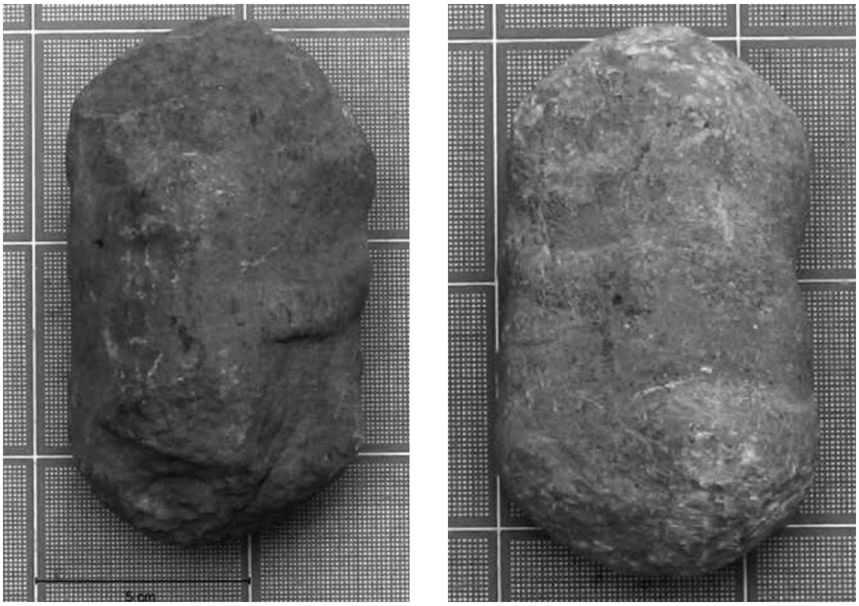

**Figure 13.** Cylindrical hammerstone from Sierra de las Navajas showing evidence of multiple use.

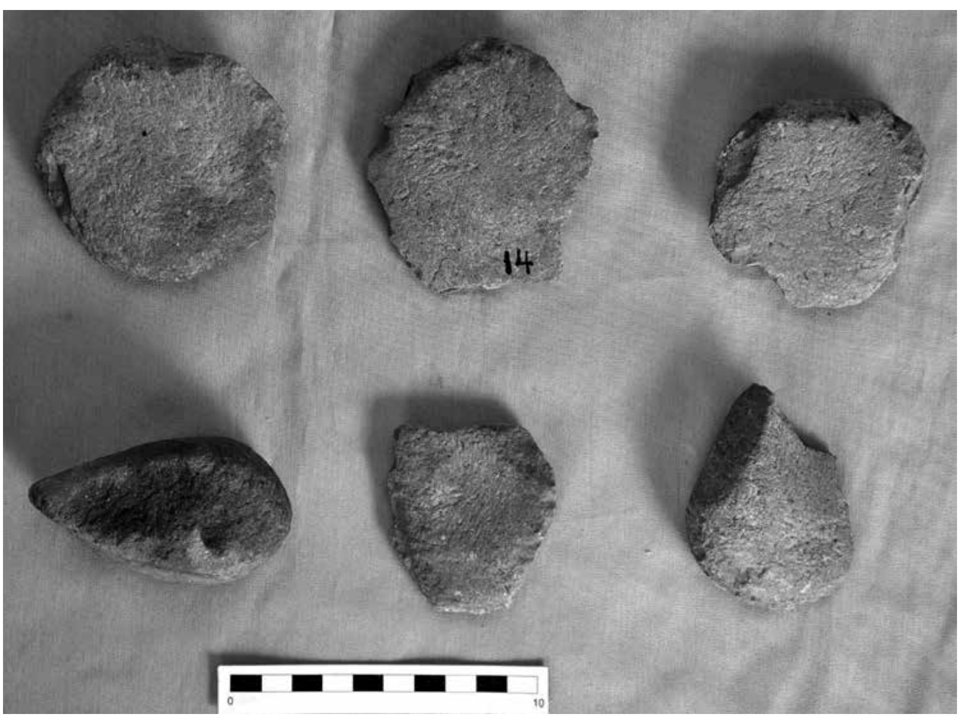

**Figure 14.** Small abrading stones from Sierra de las Navajas. Some are broken hammerstones or large flakes broken from rhyolite hammerstones.

been made at this source. As evident on the cylindrical hammerstone pictured in Figure 15, the battering on the larger rounded end extends about 4-5 cm up the shaft and is symmetrical all around the shaft. There are no facets confined to the very end of the tool. The extensive yet homogeneous wear is unusual for hammerstones and may be evidence the hammerstone was used with a baton-like motion instead of being held immobile, with all of the needed movement for guiding the tool coming from the hand, wrist, and elbow. The wear is neither confined to the end, edges, or broad faces of the tool, options discussed above for hammerstones.

## El Cerrito Hammerstones

Figures 16, 17, and 18 are more group shots of hammerstones of entirely different character than those

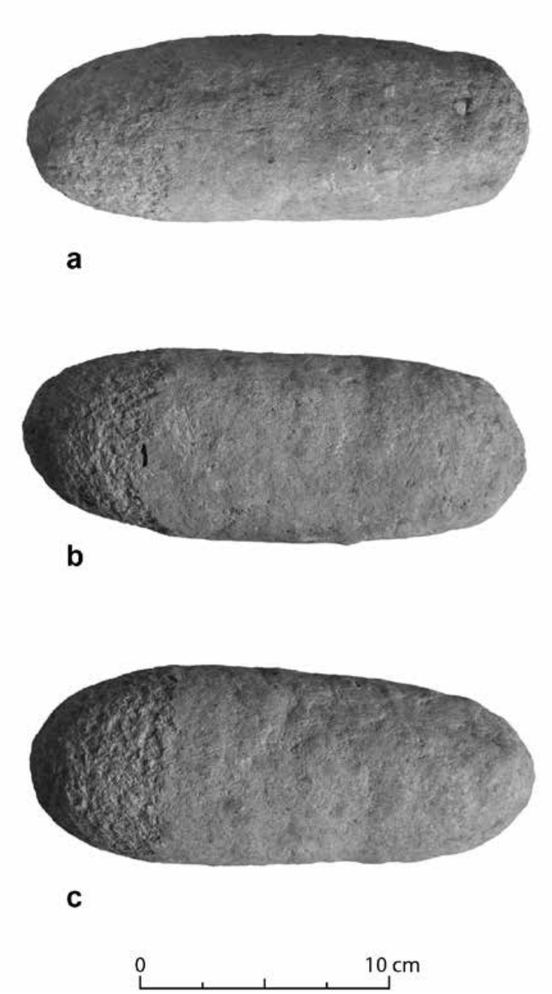


**Figure 15.** Three views of a cylindrical hammerstone from Sierra de las Navajas showing the knapping wear at the wide end of the hammerstone.

shown in Figure 11, and from a site about as different from the Sierra obsidian mines as can be. Most of the Sierra hammerstones are of relatively soft and light stones that have slightly grainy textures or tooth appropriate for working obsidian. In contrast, the hammerstones shown in Figures 16-18 are all hard hammers of quartz, quartzite, or chert. Some were used for processing river cobbles of quartz, quartzite, or very hard sandstone, or more angular nodules of chert (Figs. 16, 17). These hammerstones were used in direct percussion and bipolar percussion to break flakes from hard stones. Some of them were used long enough to develop facets and bevels indicative of handedness, such as the keeled hammerstones shown in Figure 17. In contrast, the hammerstones pictured in Figure 18 were for shaping limestone for building stones rather than for knapping. These hammerstones had sharp edges or points for cutting stone rather than for breaking it. Some of the flakes and chunks broken from river cobbles at El Cerrito were also used as small pics for shaping stones, a task which blunted their sharp points. Figures 10 through 12 show a range of sizes and forms of hammerstones, many of which could be confused, from the photographs alone, with those from Sierra de las Navajas. But these tools on actual examination should never be confused. The El Cerrito tools are of an entirely different character and type of stone and served different purposes.

El Cerrito is a small Maya site in central Chiapas that dates to the Protoclassic period (ca. 100 BC to AD 100) (see Bryant and Clark 1983). It is barely over a hectare in size and consists of three small mounds atop a small mesa. Obsidian is scarce at the site, and it was imported as ready-made fine blades from the El Chayal source in Guatemala (Clark and Lee 2007). Basic cutting tools were made of local chert, or of quartz or quartzite flakes broken from river cobbles. Clark found over 150 hammerstones in his brief survey and test excavations at this site. His typology of these hammerstones, devised in 1980, focused on the primary distinction advocated here between knapping hammerstones and sculpting hammerstones. The most common hammerstones were unmodified river cobbles used to break other cobbles. Hammerstones used to shape stone were sharp-edged tools: choppers, pics, and expended flake cores of chert or quartzite. Expended cores turned into hammerstones were blocky and had flake scars on most faces. These flake ridges became blunted and rounded when the cores were used as cutting hammerstones, until some of these blocky cores eventually became cubic or spherical in shape, with multiple flat facets from using these hammers to dress other stones (Fig. 8).

Detailed descriptions of the 12 types of hammerstones will be presented in the final monograph. In his 1980 study, Clark called the hammerstones used to sculpt and cut other stones *desgaste* ("wear away") hammerstones – meaning they were meant to peck or pulverize away small portions of stone work pieces instead of fracture the stone. No English term quite captures the notion that these lacerating hammerstones were meant to peck, pulverize, and wear-away the surfaces of the stones being shaped and sculpted. It is important to stress that the distinctions among different kinds of hammerstones begin to disappear with extensive use, and all hammerstone begin to converge on a single type of faceted or spherical hammerstone. The sharp ridges, edges, or points of *desgaste* hammers get beaten down with use until they cease to have any semblance of a cutting edge. Where there was once a sharp edge a broad, flat facet can develop, such as those seen on knapping hammerstones (Fig. 16). Really flat surfaces are very useful for dressing groundstone tools but not for preliminary pecking. To summarize, a hammerstone may begin its career

**Figure 16.** El Cerrito knapping hammerstones.

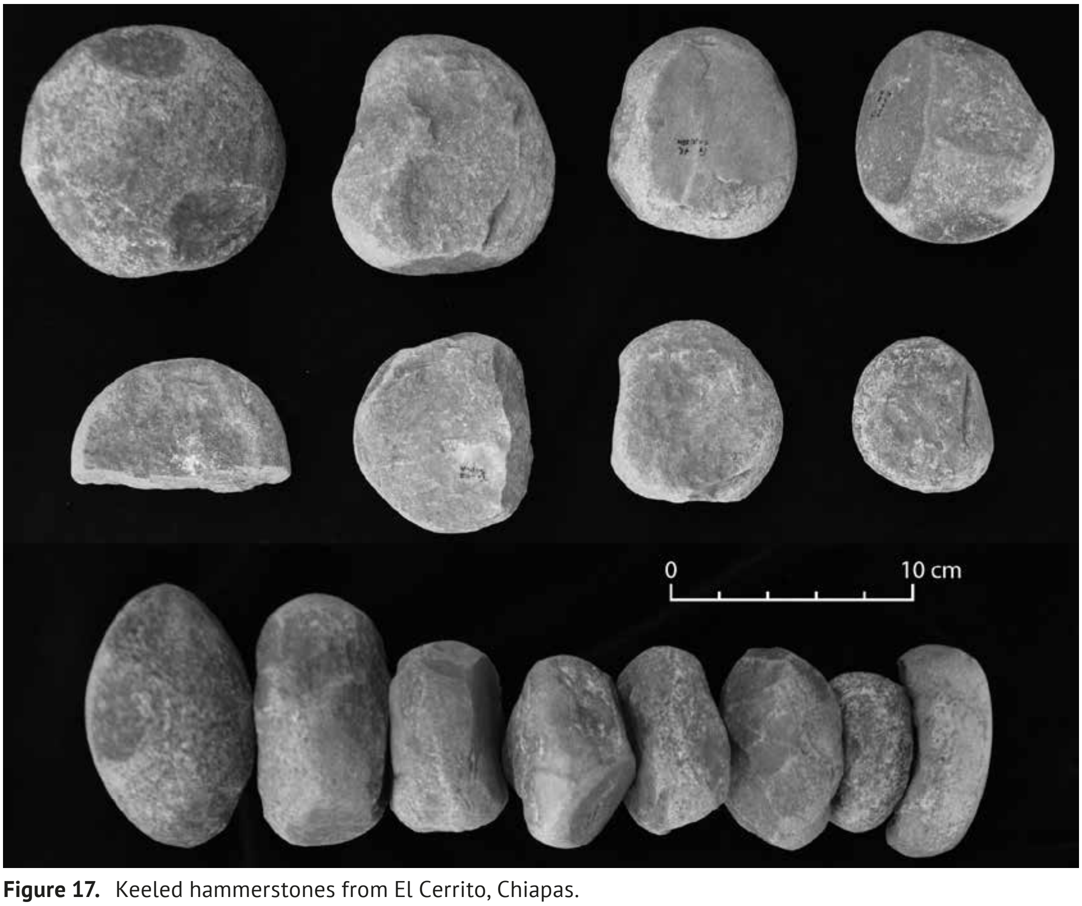


**Figure 17.** Keeled hammerstones from El Cerrito, Chiapas.

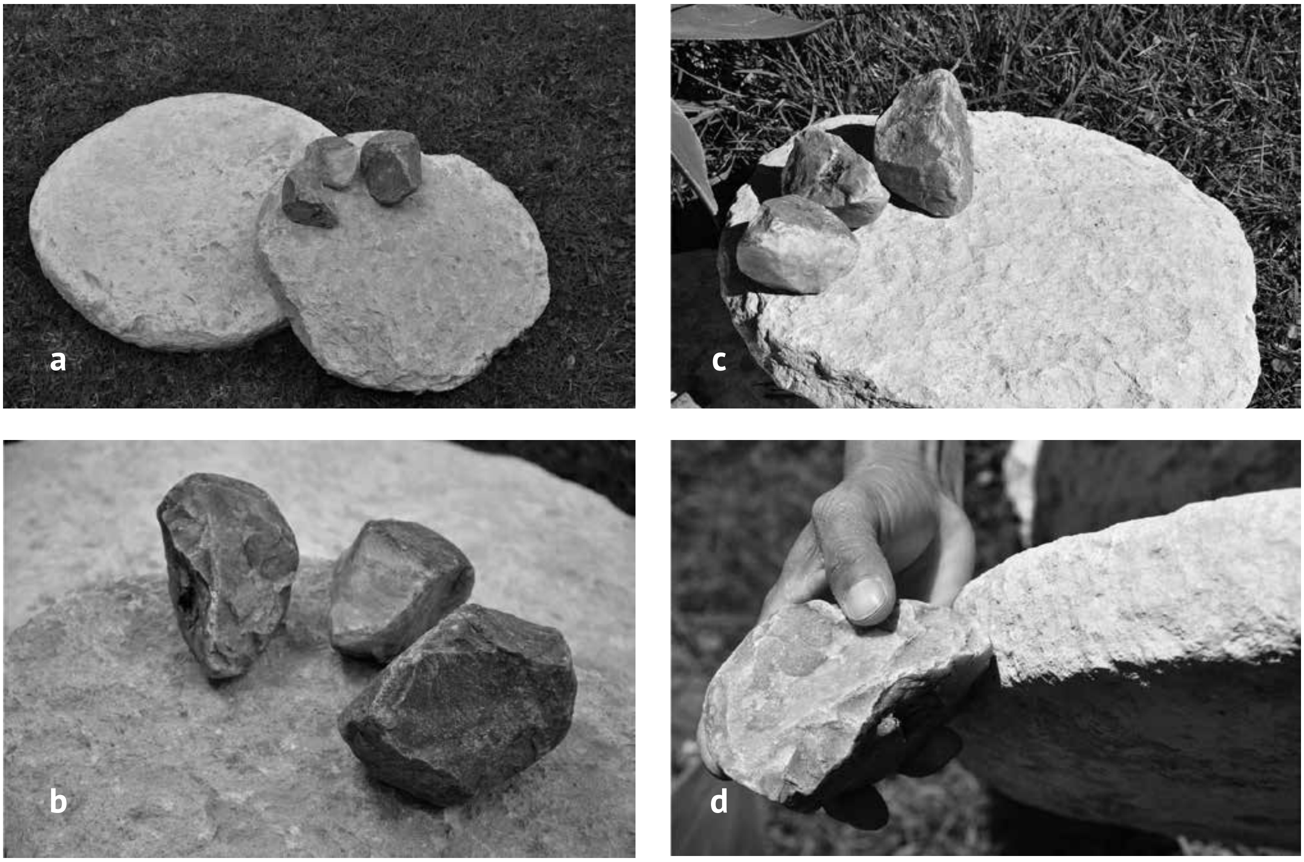


**Figure 18.** El Cerrito desgaste hammerstones. a. hammerstones on two limestone disks used as chultun lids b., close-ups of hammerstones, c-d. close-ups showing the texture of the worked limestone disks.

as one type and through use be transformed into a different type. For El Cerrito tools, a distinction was made between hammers with sharp points, like pics, versus those with longer cutting edges, like choppers. These tools were used in slightly different ways, thus the distinction between kinds of desgaste hammers. Choppers and pics tend to have acute-angle edges, and expended cores used as hammers have more obtuse-angled edges.

## Chiapa de Corzo Hammerstones

The most extensive published study of Mesoamerican hammerstones for an agricultural community, of which we are aware, is Arnoldo González and Marta Cueva's (1998) analysis of river cobble tools from Chiapa de Corzo, one of the major Preclassic and Classic ceremonial centers of the state of Chiapas, Mexico. The site is located on the outskirts of the modern city of the same name. The artifacts of interest here came from two salvage operations of mounds dating to the Protoclassic period and were the topic of González and Cueva's co-authored Master's thesis in 1990. The mounds were contemporaneous with the site of El Cerrito located upriver, and the lithic industry and hammerstones were also similar to those illustrated from El Cerrito, although these authors had no way of knowing this fact since the El Cerrito study remains unpublished. The Chiapa de Corzo and El Cerrito studies were completely independent of each other.

The Chiapa de Corzo study is of special interest because it derives from a different analytical perspective than advocated here but comes to similar conclusions. González and Cuevas focus on the lithic industry of making useable flakes from river cobbles available on the terraces of the Grijalva River located within a kilometer of the site. The initial study was done with Pedro Guzzy, an archaeologist with special interest and talents in pre-ceramic periods (see Guzzy and González 1988). González and Cuevas accord special attention to hammerstones. Of particular merit in their study are the detailed illustrations and descriptions of these hammerstones, showing them from four views and indicating the locations of various kinds of wear. The 56 hammerstones of their study are divided into three broad classes based on weight and size since these characteristics dictated how these tools could have been held in the hand, or hands, and used. Thirteen varieties of hammerstones are identified based upon the types of wear on tools in each size class (González and Cuevas 1998:129, 146). These varieties correspond to some of our distinctions of shape. What we describe as cylindrical hammers used at both ends they describe as "double" hammers (used at two ends). Their category of "circular" hammerstones with continuous used edges corresponds to our discoidal hammerstone type.

González and Cuevas took inspiration from Hayden's (1987) study of the metate-maker in highland Guatemala, and they describe most of the Chiapa de Corzo hammerstones as having been used to process limestone for building construction. We concur with this assessment. We differ on a number of minor points worth mentioning. These authors describe hammerstones used for knapping versus those for sculpting, but they do not make this a categorical distinction in their classification. Many artifacts which look like broken hammerstones or flakes broken from hammerstones they classify as intentional products broken from cobbles, and they describe these severed cobbles as a different technique.[18] They do not distinguish among the rock types worked or the stones for working them. Most of the artifacts they illustrate with photographs rather than line drawings appear to be quartzite, so these were hard hammers used to work similarly hard stone.[19] Their hammerstones and the flakes and chunks broken from cobbles are similar to those from El Cerrito. González and Cuevas (1998:58) mention limited experimentation to check some of their ideas, but they are not experienced knappers and did not view these tools from a perspective of familiarity. Many illustrations in their publication showing tactics for breaking cobbles into various kinds of flakes depict hammerstone holding-positions and work angles that seem highly unlikely to impossible, but overall their study is a major advance meriting greater notice. A principal goal was to bring to scholarly attention a lithic industry and tools that archaeologists at the site had been throwing away through sheer ignorance of not recognizing these ugly chunks of bruised rock as significant artifacts.

18 González and Cuevas describe five different techniques for breaking rounded cobbles, but they really refer to knapping tactics rather than techniques per se (see also Guzzy and González 1988). The principal technique was direct percussion, and they allude to bipolar percussion and core-on-block technique, but they confuse technique (as the means of applying force to the stones being worked) for different kinds of breaks given to cobbles.

19 They claim in their text that most of these hammerstones were "granite" (González and Cuevas 1998:53), but this appears to be a misidentification meriting independent verification. Granite is extremely rare at Chiapa de Corzo and is not part of the local geology or river gravels. Such stones would make poor hammerstones for working quartzite river cobbles and even poorer tools for shaping limestone building blocks. In the earlier text, Guzzy and González (1988:31, 32) report that 85 percent of the raw material was quartzite.

**Cantón Corralito Hammerstones**

We report here some observations of a study in progress because they represent an analytical problem many analysts will confront. Cantón Corralito is an Early Formative Olmec site located on the southern coast of Chiapas (Cheetham 2006, 2009, 2010). This coastal plain proper is devoid of stone of any kind, so the only rocks available are those the rivers carry down from the adjacent Sierra Madre Mountains. River cobbles near the site are predominately andesite and related volcanic stones, with a few small cobbles of metamorphic greenstone. Cantón Corralito was located near the Coatan River, and so inhabitants of the site had ready access to rounded river cobbles of a wide range of sizes. In the excavations, all stone cobbles and pebbles were saved, amounting to about half a ton of stone for one season of excavation. The analytical difficulty was to sort river cobbles used as tools from those that were not. All of the stones in question had been carried at least a few hundred meters into the site and into a cultural context, but in what capacity must be determined through analysis of clear traces of human use. Many cobbles were used in cooking, as evident in various kinds of thermal alteration and fracture. Others were used for minor grinding tasks, and many were used for pounding or hammering.

All cobbles show some battering, but this is a natural condition of being river cobbles. In sorting hammerstones from "unused" cobbles a baseline of what river cobbles look like in their natural state had first to be established. Battering and bruising beyond this "natural" baseline was taken as evidence that the stone had been used as a hammer or a pounder. Stones used extensively are obvious, but those with little use are not. As knappers, we have reserves of stones we have picked up for possible future use as hammerstones, but we never get around to using most of them. Many of the cobbles found at Cantón Corralito could fall into the category of "future tools." The archaeological context, however, was not specific enough to allow for the identification of unused cobbles selected for future use. For analytical consistency, we limited identifications of hammerstones to cobbles showing some clear signs of use. Had such cobbles been found in a cluster on a house floor or in a feature, we would have treated them as stones selected for use. For cobbles in undifferentiated midden, we could not make this identification. This is to make the point that archaeological context is as important as the geological context for identifying some "natural" stone tools. Many of the cobbles from Cantón Corralito could have been used to pound soft materials. Such usage would only leave obvious wear if another stone were used as an anvil or working surface. Many fragments of stone mortars and bowls of local andesite were found. Many of the battered greenstone hammerstones could have been used to manufacture these groundstone objects, a possibility verified through experimentation with these materials (Figure 19).

### General Considerations in Classification

Space limitations preclude presenting detailed classifications of hammerstones from any of the four cases mentioned or of a comprehensive system in general. Our main objective in drawing attention to disparate examples is to show some possibilities of classification and that such exercises need to be case specific and take particular heed of geological and archaeological contexts. We do not advocate a single, universal typology, but many – based on significant differences. Any classification system or taxonomy distinguishes different levels of division in a prescribed technological order, such as family, genus, and species. Higher order categories entail lower order ones. These levels of taxonomy may also represent a decision tree or analytical protocol for classifying archaeological specimens. The following list is our recommended protocol and hierarchy for devising a useful classification of hammerstones. Imagine you have excavated a riverside archaeological site such as Cantón Corralito and have to sort all the river cobbles and rock chips to find the tools. Some rational system is needed to sort the material.

I. Separate stone from non-stone artifacts.
II. Separate chipped or fractured stone from non-fractured stone. (This is all ready a tricky and dubious distinction because some cobbles are broken but this could be from use rather than from having been used as cores to produce flakes. Broken cobbles are considered natural tools rather than chipped artifacts.)
III. Separate natural stones (unmodified and broken cobbles) from groundstone artifacts.
IV. For natural stone tools distinguish those used for pounding from the rest.
V. Separate hammerstones used for working stone from cobbles with other kinds of pounding. This includes separating ephemeral tools from curated tools (those showing significant use and/or maintenance).
VI. Separate different classes of hammerstones.
    A. Pecking hammers.
    B. Chipping hammers.
    C. Battering/dressing hammers.
VII. Subdivide each class of hammerstone by type of raw material (inherent in this distinction are the properties of stone density, hardness, tenacity, and texture).

**Figure 19.** John Clark making a stone bowl from an andesite cobble with a hammerstone of metamorphic greenstone (ca. 1993). Both stones were taken from the Coatan River of the Mazatan region of the Chiapas, Mexico, coast.

VIII. Further divide each of the raw material hammerstone types by size (includes mass and weight) and form (these can be categorical forms; for chipping hammers we have egg-shaped, ovate, discoidal, spherical, etc.).

There are inconsistencies with this scheme, and there will be some for any alternative order of distinguishing traits. The foregoing scheme differs significantly from those generally followed for analyzing chipped stone in which forms are arranged by technology, with the functions or uses of tools being the lowest-order distinction, and one that cross-cuts most technological types. Here we recommend that functional considerations (meaning different ways of using the hammers) precede even identifications of raw material. If we are right, separating hammerstones in this manner will also sort raw materials since hammers of different hardness would have been for different tasks. Our scheme smooths over some logical inconsistences, starting with the second separation of chipped from non-chipped stone. Some of the hammerstones at Sierra de las Navajas, for example, were also chipped and pecked into the preliminary shapes at the start. Moreover, many pecking hammers or pics have chipped cutting edges and technically can be considered chipped stone tools. Other angular cobbles were used as pics, however, without any initial chipping. Since the two types were used for the same purpose, we think they ought to be the same type. Consequently, we tolerate some logical inconsistencies in the taxonomy in grouping pecking hammers with chipped bits with the rest of the pecking hammers that served the same function. Strict logical consistency is not always possible from a functional point of view, so we privilege overall tool use in sorting artifacts into classes and types we think are analytically helpful. As noted, some hammerstones break, and flakes spall off of others during use. A flake removed from a hammerstone does not make it a chipped stone tool, only a natural tool with a specific kind of damage. What is critical here is inferred ancient intent.

The foregoing generic scheme leaves ample room for innovation and for different degrees of specificity. For example, identifications of rock types can be a rather generic, such as granite and flint, or precise mineralogical identifications that specify bulk and trace chemicals and crystal types, sizes, and frequencies of intrusive igneous rocks. Analytical needs and analyst ability should dictate the specificity of raw material identifications. Sizes and shapes can be simplified to general classes, such as one-handed versus two-handed pics. Shapes of knapping hammers should differ significantly from those of hammerstone pics, so morphological subdivisions for each class or type of hammerstone can and should probably privilege different form criteria. As mentioned, once pics loose their edge and become completely blunted or flattened, they can move from being pics to become battering or dressing hammers. They could also be used for some knapping and thereby move from one category to another. Other transformations are possible. For example, expended sandstone hammers may gain a second life by being used as abraders. Some broken rhyolite hammerstones, or large flakes from them, at Sierra de las Navajas were used as small abrading stones (see Figure 14). Our recommended categories refer to major use or intended function, but descriptions of actual archaeological specimens should record all use wear and functions apart from their categorical identification, even secondary or tertiary uses.

The proposed scheme will lead to some counterintuitive results in analysis. Imagine three hammerstones each 8 cm in diameter and spherical in shape, each with fine battering marks covering its entire surface. In terms of form, size, and use-wear they appear like triplets, and most analysts would drop them into the same category. But if one is jade, another flint, and another hard sandstone, we would put them into three different classes and types because they surely were used for different purposes, based on differences in hardness, density, toughness, and texture. Consider an alternative scenario, three stones of quartzite of moderately different sizes and shapes. As with the example described by Schick and Toth (see above), all three could be the same functional type and represent three different states in the normal use life of this kind of tool (se Figure 8). Of course, the general size should be about the same (fits in one hand), but the precise size would not. Grouping like hammerstones by function requires that analysts understand how hammerstones can change shapes and sizes from use. We think grouping hammerstones together according to the life-cycle principle is important.

As noted, pecking hammers can transform into battering hammers and/or dressing hammers. The distinctions among them will be evident in their specific wear patterns. The major distinction in the sequence is when a hammerstone ceases to be a cutting or indenting tool and develops a flattish surface that can only pulverize sections of a workpiece rather than gouge them out. Consider a specific example; an expended blocky core of flint has numerous ridges on all faces from removed flakes. All faces of the expended core can be used to peck another workpiece, even one of chert. Impacts from use pulverize the ridges and eventually extend into the troughs of the original flake scars. With continued use the hammer can become spherical and battered all over (see Figures 8 and 17). Pecking hammerstones that lose their "noses," points, or cutting ridges transform into battering hammers. In most circumstances, grouping "dressing" hammers with battering hammers will probably do. In our experience, the working surfaces of battering hammers mirror those of their work pieces. For instance, preliminary battering leaves a pocked surface on both the workpiece and hammer due to hard blows. Finishing work with a dressing hammer requires lighter blows that remove the pocked surfaces and make a smooth, continuous, but still rough surface.

General shapes of chipping or knapping hammers relate to their working surfaces. Knapping manuals describe them as egg-shaped or oval cobbles, meaning one-ended versus two- ended hammerstones. These can develop facets indicative of handedness, depending on how they are used. Flattish cobbles can be used on all prominent edges, and with consistent use they can become discoidal, or a discoidal stone can be chosen to begin with. A discoidal hammer has advantages over one-end or two-end hammers since any part of its perimeter can be used. Once the peaked edges of discoidal hammers become too flat and wide from ablation, they may have to be discarded or used in a different way (e.g., as edge-ground hammerstones). Spheroid hammerstones have even greater range than discoidal hammers because all of their surfaces are equally useable. If a knapper rotates the hammer properly it maintains its spherical shape throughout its use-life.[20] Through time the spherical hammer becomes smaller, so its utility may shift through time towards finer work. Discoidal and spherical hammerstones can be used in such a manner that they retain their shapes; these are shapes that allow them to be used with either hand. As mentioned, even a hard hammerstone battered into a spherical shape can be used to do soft hammer work, so some hard hammers could move out of their original category. We think ancient knappers were practical about this sort of thing. Tool use was not an essential property of a hammerstone but a cultural decision.

The shapes of pecking tools differ from those of other hammerstones. The chopper form of sharpened hammerstones preserves a natural grip on the unmodified end and builds in an active edge on the opposing edge. Consequently, these are generally one-edge tools. Natural cobbles selected for their natural pick-like form may be more angular and present greater challenges for holding in pecking work. As described for the early experiments of Havlor Skavlem, chert flakes and other hard stone flakes also make excellent pecking tools. Unlike hammerstones, these clearly relate to chipped stone industries, with pecking their specific and final function.

20 There are several good examples of these in Crabtree's hammerstones in the collection of his knapping equipment at the Herrett Museum

The main message of our article is that hammerstones of different functions have different properties, so a useful classification should get at general and specific functions. A corollary is that a serviceable typology need not decide all of these matters. For instance, in lieu of a final typology based on known function one could classify stone hammers according to signal attributes known or suspected to be significant, beginning with raw material type, which includes hardness, density, toughness, and texture. Use-traces relating to function are a higher level category, as argued, but at any level of analysis once each tool is categorized its critical attributes merit thorough description, such as provided by González and Cuevas for the Chiapa de Corzo hammerstones. As noted, hammerstones are morphologically dynamic; they change shapes and are reduced in size as a consequence of use. Their one constant is the raw material they are made of. Hence, definitions of hammerstone types should consider them within a range of shapes and weights and different degrees of wear.

A good classification does not obviate good descriptions of individual artifacts. At some sites, the number of hammerstones recovered and identified may be too few to merit a typology. Thick description of these stones would suffice. We recommend that analysts begin by trying to hold the stones in their hands to see how they fit, or don't fit. Good analysis of hammerstones should be hands-on work. "A careful examination of any stone tool will readily show the method pursued in fashioning it, and it will be found that it was ground, battered or chipped, or that there was a combination of these processes for the same implement. The striae produced by grinding often indicate the method of work" (M'Guire 1893:310).

## Concluding Remarks

Our thesis is that hammerstones are among the most under-valued and under-studied tools in prehistory, at least those associated with sedentary societies. With the exception of a few stellar studies from the end of the nineteenth century, the best information on hammerstones is tucked away in accounts of knapping experiments and in flintknapping and crafting handbooks. By any measure, the inattention accorded hammerstones is incommensurate with their past importance. All kinds of tools today serve functions anciently fulfilled by stone hammers. Hammerstones appear archaeologically ubiquitous but remain analytically invisible. To check this possible bias, Clark spent two days in the National Museum of Anthropology in Mexico City looking for hammers and hammerstones in the displays. Most visitors only see the archaeological exhibits on the main floor and not the ethnographic displays on the second floor dedicated to the descendants of the peoples whose archaeology is displayed on the main floor. Clark expected to find hammers in most ethnographic exhibits and fewer in the archaeology displays, but this was not the case.

No hammers are displayed in over 3000 square meters of the ethnographic displays, and only two claw hammerheads appear as inventory in a representation of an indigenous store. The distribution of hammerstones in the archaeology halls was barely better. Three dioramas in the early man hall represent men chipping tools, and a running video shows a modern knapping demonstration, but no stone hammers are exhibited among the showcased stone tools. One supposed knapping hammerstone (no label) is shown in an early village display for the village of Tlatilco and two possible hammerstones (no label) are grouped with some shells in the Aztec hall, the implications being that the shells were worked by percussion into forms to export to Mexico City. It was not until the museum's final display, and in a dark corner, that Clark found multiple hammerstones and pics (no labels) displayed as such, related to turquoise mining in Western Mexico. In sum, on both floors of this massive museum, the few hammers relate to themes of specialized production and trade, and only one stone may relate to common domestic activity. For perspective, more than half the archaeological objects in the museum were fashioned, or partly so, with hammerstones, yet these are nowhere apparent, even in displays crying for them. Admittedly, aesthetically arranged hammerstones are unlikely to draw thousands of tourists or foreign dignitaries to the museum, but many a display would be better with a hammerstone to nudge the narrative. The National Museum was deemed particularly apropos for checking for hammerstone bias because Marxist theory impacted the creation of many of the displays. With its theoretical emphasis on the means, forces, and social relations of production surely ordinary, essential tools such as hammerstones would be included. Not so. Prehistoric antecedents of the hammer and sickle are nowhere to be seen. We think much of the bias against these tools comes from the mistaken idea they all served the same purpose. Our brief review of early archaeological hammerstone studies and more recent experiments shows this presumption cannot possibly be true.

Given the current state of affairs, the important question is what ought to be done now. Unless and until archaeologists come to believe that hammerstones have analytical value it is unlikely that things will change. Our overview attempts to demonstrate that hammerstones are of many different sorts and fulfilled myriad needs. A next step will be to describe and illustrate in detail different classes, kinds, and types of hammerstones from a range of archaeological sites, with an end in mind of determining their specific uses and functions. We know from having examined many archaeological and modern hammerstones that some were used in multiple ways for a range of tasks. Other hammerstones were parts of series related to the staged reduction of stones for the production of tools. The most famous is the obsidian blade industry, with hammerstones ranging in size from 25 kilos to 200 grams (Fig. 11). Where each of these hammerstones fits in the reduction process has yet to be established.

Our recommendation is that hammerstones be analyzed for their properties and traces of human modification to establish their past use. Different kinds of stones perform more or less well for different tasks because of inherent properties of the tools and the materials processed. For instance, quartz crystals all over the world share the same structure, hardness, and flaking properties. Most stones such as granite, flint, obsidian, and jade, have consistent properties as well, although they are not as constant as properties of minerals. Essential properties of different kinds of stone provide known parameters for evaluating ancient artifacts.

Elements of human choice were also part of the mix. We aver that ancient artisans, when they had the time and options (i.e., were not behaving expediently or under duress), chose tools best suited for the tasks they wanted to perform. Expedient hammers offer special challenges, as described above, but for well-used hammers one can assume they were suitable for the tasks they were made to perform. One can further assume efficient use by persons with practiced skills within their cultural tradition. These are important postulates because they allow analysts to work backwards from effects to the probable causes. One starts with the used hammerstone recovered from an archaeological context and then proceeds to infer its function forensically by recording the hammer's general physical properties (raw material, size, shape, density, tenacity, texture, tooth) and human subtractions (bruising, crushing, polishing, breakage, placement of facets, angles of the facets, unmodified portions). How does the tool fit in a human hand? How can it be used? How was it used?

Other critical information for inferring function is contextual. This includes the archaeological context: what other artifacts go along with the hammerstone in terms of time and place? The broader cultural context is important, if information exists: what was the cultural "world" of the people involved? A more accessible context is the so-called physical world, in this case the lithic landscape. What rocks and stones were available to the people who used the hammerstones under study? These tools may not have been the best possible, but they probably were among the best available. This is a falsifiable proposition. An evaluation of lithic resources in light of modern knowledge of hammerstone use could show that the tools in question were not the best and/or were not used with much expertise or efficiency. This last point brings us back to where hammerstone studies began, in early nineteenth century Denmark with Sven Nilsson teaching himself how to duplicate ancient stone tools. Replication experiments and knapping experience will play a key role in identifying the parameters and stigmata for different kinds of hammerstones and their uses.

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