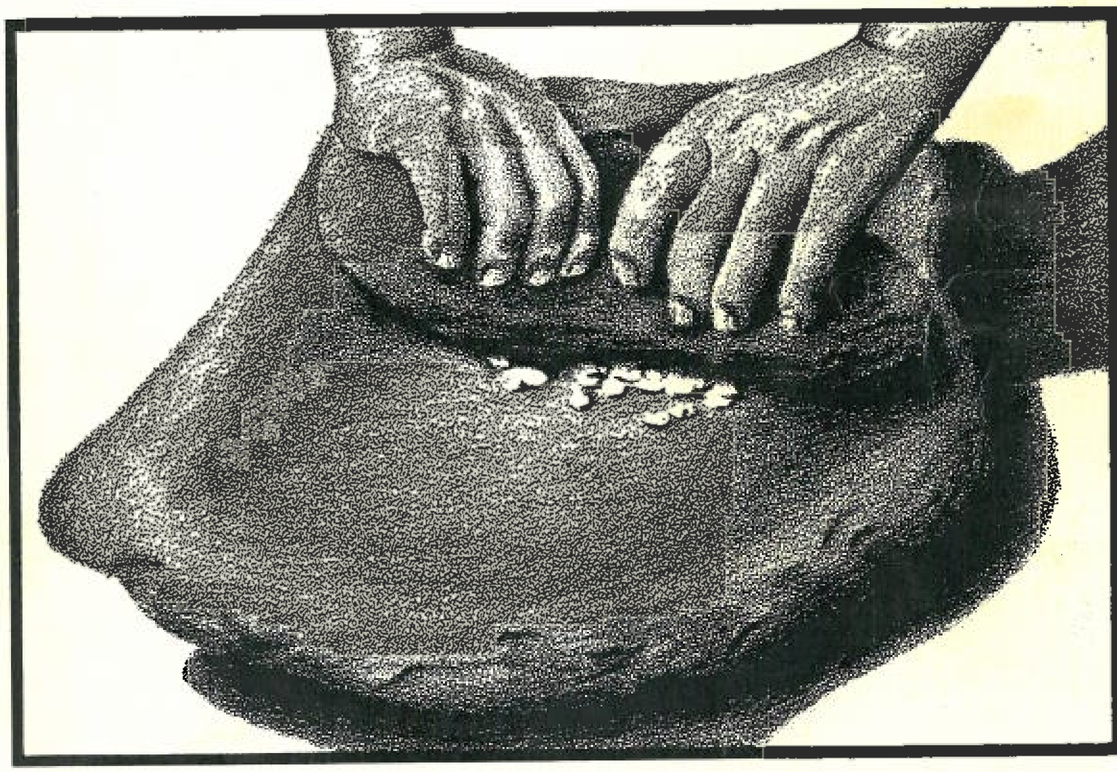
Manual for a Technological Approach to Ground Stone Analysis

By
Jenny
L.
Adams



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The front cover was designed and illustrated by Victor Serra, a student at The Art Center, Tucson, Arizona.

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A manual such as this is the creation of an army of people. Various versions of the manuscript were read by Sally Bird, Donna Breckenridge, Chip Colwell, Otehlia Kiser, Lisa Piper, and Arthur Vokes, and their comments are greatly appreciated. Several artists rendered the illustrations. Chip Colwell produced most of them with contributions by Lisa Armstrong, Ron Beckwith, R. Ciaccio, and Doug Gann. The cover was designed and produced by Victor Serra. Report production was directed by Donna Breckenridge–her editing skills greatly improved the quality of the text. Her crew, Elizabeth Black and Elizabeth Gray, spent endless hours creating forms, entering text, and laying out figures. Sally Bird helped me work out some kinks in the manuscript. I would also like to thank Bill Doelle and the Center for Desert Archaeology for making it possible to bring this manual to completion.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

MANUAL FOR A TECHNOLOGICAL APPROACH TO GROUND STONE ANALYSIS

Jenny L. Adams

INTRODUCTION

The purpose of a technological approach to ground stone analysis is to move beyond the usual form-function classification of artifacts to an assessment of how grinding technology was actually developed by prehistoric people. Ground stone artifacts have been used as hallmarks for vegetal food processing, but they were involved in many other activities as well.

How were ground stone artifacts used prehistorically? This question can be answered through ethnographic analogy and experimentation. *Ethnographic analogy* is most commonly accomplished through a literature search. Reports were written by some of the first non-Indians to live and work among native groups, when stone tools were more common than they are today. Their work makes it possible to consider how tools might have been used at different locations in a village; how some might not have been needed at every settlement type; how some might have been more commonly women's tools while others belonged to men; or how certain tools might have been used for more than one activity.

It is also possible to talk with people who either used or watched others use stone tools. For the southwestern United States, information from Puebloan groups, such as the Hopi or Zuni, and non-Puebloan groups, such as the Tohono O'odham, Walapai, Maricopa, and other Yuman tribes, is the most pertinent.

Experiments allow us to use the tools ourselves, so we can better understand the motor habits involved and the creation of use-wear patterns. Most of the experiments referred to in this manual were conducted by the author with the help of numerous University of Arizona graduate students and Earthwatch volunteers (Adams 1989a, 1989b). Other experiments were conducted to answer specific questions for the following projects: the Walpi Research Project (Museum of Northern Arizona); the Homol'ovi Research Program (Arizona State Museum); the Point of Pines Project (Arizona State Museum); the Roosevelt Community Development Project (Desert Archaeology); and the I-10 Improvement Project (Desert Archaeology).

RESEARCH QUESTIONS

By viewing ground stone artifacts as part of a larger technological system, we can discuss how prehistoric people solved specific problems with grinding technology. We can also assess how grinding technology changed to meet different needs, or as a result of contact with other people who had different technological solutions to the same problem. Thus, these general research questions can be considered:

How was grinding technology involved in obtaining and processing food?

What other aspects of prehistoric life involved grinding technology–pottery production, wood or bone tool manufacture, or production of ritual items?

Were the artifacts used for only one task, reused in another task, used for multiple tasks, or recycled completely out of their original use?

Does any part of the ground stone assemblage reflect an exchange of ideas or artifacts with other people?

GRINDING TECHNOLOGY

Grinding technology can be defined as the combination of knowledge, ideas, behavior, and equipment to solve the problems of altering surfaces or substances. This is done through the interaction of mechanical and chemical processes that occur when two surfaces come into contact (Adams 1995, 1994a, 1993b). Artifacts that are either altered by or used to alter other items through abrasion, polishing, or pecking are commonly referred to by archaeologists as "ground stone" artifacts. Included in this category are:

Artifacts used to reduce intermediate substances to a finer texture; for example, manos, metates, mortars, and pestles, which are used to process vegetal products, pigments, clays, and tempers.

Artifacts used to shape other artifacts, for example, abraders, polishing stones, and hammerstones.

Artifacts shaped by abrasion, polishing or pecking, for example, axes, pipes, figurines, personal ornaments, and architectural pieces.

Understanding technological processes begins with considering how an artifact was designed and manufactured; these are the first stages in the life-cycle of a tool. Decisions made at this stage generally begin by selecting lithic material for size, shape, and texture (Horsfall 1987:340). For example, a polishing stone is manufactured from a particularly smooth rock because a rough texture abrades rather than polishes. An understanding of grinding technology is not complete, however, without an assessment of the entire life history of an artifact, from design and manufacture, through use (including a use-wear analysis), to an assessment of the archaeological context in which the artifact was found.

Artifact Design and Manufacture

Material selection is the first step in artifact creation. For some tools, texture is an important aspect of material selection and tool design. Lithic material has a natural granularity that was exploited by prehistoric tool makers to either smooth or roughen the surfaces of other items, or to alter the texture of a substance worked between two stones. Identification of material granularity can be standardized by a chart with grain sizes marked as coarse, medium, and fine. Some material has a combination of grain sizes, and some material is smooth enough to categorize as having no texture. Vesicular material can be categorized by large, small, or a combination of vesicle sizes. (Vesicles are cavities in volcanic rock, left by bubbles of air or gas that escaped as the molten rock hardened.)

Natural granularity can also be changed through use and maintenance of tools. The surface of a tool made from a medium-grain material may become worn smooth. If the tool was designed to abrade, the smooth surface would have to be re-roughened. Similarly, the texture of a tool made from fine-grain material may be roughened by pecking the surface with a hammerstone. Thus, natural granularity may not tell us as much about the use of a ground stone artifact as does its altered surface texture.

Artifact design and manufacture can be assessed in terms of complexity (Adams 1995:45). If the natural shape of the rock was altered only through use, the artifact is considered to have an *expedient* design. Modifications, such as pecking, grinding, chipping, drilling, incising, or grooving, which made the tool easier to hold or achieved a specific shape, indicate a *strategic* design. Analyzing artifact design allows us to determine whether strategically designed tools were used or treated differently from those of expedient design. Were they stored in more protected locations, and were they subjected to more or less primary or secondary use than tools of expedient design?

Some artifacts went through the design stage but were never used. Those that never made it past the initial stages of manufacture are blanks that could have been turned into any number of artifact types. Unused artifacts are those that were manufactured with all the necessary attributes to be a specific tool but were never used.

Artifact Use

Artifact use can be evaluated in terms of primary and secondary uses (Adams 1995, 1994a). Primary use is the original or first use of an artifact. Although an artifact might have been designed or selected for a particular use, it also might have been applied to multiple activities. Secondary use describes how an artifact has been reused, redesigned, used in multiple activities, or recycled. The following use categories make reference to artifact types that are defined in the section beginning on page 10.

Single-use artifacts were selected or designed for a particular activity and were employed only in that activity. Examples include manos and metates, polishing stones, axes, and grooved abraders.

Reused artifacts were designed as single-purpose artifacts but were reused for another task without altering the design. Examples include manos and metates designed for food processing but reused to grind pigment or manos used secondarily as hide-processing stones. Reused artifacts can also include mundane objects that took on ritual significance as funerary or other ceremonial objects. The important attribute is that the tool configuration remained unaltered, and even though the artifact was employed in a second activity, it still could have been used in the first activity.

Multiple-use tools were selected or designed for one activity, but unlike reused artifacts, another area or surface on the tool was altered for use in a different activity. However, use in one activity still would not have inhibited the continued use of the stone in the other activity, even

Figure 1. Example of concomitant use tool. Abrader/polishing stone with grooves on one side and use as a polishing stone on the opposite side.

though the second slightly altered the configuration of the tool. Examples include manos with upper surfaces that served as lapstones or abraders, and pestles that were used for crushing on one end and grinding on another surface.

Reused artifacts and *multiple-use tools* are considered to be of *concomitant secondary use* (Adams 1995) (Figure 1). They could have been used in either the primary or secondary activity. The purpose of concomitant secondary use tools may have been to broaden the range of possible activities without increasing the number of tools, thereby conserving raw material or maintaining low numbers of stored objects. Perhaps the original designer and user reused or multiply used tools, not wanting to destroy their primary functions.

Redesigned tools were designed and used for one activity and then either remanufactured or altered through use in a second activity so that they could no longer be used for the first activity. Examples are trough metates with basins pecked into them, and manos reshaped through use as pestles or redesigned as hoes with notches for hafting.

Recycled tools were designed and used for one activity but ultimately were employed in a completely different context that may not have physically altered the tool. Examples include manos and metates employed as building stones or turned into cooking and heating stones. The important attribute is that they were no longer manipulated as tools.

Redesigned and recycled tools are considered to be of *sequential secondary use* (Adams 1995) (Figure 2). The original designer and user may not have been the same person as the user of the redesigned or recycled tools, who did not care to maintain their original functions.

Analyzing primary and secondary uses and whether artifacts were secondarily used concomitantly or sequentially allows us to assess the relationships between tool use and site occupation strategies. Are single-use tools more common to sites with limited or short-term occupations, and secondarily used tools more common to long-term occupations or sites repeatedly abandoned and reoccupied? Are single-use tools more often found in pits where access might have been restricted? Tool use may provide yet another line of evidence for understanding behaviors such as curation, storage, abandonment, and scavenging.

Wear

Evidence of how an artifact was designed, manufactured and used has thus far been described in the context of artifact type identification. The next question is: how much wear has an artifact received? Wear is the progressive loss of substance from the operating surface of a ground stone artifact as a result of relative motion between contacting surfaces (Adams 1993b:63, 1988:310; Czichos 1978:98; Szeri 1980:35; Teer and Arnell 1975:94).

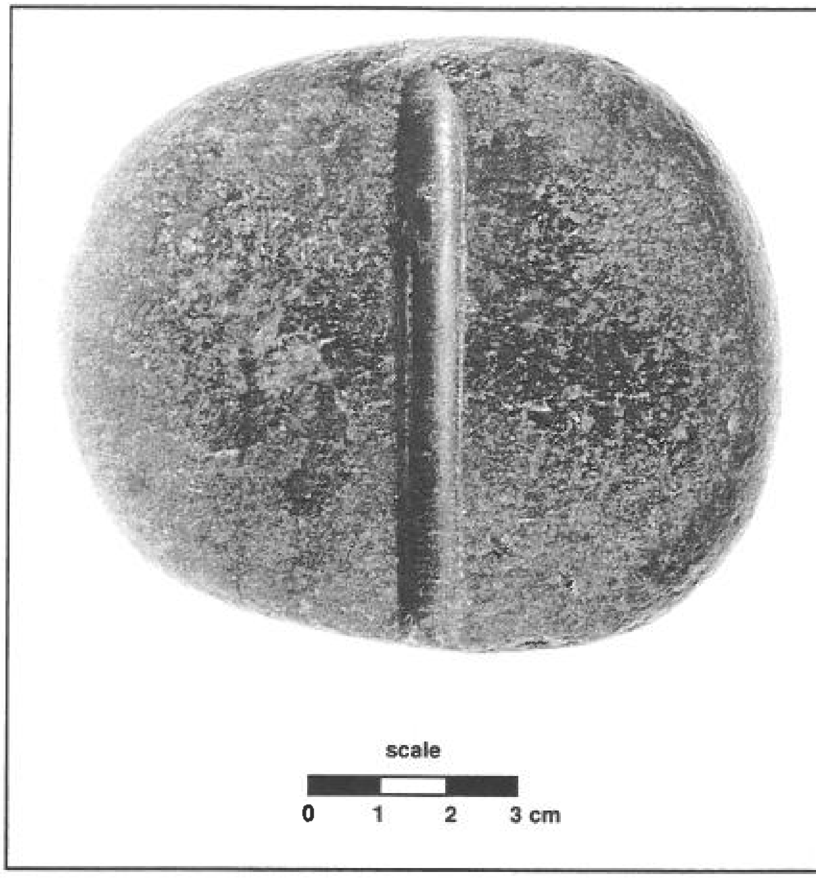

Figure 2. Example of a sequential use tool. Abrader/polishing stone with groove placed across the polishing surface.

The amount of damage created through wear is classifiable using a relative scheme. *Light wear* leaves so little evidence that it can barely be seen with the unaided eye. *Moderate wear* is enough to leave obvious damage but not alter the basic shape of the tool. *Heavy wear* changes the natural or manufactured shape of the tool. Some tools have been used so much that it is difficult to hold them for continued use, or the usable surface or edge is almost gone; these are *nearly worn out*. *Worn out* artifacts are no longer usable in the activity for which they were designed. *Unused* artifacts may have damage to their surfaces if, as part of the manufacture process, pecking or grinding was employed to create the surface, but there is no damage from use.

Wear can be assessed on the artifact level and on the surface level. If a tool was used in more than one activity, it might have been used moderately on more than one surface and has a whole be considered a heavily worn tool. Each separate surface can also be evaluated with these defined categories. Combined with this assessment of wear is an evaluation of whether a surface has been resharpened or reroughened. By recording this attribute separately from the amount of wear, it is possible to assess wear management.

Wear management is a strategy for maintaining the usefulness of a tool. For manos, this might include rotating the mano so that the wear is evenly distributed, keeping the surface flat so that

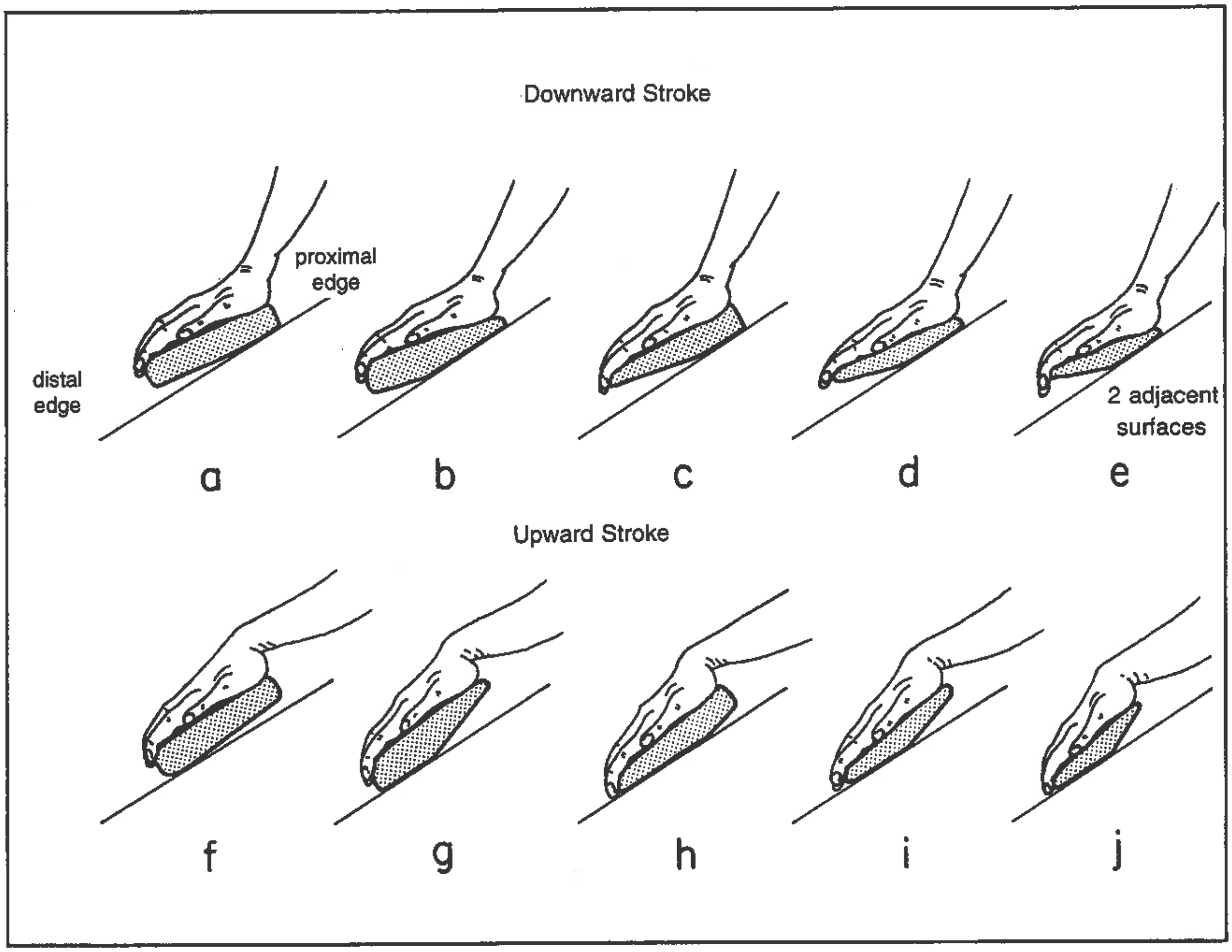

Figure 3. Schematic drawing of mano configuration created by pressure on the proximal edge during the downward part of the stroke, a-e. A lighter pressure on the distal edge during the upward part of the stroke brings the meal back to the top of the metate, f-j. Redrawn by Ron Beckwith, based on Bartlett (1933:Fig. 8) (Adams 1993b:335).

the largest possible area of the mano remains in contact with the metate (Adams 1993a:334-336; Bartlett 1933:15) (Figure 3). Another strategy might be to create more than one usable surface on the mano; these could be two opposing surfaces, or as the mano becomes heavily worn, two adjacent surfaces. This technique allows the grinder to keep grinding when one surface has become smooth until both surfaces become inoperably smooth and require resharpening to make them rough enough for efficient grinding. For axes, a wear-management strategy might incorporate chipping or grinding to resharpen a blunted bit edge.

Obviously, examining the amount of wear and the application of wear-management strategies could be helpful in making statements on prehistoric behavior. It might be useful to compare the amount of wear and the types of wear management at large and small sites. Sites with longer-term or more intense occupations might have a collection of artifacts with heavier amounts of wear and more attention to wear-management strategies than sites with shorter-term or special-use occupations. These techniques of wear evaluation can be enhanced by a use-wear analysis.

Use-Wear Analysis

Use-wear analysis is the examination of an artifact for macroscopic and microscopic evidence that allows us to understand how it was altered through use. For research on ground stone artifacts, four mechanisms are helpful in describing and understanding the formation of specific damage patterns: adhesive wear, abrasive wear, surface fatigue, and tribochemical wear (a combination of mechanical and chemical interaction). These are not mutually exclusive in how they change the surface of an artifact, nor is each the result of a single independent event. Rather, the four mechanisms interact, with one dominant over the others depending on the characteristics of the contacting surfaces and the nature of any substances between the surfaces (Adams 1988, 1989a, 1989b, 1994a, 1993b). These concepts have been developed for application to ground stone artifacts by building upon the research of tribologists who study friction, lubrication, and wear (Blau 1989; Czichos 1978; Dowson 1979; Kragelsky et al. 1982; Quinn 1971; Szeri 1980; Teer and Arnell 1975).

Many things can be discerned about damage patterns by simply looking at the surface of a ground stone tool without magnification. Striations, crushed grains, leveled areas, and sheen are all damage patterns visible macroscopically and are indications that surface wear has occurred. The location of these damage patterns is important to note for assessing contact situations. For example, if the topography of a stone's surface has a lot of elevational differences and the damage patterns are visible only on the highest elevations, the stone was probably in contact with another stone, or a very rigid surface. If the damage extends into the lower elevations as well, then the opposing surface must have been pliable enough to reach into these depths (Adams 1989a, 1989b). Wood or bone surfaces are pliable enough to contact the sides of grains and reach part way into the spaces between grains. Soft surfaces, such as hide, can reach into the deepest spaces.

These macroscopic observations also help us determine the motor habits of the manufacturer or manipulator of the artifact. The direction of abrasive striations indicates whether the artifact was used with a reciprocal (back and forth) stroke, a circular stroke, or a random stroke. The location of the damage patterns also indicates if the artifact was rocked or rotated during manufacture or use, as described further in the next section on motor habits.

To fully understand damage patterns, however, you must look at the surfaces under low magnification of 18 to 40 power. Under magnification, the surface of a ground stone tool has an entirely different topography, with grains in high relief and the interstices, or gaps between the grains, in low relief. Before judging the microtopography for evidence of damage, it is important to know what undamaged material looks like. An unworked area of the tool should be examined to determine the nature of the lithic material. Is it granular or vesicular? Are the grains angular or rounded? Do they have naturally occurring step fractures or a natural sheen? Are the vesicle margins rounded or sharp? What do the interstices or the insides of the vesicles look like? Once the nature of the stone is assessed, damage caused by contact with an opposing surface can be recognized.

A use-wear analysis is critical to understanding how an artifact actually was used, and it is the single, strongest argument against the model that function can be determined by form. For example, some hide-processing stones have the same shape as some manos, and only a use-wear analysis can distinguish the wear patterns created by stone-against-stone food grinding from those created by a hide rubbing against the stone surface. Misidentified hide-processing stones may lead to inappropriate assumptions about the presence of food-processing activities. The

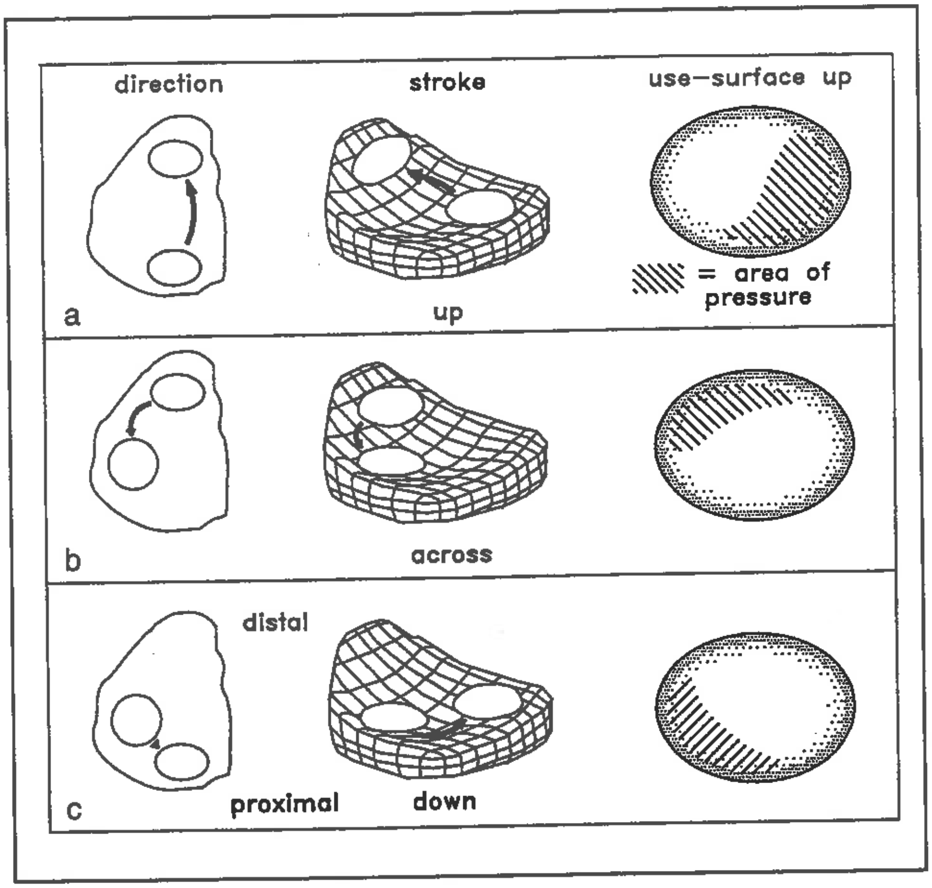

Figure 4. Schematic of how a mano moves in a circular stroke across a metate.

effects of a misidentified tool are multiplied when the presence or absence of food-processing tools at sites is used to build models of the distribution of agriculturally dependent people through time or across space. A good use-wear analysis can make a stronger argument than an analysis based on form alone for how specific ground stone tools were used.

Motor Habits

Motor habits are the movements or strokes required to operate specific tools. The nature and location of abrasive scratches, impact fractures, chips, and wear facets on tool surfaces provide information on the type of stroke used with each tool and thus reflect the motor habits involved in tool use. The direction of abrasive scratches indicates whether the stroke was a reciprocal, back-and-forth movement of the tool or a circular stroke, where the tool was rotated as it was used. The location of wear facets indicates where pressure was applied during the stroke.

For example, a mano used with a circular stroke has pressure exerted on varying spots as it is moved across the metate (Figure 4). The hand applies the greatest pressure under the palm, with the fingers lifting the mano as it is moved along the edge of the metate. This creates a wear facet on the mano along the proximal edge and on one end (the right or left end, depending on whether the stroke circulates right-to-left or left-to-right). The pressure is transferred from the palm to the fingers as the mano is dragged across the top of the metate and starts down the opposite side. Fingers do not exert as much pressure as the palm of the hand, so the wear facet along the distal edge and the other end is not as pronounced. As the mano moves toward the proximal end of the metate, pressure changes toward the thumb. Thus, the circular stroke can involve not only the broad surface of the tool but also the edges at various contact points if it is rocked on to the edges as it is moved around the metate.

It is possible to move a mano across a metate in a circular stroke without lifting the proximal or distal edges, thereby confining all the wear to the broad surface and not involving the edges

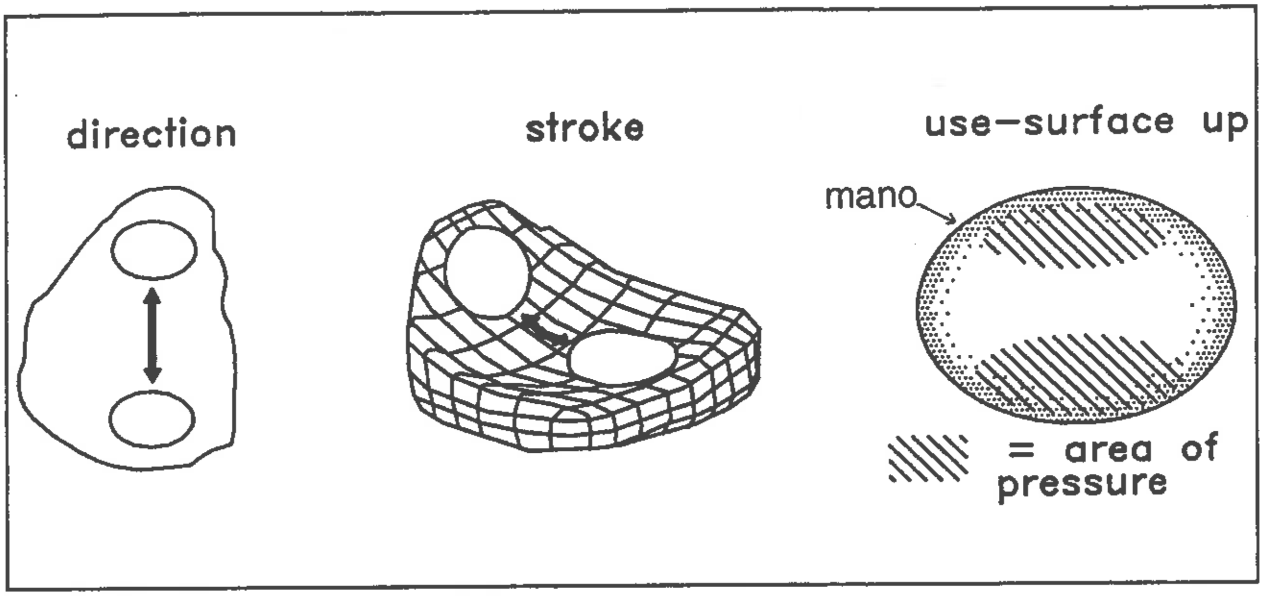

Figure 5. Schematic of how a mano moves in a reciprocal stroke across a metate.

at all. The lifting of the edges is called rocking, so it is possible to describe the stroke as circular with a rocking motion or circular with a flat motion.

A mano used with a reciprocal stroke moves back and forth across the metate surface with straight, back-and-forth movements (Figure 5). It too can be rocked so that the distal edge is lifted as the stroke moves away from the grinder and the proximal edge is lifted as the stroke returns toward the grinder. This rocking motion creates wear facets along the edges, with a larger facet along the proximal edge because of greater pressure exerted on the away or downward stoke. Reciprocal strokes can also be used without rocking so that the mano stays entirely in contact with the metate.

Impact fractures and chips are caused when one surface is brought into forceful contact with another, such as when a pestle is used with a mortar or a pecking stone is used to resharpen a metate surface. The more forceful the stroke, the larger the impact fractures and chips. When the weight of the stone alone is used to crush an intermediate substance, the impact fractures are uniformly shallow and uniformly distributed across the surface of the stone. A rotating or rocking of one surface against the other might further crush the intermediate substance and add abrasive scratches to the impact damage.

When more force is brought to the contact, either from the stone is being lifted higher or brought down with more muscle power, the impact fractures are deep and concentrated along the area of contact between the surfaces. Repeated forceful strokes cause the shape of the surface to change with the removal of chips and loose grains. For descriptive purposes, crushing is the stroke that uses the weight of the stone as the primary method for reducing the intermediate substance, and pounding describes an even more forceful stroke.

Other stroke categories, such as pecking and chopping, describe a combination of forceful, downward strokes and the configuration of the surfaces initiating the stroke. For example, pecking describes a stroke used with a tool that has a rounded or convex surface. Pecking alters the configuration of the contact surface by creating small impact fractures that may be difficult to discern from impact fractures made by a crushing stroke. Chopping describes the stroke used with tools that have sharp edges designed to break away pieces of the contacting surface. Such a stroke would be used with an axe for chopping trees, or with a tabular tool for chopping agave leaves.

Up to this point, individual artifact attributes have been described and classified, defining the various stages of design, manufacture, primary and secondary use, and wear. These clarify what happens to an artifact prior to its entrance into the archaeological record.

Archaeological Context

Where an artifact was found, or its archaeological context, must be considered when trying to determine how an artifact can be used as evidence of prehistoric behavior. Assessing context helps us understand whether artifacts were found where they were used or stored by the prehistoric occupants, were discarded as trash, or were left in a ritualistic fashion. Examples of important contexts are architecturally related structure fill (such as roof fall, wall fall, or floor fill), floor contact, interior pit, exterior pit, trash mound, and wall fall, among others. Information provided by excavators is important for determining archaeological context and whether features contained trash or possible de facto deposits. De facto deposits as used here were defined by Schiffer (1987:89) as " . . . tools . . . that although still usable (or reusable), are left behind when an activity area is abandoned." Those features with de facto ground stone deposits can be used to strengthen behavioral interpretations about the nature of prehistoric life at each site.

GROUND STONE ARTIFACT TYPES

Background

In his classic analysis of stone implements of northeastern Arizona, Woodbury (1954:12) discussed how he used classification and the concept of types to structure the data to address his specific concerns of temporal and cultural variation. He concluded, as did Brew (1946:44) before him, that the classification of assemblages into types should be done for specific purposes, so that different classification schemes are used for different projects. This attitude towards classification is lauded today (Adams and Adams 1991:157) and is used here to define ground stone artifact types. The specific purpose of the classification presented here is to emphasize the technologically important features of design, manufacture, and use, but it builds on the classification schemes employed by Woodbury (1954).

Woodbury (1954:13) organized the ground stone assemblage first by function; if function could not be determined, then descriptive attributes were used. Artifact function was determined through ethnographic analogy, and descriptive terms were used to highlight unusual characteristics of the artifacts (cupped stone or notched disk). Woodbury (1954) summarized the culture-specific attributes of artifacts and noted artifact distributions through time and across space. For the Colorado Plateau area, Woodbury's classification scheme remains useful.

Ten years after Woodbury's publication, Rinaldo analyzed the stone artifacts from Casas Grandes with a similar form-function approach and expanded on some temporal and cultural variations identified by Woodbury (Di Peso et al. 1974). Rinaldo attempted to standardize the identification process by presenting charts and tables showing structural variation and assigning computer codes to keep track of artifact attributes (Di Peso et al. 1974:2-16). The contribution of both Woodbury and Rinaldo is that their classification schemes are clearly spelled out so others can use them. The following descriptions draw heavily on previous descriptions and add new information based on subsequent ethnographic and experimental research. They are accompanied by illustrations showing a "typical" artifact with attributes labeled and points where measurements should be taken. The forms and coding sheets included in the appendices suggest ways in which artifact attributes can be quantified for comparisons between assemblages.

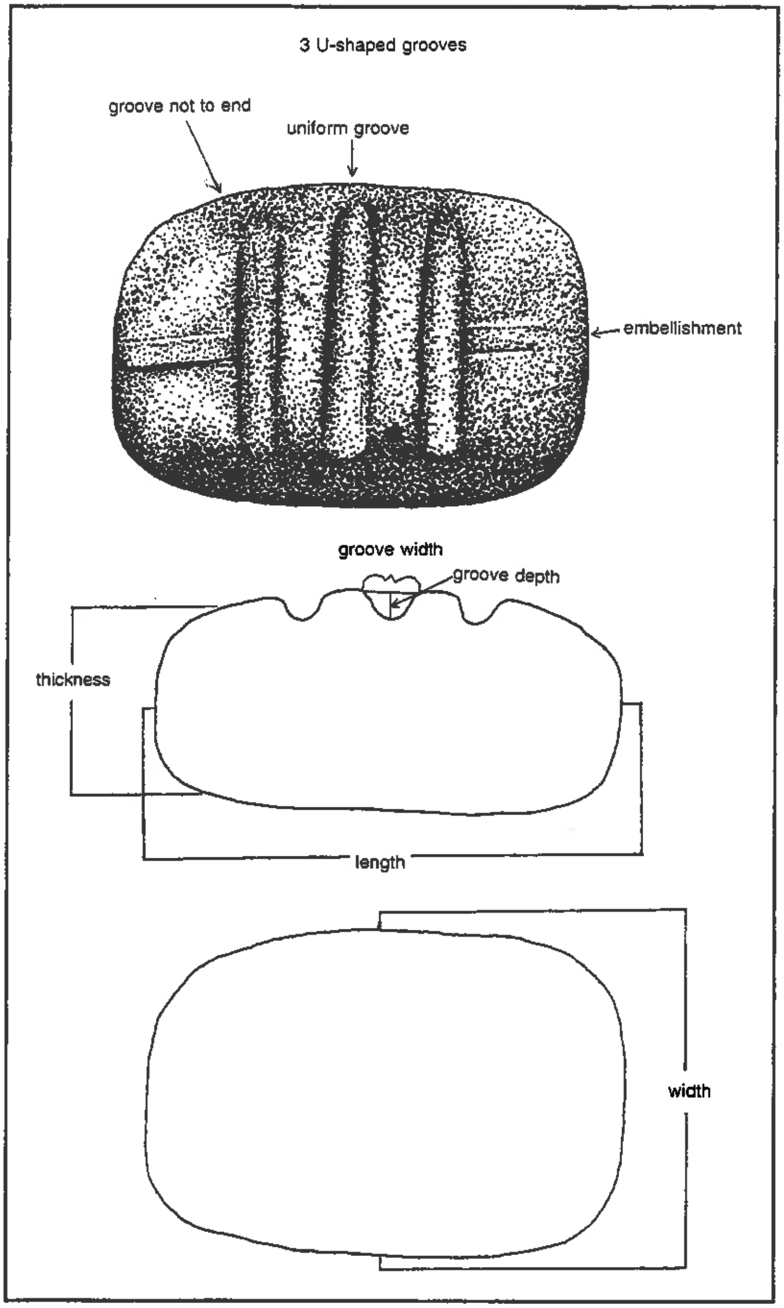

Figure 6. Ground abrader.

Artifact Types

Abraders are handstones (see definition, p. 21) that have a rough surface useful for shaping the surfaces of other items. The texture of the abrader determines the extent and type of damage done to the opposing surface, so that a finer texture may be used to polish more than to abrade (see the description of polishing stones, p. 32). Woodbury (1954:98-100) discusses the typological difficulties of defining flat abraders and their distribution in the Southwest, and he recognizes that artifacts of different materials were shaped with flat abraders. For example, wooden weaving tools or ceremonial altar pieces, stone axes, figurines, and personal ornaments all might have been worked against a flat abrader at some point in their manufacture. The ultimate shape of an abrader depends on its use. The surfaces of flat abraders may remain flat or become convex or concave, depending on what they are used against.

Abraders with U-shaped grooves (Figure 6) were employed for shaping cylindrical objects, such as wooden or reed shafts for arrows, wooden spindles for spinning fiber or for drills, prayer

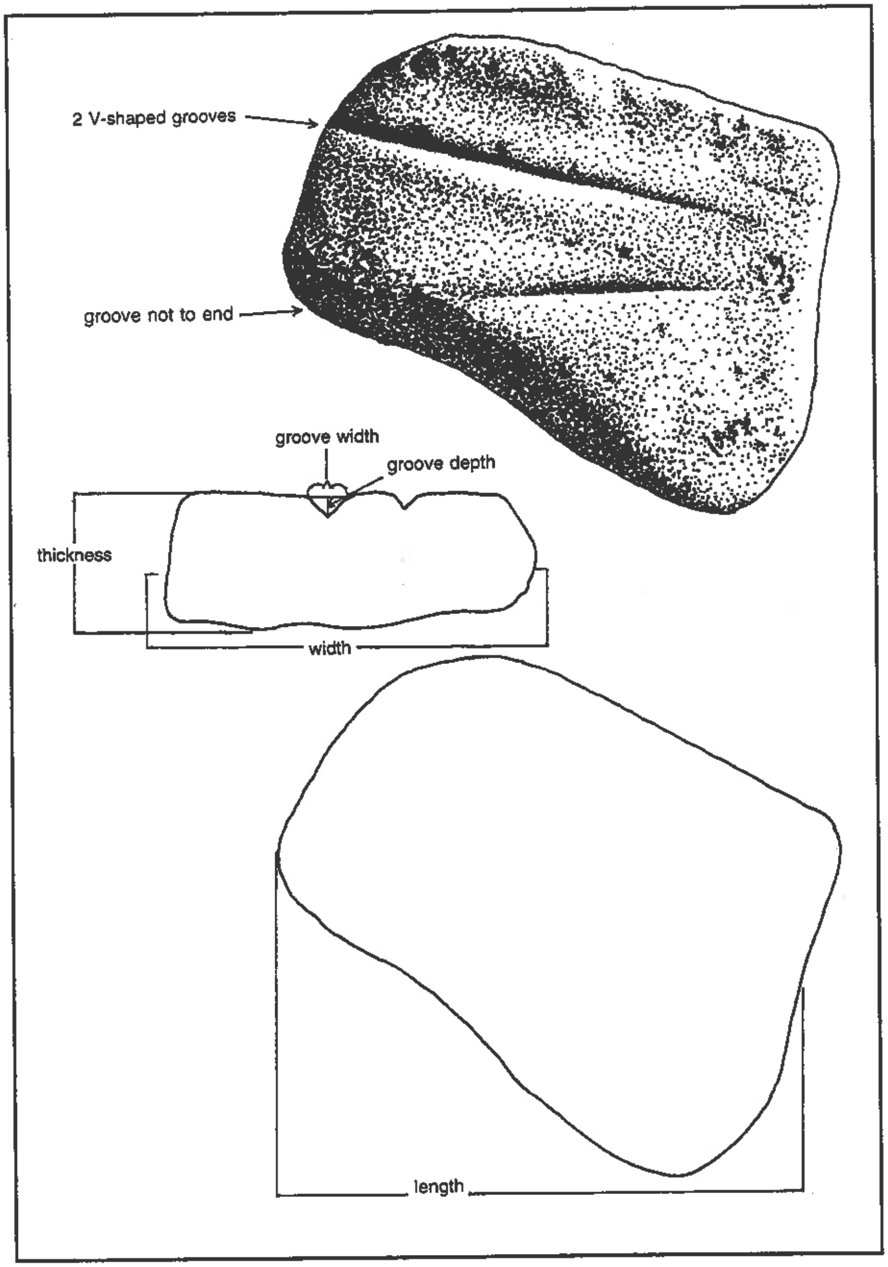

Figure 7. Grooved abrader.

sticks, stone awls, or strings of stone beads (Jernigan 1978:Figure 95). Rinaldo (Di Peso et al. 1974:136-138) identified some grooved abraders as having been used to straighten and smooth yarn, or to knock the rough spines off bear grass or other basket-weaving material. Abraders with U-shaped grooves (Figure 6) were employed for shaping cylindrical objects, such as wooden or reed shafts for arrows, wooden spindles for spinning fiber or for drills, prayer sticks, stone awls, or strings of stone beads (Jernigan 1978:Figure 95). Rinaldo (Di Peso et al. 1974:136-138) identified some grooved abraders as having been used to straighten and smooth yarn, or to knock the rough spines off bear grass or other basket-weaving material. Some grooved "abraders" were made from a lithic material with little or no asperity and were used to straighten or polish, rather than to abrade (Woodbury 1954:101-111; Haury 1976:285-286; see Flenniken and Ozbun 1988:37-52 for ethnographic and experimental research on grooved abraders). These have been termed "shaft straighteners" or "shaftsmoothers" in some reports (Woodbury 1954:101; Di Peso et al. 1974:86). They usually have been heated to help shape the shaft.

Abraders with V-shaped grooves (Figure 7) were used to shape or sharpen awls or needles, or possibly to dull the edges of lithic tools. Castetter and Bell (1951:94) note that the Papago shaped digging sticks with a flat, rough stone. The Maricopa shaped their arrows with flat abraders and used their teeth to straighten the shafts (Spier 1933:134). Some tools are flat abraders on one surface and have grooves on another surface. Others have grooves of both U and V configurations. A few manos found at some of the Point of Pines sites were redesigned with grooves (Adams 1994a:102). These are multiple-use tools that may have interesting behavioral implications, as discussed in another section.

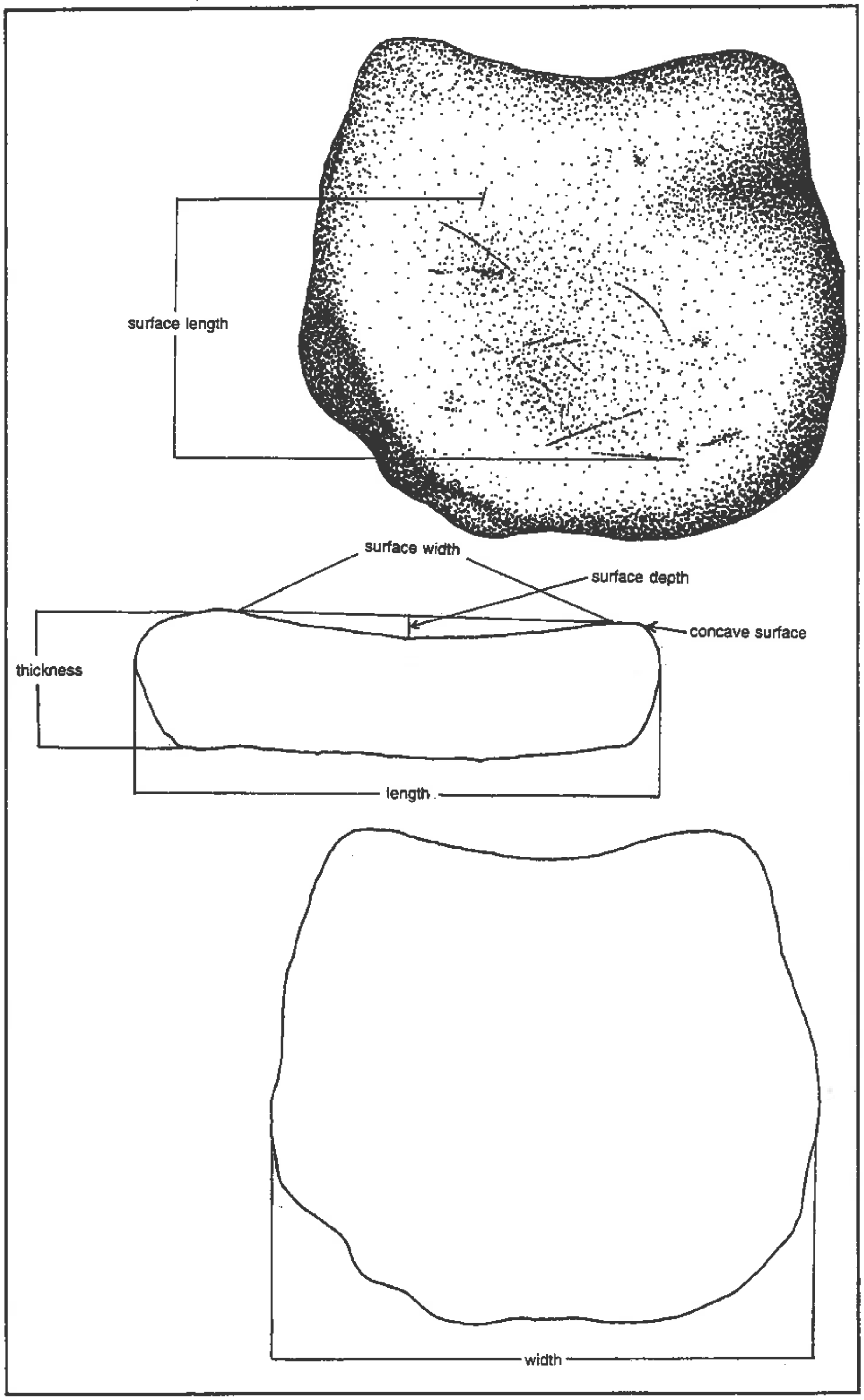

Figure 8. Anvil.

Abraders can be of either expedient or strategic design, depending on the nature of their manufacture. Abraders with U-shaped grooves were more likely to have been strategically designed to create a guide for the shafts. Some have been carefully ground to a specific shape and/or embellished with one or more ridges or cuts positioned perpendicular to the grooves. Such embellished abraders and shaft smoothers have been found at Pecos Pueblo (Kidder 1932:76-79) and in the Tonto Basin (Adams 1997). V-shaped grooves are most often worn into the stone, making these abraders of expedient design unless there was intentional shaping of the stone.

Anvils are netherstones (see definition, p. 28) upon which other items were shaped in a manner that left impact fractures and abrasive scratches (Haury 1976:278). See lapstones (p. 21) for a comparison. Anvils are of either strategic or expedient design, depending on the effort expended on shaping the stone (Figure 8). Pottery anvils are hand-held tools that provide firm bases against which paddles are used to shape clay

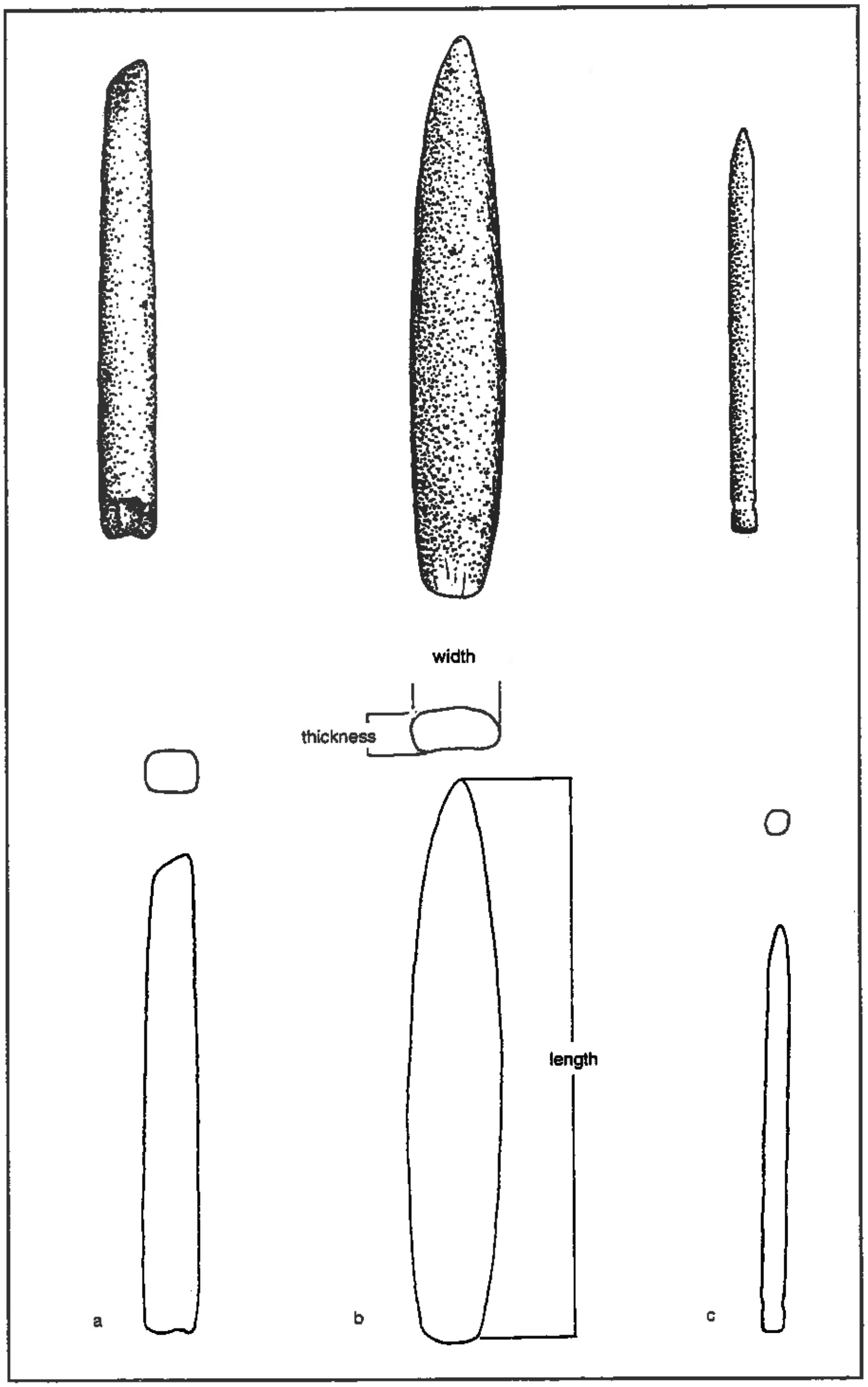

Figure 9. Stone awls, weaving tool (b), and pin (c).

into a pot. Some pottery anvils have either a groove or handle to facilitate carrying, and are thus of strategic design. Expediently designed pottery anvils are rocks or cobbles selected for their appropriate size and shape.

Architectural stones are pieces of ground stone built into structures or are the slabs used to construct small features, such as hearths and bins. These pieces are usually of strategic design, as they were pecked or ground to fit a specific space. Some, such as thresholds and floor slabs, become worn through foot-traffic. Lintels, bin slabs, and rings used to line pit openings may not have macroscopically visible use-wear damage. Generally, masonry blocks are not coded as artifacts, even if they have been pecked or ground to shape.

Stone awls are small conical or cylindrical pieces of stone sharpened to a blunt point (Figure 9). Damage patterns include abrasive scratches, perhaps a remnant from tool manufacture, and rounding of rough edges from use of the tool against a soft surface. Stone awls may have been used in much the same way as bone or wooden awls–for stringing corn cobs, for poking holes in leather or basketry, or for use in weaving textiles (Adams 1980:3-8). Included in this generic category are pieces that are slender and could have been hair or clothing pins. Generally stone awls are of strategic design, being carefully worked to a specific shape.

Axes (Figures 10a, 10b, and 10c) are composite tools designed for chopping. They are not truly functional as designed until they are hafted with a wooden handle. Axe heads are described in terms of the groove used to hold the handle in place. Some have 3/4 grooves where two broad surfaces and one edge are grooved. Occasionally, a smaller groove running lengthwise on the "ungrooved" edge supported the handle and is called a "wedge groove." Full grooved axes are completely encircled by a groove. There are occasional variations, such as the spiral groove–a full groove with a ridge in the center to hold a doubly wrapped handle. Some axes are also regrooved as a maintenance strategy to keep worn out axe heads functional by rebalancing the bit and poll ends (Adams 1994a:131).

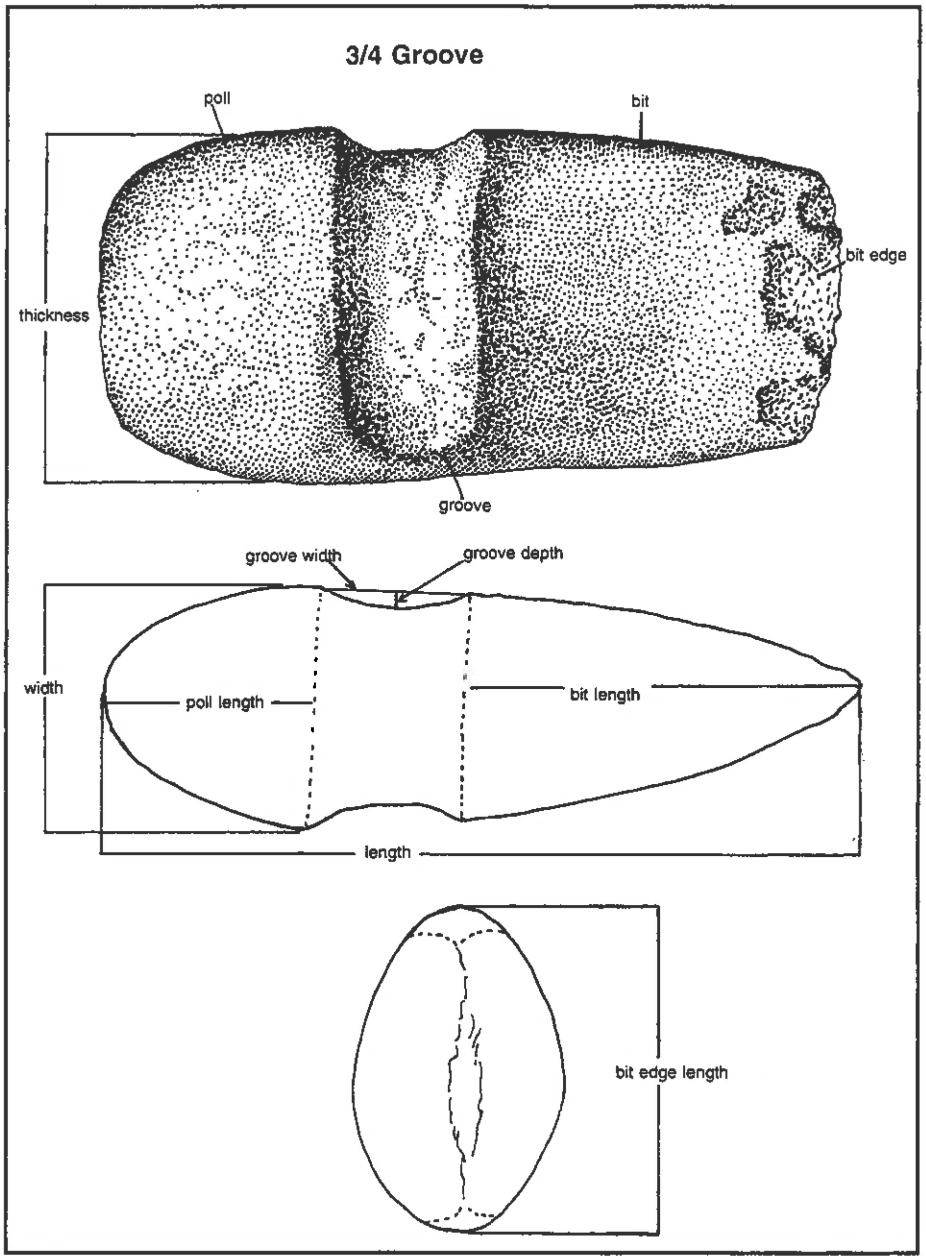

Figure 10a. Axes.

Archaeologists generally agree that the ¾-groove axe originated somewhere in Mexico and was a common Hohokam design for several centuries before it was introduced into northern Puebloan cultures in late Pueblo II or early Pueblo III (about A.D. 1100). On the other hand, the full-groove axe originated in northern Anasazi country, perhaps as early as A.D. 700, working its way south into the Mogollon area by the mid-to-late A.D. 1200s and later to Casas Grandes in northern Mexico (Di Peso et al. 1974:58-59; Woodbury 1954:36). Mimbres seems to be the southern limit of the distribution of full-groove axes in New Mexico, and they are rarely found at Hohokam sites. The earliest axes found in the Anasazi area were notched to accommodate a handle.

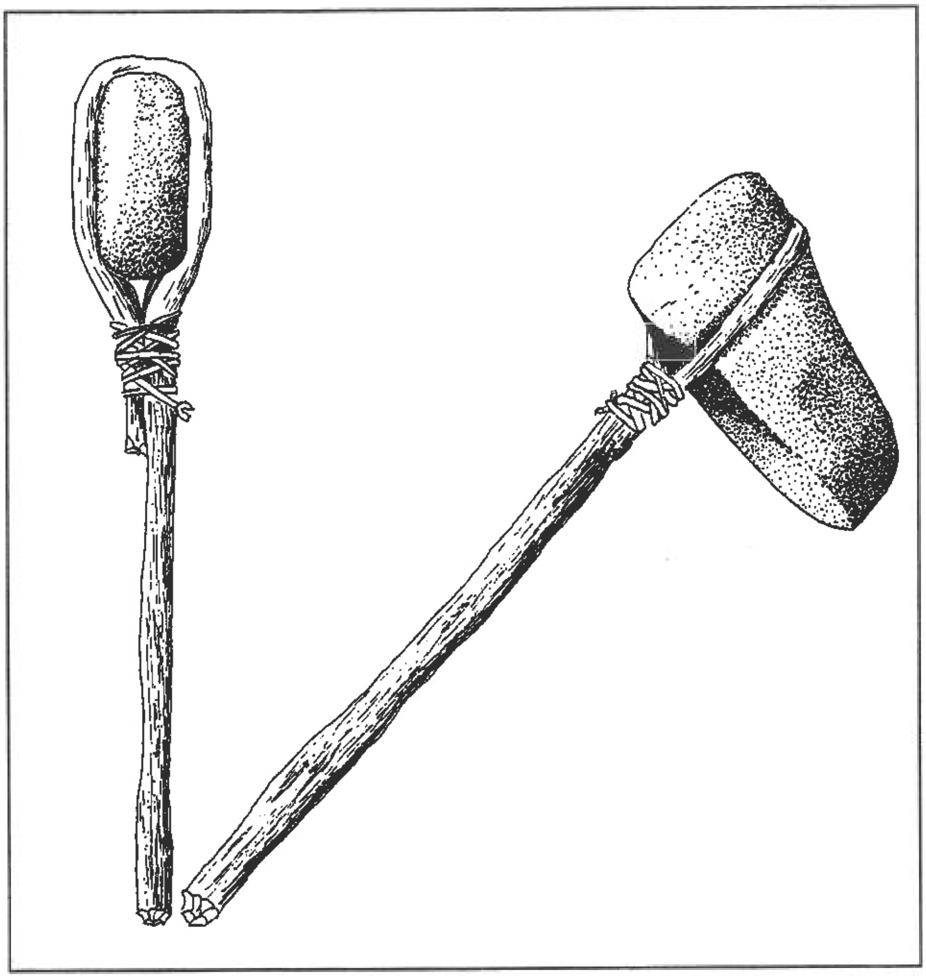

Figure 10b. Grooved hafted axe.

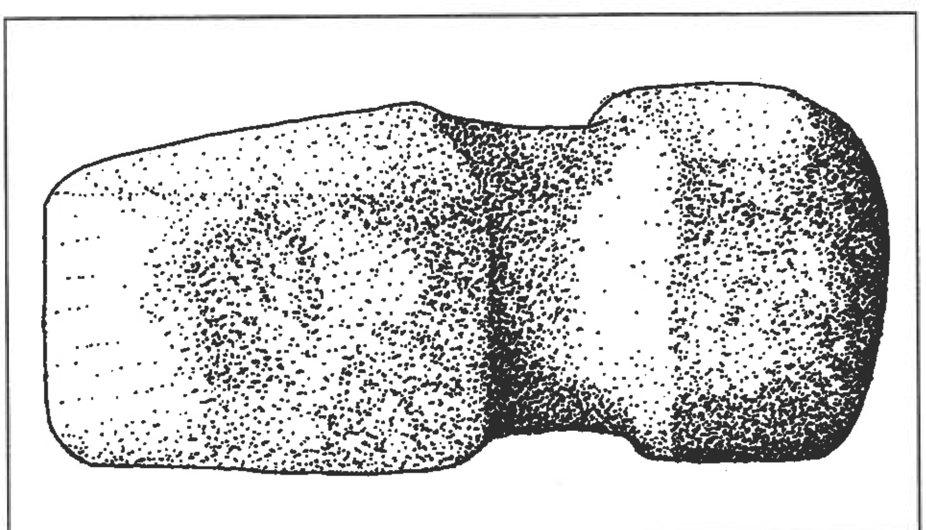

Figure 10c. Full-grooved axe head.

Ethnographic accounts of axe use by the Hopi and the Tohono O'odham indicate that most stone axes were collected from prehistoric sites and were employed in the manufacture of metates or masonry blocks (Hough 1918:270-271; Russell 1908:110; Woodbury 1954:40-42). Axes collected from prehistoric sites are also a component of ritual altars at Hopi (Hough 1918:271; Woodbury 1954:41). Some axes are believed to have been used to dig clay (Haury 1945:132). It has also been postulated that some axes served as hoes to grub bushes out of the ground for clearing agricultural fields (Mills 1993:393-413). Experimental replication of axe use has produced use-wear patterns that may help determine if specific prehistoric axes were similarly employed. Thus, although stone axes were primarily designed for chopping wood, that may not have been their ultimate use. Recent research in the Four Corners area suggests that axe heads were commonly collected and stored for potential future use (Larralde and Schlanger 1994:10).

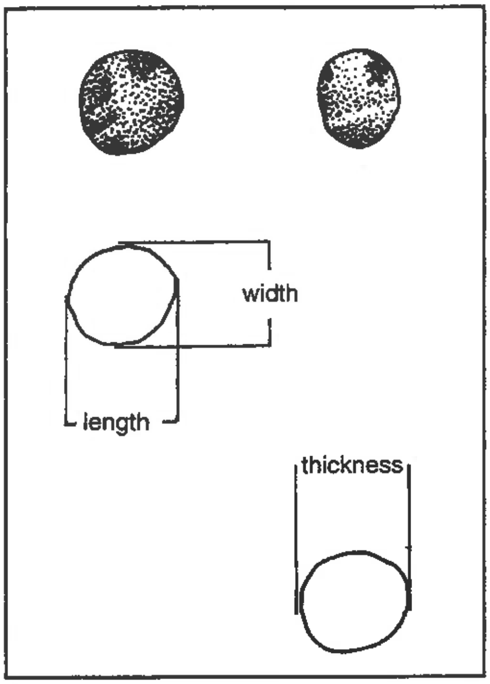

Figure 11. Balls.

Similar behaviors may account for the accumulations of axe heads with varying amounts of use at Turkey Creek Pueblo, in the Point of Pines area (Adams 1994a:126-130).

Double-bitted axes seem to be fairly rare in the U.S. Southwest, with only a few known from the Four Corners area. These are mostly notched. A few double-bitted axes have been found in the Casas Grandes area and the Point of Pines area. The largest concentration of 10 double-bitted axes was found at Los Muertos (Haury 1945). These might have been used as war axes; flaked double-bitted axes are considered war clubs by the Tewa (Jeancon 1923:18).

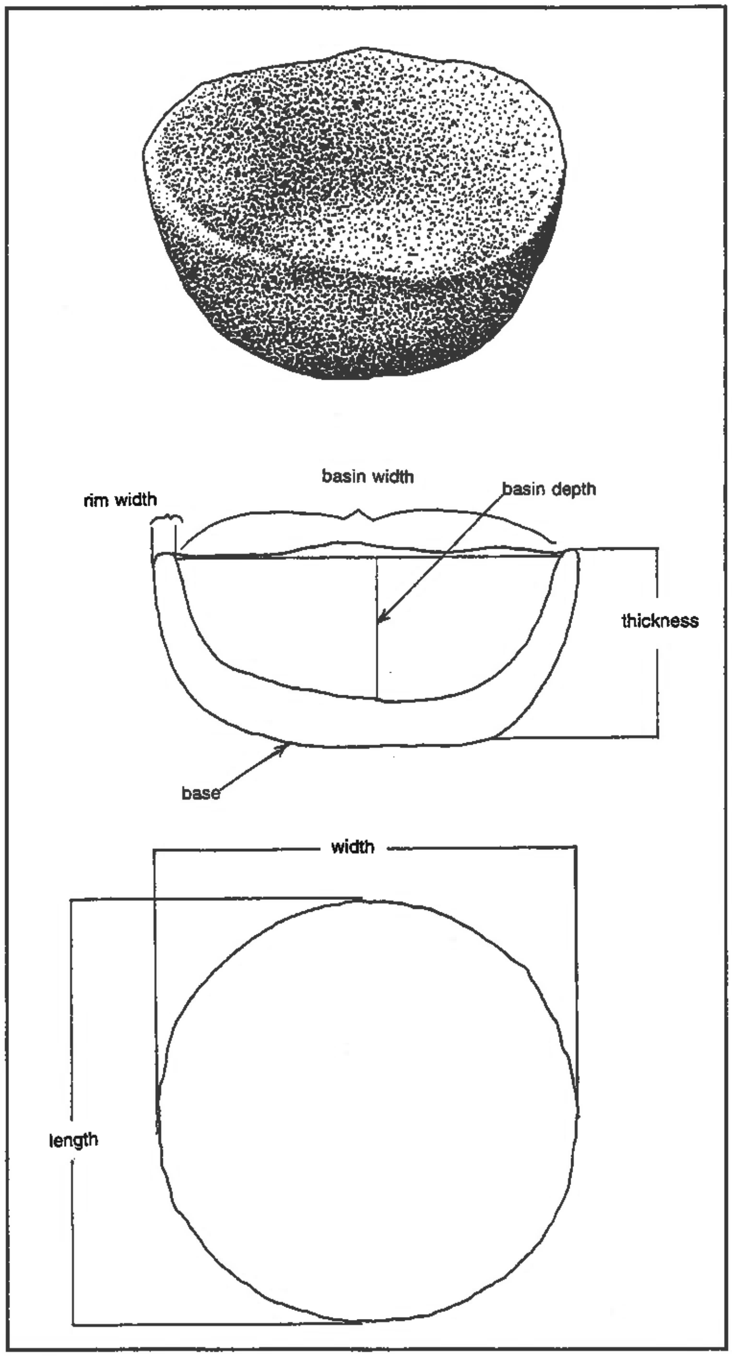

Figure 12. Plain, flat-bottom bowl.

Balls (Figure 11) are roughly spherical pieces of stone that have been ground all over to shape. Through ethnographic studies of the Pueblo and Tohono O'odham peoples, stone balls have been most commonly identified as gaming pieces, club heads, noise-making stones, or racing stones (Adams 1979:90; Russell 1908:172-173,179; Stephen 1936:271-280; Underhill 1939:146-150; Woodbury 1954:173). The Tohono O'odham prepared racing tracks at Sacaton Flats and Casa Blanca; races were run on these tracks, as well as through open country (Bahr 1983:Fig. 8; Russell 1908:Fig. 88).

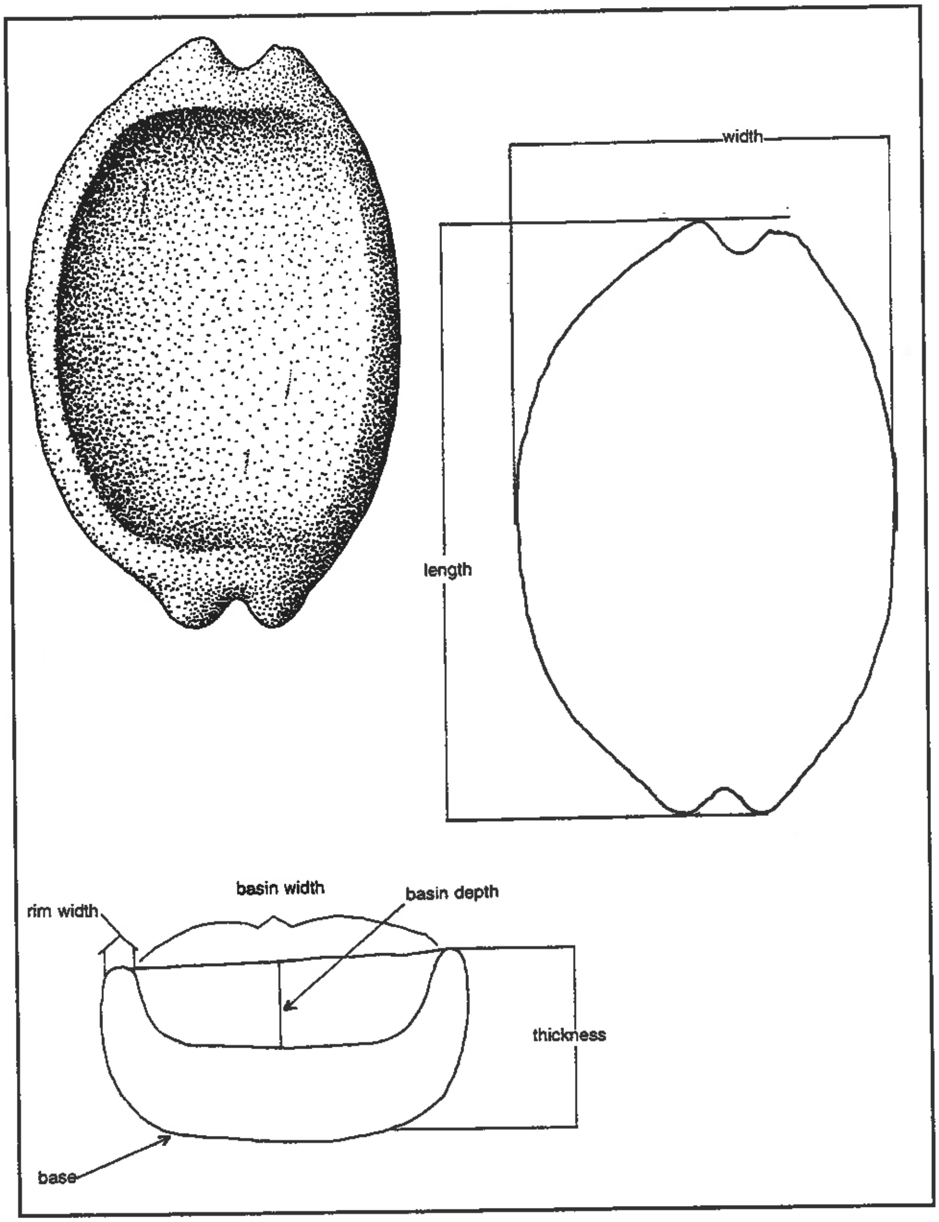

Figure 13. Tray-bifurcate.

Racing stones, also called kickballs, are identifiable by impact fractures. Some have flattened surfaces or slightly concave sides where pitch was applied to make the stone adhere to the foot and allow the racer to heft the ball into the air for more distance (Adams 1979:90). Stone balls were also rolled across wooden covered pits to simulate the sound of thunder (Woodbury 1954:172). Balls used as "thunder stones" are generally more spherical than kickballs, and use-wear damage patterns are less obvious. Impact fractures and asperities are rounded from being rolled across a wooden surface.

Bowls (Figure 12) were strategically designed and shaped to be containers, but their use for mixing sometimes blurs the distinction between bowls and mortars. Bowls may be plain or decorated, with carved or incised designs. Those found at Casas Grandes are plain, whereas some of those found at Snaketown have more elaborate designs (Di Peso et al. 1974:206-218; Haury 1976:289). Some containers are broader with lower sides than bowls and are frequently called *trays* (Figure 13). Other containers have shapes that are not easy to classify–these are called *vessels*. If there is use-wear damage from the working of a pestle, the container may be classified as a mortar.

Censers are specialized containers that at Snaketown were used with palettes, possibly to burn incense or other chemicals in association with mortuary rituals (Haury 1976:288-289).

Disks (Figures 14 and 15) are strategically designed and shaped, tabular circles of stone. Some are perforated with a centrally located hole that fits over a spindle shaft, and are called *whorls.*

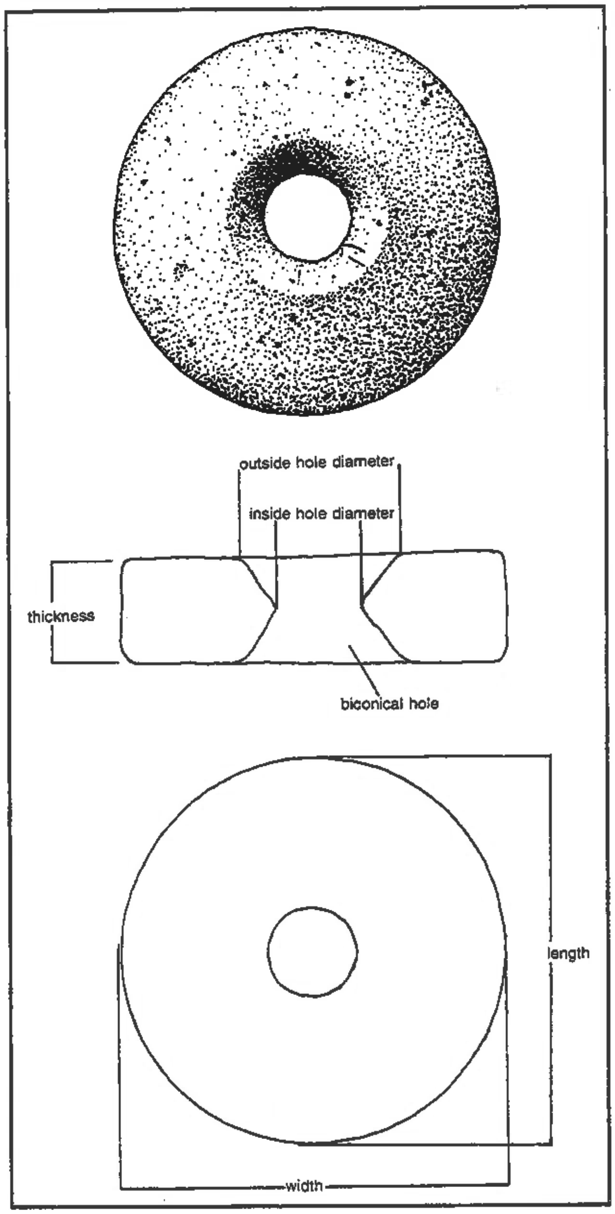

Figure 14. Perforated stone disk or doughnut stone.

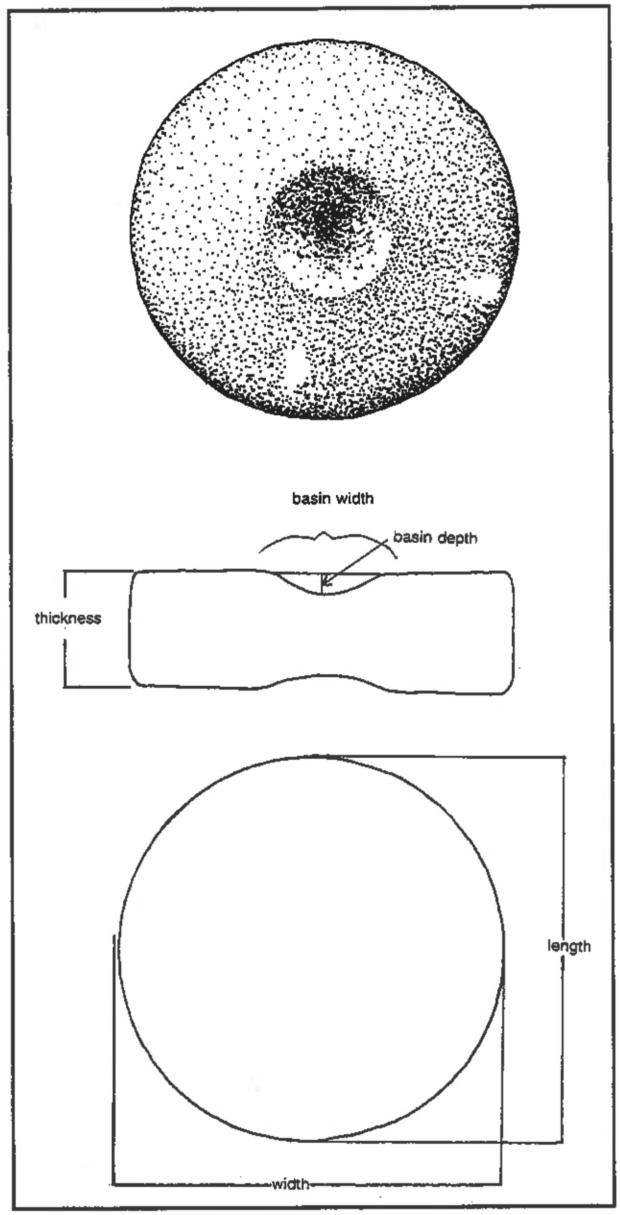

Figure 15. Disk mortar.

Whorls are the fly-wheels that maintain the spinning momentum. Clay and reworked sherds have also been used to make whorls. Wilcox (1987:145-162) and Greenwald (1988:150) discuss perforated stone disks and the possibility that differences in whorl sizes relate to the types of fibers processed. However, Teague (1991:68) questions the direct relationship between whorl size and the types of fibers spun, and it seems unwise at this point to infer the precise use of whorls. The spindle/whorl configuration also may have been used by jewelry makers in hand drills or even pump drills (Judd 1954:Pl. 20; Ladd 1979:Fig. 5). Whorls on short spindles were used as toy tops by the Hopi (Culin 1907:743).

Another type of perforated disk included in this category has been called a *stone ring* by Haury (1976:290-291) and has also been described as *doughnut* shaped (Di Peso et al. 1974:32, 307). Suggestions regarding their possible uses include shelling corn, as weights on digging sticks, or as chunky stones in a hoop-and-pole game (Haury 1976:290). Nothing similar has been identified in any historic assemblage in the United States Southwest. Archaeological context does not provide much information as to how these disks were used, except for the association of one of the doughnut stones with an axe and other axe-shaping tools on the floor of a Maverick Mountain structure at Point of Pines Pueblo. The doughnut stone hole is 2.6 cm in diameter, and the groove width on the axe is 2.2 cm. The hole could have served as an abrader to smooth and possibly bend a handle for the axe. However, the damage patterns on all doughnut stones are not the same and their use remains speculative.

Some disks are not perforated and their function, as well, is speculative. Ethnographically identified uses include gaming pieces or counters (Culin 1907). There are also disks, similar in shape to doughnut stones, with what are perhaps the beginnings of perforations. The incomplete holes may have served as basins, similar to the basins in pebble mortars (see definition, p. 26). The presence of pigment in the basins of some disks found at the Santa Cruz Bend site in Tucson influenced the decision to call these disk mortars and to consider their use as being different from perforated and unperforated disks (Adams 1996a). Other Santa Cruz Bend disks had basins that were unburned, while the rest of the disk was smoke blackened. It was suggested that these might have been used as oil-burning lamps, with experimental replication reinforcing the possibility of a lamp function for this configuration (Adams 1996a).

Fergolith is a term now in general use in southern Arizona and is used here to include stones that previously have been called *crushers* (Di Peso 1951:144). Most fergoliths are large and have a distinctive T-shape (Ferg 1991). The use-wear patterns vary considerably, suggesting that they were multiple-use tools. Most commonly, the base of the T is battered or chipped, and the broad sides have been damaged by abrasion. The cross piece of the T serves as a handle, perhaps to lift the stone for use as a crusher. The crushing and abrading may have been two steps in a processing task.

A *fire-drill hearth* is the netherstone (see definition, p. 28) part of a fire-starting kit. Small, notched cupules serve to contain the spark created by friction from a rotating fire drill. A hearth may have a single basin or multiple basins. Grooves cut into the cupules allow flammable pieces of material to come into contact with the spark, thereby generating a flame. Ethnographic accounts of puebloan and non-puebloan fire starting describe men as the tool users (Hough 1890:531-532, 1915:164; Spier 1933:79). Most fire-drill hearths are wood (Hough 1890:531-532); however, stone hearths have been found at Casas Grandes and at several Point of Pines sites (Adams 1994a:137-138).

Geometrics are specially shaped stones that have no obvious use-wear damage. Shapes include balls, cylinders, rectangles and other geometric shapes. They may have been ritualistic paraphernalia, fetishes, gaming pieces, or toys of some sort.

Griddles are tabular pieces of stone that were placed over fireplaces and used for cooking various types of tortillas or cakes. Woodbury (1954:176-177) lumps all cooking slabs in one category but a distinction is made here between the more expediently designed griddles and the strategically designed pikistones (see definition p. 31), which are highly prized commodities of modern pueblo women (Adams 1979:23). In general, griddles are designed to be thinner than pikistones, and there is less attention to the finishing of the cooking surface. Griddles can be recognized by their tabular shape and smoke-blackening or oxidation from use over a fire.

Generally, *hammerstones* are irregularly shaped rocks that have been selected for their useful size and weight (Haury 1976:279). Woodbury (1954:85-93) subtypes hammerstones based on their shape. Even those that are disks or spherical are naturally shaped and are thus of expedient design. Primarily edges, but sometimes broad surfaces, are used with a forceful stroke against another surface. The purpose is to chip or smash away the unwanted parts of the other item. Damage to the hammerstone includes impact fractures and chipping. Hammerstones and mauls have the same general function and incur the same use-wear damage but are distinguished by the presence of a groove that allows the maul to be hafted (see p. 25).

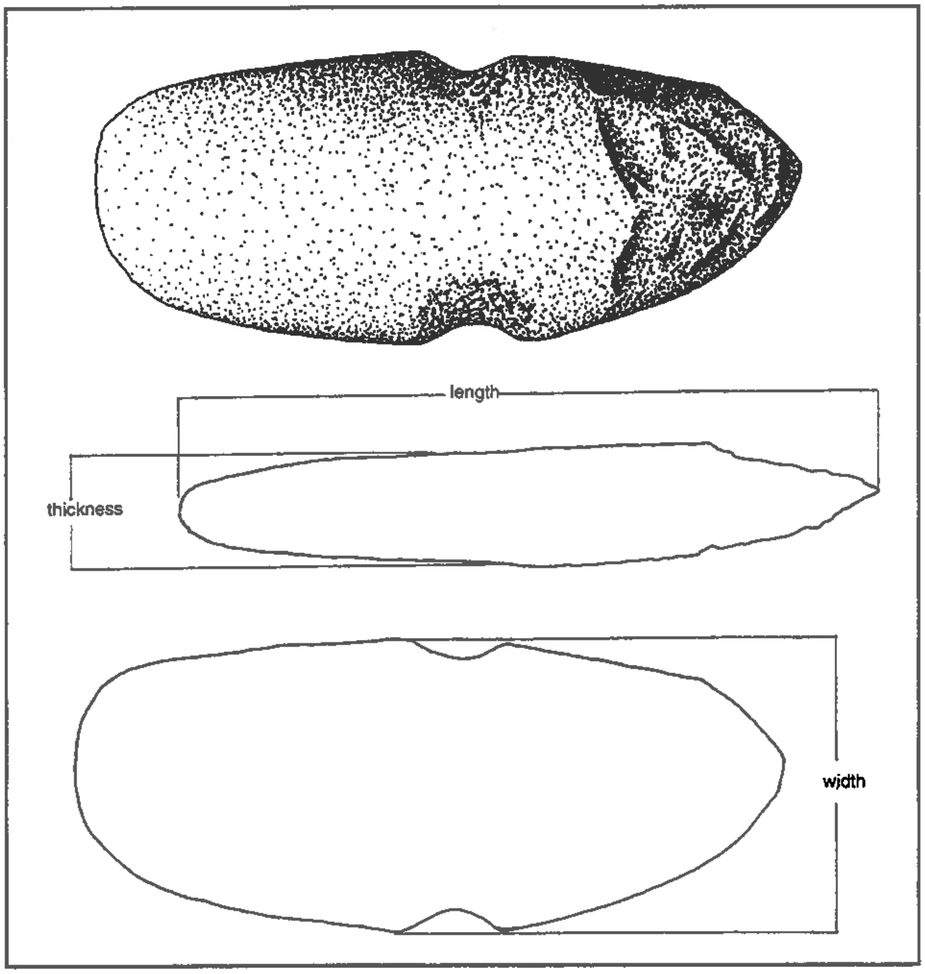

Figure 16. Hoe with notches for hafting.

The category of *handstones* is reserved for those hand-held tools without specific attributes that allow them to be categorized as manos, polishing stones, or pestles. Their use may be more ambiguous than the other hand-held tools. The term handstone also has meaning at a generic level as any hand-held stone and subsumes the more specifically defined tool types.

Hoes (Figure 16) have been found at Snaketown (Haury 1976:285) and at Casas Grandes (Di Peso et al. 1974:360) and are thin tools that were hafted and used in agricultural fields. Similar tools have been found at Anasazi and ancestral Hopi sites (Woodbury 1954:166-170). On the Colorado Plateau, many manos have been redesigned as hoes, with the addition of notches on the edges to accommodate a haft (Seibert 1987). Artifacts found primarily in the Four Corners area and called *tchamahias* are thought to have been used as hoes. Some tchamahias have projections that might have been useful for hafting a handle; others show no evidence of hafting or use. Woodbury (1954:166-170) speculates that the tchamahia ceased to function as a hoe at some point in the prehistoric past and instead became a symbol important enough to have been included in certain ceremonial altars.

Lapstones are netherstones (see definition, p. 28) that served as bases upon which other artifacts were shaped or intermediate substances processed with a small handstone. Lapstones can be distinguished from anvils primarily by size. Anvils rest on the floor and have impact fractures and abrasion from supporting other artifacts during manufacture. Lapstones are hand-held and

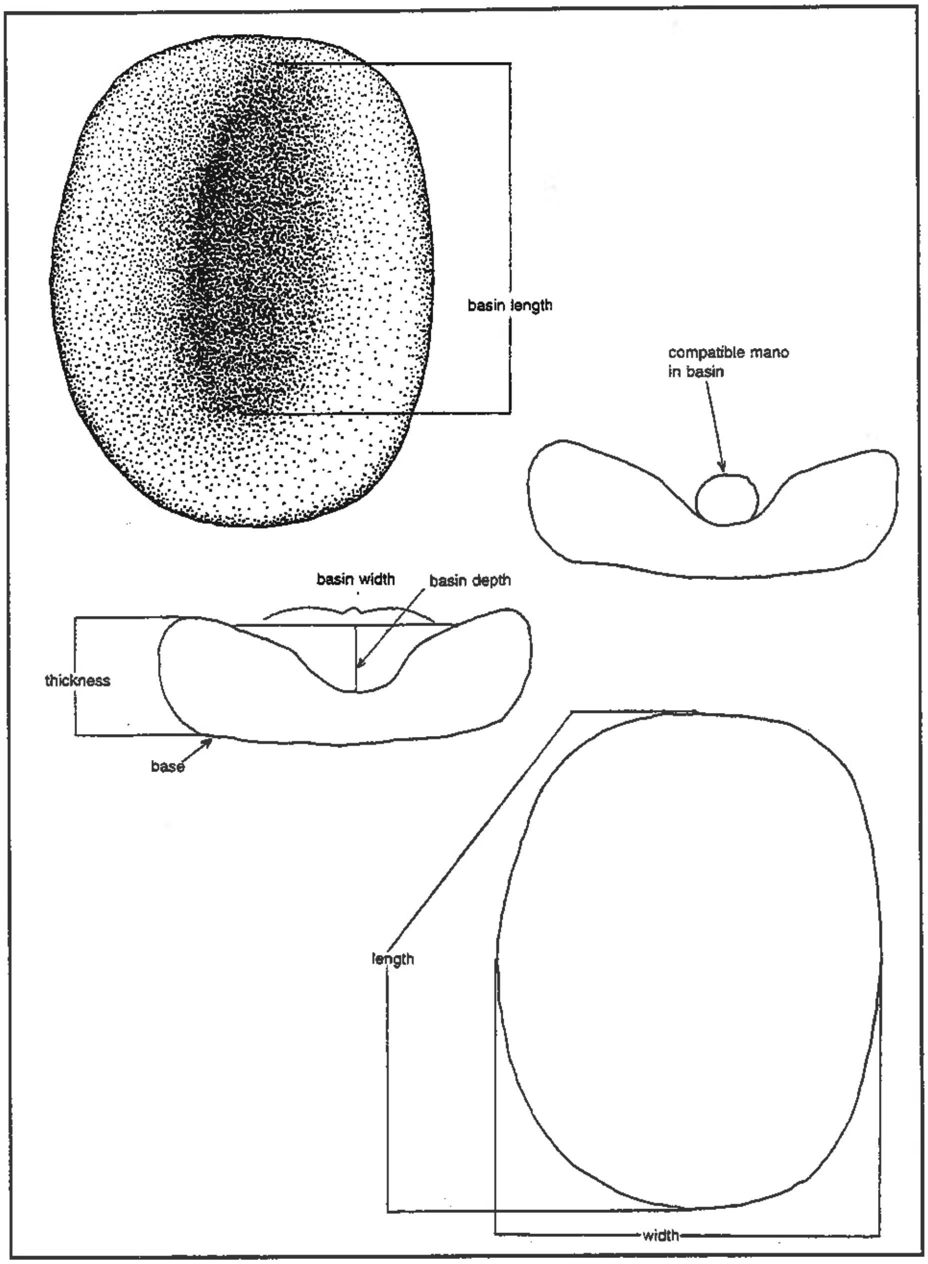

Figure 17. Basin metate.

most often have abrasion or sheen from having artifacts worked against their surfaces. Lapstones differ from flat abraders in that they were the bottom, passive stones against which something was worked, whereas abraders were the active stone worked against another surface. A common use of lapstones by Early Agriculturalists in the Tucson Basin was to process pigments, perhaps mixing them with a binder or vehicle, such as water or oil, to create paint (Adams 1996a). Lapstones are distinguished from palettes by their simple design (palettes are strategically designed with borders and embellishing decorations). Past descriptions have used the term proto-palette for anything used to process pigment, but this creates confusion with the palettes found in later Hohokam deposits (which may not have been pigment processing tools) and leaves unclassified tools of the same, simple configuration but lacking pigment. Thus, lapstone is a generic term, encompassing palettes, and the term proto-palette will not be used here.

Loomblocks are large stone blocks used to anchor the wooden frame of a loom. Most have one or more circular depressions which hold the frame. Some have larger depressions that have been called handgrips (Woodbury 1954:153-157). The presence of V-shaped grooves on the upper surfaces indicates that these were also used for sharpening other tools.

Manos and metates are two components of food-processing equipment. The metate is the netherstone, and the mano is the smaller, hand-held component. Because manos and metates were used together, the use-wear on the surface of one tool reflects that on the surface of the

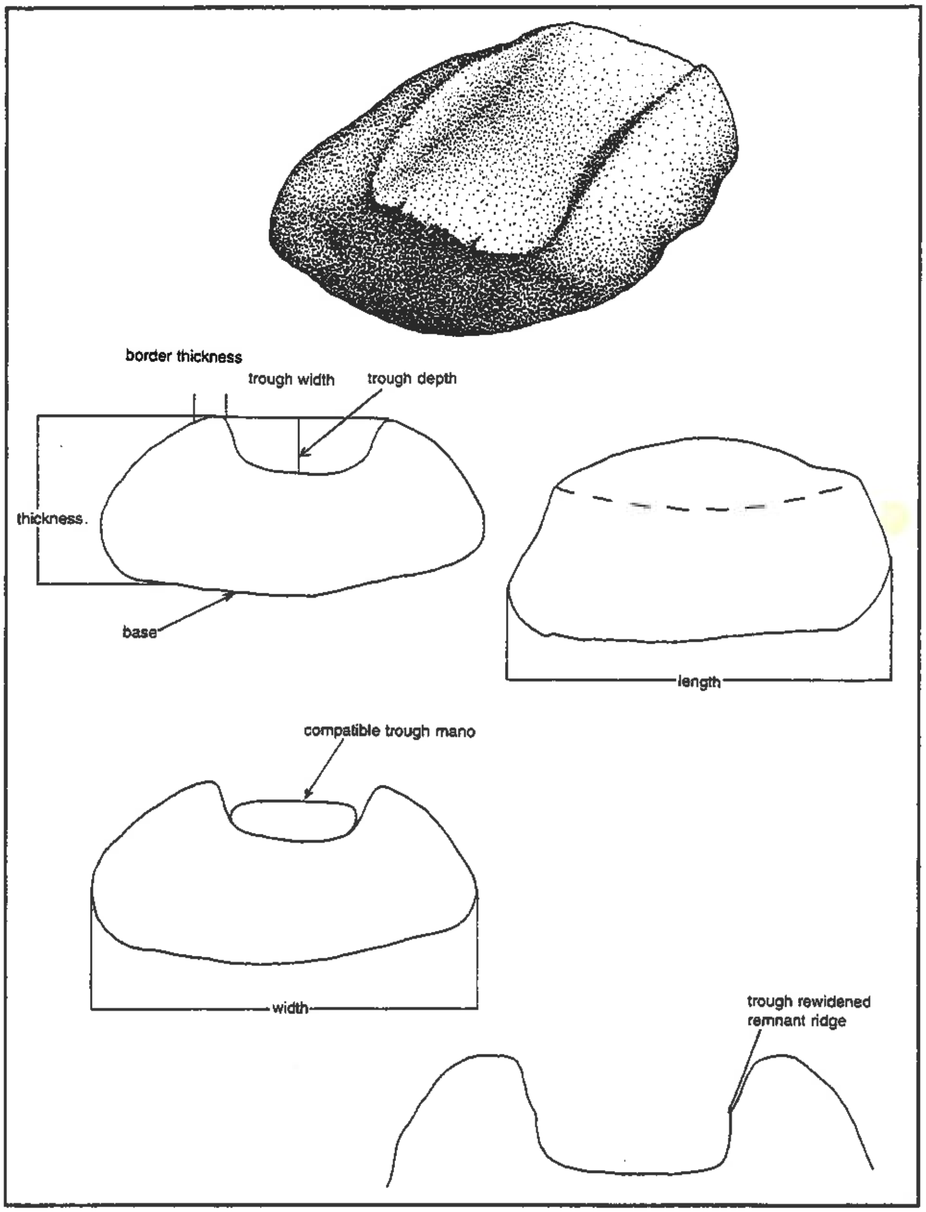

Figure 18. Open trough metate.

other. This concomitant wearing of surfaces makes it possible to identify manos or metates that have compatible surface configurations and could have been used together. Metates have been variously typed by archaeologists according to surface configuration, but the lack of attention to how metates were worn through use makes this kind of classification problematic (Adams 1996b). The surface configuration of some metates is dependent on the length of the mano manipulated against the surface. Metates that started out with flat surfaces, but were worked with manos shorter than the width of the metates, developed concave surfaces that, if deep enough, might have functioned like basin or trough metates. Metates with borders, such as basin and trough metates, were probably designed intentionally to be a particular size and shape, but subsequent use determined the final surface configuration of both the mano and metate. Through extended use the mano becomes shorter and the trough narrower, thus reducing grinding area size. Maintenance to enlarge the surface involved pecking the trough sides, which left a ridge and required the use of a longer mano.

Mano and metate subtypes can be identified by design variations. Metates are typed as *basin* if the surfaces have intentionally manufactured, elliptical basins worn by circular and reciprocal mano strokes (Figures 4, 17). Manos worked in basin metates develop use-wear facets on their edges and ends. *Trough metates* have manufactured, rectangular depressions worn through the manipulation of a mano in reciprocal strokes (Figure 18). Trough metates can be subtyped by the configuration of the surface and the confining borders (Woodbury 1954:50). *Open troughs* have

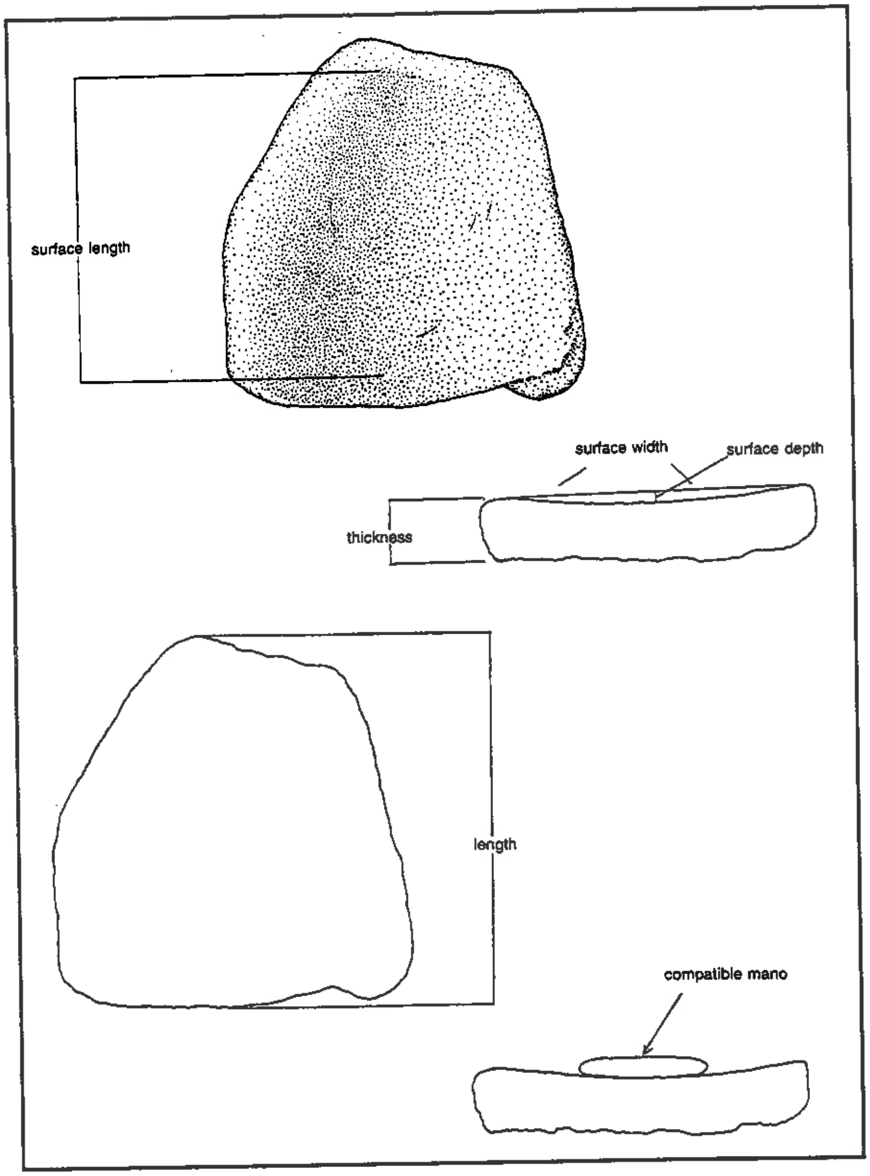

Figure 19. Flat concave metate.

borders only along the sides, so that both ends are open. *Three-quarter troughs* have borders on both sides and one end. Specialized, ¾ trough metates with flat "mano rests" on the closed end are called *Utah metates*. *Closed troughs* have borders on both sides and both ends, but they are distinguished from basin metates by the strictly reciprocal mano strokes. *Flat metates* might have started out as flat or unshaped surfaces, but they remained flat only if a mano of the same length as the width of the surface was used. If the mano was shorter than the width of the metate, eventually a concave surface was worn on the metate, and a convex surface on the mano, so the metate is typed as *flat/concave* (Figure 19).

The difference between a trough metate and a flat/concave metate is in the intentional shaping of the trough. The main differences between a basin metate and a flat/concave metate are the result of mano configuration and the type of mano stroke. A *basin mano* (Figure 20) has a convex surface and is worked against the metate in a combination of circular and reciprocal strokes. *Trough manos* show distinctive abrasive use-wear damage on their ends, where they come into contact with the borders of the metate (Figure 21). A *flat/concave mano* (Figure 22) has a flat to slightly convex surface and is moved against the metate primarily with reciprocal or elongated circular strokes. *Flat manos*, with their surfaces as long as the width of the flat metate, have no use-wear damage on the ends and also have flat grinding surfaces.

Medicine stones are most commonly made from scoria (a vesicular, volcanic material) or some other lightweight material. The shapes vary and are sometimes merely enhanced natural shapes (Haury 1976:293). There are no obvious use-wear damage patterns to help identify how they were used, and thus their function is unknown. Some look like plummets (see p. 32), but there is no obvious means of suspension. They are called medicine stones and are primarily thought

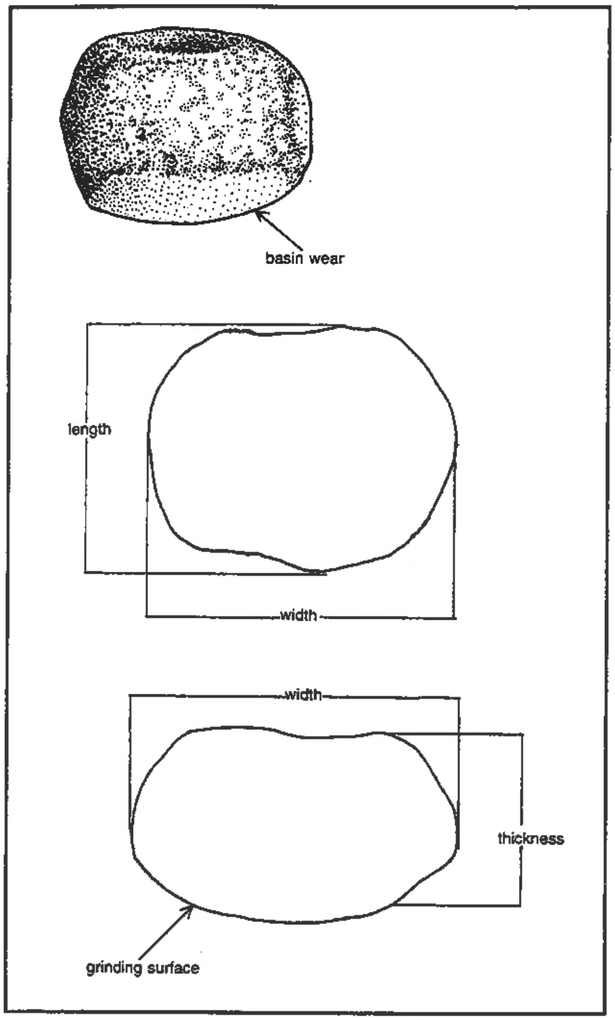

Figure 20. Basin mano.

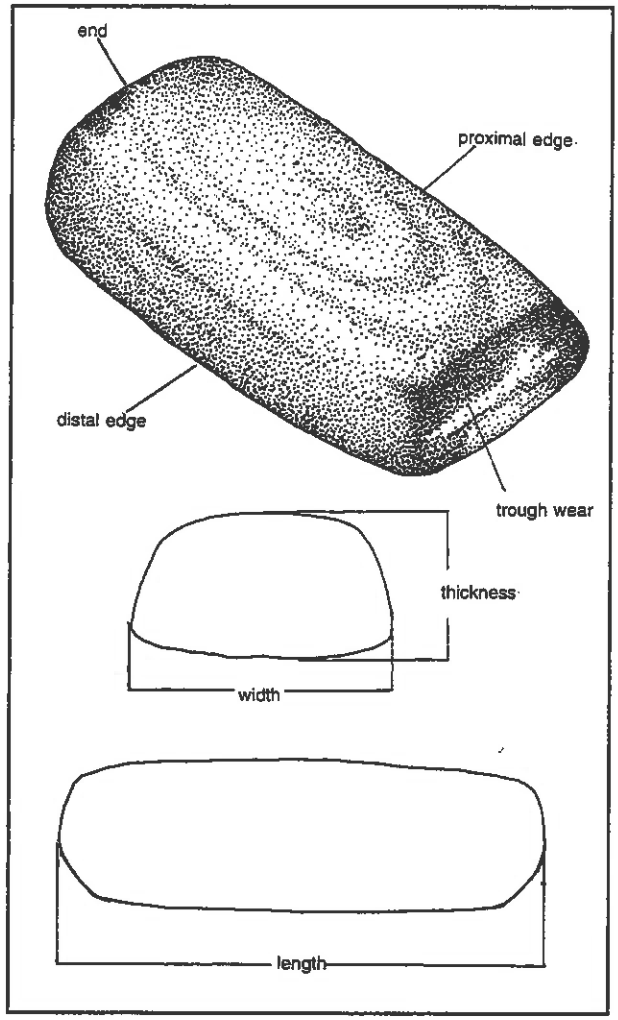

Figure 21. Trough mano.

to have been ritual because of their association with burials and caches. An alternative possibility was recognized during an analysis of a collection of cylindrically and conically shaped medicine stones from Point of Pines sites. One came from a burned room and had minute burned fibers visible only under magnification. Lynn Teague identified the fibers as agave. Perhaps these stones were used somehow in straightening or cleaning fibers.

Mauls are large rocks that were grooved for hafting a wooden handle. Mauls can be distinguished from similarly grooved axes by the lack of a bit. The hafting groove of a maul essentially separates two equally sized and shaped polls. It has been suggested that mauls were used for heavy pounding work, such as pounding stakes, driving wedges, and possibly in the early stages of processing some food resources (Di Peso et al. 1974:154). Use-wear damage includes impact fractures and chips. Hammerstones are identical in pounding function to mauls but lack the groove for hafting (see p. 21).

Mauls with various groove configurations occur in Mogollon assemblages from the earliest to the latest periods (Wheat 1955:122), and in Anasazi and Hopi assemblages, as well (Adams 1979:115; Woodbury 1954:43-49 calls them hammers). Wheat (1955:122) identifies a groove

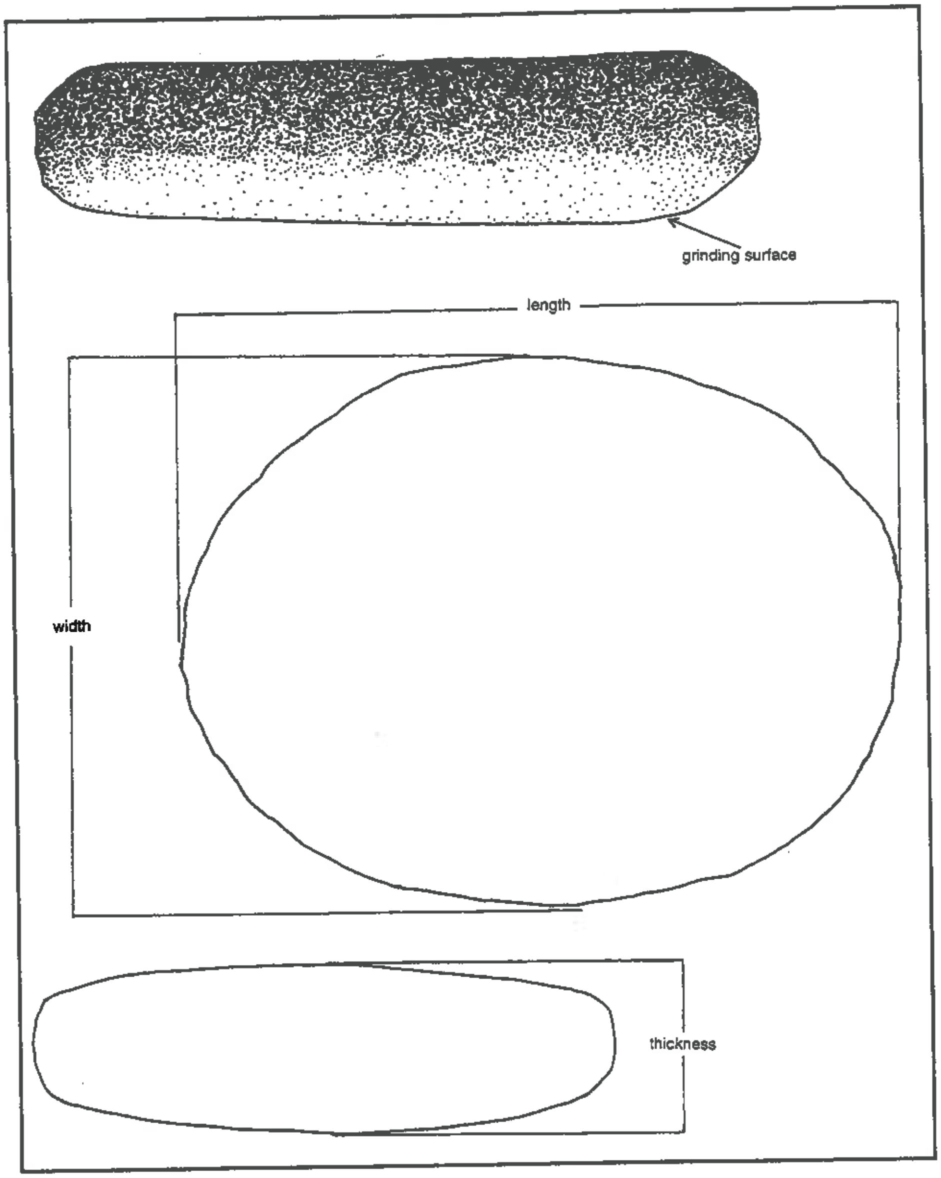

Figure 22. Flat/concave mano.

technique that encircles 7/8 of the tool's circumference. He calls this technique most typical of Mogollon but does not discuss whether it is common to all branches of the Mogollon or is specific to Point of Pines, where he first recognized it (Wheat 1954:127, 140). Nothing similar is illustrated by Woodbury (1954), Di Peso et al. (1974), Gladwin et al. (1938), or Haury (1976). In Martin's Mogollon reports, only one from a Tularosa phase site is described (Martin et al. 1957:68).

Mortars have basins within which substances were reduced through the crushing and grinding actions of a *pestle* (see p. 30). The size and configuration of mortars vary greatly. Some mortar basins were made in large, immobile rocks or rock outcrops and are called *bedrock mortars*. Other mortars are smaller and portable, and they may be either carefully shaped (Figure 23) or merely basins in unworked rocks. *Pebble mortars* are sized so that only small quantities, perhaps of herbs or spices, could have been worked in them. Several have been found at the Point of Pines sites with pigment in the basins (Adams 1994a:113). Use-wear damage patterns include abrasive scratches more often than impact fractures, suggesting something granular was mixed and not crushed in the basins. Therefore, it is assumed they were used either to mix or grind pigment or some other powdery substance.

Food-processing mortars are identified by Hopi as used to pound dried meat to soften it for those who had no teeth (Adams 1979:25). They have been used by the Walapai, Maricopa, Pima, and other non-pueblo groups to crush the pods of mesquite beans (Doelle 1976:53-68; Euler and Dobyns 1983:259; Spier 1933:51; Castetter and Bell 1937). Once the pods were broken apart with mortars and pestles, they could be reduced further with a mano and metate (Castetter and Bell 1951:179; Spier 1933:51). As with the mano and metate, ethno- graphic accounts of non-pueblo mortar-and-pestle use describe women as the tool users (Castetter and Bell 1951:96; Doelle 1976;

Euler and Dobyns 1983:259; Fontana 1983:Fig 6; Spier 1933:57, 96; Webb 1959:12). Chemical analyses that recognize the presence of animal immunoglobins on mortars and pestles in California have been conducted, suggesting that animal as well as vegetal resources may have been processed with prehistoric mortars and pestles (Yohe et al. 1991:663).

These varied food- and nonfood-processing activities may or may not leave distinctive damage patterns; however, the use of a pestle in a mortar damages both the end of the pestle and some distance up its side. A downward stroke brings the pestle forcefully into contact with the mortar, crushing any intermediate substance and creating impact fractures on the contact surfaces of the mortar and pestle. Additional circular or reciprocal movements of the pestle in the mortar basin grinds the intermediate substance and causes abrasive damage to the surfaces of both. Pestles need not be of stone, and some use-wear patterns in basins suggest the working of wooden pestles. Use on the ground concentrates use-wear damage on the distal end of the tool. In crushing clay, the damage would be seen as impact fractures, chips, and abrasion, depending on the hardness of the clay chunks and the hardness of the surface beneath the blanket. Thus, unlike manos, some pestles were damaged through use without a lower counterpart, and this may distinguish nonfood-processing pestles from those involved in food processing.

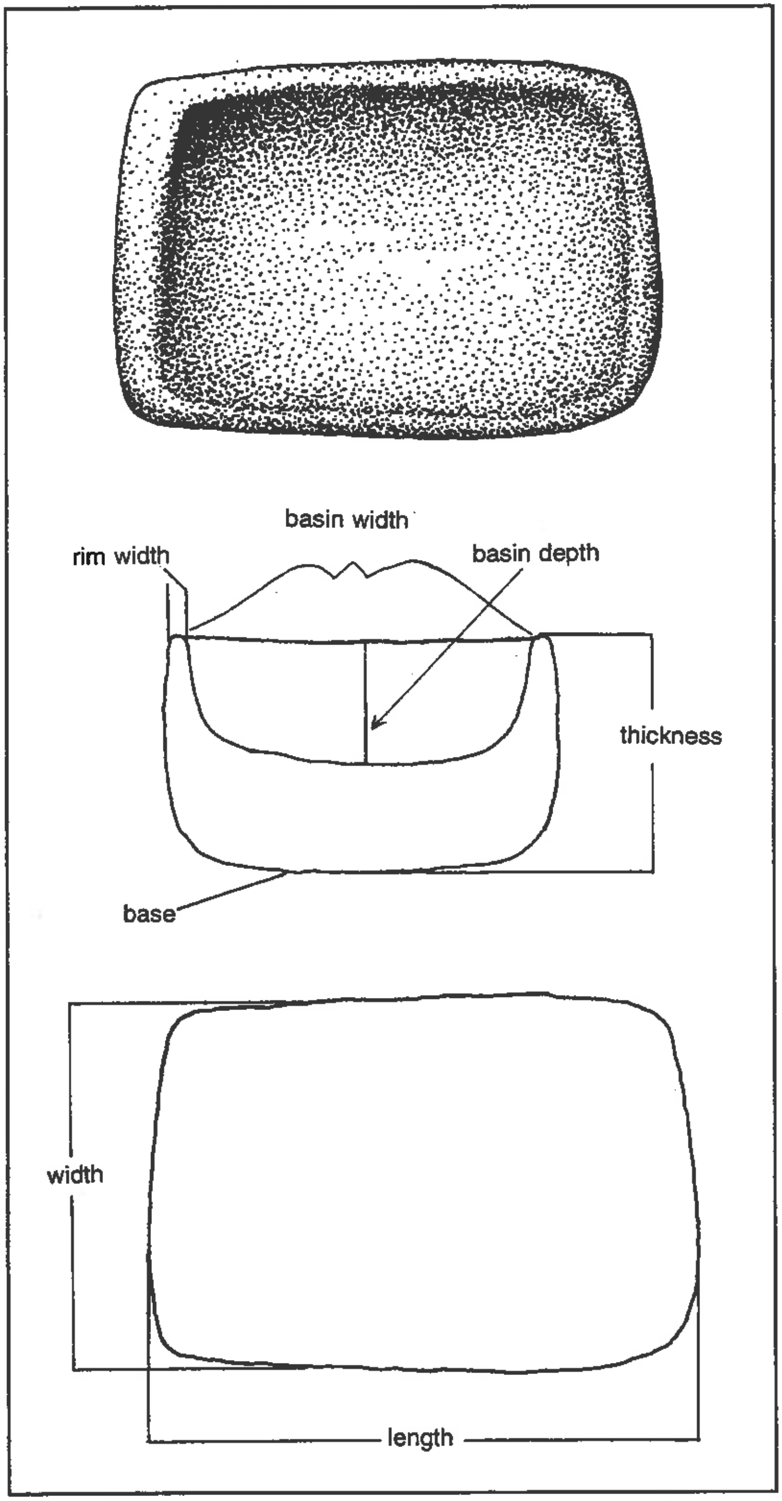

Figure 23. Rectangular mortar.

Research at the historic Hopi village of Walpi (Adams 1979:25-26) helped identify attributes of mortars used in food-processing activities and those of mortar-like tools employed in other activities. Some artifacts typed by archaeologists as mortars were identified by Hopi as eagle-

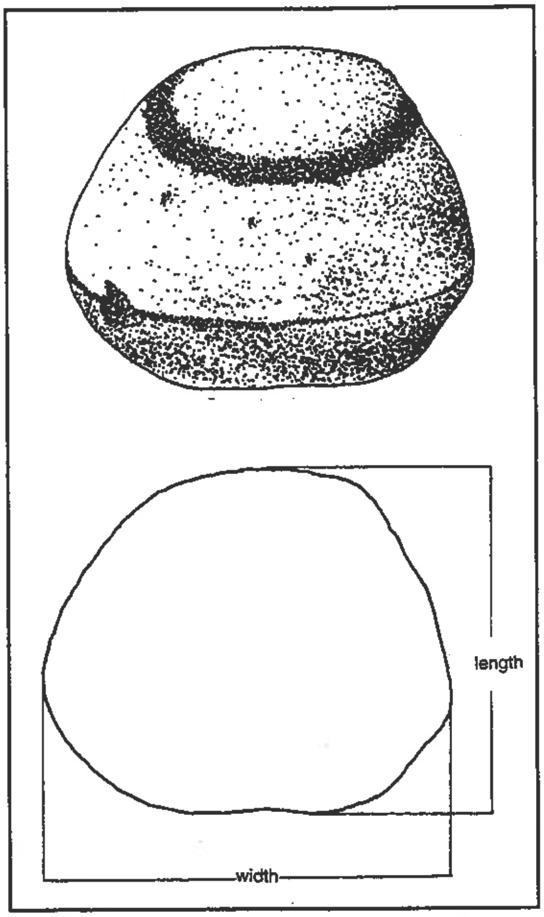

Figure 24. Natural shape.

watering bowls. The distinctive attributes of a watering bowl are a flat bottom, a square rim, and a broad, deep basin damaged only through manufacturing techniques (impact fractures and only minor abrasive scratches). However, mortars used in food processing have flat to rounded bottoms, variously shaped rims, and deep, conical basins with both impact fractures and numerous abrasive scratches caused by the pestle. Additional descriptions of food-processing mortars can be found in Euler and Dobyns (1983:259-262).

Natural stones were probably collected for their interesting natural shape and include concretions, fossils, meteorites, and crystals. For the most part, they have not been altered, although handling or moving them may have caused some wear (Figure 24). These are most often assigned some sort of ritual significance by archaeologists because they have been found in kivas, caches, and graves (Kidder 1932:104-110).

Netherstones are bottom stones against which something was worked. The category also includes artifacts that do not have specific attributes to classify them as metates or grinding slabs. Like lapstones, they have been damaged by abrasion, but they are larger–generally too large to hold. Ladd (1979:495) illustrates a Zuni man shaping a string of beads against a flat netherstone. In a generic sense, the term netherstone can be used to subsume all bottom stones against which something else was worked.

Ornaments include a wide variety of items: beads, pendants (including earrings), mosaic tesserae, nose plugs, bracelets, rings, figurines, crescents and other geometrics (Di Peso et al. 1974; Gladwin et al. 1938:126-130; Jernigan 1978; Judd 1954). The classification presented here is a simplified version of that used by Jernigan (1978) for ornaments of a variety of material. Jernigan also presents some attributes that might be specific to different prehistoric groups.

Beads are perforated with a suspension hole that extends approximately through the middle from side to side so that the edge or perimeter of the ornament is most visible when strung. *Disk beads* measure thinner than their circumference, while *barrel beads* measure thicker than their circumference. *Biconvex beads,* also called *lenticular beads,* are disk beads with curved rather than flat surfaces; *plano-convex* beads have one flat and one convex surface. *Tube beads,* like barrel beads, measure thicker than their circumference but they can be distinguished from barrel beads by their straight perimeter; barrel beads have a slightly convex perimeter. *Tear-drop* and *bilobe,* also called *figure 8 beads,* are a little different in that their hole is slightly off center, but they can be distinguished from pendants by the fact that the perimeter is most visible when strung. *Spool beads* have a constriction encircling the bead perimeter. *Cuboid beads* have a rectilinear rather than circular perimeter. The distinctions between categories are often a matter of degree, so various analysts might categorize minor variations differently. The main goal is to be consistent.

Buttons are small disk pieces drilled with one or more holes for attachment as a fastener. Those with one hole may be hard to distinguish from beads or pendants. For the most part, buttons have larger diameters than beads and more centrally located holes than pendants.

Figurines can be classified by whether they are two- or three-dimensional representations and according to what they represent: anthropomorphs, zoomorphs, or geometric shapes. In contemporary Native American groups, these items may be considered fetishes and have ritual significance.

Within both the bead and pendant categories, there are figurine types that can be either two- or three-dimensional. The positioning of the suspension hole, which determines how the piece hangs, is what distinguishes a *figurine bead* from a *figurine pendant* in the same manner as described above. The same is true for pieces that are of various geometric shapes: triangular, square, rectangular, etc.

Finger rings are small, complete rings that encircle a finger or toe. *Ring bracelets* are larger complete rings that encircle an arm. These are distinguished from *C-rings* and *C-bracelets*, which have an opening to facilitate hooking them over a nose, ear, or arm.

Mosaic tesserae are small, thin pieces of material cut into a variety of shapes and used to create a pattern of stone attached with a resin or tar to a thin backing of shell, wood, bone, or other material.

Pendants are perforated with a suspension hole located nearer one end than the other and are strung front to back so that a broad surface is most visible. Some larger tear-drop and bilobe beads may be indistinguishable from small pendants.

Plugs are manufactured in a variety of sizes and shapes and were placed through ears, cheeks, noses, and lips. Shapes range from cylindrical to spool.

Toggles are basically cylindrical in shape with an encircling groove for fastening the toggle. Toggles may be difficult to distinguish from plugs, but a rule of thumb is that plugs are more carefully shaped and of more valued material than toggles.

Palettes are thin, tabular pieces of stone that have been most frequently associated with Hohokam mortuary rituals (Haury 1976:288). As specialized lapstones, many are embellished with border decorations, (Figure 25) some have evidence of having been used with censers, and others have various minerals burned on them (Haury 1976:288; Hawley 1938, Appendix IV; Schroeder 1990). Others have depressions worn in them through use with a small, smooth handstone. These may have been used more like pigment-processing lapstones (see definition p. 21). A chronological sequence for palettes has been developed, suggesting the elaborateness of decoration reached a peak in the Colonial and Sedentary periods (Haury 1976:286). Dean's (1991:82-83) reassessment of Hohokam dating would place this sequence during the Gila Butte and Santa Cruz phases.

Pecking stones are handstones that have been used to alter other items through impact, resulting in fractures on both surfaces. These stones could have been used in the shaping of manos, metates, and other large objects, or in renovating grinding surfaces by re-roughening them as

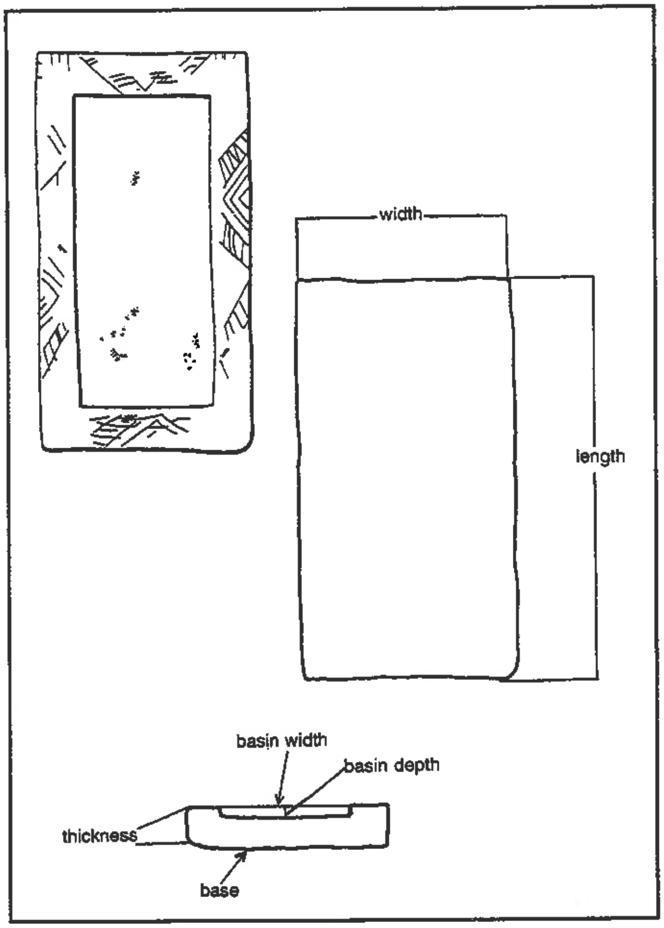

Figure 25. Palette.

they became worn smooth. Pecking stones are distinguished from hammerstones by the nature of the use-wear damage. Hammerstones are used with more forceful blows, creating large impact fractures and dislodging chips. The force used with pecking stones is enough to create an even distribution of similarly sized impact fractures.

Pestles are handstones used to crush, or to crush and grind. They might have been worked in stone or wooden mortars to crush food or nonfood substances (see mortars, p. 26). Use-wear damage patterns include impact fractures, chips, and abrasion. An ethnographic report of a Maricopa woman using a stone pestle to crush chunks of pottery clay on a blanket (Sayles and Sayles 1948:29) should make us more carefully assess the damage patterns on archaeological pestles and not assume that all pestles were used in mortars. The location of the damage helps identify whether the pestle was used in the basin of a mortar or against a flat surface. Those used on flat surfaces, such as the ground, have wear concentrated on the flattest part of the end, while those used in curved mortar basins have wear covering the convex end and for some distance up the sides. The nature of the damage also reflects the type of stroke used with the pestle. Small evenly spaced impact fractures are created when the weight of the stone supplies most of the force used to crush intermediate substances. Deep impact fractures and chips reflect the use of additional force, such as that supplied by muscles or plunging the pestle down from some distance above the surface.

Pestles vary in the complexity of their design. Some are of expedient design, where appropriately sized pebbles or cobbles were selected and used without further modification. Others are of strategic design, with finger grips or notches for holding, or are carefully shaped by pecking and grinding techniques. One carefully shaped pestle subtype has been called *tooth pestles* because of their resemblance to teeth (Figure 26). The broad distal end was used against the mortar. The narrower end on some is grooved, some have holes, and some have both. The groove and the hole may be attributed to a design for secondary use as an abrader or straightener.

Among the pestles found in the Tonto and Roosevelt basins are a few that also have surfaces used for grinding (Adams 1997). These multiple-use pestles may have been involved in processing in various ways. One activity may have used the pestle in a crushing motion, while a separate activity involved the tool in a grinding motion, similar to a handstone. The separate crushing and grinding motions may have been two steps in the same processing activity. An example of the first might be a pestle used to crush mesquite pots in a bedrock mortar and in an unrelated activity to grind pigment against a netherstone. The remnants of pigment on only the grinding surface would be one clue that the pestle was used in two different processing activities. An example of the second use might be a pestle used to crush mesquite seeds in a mortar, and then another surface used to grind the mesquite flour against a netherstone.

Pikistones are carefully selected and prepared slabs upon which piki is cooked (Adams 1979:23-24; O'Kane 1950:40-46; Woodbury 1954:176-177). Piki is a multiple-layered roll of paper-thin corn "tortillas." Ethnographic accounts of pikistone manufacture and use indicate that the quarries for pikistone material are few, guarded, and require ritualized methods for procuring new material (Woodbury 1954:177). Once the proper material is procured, there is a long period of preparation with grinding and oiling to create a surface smooth enough to prevent sticking of the piki batter to the stone (Adams 1979:23; O'Kane 1950:40-46). Modern pikistones are fairly thick, 3 to 6 cm, but repeated heating and cooling causes them to become friable, with pieces breaking off the side closest to the fire. Sometimes the only part recovered from archaeological contexts is the oil-saturated surface.

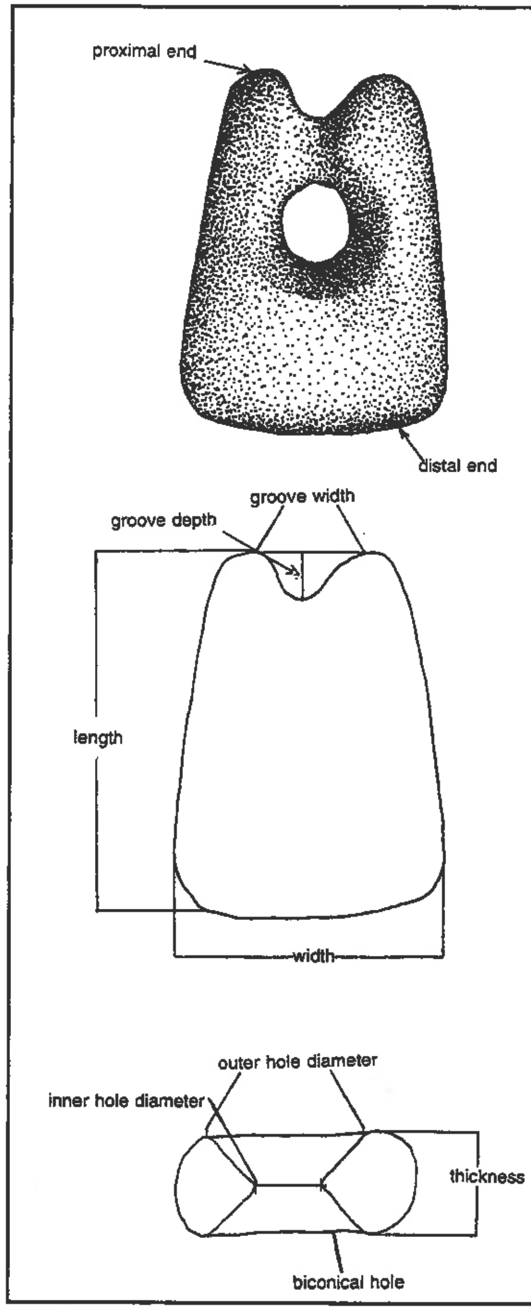

Figure 26. "Tooth" pestle.

Pikistones can be distinguished from griddles by the formal preparation of the surface. Frequently, the oil penetration of a prepared pikistone is visible 2 to 7 mm into the profile of the stone. Whole griddles also tend to be thinner than whole pikistones.

Pipes or tubes are cylindrical or conical-shaped tubes used for smoking tobacco or creating smoke (Woodbury 1954:174-175). Some tubes do not have smoke-blackening in the bore, and they may have been used for something else, but for the most part, they are of the same size and configuration as those that do have smoke-blackening. Pipes and tubes can be categorized by their general shape and the configuration of their holes. These differences are related primarily to manufacturing techniques. For example, some are manufactured with a socket for the attachment of a stem. Certain elaborate pipe designs called "elbow- pipes" have been recovered from Pecos Pueblo and may have been influenced by pipes from more easterly native groups (Kidder 1932:85). Ethnographic accounts of pipe smoking describe men socially sharing the pipe or blowing smoke over objects or people in ritual observances (Stephen 1936:683). Pipes are also components of certain Hopi altars (Hough 1915:137).

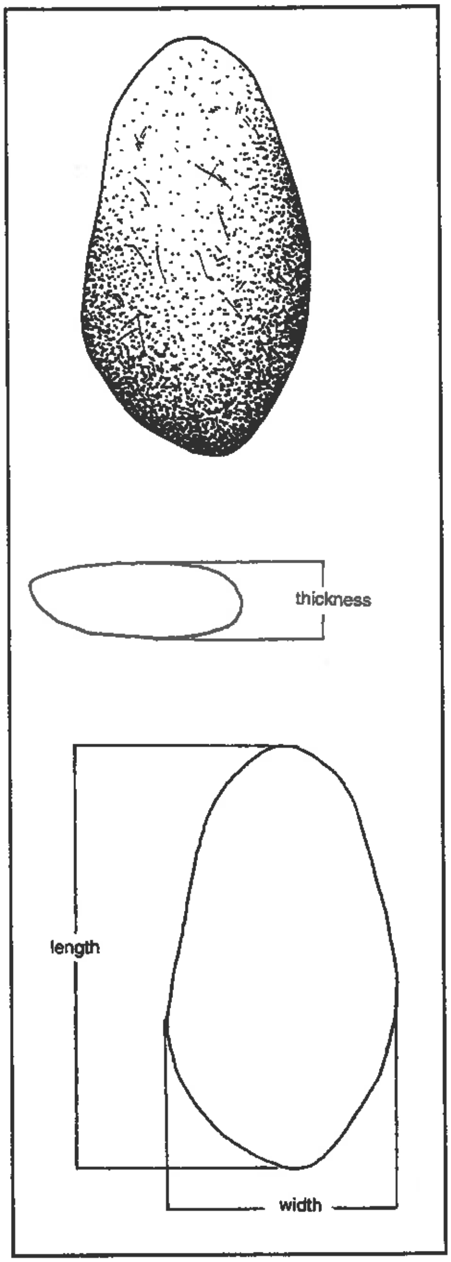

Figure 27. Polishing stone.

Planes are tools with angled working edges employed to scrape something pliable, most probably wood. These are distinguished from chisels and abraders by the configuration of the working surfaces and by performance. A plane smooths a surface through pressure, whereas a chisel cuts into a surface through impact. The damage to the working edge of a plane is from abrasion; the working edge of a chisel is damaged from chipping. Both planes and abraders smooth surfaces; however, the smoothing done with a plane uses an edge, while an abrader uses a flat surface.

Plugs, caps, and pot lids are pieces of stone strategically designed to seal the narrow opening of containers, such as canteens or gourd "bottles." Plugs are more or less cylindrical and fit wholly within the diameter of the container's neck (Adams 1994a:142), while caps are plugs with wide tops that rest on the rim of the container's neck. Pot lids are thin slabs of stone that rest on the tops of ceramic vessels (Kidder 1932:75, called pot covers; Woodbury 1954:179, called jar lids). Pot lids can be distinguished from plugs and caps because they are flat and do not extend into the neck of the vessel. Sometimes pot lids are of expedient design in that appropriately sized pieces may be available, and they do not need further modification. Most are chipped and ground a little to shape. Plugs and caps are of strategic design, being pecked and ground to the appropriate configuration for sealing containers.

Plummets are of strategic design since they are pecked and ground to a conical shape, and grooved, notched or perforated for suspension. These are thought to have been used as architectural instruments in the laying out of villages (Di Peso et al. 1974:237) and perhaps in aligning canals.

Polishing stones are defined here as handstones of a smooth surface texture involved in the final stages of the manufacturing or production of other items (Figure 27). The texture of a polishing stone alters the surfaces of other objects by creating a smooth and frequently shiny surface (Adams 1993b). Polishing stones have been identified with the manufacture of pottery, wood, or bone items, as well as the application of plaster to walls and floors (Adams 1979:51; Woodbury 1954:93).

Ethnographic accounts of puebloan (Dillingham 1992:10; Simpson 1953:75; Stanislawski 1978:217) and non-puebloan (Spier 1933:107) groups document that pottery production was women's work. The teaching frameworks employed may have varied slightly, but generally, women taught their relatives and perhaps their neighbors how to make pottery (Stanislawski 1978:219). Their instructions included the proper selection of raw material to make the pottery, as well as the proper use of tools for finishing. Pottery-polishing stones are generally pebbles selected for their smooth texture; therefore, they are of expedient design. River pebbles were commonly chosen because of their roundness and a lack of texture that would have caused abrasive scratches on the pottery (Adams 1979:49-51). However, things other than pottery also might have been polished with river pebbles. Experiments conducted with river pebbles indicate that the polishing of wood and bone surfaces produces use-wear patterns distinctive from those produced by polishing stone and pottery surfaces (Adams 1994a:119).

Floor polishers can be distinguished from other polishing stones by their size and shape (Figure 28). They are more often strategically designed than other polishing stones, being pecked and ground to a disk shape with opposing flat surfaces (Adams 1979:51; Kidder 1932:64; Woodbury 1954:90). If a naturally shaped stone was suitable for use as a floor polisher, no manufacturing was done. Artifacts specifically identified as floor polishers by the Hopi were distinguished by a pecked area in the center of the flat polishing surface (Adams 1979:51). These stones were used in the application and finishing of plaster to both walls and floors in Hopi structures (Adams 1979:52).

Reamers have projections that were used in a rotary motion to shape holes in other artifacts. Most were involved in shell working and were used to shape bracelets or rings, depending on the diameter of the projection (Haury 1976:284).

Shaped stones are pieces of stone ground into specific abstract shapes, but it is not possible to explain why. They have been altered only through manufacturing. If there is any use or wear, it is from handling.

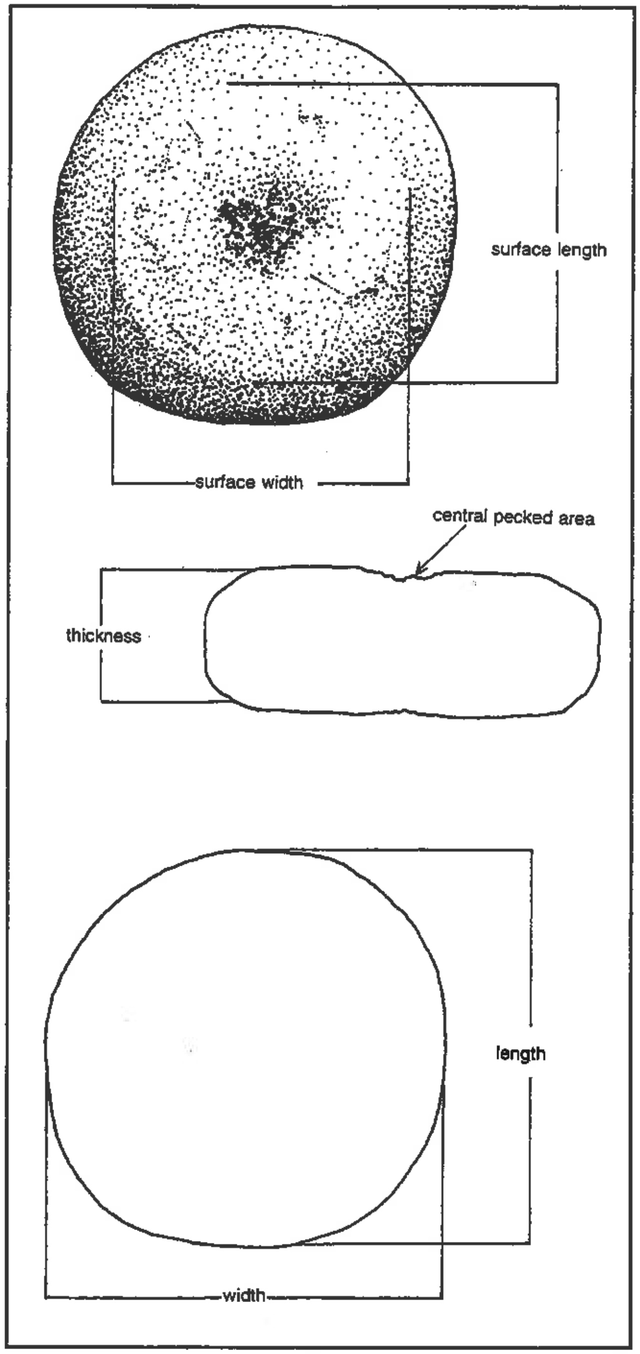

Figure 28. Floor polisher.

Some ground stone artifacts are tabular but are not tools or architectural pieces. They are abraded, but it is unclear whether this is from use or occurred during manufacture. These are typed as *slabs*.

Roasting or heating stones are often distinguished by their fragmentary, heat-cracked, or burned condition. Ground stone artifacts of all types have been recycled into pits, along with unaltered rocks for use in cooking and heating events.

Spindle bases are the netherstones used with spindle whorls (Di Peso et al. 1974:138). They provide a firm surface, sometimes a depression, in which to place the spindle, and that confines but does not restrict the movement of rotating spindles.

Tabular tools are thin, tabular pieces of stone of varying sizes, with one or more edges used in cutting, scraping, slicing, or chopping motions. The tools vary from being basically unmodified (if a sharp edge occurs naturally) to those with carefully prepared edges and areas for holding the tool. Archaeologists most often associate tabular tools with agave production (Bernard-Shaw 1990:190; Castetter and Bell 1937; Greenwald 1988:173-186), but other uses may include the working of wood, bone, or hide (Adams 1994b).

ANALYSIS STRATEGY

Data Collection

An analysis of ground stone artifacts can be conducted on at least two levels. The first is an inventory where every artifact is counted, typed, assessed for completeness, and perhaps identified by material type. Such an accounting is useful for preliminary reports that describe what was found. The next, more intensive level of analysis incorporates more detail, including measurements and assessments of attributes that identify design and manufacture, primary and secondary uses, use-wear, and archaeological context.

Measurements should be taken in the same manner on each artifact. When possible, a tool should be oriented according to how it was held. The edge closest to the user is the proximal edge, and the one most distant is the distal edge. (See the illustrations accompanying the artifact type descriptions, which provide standardized locations for taking measurements and the terms used to describe specific attributes.) Examples of coding sheets, attribute explanations, and recording forms are in the appendices. The numbers assigned to each of the attributes on the coding sheets are arbitrary and can be changed. It is best, however, to maintain the same codes so that comparisons can be made across assemblages from different projects. This recording system was devised so that new attributes can be added and assigned a unique number as they are discovered. Once the attributes for each artifact have been recorded, it is possible to create data sets that will help address the research questions asked previously.

Answering Research Questions about Food Processing

To answer questions about how grinding technology was used in obtaining and processing food, the data on manos and metates, mortars and pestles, hoes, and perhaps axes can be evaluated in a number of ways. The presence of hoes and axes with use-wear damage from working in the soil is evidence of farming activities. Particularly with axes, however, a use-wear analysis is required to distinguish farming from wood-cutting activities. Assemblages that have both manos and metates, and food processing mortars and pestles, may represent the processing of a variety of food resources. However, some ethnographic accounts suggest that both tool sets were being used in the processing of mesquite pods, with the mortar and pestle used in the first stages of crushing the pods and separating the seeds, and the mano and metate used in the final stages of grinding the pods and sometimes the roasted seeds (Castetter and Bell 1951:179; Spier 1933:51). The caveat here is that even the variety of tools involved in processing food items does not adequately reflect the variety of food resources processed. More than one tool type might have been involved in processing the same food, or more than one food may have been processed with the same tool. For example, pollen samples taken from prehistoric metates record the processing of a variety of wild foods in addition to corn (Greenwald 1993:438-439; Lancaster 1984:257).

An analysis of the types of manos and metates in an assemblage will determine the most common tool design. Similarities and differences between the predominate mano and metate designs can help determine if artifacts are missing from an archaeological assemblage. For example, a recent analysis of manos and metates from the Santa Cruz Bend site determined that the most common metate type recovered was basin; however, most of the manos had been used on flat/concave metates and only one or two in basin metates (Adams, 1996a). Thus, it was interpreted that most of the flat/concave metates either had been removed from the site at the time of abandonment, or perhaps scavenged sometime after abandonment. The basin metates left behind may represent obsolete tools. In this case, the metate assemblage alone provides little information about food-processing activities at Santa Cruz Bend.

An assessment of artifact attributes may provide information on tool efficiency and intensity of use. Grinding efficiency is the amount of effort expended at the grinding task and is measured by output of grain product per unit of time. Improved grinding efficiency (a definite technological advantage) results from designing and manufacturing larger tools (Hard 1990:137; Mauldin 1993:319; Plog 1974:140). However, the size of tools is limited by human strength and endurance, as well as by the availability of appropriately sized raw materials.

Intensity is measured by the amount of continuous time spent at each grinding task. For example, equipment manipulated four hours a day has been more intensely used than that manipulated only one hour a day for four days. Increased intensity does not require larger tools, but limitations of human strength and endurance and material resistance to wear might govern tool design. Knowing these limitations, designers could select wear-resistant material of appropriate size and perhaps develop techniques to manage wear. Grinding intensity has implications for specialization and the social networks of food processing (Adams 1993a). For example, when Puebloan women spent four or more hours a day grinding corn, they did it in a setting where several women could work together at multiple grinding stations (Hough 1915:62-63; Stephen 1936:153-154). These women were related in various ways, and their products were distributed according to their relationships.

Improving grinding efficiency and increasing grinding intensity have distinct purposes and results:

> (1) Improved efficiency means less time spent grinding to feed the **same number of people** the **same amount of grain**. This implies that the grinder would have more free time to participate in other activities.
>
> (2) Improved efficiency could also mean the **same amount** of time spent grinding to **feed more people,** or to **increase the amount of grain** in the diet.
>
> (3) Increased **intensity** means **more time** spent at the grinding task either to **feed more people** or to **increase the amount of grain** in the diet.

Data on the presence of finger grooves, or shaping of the mano for comfortable holding, may indicate that the mano was intended for intensive use, especially when compared to one lacking designed "comfort features." Comparisons based on the presence or absence of mano comfort features may add support to conclusions made at the site level about the duration or type of occupation. Combined with an analysis of the number of used surfaces on manos and the degree of wear, an argument can be developed for how intensely particular mano assemblages were used. At the site level, evidence for intensity of use might indicate occupation duration or type, degree of reliance on ground resources, or even specialization in food production. For example, a site with lots of manos strategically designed with comfort features with multiple surfaces and heavy wear may have been occupied over a longer period of time than a site with expediently designed manos, with single surfaces and light wear. Alternatively, at the first site, there may have been fewer grinders who used their tools more intensely to feed the same number of people as at the second site, where people were simply being serviced by more grinders. Thus, the grinders at the first site would have used their manos during grinding tasks of longer durations and may have been more concerned with wear management than the grinders at the second site.

Measuring grinding surface area, counting the number of used surfaces, and assessing the amount of wear will provide data useful for making statements about relative amounts of grinding activities. It will not, however, directly inform on what specifically was being ground. For that interpretation, analyses of pollen and residue are needed. If such samples are not directly available from ground stone, macrobotanical studies can provide a range of possible foodstuffs that might have been ground. The above examples are but a few possible approaches to data analysis that can be taken with a technological analysis to ground stone studies.

Answering Questions about Other Processing Activities

Many kinds of ground stone artifacts can be used to understand the role of grinding technology in aspects of prehistoric life other than food production. Certain polishing stones and pottery anvils can help us analyze prehistoric pottery production. Use-wear damage patterns on pottery polishing stones provide evidence for intensity of use and the nature of the finished pot. Wear facets are created only through a repetitive use. Abrasive scratches are created by rocky temper, and lustrous sheen through contact with smooth pottery surfaces. Polishing stones with damage created through contact with more pliable, or oily, surfaces may provide evidence for use in shaping wood or bone artifacts.

Abraders of varying textures and surface configurations can be used to infer the shaping of shaft tools, or flat wooden or bone tools used in weaving textiles or baskets. Artifacts that have been shaped but are not functional might indicate behaviors not related to work activities. Even more than their form, where these artifacts were found in the archaeological record may help with the interpretation of their use.

One of the most interesting aspects of a technological analysis of ground stone is the ability to recognize that some artifacts were used in more than one activity. Secondary use may provide yet another mechanism for discussing site occupation duration and type. For example, if a large percentage of the ground stone artifacts from a particular site had sequential secondary use, it could be argued that abandoned tools served as "raw material" for the manufacture of different tools for use in other activities. This would probably be most likely to happen if the designer of the second tool was someone other than the maker and user of the first. This scenario might apply to sites that were reoccupied, so that the new or returning inhabitants scavenged the leavings of the former occupants; or at a large village, occupants of one area may have scavenged the abandoned areas for usable materials. Thus, sequential secondary use of artifacts may be evidence of reoccupation of some sites and long-term occupation of others.

On the other hand, if a large percentage of the ground stone assemblage from a particular site had concomitant secondary use, it could be argued that individual tools were used interchangeably in a variety of tasks. This could have been in an effort to conserve scarce raw material, to conserve the energy required in making an entirely new tool, or to limit the number of tools requiring storage space. The last reason would seem most plausible if the maker and user were the same person, and the tool was still needed in all of the tasks for which it was designed. This scenario might apply to sites occupied for long periods of time, where material sources may have been some distance from the site, access may have been restricted, or storage space may have been limited.

Answering Questions about Group Identification

A technological analysis of ground stone artifacts allows us to discuss concepts such as design, and the transmission of the knowledge needed to manufacture and use tools of a particular design. For this reason, it is possible to recognize that certain attributes, such as axe hafting grooves, or bead suspension holes, are design-specific. Different designs are related to knowledge about different techniques for attaching handles or making holes. For example, at Turkey Creek Pueblo, the axe assemblage is dominated by ¾-grooved axes, which are found most commonly in southern Arizona and are associated with the Hohokam. However, full-grooved axes were also found, and this design is common to the Anasazi of the Four Corners region. The most interesting axes are those that were originally ¾-grooved but were regrooved with full grooves, or were originally full-grooved and were regrooved with ¾ grooves (Adams 1994a:124-137). These axes demonstrate how the original designer used knowledge specific to a particular tradition, but later someone with knowledge of a different tradition altered the design.

The configuration of suspension holes in beads and pendants provides information on how they were manufactured and may have some significance for identifying artisans. Basically, there are three types of holes: conical, biconical and cylindrical. Conical holes were drilled by a stone drill-point with a large body diameter that tapers to a narrower tip. Thus, as the drill works through the stone ornament, it leaves a conical hole bigger on the surface where the drilling began and smaller on the side where it ended. A biconical hole is created with the same tool, but during the drilling process, the bead is flipped so that a connecting hole is started on both sides of the bead. This leaves an interior hole diameter and a larger exterior diameter. The resultant interior ridge is an excellent place to see use-wear created by stringing. A cylindrical hole may also have been drilled with the same type of stone drill bit used to create conical and biconical holes, but a second step then enlarged the hole to a uniform diameter. Haury (1931:85-86) suggests that cactus spines would be useful instruments for making or enhancing cylindrical holes. Because there seems to be no particular functional difference, the selection of hole-manufacturing technique may be merely a matter of artisan preference. Before this determination can be made, more research should be done comparing hole-drilling techniques of various bead and pendant types to see if they correlate with material types or distribution patterns.

Research on beads of similar metamorphic material in the Roosevelt Basin recognized a pattern in the distribution of holes drilled from only one side of the bead and holes drilled from both sides (Adams 1995:125). Among the 13 cremated remains recovered from the Meddler Point site were nine with numerous stone beads. Of these nine, four had beads with holes drilled only from one side, and two had beads drilled from both sides. Three cremations had beads drilled with both techniques: one had disk beads all drilled from one side and tube beads drilled from both sides; the second had five disk beads, with four drilled from both sides and one drilled from one side; and the third had eight disk beads, with seven drilled from both sides and one drilled from one side. These different drilling techniques might reflect one of several scenarios. The first situation may be an example of different drilling techniques being specific to bead type. The tube beads may have been too thick for the drill to make a hole completely through the bead, and so it was necessary to work from both sides. The second and third situations may be examples of different artisans at work. If the composite necklaces or bracelets to which these beads belonged were repaired or restrung by a different artisan, beads with different drilling techniques might have been incorporated. However, there is also the possibility that the beads recovered from these cremations were not from necklaces or bracelets belonging to the deceased, but were introduced into the cremation as offerings, as suggested by Di Peso et al. (1974:239) for cremations at Casas Grandes.

The above example of axe-hafting techniques at Turkey Creek Pueblo provides an opportunity to discuss the possibility of people from different ethnic traditions occupying the same site at some point in time. Few other ground stone tools have distinctive design attributes that seem to vary regionally across the United States Southwest. However, another possibility exists with metates. Truly flat metates seem to be predominant in the northern areas of the United States Southwest, where prehistoric people referred to as Anasazi lived. Perhaps as early as A.D. 900, trough metates were replaced by flat metates and positioned in slab-lined bins. Mano configuration changes were a response to the changes in metate design. The flat metate/bin configuration was not common in the southern regions of the United States Southwest, which were associated with Hohokam occupation.

Ethnographic accounts of pueblo and non-pueblo groups provide interesting comparisons for studying technological traditions. Accounts of non-pueblo groups, such as the Pima and Papago, illustrate women using free-standing mano/metate equipment outside their houses (Fontana 1983:Fig. 6; Spier 1933:Pl. III). In each account, one woman did the grinding; if another woman was involved, she attended to some other preparation task. Women who prepared foods together took turns grinding with the same equipment (Underhill 1979:67). Illustrations of historic Hopi and Zuni habitation rooms show multiple slab-lined bins as permanent fixtures (Bartlett 1933:Figure 7; Ladd 1979:Fig. 3; Mindeleff 1891:Figures 101, 105). Pueblo women frequently ground in groups of two or three and often worked in rhythm to singing or flute music supplied by a male visitor (Hough 1915:62-63; Kidder 1932:67, quoting Castaneda; Stephen 1936:153-154, 882).

Food preparation was the responsibility of women, with a few exceptions, such as Maricopa men who cooked the small game and fish they procured (Spier 1933:77, 80). Such foods, however, did not involve grinding, and according to a Papago account, it looked bad for a man to grind food (Underhill 1979:64). Thus, the pattern was consistent among both pueblo and non-pueblo groups: grinding was the main responsibility of women. Young girls learned the art of grinding from their mothers, and they had to demonstrate their expertise to prospective husbands and mothers-in-law (Hough 1915:62-63; Spier 1933:79; Underhill 1979:35). In preparation for marriage, Hopi women performed a grinding ceremony as part of the courtship ritual (Simpson 1953:39).

It should also be noted that there was a difference between pueblo and non-pueblo groups in the network of ground food distribution. In non-pueblo groups, the women ground on a daily basis for their households and any visitors. Small amounts of stored meal may have filled an extra pot or two (Spier 1933:52), and extra meal may have been taken to festivals or large gatherings (Underhill 1979:82), but this extra was mostly for personal consumption. Pueblo women, on the other hand, ground massive amounts of meal, beyond their daily household needs, for consumption by a large network of people (Hough 1915:70). Large quantities of food were consumed at various occasions: feasting activities accompanying marriages and ceremonies (Hough 1915:95; Simpson 1953:39); the feeding of public performers, such as Katsinas, or social dancers (Stephen 1936:134, 589); and the feeding of those watching the public performances (Stephen 1936:17-19, 369, 505; Titiev 1972:216).

Answering Questions about Individuals

On a more individual level, manos and metates provide a unique opportunity to understand behavior learned within the framework of culturally derived technological traditions. Based on her observations of Hopi women, Bartlett (1933:15) provides a fairly detailed discussion of two types of grinding strokes using a two-hand mano against a flat metate. Both strokes are used against a metate that is tilted down and away from the grinder. With the first stroke, the grinder exerts pressure on the proximal (nearest) edge of the mano on the downward part of the stroke, while holding the distal (farthest) edge of the mano away from the metate surface. On the upward stroke, the grinder rocks the mano forward so that the distal edge is held against the metate and the proximal edge is lifted up, carrying grain back to the top of the metate (Figure 3). This movement creates more pressure, and thus more wear, on the proximal edge, which eventually becomes thinner than the distal edge. To counteract this uneven wearing, the grinder rotates the mano so that the distal edge becomes the proximal edge. Eventually two adjacent surfaces are created, forming a triangular profile. This provides the grinder with a raised edge that keeps the fingers from coming into contact with the metate surface as the mano becomes thinner.

The second type of stroke maintains the mano flat against the metate surface. Because the mano is not rocked, the pressure exerted by the back of the hand wears down the proximal part of the mano only, creating a wedge-shaped profile. By rotating the mano so that the distal edge becomes proximal, the wear becomes balanced, and a single flat surface is maintained. Eventually the mano becomes so thin that the fingers are subject to grinding, and the mano is essentially "worn out." However, even if the grinder did not use the strokes described by Bartlett, wear management might have been practiced simply by flipping the mano over and using the opposite side, creating two opposite grinding surfaces. Flipping to the opposite surface would need to have been done regularly to maintain surface compatibility with the metate. While this would not counter the thinning of the mano as does the creation of two adjacent surfaces, it does provide a second surface to use when the first one has become smooth and needs roughening.

What is important in Bartlett's (1933) description of grinding motor habits is the grinder's awareness of the effects of wear and the development of a wear-management technique to prolong mano use-life. A grinder might want to manage wear for several reasons. A particular mano might be more comfortable to hold, or raw materials might be scarce. It might be more desirable to prolong mano use-life rather than expend the energy to procure new material, manufacture a new tool, and break in that tool until it is compatible with an existing metate. Thus, it can be argued that wear management is a skill learned by an individual within a tradition-bound framework. Ground stone artifacts in general, and manos and metates specifically, are the basic tools used in the everyday production of food and other items. The challenge for the ground stone analyst is to discover those attributes that most accurately reflect the technological traditions of the people who used them.

CONCLUSION

Ultimately, an analysis strategy should be selected to maximize the information obtainable from a specific collection. Not all ground stone assemblages are created equal. For example, at the Early Agricultural site of Santa Cruz Bend, where there were many more manos of different designs than there were metates, it was not possible to determine much about the food-processing activities by looking only at manos or metates (Adams, 1996a). Most of the recovered metates were of basin design and were found in exterior pits. However, most of the manos had been used in flat/concave metates and were found on pithouse floors or in pits in the floors, suggesting that most of the metates had either been removed or were located in an unexcavated portion of the site. While we may not have learned a great deal about food processing with this assemblage, it is possible to understand some nonfood-processing activities because of the quantity of pigment-processing tools. In contrast, the assemblage from a Pueblo site near Point of Pines (W:10:51) had an extensive floor assemblage of metates in bins and assorted manos scattered across the floors of several structures. From this assemblage, we can learn a great deal about food processing but very little about nonfood-processing activities. To minimize speculation, analysis of each ground stone assemblage must be tailored so that specific questions can be reasonably answered with the data available.

This manual is intended to serve as an introduction to the analysis of ground stone, a large class comprised of many artifacts used to perform a wide range of activities. Many types and subtypes have not even been mentioned. A technological approach to ground stone analysis allows for growth and development of analysis techniques as our understanding of how prehistoric tools were used increases. We are not limited by the constraints of "form equals function." Rather, we can record and study attributes that relate to design, manufacture, and primary and secondary uses, and we can incorporate archaeological context into the interpretive process. This will allow for a clearer understanding of prehistoric behaviors.

GENERAL ARTIFACT FORM

ARTIFACT ATTRIBUTE EXPLANATIONS

Every artifact should be recorded on this form.

Artifact types (Art Type) and *subtypes* (Sub Type) can be discerned using the descriptions in the manual.

Artifact condition (Condt) is straightforward. An artifact is considered whole even if it has been chipped. If the artifact is broken but the measurements for the whole artifact can still be obtained, it can be treated as a whole artifact in summary descriptions. If fragments can be rejoined, they are counted as a single artifact.

Shape describes the artifact plan-view outline. It is most useful for remembering specific artifacts and has no analytical value.

Texture can be standardized so that material with grains of less than 1 mm are considered fine, 1-2 mm are medium, 2-4 mm are coarse, and larger than 4 mm are conglomerate. Material without macroscopically visible grains has no texture. Small vesicles are less than 2 mm; large are greater than 2 mm.

A *burned artifact* (Burn) may be detected by a color change created by oxidation, smoke blackening, or the presence of carbonized residue. A heat-cracked artifact may not be easy to identify without oxidation or blackening.

Manufacturing (Manuf) is an attempt to record the location and nature of damage created by manufacturing techniques. Categories can be added as needed. The purpose is to get the analyst to thoroughly examine the artifact and decide if it is of expedient or strategic design. If the only manufacturing damage is on the use surface, the artifact is considered to be of expedient design.

Use categories are defined elsewhere in this manual.

Second use (Scnd) records the artifact code for the second use of the artifact.

Number of used surfaces (Num Surf) keeps track of the location and orientation of used surfaces. This is not applicable to all artifact types.

Processing type (Proc Type) is an interpretation of how the artifact was probably used. Sometimes the attributes recorded on the other sheets need to be evaluated before this interpretation can be made.

Measurements (Length and Width) are always taken in the same way. Many of the illustrations in the manual show the best places to take artifact measurements.

Surface position (Surf Pos) is something that must be recorded in the field. The excavator must mark the surface resting against the floor. This information can help determine if the floor artifacts were recovered in use, storage, or discard contexts.

Sequence (Seq) refers to the nature of secondary use, which is defined in the manual.

Comments should be written about each artifact as these coding forms are incapable of covering all possibilities.

Table A.1. is an example of a general artifact form, and Table A.2. lists the codes used on the form.

Table A.1. Ground stone analysis form for general artifacts.

Date 9 / 15 / 1996

ASM # SITE U:3:276/ 1/1

Feature Number	Provenience/ Bag	Art Type	Sub Type	Condt	Shape	Texture	Burn	Manuf	Use	Scnd	Num Surf	Proc Type	Length	Width	Thick	Surf Pos	Seq	Com- ments
4	3060.02	20	82	1	11	11	1	4	3	9	2	4	13.7	6.6	4.5	3	2	1
4	3055.02	5	34	5	3	11	6	3	1	0	6	2	8.8	5.2	4.1	3	3	1
41	6272.04	2	2	1	17	4	1	14	4	2	1	1	17.2	10.2	4.3	3	1	1
26	6069.04	1	4	1	12	7	1	12	6	0	8	7	11.3	9.7	8.1	3	5	1
22	3178.01	15	55	1	1	4	1	1	1	0	2	3	18.2	9.5	7.1	1	3	1
49	5299.02	12	51	1	3	7	5	4	7	0	1	1	47.5	32.3	14.2	3	3	1
3	270.07	6	200	1	16	11	5	16	3	5	9	3	23.4	7.1	0.7	3	2	1
60	4380.07	2	1	1	19	4	1	5	1	0	2	1	10.4	9.6	6.9	6	3	1
389	581.03	49	171	4	1	11	1	3	4	0	7	5	3.5	1.0	0.3	3	3	1
1002	103.03	46	104	1	6	4	9	7	1	0	7	5	10.4	3.4	3.4	3	1	3

Table A.2. Coding numbers for general artifact form.

COLUMN

FEATURE NUMBER

PROVENIENCE/BAG NUMBER (Unique Artifact Number)

ARTIFACT TYPE (Art Type)

Handstones

5. abrader
81. hammerstone
1. handstone
2. mano
80. mano/metate
9. pecking stone
3. pestle
61. plane
4. polishing stone
8. pottery anvil
82. pulping stone
60. reamer
6. tabular tool

Netherstones

16. anvil
11. grinding slab
15. lapstone
12. metate
13. mortar
10. netherstone
14. palette
17. unidentified

Composite Tools

20. axe
22. hoe
21. maul
23. whorl/axe

Containers

30. bowl
31. censer
32. tray
34. vessel

Shaped Items

51. architectural
123. awl/pin
48. ball
121. disk
56. fergolith/crush
50. figurine
52. geometric
41. griddle
54. grooved stone
43. loomblock
44. medicine stone
98. natural shape
99. not an artifact
124. offering
49. ornament
55. pigment source
42. pikistone
46. pipe
45. plummets
120. pot lid
100. roasting rock
122. shaped
40. slab
47. tube
75. unidentified

COLUMN

SUBTYPE (Sub Type)

Abrader

30.	flat	31.	single V	32.	single U
33.	multiple V	34.	multiple U	35.	both 1V& 1U
36.	flat & single V	37.	flat & single U	38.	flat & multiple V
39.	flat & multiple U	40.	flat & both V & U		

Architectural

152.	bin stone	154.	lintel	155.	threshold
150.	building stone	153.	ring		
151.	hearth stone	156.	splash stone		

Awl

43.	flat	42.	needle (no head)
45.	indeterminate	41.	pin (headed)

Axe/Maul

87.	blank	85.	regrooved	89.	3/4-double bit
81.	full groove	84.	spiral groove	83.	5/8 groove
86.	incomplete groove	82.	3/4 groove		
80.	notched	88.	3/4 and wedge groove		

Ball

120.	spherical	121.	1 flat side
123.	irregular	122.	2 flat sides

Bowl

90.	plain-flat bottom	91.	plain-round bottom	92.	effigy-flat bottom
93.	effigy-round bottom	94.	shaped-flat bottom	95.	shaped-round bottom
96.	incised-flat bottom	97.	incised-round bottom	98.	tray-plain
99.	tray-bifurcate				

Disk/Whorl

130.	flat disk (unperforated)	133.	concave donut	135.	unperforated donut
131.	concave disk (unperforated)	134.	biconcave donut	137.	ring
132.	flat donut (perforated)	136.	basin donut (incomplete perforation)		

COLUMN

SUBTYPE (Sub Type)

Figurine

140. human	141. human part	142. animal
143. animal part	144. natural	

Handstone/Mano

1. basin	225. hide processing	8. pottery anvil
5. blank	4. indeterminate	226. polishing
3. flat	6. multiple	2. trough
7. flat/concave	9. other	

Mortar

77. blank	70. pebble	400. tray-plain
72. boulder	71. rock	401. tray-bifurcate
73. bowl	74. shaped-anthropomorphic	
76. disk	78. shaped-zoomorphic	

Netherstone/Metate/Grinding Slab/Lapstone

50. basin	58. flat/concave	51. trough-open
160. basin-open	57. flat/concave edge	54. trough-Utah
162. basin-3/4	56. flat/concave end	52. trough-3/4
172. blank	53. trough-closed	171. indeterminate
55. flat	59. trough-indeterminable	

Palette

62. anthropomorphic	61. bordered	63. zoomorphic
64. blank	60. unbordered	

Personal Ornaments

304. bead-barrel	350. blank	310. pendant-2-dimensional
305. bead blank	325. bracelet-C	311. pendant-3-dimensional
308. bead-bilobe	320. bracelet-ring	332. plug
315. bead-convex	331. button	326. ring-C
302. bead disk	340. figurine-2 dimensional	321. ring-finger
306. bead-irregular	341. figurine-3 dimensional	333. toggle
309. bead-luboid	345. geometric	360. whizzer
316. bead-plano-convex	330. mosaic tesserae	312. zoomorphic inlay
307. bead-tear drop	370. necklace	323. indeterminate
300. bead-tube	313. pendant-blank	
303. bead-zoomorphic	314. pendant-inlay	

COLUMN

SUBTYPE (Sub Type)

Pestle

~~400~~ 402.	blank	12.	cylindrical	14.	pebble
17.	block	15.	indeterminate	18.	shaped
16.	cobble	19.	natural	13.	triangular
10.	conical	11.	parabolic		

Pipe/Tube

100.	conical-conical hole	101.	conical-cylindrical hole	102.	cylindrical-conical hole
103.	cylindrical-cylindrical hole	104.	conical-biconical hole	106.	elbow
107.	socketed	105.	cylindrical-biconical hole		

Plummet/Medicine Stone

118.	bilobed	110.	cylindrical	112.	parabolic
111.	conical	113.	cylindrical & groove	115.	parabolic & groove
114.	conical & groove	116.	cylindrical & head		
117.	conical & head	119.	geometric		

Polishing Stone

26.	disk	24.	handstone	20.	pebble-surface
27.	faceted	25.	indeterminate	21.	pebble-edge
23.	floor	22.	pebble		

Pottery Anvil

250.	grooved	251.	handled	252.	plain

Tabular Tool

204.	1 concave edge	210.	> 1 irregular edge	213.	multiple surfaces
205.	> 1 concave edge	200.	1 straight edge	214.	hafted
202.	1 convex edge	201.	> 1 straight edge	216.	notched
203.	> 1 convex edge	206.	multiple edges	215.	shaped but not used
209.	1 irregular edge	207.	edge and surface	212.	too fragmentary
				211.	unused material

COLUMN

ARTIFACT CONDITION (Condt)

1. whole
6. measurable
5. reconstruct whole
2. > 1/2
3. < 1/2
7. conjoined fragments
8. reused fragment
4. indeterminate

SHAPE

11. bilobe
17. broken
7. conical
15. crescent
6. cylindrical
13. diamond
8. disk
9. donut
16. irregular
18. morphic
3. ovoid
12. pebble/cobble
1. rectangular
10. ring
19. round
14. semicircular
20. slab
4. spherical
2. square
5. triangular

TEXTURE

2. coarse
6. coarse & fine
5. coarse & medium
1. conglomerate
4. fine
7. fine & medium
3. medium
8. large vesicles
9. small vesicles
10. large & small vesicles
11. no texture

BURNED (Burn)

1. no
4. after use total
5. after use partial
3. before use
7. before and after use
8. before second use
2. from use
6. heat cracked
9. indeterminate

MANUFACTURING (Manuf)

10. carved
16. chipped
15. chipped & ground
11. chipped for hafting
3. ground
19. ground edge only
17. ground and incised
5. ground perimeter
23. ground for stability
24. ground surface only
1. natural
2. pecked
4. pecked and ground
18. pecked for stability
2. 22 pecked edge only
13. pecked surface only
21. pecked & surface to hold
7. pecked and polished
14. pecked to hold
8. pecked & ground to hold
20. pecked perimeter
6. polished
12. indeterminate

COLUMN

USE

8.	destroyed	9.	offering	2.	reused
6.	indeterminate	5.	recycled	1.	single
3.	multiple use	4.	redesigned	7.	unused

SECOND USE (Scnd)

(insert artifact type)

NUMBER OF USED SURFACES (Num Surf)

1.	1	5.	4-2 adjacent each	10.	edge and corner
2.	2 opposite	6.	multiple surfaces	11.	corner
3.	2 adjacent	9.	1 edge	8.	indeterminate
4.	3 opposite & adjacent	12.	multiple edges	7.	not applicable

PROCESSING TYPE

1.	food	4.	multiple	7.	indeterminate
2.	nonfood	5.	not for processing	8.	uncertain
3.	ambiguous	6.	procurement	9.	container

LENGTH

WIDTH

THICKNESS (Thick)

SURFACE POSITION (Surf Pos)

1.	used surface down	4.	not applicable	6.	used surface up & down
2.	used surface up	5.	broken side down		
3.	not recorded			7.	on edge

SEQUENCE (Seq)

1.	sequential	3.	not applicable	5.	indeterminate
2.	concomitant	4.	both		

COMMENTS

1. yes (written comments in a computer file)
2. no

HANDSTONES FORM

ARTIFACT ATTRIBUTE EXPLANATIONS

This category includes generic handstones, manos, abraders, polishing stones, etc.

Artifact type (Art Type) should be the same as on the general form.

Grips/Grooves keeps track of the nature and location of finger grips, grooves, notches, handles, and other methods of holding artifacts. Grips are rough-ended areas; grooves have depth.

Design characteristics are defined in the manual.

Condition records the overall artifact wear condition. If the tool has been used on more than one surface, each surface might have a light or moderate amount of wear, but the tool itself is well used because it has more than one use.

Wear records the condition of wear on each surface. A separate line on each form should be filled out for each used surface. If wear is barely visible on the surface, it is light. If it is easy to see but does not alter artifact shape, it is moderate. If the wear alters the artifact shape, it is heavy.

Surface number (Surf Num) records the number of the surface described in the wear category. Generally the largest or most heavily used surface is recorded first (see Figure B.1).

Surface configuration (Surf Conf) records the general shape of the surface. For example, some surfaces are flat from end to end and convex edge to edge. Abrade grooves may have been worn in a uniform manner or they may have been used in such a way that they are deeper toward the end. Some tools, such as tabular tools, have an edge, or both an edge and a surface.

Surface texture (Surf Text) records the nature of the use-surface. A coarse grain material can be worn smooth and then resharpened by pecking to restore the roughness of the stone.

Length and *width* measurements are taken of the surfaces so that we can understand how much of the tools surface was actually a working part of the tool.

Wear level is an assessment combining both macroscopic and microscopic observations. The section on use-wear analysis in the manual explains why these are important attributes to observe.

Wear type is also an assessment made using both macroscopic and microscopic observations. The use-wear analysis section in the manual explains these attributes further.

Contact type (Cont Type) is an interpretation based on the assessment of the two previous attributes.

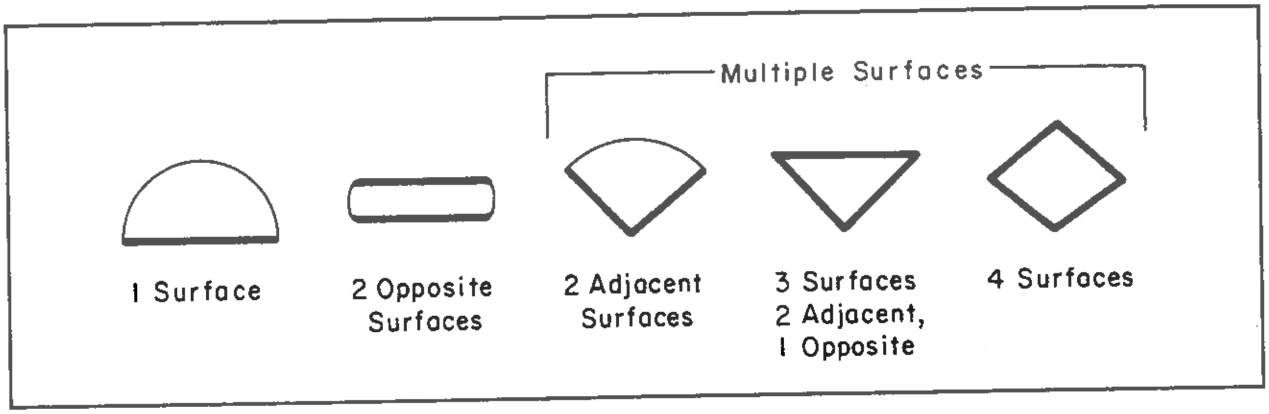

Figure B.1. Examples of types of surfaces recorded in the wear/surface number categories.

Stroke records the type of motor habits used with the artifact. The section on motor habits define stroke types.

Compatible (Compat) records the number of any other artifact that might have been used with the artifact being recorded. For example, some manos are compatible with certain metates and not others.

Residue records the nature of visible residues. Most residues are probably remnant from burial, however, some may be related to use and this allows for tracking items that may require further investigation.

Weight (Wt) records the weight of the individual artifacts.

Table B.1. is an example of a handstones recording form. Table B.2. lists the codes used on the form.

Table B.1. Ground stone analysis form for handstones.

Date 9/ 15 / 1996 ASM # SITE U:3:276 / 1/1

Feat Num	Prov/ Bag	Art Type	Grips/ Grooves	Design	Cond	Wear	Surf Num	Surf Conf	Surf Text	Length	Width	Wear Level	Wear Type	Cont Type	Stroke	Compat	Residue	Wt
41	6272.04	2	7	2	2	2	1	4	7	9.8	9.8	3	1	1	2	0	5	688
26	6069.04	1	1	2	2	2	1	4	3	6.4	5.2	3	1	1	3	0	5	584
3	270.07	6	5	2	2	2	1	14	8	21.6	0.3	1	13	9	18	0	6	141
60	4380.07	2	1	2	2	2	1	4	6	9.5	8.9	1	1	1	4	4397.04	4	650
						2	2	4	6	9.5	8.5	1	1	1	4	4397.04	4	0

Table B.2. Coding numbers for handstones form.

COLUMN

FEATURE NUMBER

PROVENIENCE/BAG NUMBER (unique artifact number)

ARTIFACT TYPE (Art Type) (from general form)

GRIPS/GROOVES

1.	no	11.	groove-encircling	9.	notched
3.	grip-1 edge	12.	ground for holding	4.	too worn
7.	grip-2 edges	8.	handle	10.	wear only
2.	groove	5.	not applicable	6.	indeterminate

DESIGN

1.	expedient	2.	strategic	3.	indeterminate
4.	not applicable	5.	incomplete		

ARTIFACT CONDITION (Cond)

1.	light	2.	moderate	3.	well used
4.	nearly worn out	5.	worn out	6.	not applicable
7.	indeterminate	8.	not used		

SURFACE WEAR

1.	light	2.	moderate	3.	heavy
4.	unused	5.	indeterminate	6.	not applicable

SURFACE NUMBER (Surf Num) (see Figure B.1)

SURFACE CONFIGURATION (Surf Conf)

1.	flat all over	8.	concave-end; flat-edge	11.	groove not to end
2.	flat-end; convex-edge	7.	irregular	15.	basin
3.	flat-edge; convex-edge	10.	variable	13.	edge
4.	convex all over	5.	grooves uniform	14.	serrated edge
9.	concave all over	6.	grooves worn end	12.	indeterminate

COLUMN

SURFACE TEXTURE (Surf Text)

1. smooth
2. fine
3. medium
4. coarse
5. mixed
10. still rough from manufacture
6. resharpened
7. resharp/worn smooth
8. not applicable
9. indeterminate

LENGTH

WIDTH

WEAR LEVEL

1. highs only
4. smooth all over
2. highs and lows
5. indeterminate
3. smooth spots
6. unused

WEAR TYPE

1. abrasion
7. abrasion & sheen
22. abrasion & rounding
5. abrasion & impact fractures
15. abrasion, impact fractures & chips
3. chips
10. chips & sheen
23. chips & rounding
2. impact fractures
9. impact fractures & sheen
8. impact fractures & chips
17. impact fractures & rounding
13. rounding
18. sheen & rounding
4. sheen
11. multiple
12. manufacture only
19. indeterminate

CONTACT TYPE (Cont Type)

3. stone/bone
4. stone/hide
6. stone/other
9. stone/pliable
5. stone/pottery
1. stone/stone
2. stone/wood
7. multiple
8. indetermine

STROKE

1. reciprocal-flat
2. reciprocal-rocking
3. circular-flat
4. circular-rocking
5. combination-flat
6. combination-rocking
14. multiple
13. chopping
16. crushing
19. cutting
7. pecking
8. pounding
18. scraping
9. shaving/slicing
15. stirring
17. stirring & crushing
12. not applicable
11. indeterminate

COMPATIBLE (Compat) (pv bag number of any compatible artifact)

COLUMN

RESIDUES

7. caliche
6. carbon
2. clay
1. organic
3. pigment
6. multiple
5. none
4. indeterminate
8. pigment & indeterminate

WEIGHT (Wt)

NETHERSTONES FORM

ARTIFACT ATTRIBUTE EXPLANATIONS

This category includes generic netherstones, lapstones, metates, anvils, bowls, mortars, etc.

Artifact type (Art Type) and *subtype* (Sub Type) should be the same as on the general artifact form.

Design characteristics are defined in the manual.

Surface number (Surf Num) records the number of the surface described in the wear category. Generally the largest or most heavily used surface is recorded first (see Figure B.1).

Surface coverage (Surf Cov) records the extent and nature of the surface. In some cases, this helps the analyst recognize the size and configuration of the handstone or other artifact used with the netherstone.

Wear records the condition of wear on each surface. A seperate line on each form should be filled out for each used surface. If wear is barely visible on the surface, it is light. If it is easy to see but does not alter artifact shape, it is moderate. If the wear alters the artifact shape, it is heavy.

Surface, length, width, and depth record the dimensions of the used surface. If there is more than one surface, a separate line is used for each.

Border or *rim width* is recorded if there is one.

Surface manufacture (Surf Man) records the nature of visible damage created by the manufacturing techniques used to shape the surface. If use has obliterated all evidence, then record as indeterminate.

Surface configuration (Surf Conf) records the general shape of the surface. For example, some surfaces are flat end-to-end and concave edge-to-edge. This helps understand the nature of the handstone used against the netherstone.

Surface wear (Surf Wear) records the condition of wear on the surface. If wear is barely visible, it is light. If the wear is easy to see but does not alter the artifact shape, it is moderate. If wear alters the artifact shape, it is heavy. Holes purposefully broken through the surface are recorded as killed.

Stroke records the general nature of the motor habit used with the netherstone.

Compatible (Compat) records the number of any other artifact that might have been used with the artifact being recorded. For example, some manos are compatible with certain metates and not others.

Residue records the nature of any visible residues. Most residues are probably remnant from burial; however, some may be related to use, and this allows for tracking items that may require further analysis.

Weight (Wt) records the weight of the individual artifacts.

Table C.1. Ground stone analysis form for netherstones.

Date 9 / 15 / 1996

ASMSITE U:3:279 / 1/1

Feat Num	Provenience/ Bag	Art Type	Sub Type	Design	Surf Num	Surf Cov	Wear	Surf Length	Surf Width	Surf Depth	Border/Rim Width	Surf Wear	Surf Manu	Surf Conf	Stroke	Compatible	Residue	Weight
22	3178.01	15	55	1	1	1	1	15.6	9.5	0	0	1	2	1	3	0	4	1200.8
49	5299.02	12	51	2	1	2	4	41.4	22.0	0.8	7.1	4	18	1	6	0	6	3800.0

Table C.2. Coding numbers for netherstones form.

COLUMN

FEATURE NUMBER

PROVENIENCE/BAG NUMBER (unique artifact number)

ARTIFACT TYPE (Art Type) (from general form)

ARTIFACT SUBTYPE (Sub Type) (from general form)

DESIGN

1.	expedient	2.	strategic	3.	indeterminate
4.	not applicable	5.	not applicable		

SURFACE NUMBER (Surf Num)

SURFACE COVERAGE (Surf Cov)

2.	border-flat	1.	complete	4.	indeterminate
3.	border-raised	6.	incomplete	5.	not applicable

WEAR

1.	light	2.	moderate	3.	heavy
4.	unused	5.	indeterminate	6.	not applicable
7.	killed				

SURFACE LENGTH

SURFACE WIDTH

SURFACE DEPTH

BORDER/RIM WIDTH (average)

SURFACE WEAR

SURFACE MANUFACTURE (Surf Manu)

1.	pecked to shape	7.	pecked & ground to shape	3.	combination
2.	worn to shape	9.	pecked & worn to shape	6.	natural
5.	ground to shape	8.	worn & ground to shape	4.	indeterminate

COLUMN

SURFACE CONFIGURATION

10. basin
4. concave
1. flat all over
3. flat-edge; concave-end
2. flat-end; concave-edge
7. convex
5. irregular
6. indeterminate

STROKE

2. circular
1. reciprocal
3. combination
7. pecking
5. grinding and pecking
6. not applicable
4. indeterminate

COMPATIBLE RESIDUE

7. caliche
6. carbon
2. clay
1. organic
3. pigment
8. pigment & caliche
4. indeterminate
5. none

WEIGHT

AXES AND MAULS FORM

ARTIFACT ATTRIBUTE EXPLANATIONS

Artifact type (Art Type) and *subtype* (Sub Type) codes should be the same as on the general form.

Measurement points (Bit Len through Edge Width) are illustrated in the manual.

Bit edge shape (Edge Shape) records whether the bit edge has been resharpened or not. Resharpening usually creates an off-center edge.

Bit edge damage (Edge Dam) records the nature of the use-wear damage as defined in the manual.

Bit edge sharpness (Edge Sharp) records the nature of the bit edge. The edge is considered sharp if it is less than 2 mm thick, dull if it is 2 mm to 1 cm thick, rounded if thicker than 1 cm; and flattened if there is no curvature to the edge.

Contact type (Cont) is a interpretation based on the nature of the damage to the bit edge.

Usable is an interpretation of how usable the axe is currently (see definition in manual).

Weight (Wt) records the weight of the individual artifacts.

Table D.1. Ground stone analysis form for axes and mauls.

Date 9 / 15 / 1996

ASM # SITE U:3:276 1/1

Feat Num	Prov/ Bag	Art Type	Sub Type	Bit Len	Bit Wid	Bit Thick	Poll Len	Poll Wid	Poll Thick	Groove Wid	Groove Depth	Edge Len	Edge Width	Edge Shape	Edge Dam	Edge Sharp	Cont	Usable	Wt
4	306.002	20	82	7.0	4.2	6.5	4.4	6.5	6.6	2.4	0.6	5.3	0.4	2	2	1	7	1	381.4

Table D.2. Coding numbers for axes and mauls form.

COLUMN

FEATURE NUMBER

PROVENIENCE/BAG (unique artifact number)

ARTIFACT TYPE (Art Type) (from general form)

ARTIFACT SUBTYPE (Sub Type) (from general form)

MEASUREMENT POINTS

BIT LENGTH (Bit len)

BIT WIDTH (Bit Wid)

BIT THICKNESS (Bit Thick)

POLL LENGTH (Poll Len)

POLL WIDTH (Poll Wid)

POLL THICKNESS (Poll Thick)

GROOVE WIDTH (Groove Wid)

GROOVE DEPTH (Groove Dep)

BIT EDGE LENGTH (Edge Length)

BIT EDGE WIDTH (Edge Wid)

BIT EDGE SHARPNESS (Edge Sharp)

1.	sharp	2.	dull	3.	rounded
4.	flattened	5.	broken	6.	incomplete

BIT EDGE DAMAGE (Edge Dam)

1.	none	9.	abraded, chipped, & sheen	8.	chipped & sheen
4.	abraded	3.	battered	5.	multiple
7.	abraded & chipped	6.	battered & chipped		
11.	abraded & sheen	2.	chipped		

COLUMN

BIT EDGE SHAPE (Edge Shape)

1. original
2. resharpened
3. indeterminate
4. incomplete

CONTACT TYPE

1. wood
2. soil
3. stone
4. other pliable
5. multiple
6. indeterminate

USABLE

1. usable as is
2. usable with resharpening
3. resharpened-usable
4. resharpened-usable with resharpening
5. no longer usable- no resharpening
6. no longer usable- resharpened

WEIGHT

GROOVED ABRADERS FORM

ARTIFACT ATTRIBUTES EXPLANATION

Artifact type (Art Type) and *subtype* (Sub Type) codes should be the same as on the general form.

Groove orientation (Groove Orient) records whether the groove is oriented along the length, width, or diagonally across the stone.

Embellishment (Emb) records the nature of any embellishment.

Groove dimensions (Length, Width, and Depth) should be taken at their maximum.

Table E.1. Ground stone analysis form for grooved abraders.

Date 9 / 15 / 1996

ASM # SITE U:3:276/ 1/1

Feat Num	Provenience/ Bag	Art Type	Sub Type	Groove Orient	Emb	Groove #1 Length	Groove #1 Width	Groove #1 Depth	Groove #2 Length	Groove #2 Width	Groove #2 Depth	Groove #3 Length	Groove #3 Width	Groove #3 Depth	Groove #4 Length	Groov #4 Width	Groove #4 Depth
4	3055.02	5	34	2	1	4.9	0.7	0.4	5.1	0.9	0.6	4.8	0.7	0.4	0	0	0

Table E.2. Coding numbers for grooved abraders form.

COLUMN		
FEATURE NUMBER		
PROVENIENCE/BAG NUMBER (unique artifact number)		
ARTIFACT TYPE (Art Type) (from general form)		
ARTIFACT SUBTYPE (Sub Type) (from general form)		
GROOVE ORIENTATION (Groove Orient)		
1. lengthwise	2. widthwise	3. diagonal
4. mixed		
EMBELLISHMENT (Emb)		
3. perpendicular grooves	1. perpendicular ridge	4. incised
7. perpendicular multiple grooves	2. perpendicular multiple ridges	6. other
		5. none
GROOVE DIMENSIONS (Length, Width, and Depth)		

PIPES/PERSONAL ORNAMENTS/ PERFORATED DISKS FORM

Artifact type and *subtype* codes should be the same as on the general form.

Measurements should be taken for *inside* and *outside hole diameters.*

Hole types are defined in the manual.

Table F.1. Ground stone analysis form for pipes/personal ornaments/perforated disks.

Feature Number	Prov. Bag	Artifact Type	Subtype	Inside Hole Diam.	Outside Hole Diam.	Hole Type
389	581.03	49	171	0.2	0.4	1
1002	103.03	46	104	1.5	2.3	2

Table F.2. Coding numbers for pipes/personal ornaments/perforated disks form.

COLUMN

FEATURE NUMBER

PROVENIENCE/BAG (unique artifact number)

ARTIFACT TYPE (from general form)

ARTIFACT SUBTYPE (from general form)

INSIDE HOLE DIAMETER

OUTSIDE HOLE DIAMETER

HOLE TYPE

1. conical	2. biconical	3. incomplete
4. not applicable	5. natural	6. broken
7. conical-incomplete	8. remodeled	9. cylindrical

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