A Model for the Production of Portable Stone Mortars and Bowls

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Two incidental observations of portable mortars in the process of manufacture, one discovered by chance in the field, the other an artifact in a private collection, prompted research into the manner in which portable stone mortars or bowls were produced by the aboriginal peoples of California desert region and elsewhere. The production of steatite vessels in the California coastal regions and on the Channel Islands has been studied and well-documented; steatite, however, is a soft material, having the lowest rating (i.e., 1) on the Mohs Hardness Scale. It is easily carved to shape. The majority of the portable mortars or bowls found at archaeological sites in the deserts of Southern California are of much denser and harder lithic materials (usually 6 or 7 on the Mohs Hardness Scale). The energy expended in their production and the technology used were very different.

The production model for stone mortars that we propose hypothesizes that the manipulation of granites, basalts, andesites, sandstones, metavolcanics, and metasedimentary materials was possible employing techniques of stoneworking that were widely used for a variety of purposes. We further hypothesize that the aboriginal stoneworkers attempted to be as efficient and energy-conserving as possible. By isolating a large segment of a mortar blank and then removing that portion by percussion, they were able to create a reasonably flat working surface that would ultimately become the rim of the mortar or bowl. A variation of this technique was often used to create the central concavity.

Distribution of Portable Stone Mortars and Bowls

Stone mortars or bowls are widely distributed in California desert, coastal California (e.g., Hudson and Blackburn 1981:103-108; Glassow 1993), and the greater Southwestern archaeological sites. There is substantial ethnographic documentation of their use. Portable stone mortars and bowls are also common elements of archaeological assemblages elsewhere in the New World, largely postdating 4000 B.P. In the Old World, mortars and bowls also are widely distributed but many fall within much earlier chronological periods. For example, elaborate stone mortars, bowls, and pestles are diagnostic artifacts of the Natufian of the Levant (Garrod and Bate 1937; Garrod 1957; Kaufman 1986; Bar-Yosef and Valla 1991), a pre-agricultural sedentary or semi-sedentary culture dating from about 11,000 B.P. Stone mortars and bowls were significant elements at Jarmo, an important site in the Zagros, dating from 11,000 to 9000 B.P. (Braidwood and Howe 1960) and at sites on the plains of Mesopotamia during approximately the same period (Hole et al. 1968). Mortars and bowls also were very common at Wadi Kubbaniya, along the Nile (Wendorf and Schild 1980), at “African Aqualithic” (mesolithic) sites dating from 10,000 to 7000 B.P. (Sutton 1977, Petit-Maire et al. 1983), and at African neolithic sites (Leakey 1931). The techniques of production, proposed for California mortars, may have been employed for the production of similar vessels throughout the world.

Functions of Portable Mortars and Bowls

A variety of uses for portable stone mortars or bowls have been suggested by their archaeological context, from ethnographic information, and from residues identified by chemical analyses and immunoprotein assay. Suggested functions include their use in pulverizing foodstuffs (both floral and faunal), pigments, clays, and medicinals; use as mixing vessels, cooking vessels, storage vessels, oil or fat lamps; and serving a number of ornamental and ritual purposes.

Stone Mortar and Bowl Production

Two lines of evidence, archaeological and experimental, can be used to develop a model for the way mortars or bowls were made. Artifacts representing incomplete stages of production are occasionally found; sometimes the tools used in production are found in associated context. Using this evidence, replication experiments can be designed that provide insights into production problems, techniques, and energy investments.

Archaeological and Artifactual Evidence

William Henry Holmes, a pioneer both in observations on and experimentation with aboriginal stoneworking, described a technique used for the removal of unwanted portions of stone. First, a circular groove was cut to a specific depth around the unwanted portion and then undercut so that the supporting structure was weakened and the piece could be removed with little effort (Holmes 1897a:109). This technique was used both in small-scale and large-scale stoneworking and was employed to make building blocks at quarry outcrops in Mesoamerica (Holmes 1897b).

California desert peoples used a similar technique to make portable stone mortars of local materials. A naturally shaped boulder in a drainage in Joshua Tree National Park has a circular groove pecked completely around one end (Fig. 1). It was abandoned during the production process for unknown reasons. No hammerstones were observed nearby (Schneider 1990).

Another mortar-in-progress, observed in a private collection in Needles, California (Fig. 2), exhibits the use of percussion flaking for shaping the exterior and for removal of the central portion of a large granite boulder. The incipient rim of the mortar was pecked to shape, thereby isolating the elevated central portion for eventual removal, probably by percussion.

At Elephant Mountain, a milling-implement quarry near Daggett, California (Schneider et al. 1995) a specimen of a mortar-in-progress (Fig. 3) exhibits a somewhat less obvious method of manufacture. A block-shaped andesite blank was selected; the shape of the blank

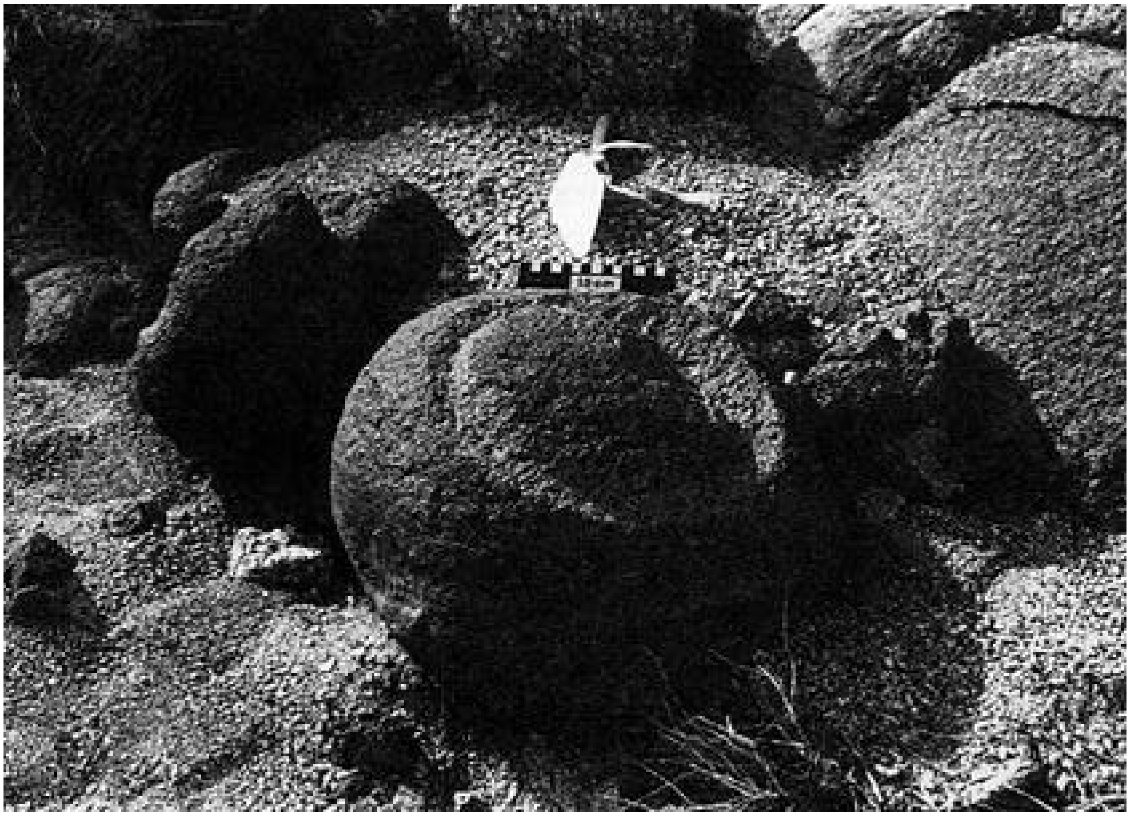

Fig. 1. Mortar-in-progress found in Joshua Tree National Park. The material is granite. A circular groove has been pecked in preparation for removal of the central portion. Boulder diameter is about 35 cm.

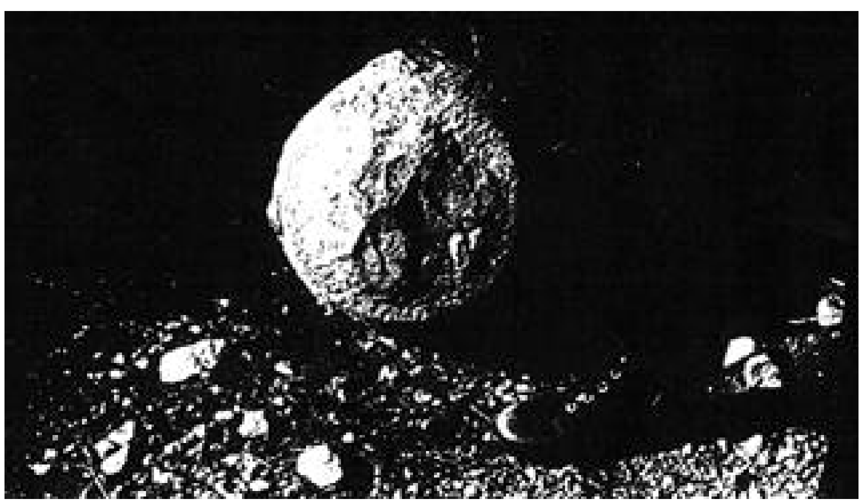

Fig. 2. Mortar-in-progress in a private collection in Needles, California. Note the rim, pecked into the boulder, and the isolated central portion, destined to be removed. Boulder diameter is about 45 cm. The material is granite.

is due to the characteristics and weathering pattern of the outcrop. The production problems were different from those when a naturally spherical cobble was used as raw material. In this case, flakes were removed for exterior shaping and the central depression had minimal pecking.

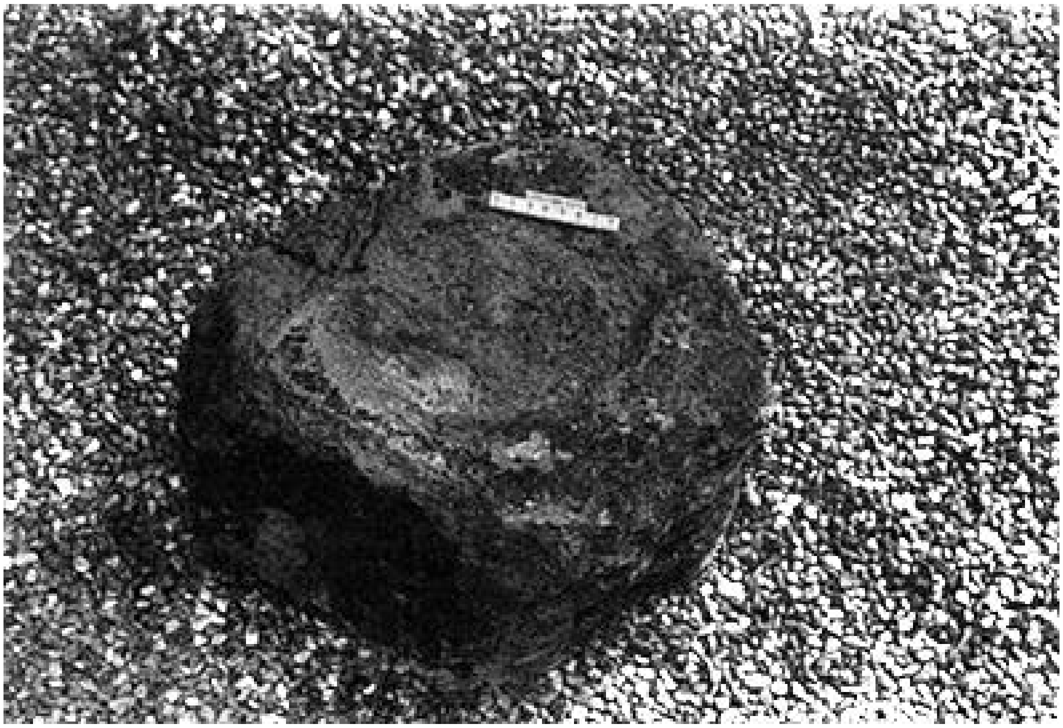

Fig. 3. Mortar-in-progress from Elephant Mountain milling-implement quarry. The blocky material is a result of the weathering pattern at this porphyritic andesite outcrop. Note the central pecked shallow concavity. Some percussion flaking of the exterior took place before abandonment. Scale is 8 cm long. Artifact is in the collections of the San Bernardino County Museum.

A fourth example of mortar production was identified at the edge of Stillwater Marsh (Anan Raymond, personal communication 1991). A single broken mortar, weighing almost 5 kg and made of nonlocal vesicular basalt, and a sizable collection of pick-shaped hammerstones were present. The hammerstones may have been used to shape the mortar that probably was broken during that process.

Other examples include an unfinished stone mortar or bowl (Fig. 4) made from a sandstone boulder (collections of the Orange County Museum of Natural History and Science). It was shaped using grooving, undercutting and probably percussion. A specimen from Baja California (Alvarez 1978) shows that pecked grooving was used to segregate four areas that would probably be subsequently removed by percussion.

Fig. 4. An unfinished mortar or bowl in the collections of the Orange County Museum of Natural History and Science. The sandstone boulder is 27 cm in diameter. Note that the top of the boulder has been removed and the rim pecked to shape before the central concavity was pecked.

The Southwest Museum collections include a number of specimens of incipient mortars or bowls from San Nicolas Island (Bryan 1961, 1970). On San Nicolas, naturally shaped boulders were circularly grooved by pecking in preparation for removing portions of the cobble (Fig. 5). Other mortar- or bowl-production areas with archaeological deposits exhibiting production technology similar to that on San Nicolas are present on San Miguel Island at CA-SMI-504 (George Kritzman, personal communication 1990), San Clemente Island (Schumacher 1880:264-265; Boyer et al. n.d.; Andrew Yatsko, personal communication 1996; and L. Mark Rabb, personal communication 1996). Schumacher (1880) described sandstone and basalt cobbles worked with sharp-pointed quartz hammerstones and sometimes chisels. Submerged mortar or bowl quarry and production areas, probably active from the Middle Holocene to late prehistoric times are 2-5 meters below present sea level off the Southern California coast. Other mortars or bowls found at greater depths in kelp beds and in submarine canyons were probably lost from water craft (Masters 1985). Other incipient stone mortars, interrupted at some stage of their manufacture, have been reported for the mainland Santa Barbara Channel region (Hudson and Blackburn 1981:106-108, Fig. 111-4).

Fig. 5. An unfinished mortar or bowl from San Nicolas Island in the collections of the Southwest Museum. The sandstone boulder is about 26 cm in diameter and 33 cm high. Note the pecked groove almost encircling the boulder.

Experimental Evidence

We are aware of only a limited amount of previous experimental research focusing on mortar production. Leventhal and Seitz (1989) replicated a mortar in connection with the recovery of two mortars at a site at Big Sur on the central California coast (CA-MNT-185/H); the site dated to 900 ± 80 B.P. The larger of the two mortars contained a cache of eight rhyolite and andesite hammerstones of nonlocal materials and was capped by an abalone shell (Motz et al. 1989). In the replication study, a central concavity was pecked[1] out using a large local-stream-cobble hammerstone, similar to the hammerstones in the cache. It took 17.2 hours and 46,000 blows to make a smaller, and much shallower, replica of the smaller of the two mortars in the Big Sur cache (Leventhal and Seitz 1989:163).

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[1] Pecking consists of hammerstone blows to a stone surface that both pulverize the stone to powder and/or remove microflakes of the stone material. Pecking is less exacting a technique than the technique used for percussion flaking, but it is very tedious.

Osborne (n.d. a, n.d.b) completed two mortar replication studies. In the first study (n.d. a), a concavity was created within a naturally formed sandstone boulder (Fig. 6); the concavity created has a volume of 215 cc (measured with sand). A single basalt pick-shaped hammerstone was used. Approximately 12.75 hours and 37,200 blows were expended; only one third of this time (approximately 3.84 hours) was actually spent delivering the blows. A circular groove was first pecked out, leaving a “plug” in the center; the “plug” was later removed with a single percussion blow (Figs. 7, 8).

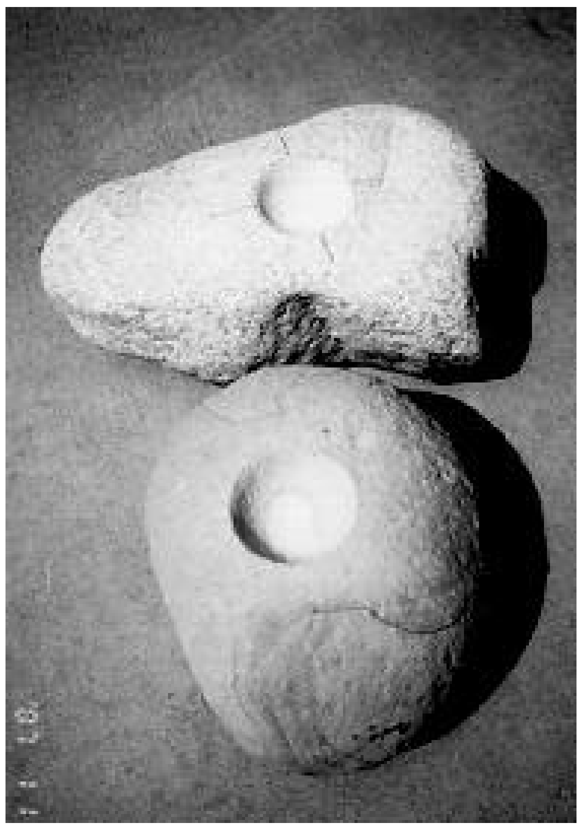

Fig. 6. Portable stone mortars replicated by Osborne. Approximately 37,200 hammerstone blows and 3.84 hours of labor were required to create the central concavity in the sandstone boulder at the bottom of the photograph. Approximately 67,200 blows and 8 hours of labor were expended in creating the shallower concavity in the granite boulder at the top of the photograph.

Fig. 7. The replicated sandstone mortar-in-progress showing the groove created in order to isolate the central portion.

Fig. 8. Richard Osborne strikes the single indirect percussion blow to remove the isolated central portion of the replicated sandstone mortar.

In the second study, Osborne replicated a granite portable mortar (Figs. 6, 9) in order to develop a time-volume ratio (i.e., the amount of time necessary to create a mortar hole of specific volume in a specific material). The time-volume ratio (TVR) could then be used to estimate the amount of time it took to create the concavity in an archaeological specimen.[2] Basalt pick-like hammerstones were initially used but found inadequate. Quartzite hammerstones were found adequate to withstand working the hard granite and three types were used in progression, depending on the depth of the cavity-in-progress. In eight hours, 67,200 blows were struck to create a 11 cm-diameter by 3.5 cm-deep depression. The pecking was “a somewhat strenuous and bone-jarring procedure” (Osborne n.d.b).

Fig. 9. Richard Osborne pecking the central concavity into the granite boulder. The completed sandstone mortar is at the front left.

Differences in stone hardness and texture are likely very important in terms of the energy expended in manufacture. In the first case, Osborne removed 215 cc of sandstone with 37,200 blows; in the second experiment only 140 cc of granite was removed with 67,200 blows. The first experiment, however, used the isolated “plug” technique, thereby saving labor time and effort; the second used pecking only. The energy spent in working the two different stone materials cannot be validly compared at this time because of the different techniques used, but this will be addressed in future experiments.

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2 The questions of whether or not the volume increased with use during processing, and the effects of the materials being processed was not addressed. Interpretations from the experiment are limited to intentional fabrication.

Treganza and Valdivia (1955) reported on the replication of “plummet” or “charmstones” common at Central Valley sites. They used flaking, pecking, and grinding. They reported that pecking was the most time-consuming part of the process.

Replication experiments that focused on producing stone pestles employed percussion flaking and then pecking (Schneider 1993:Appendix A; Schneider, Wilke, and Quintero 1993). Pecking in the final stage of production was, by far, the most time-consuming part of the production process. On the average, 11.5 hours were expended in this stage of production, while the initial shaping by percussion flaking took far less time.

Discussion

The available evidence permits a number of observations regarding the procurement of materials for portable mortars or bowls and suggestions for the probable methods of production. Suitable naturally shaped materials were available in certain areas. California coastal margins have impressive concentrations of suitably shaped and sized boulders. There is some evidence that an industry existed here that included both production and exchange of stone mortars and bowls made from these naturally shaped cobbles.

Prokopovich (1990) reported on the distribution of stone mortars in the Central Valley of California and the relationship between distribution and the geological character and availability of materials. He noted that where bedrock was available, portable mortars were not frequent. Where bedrock was not available, materials for portable mortars were obtained from certain alluvial fan deposits encroaching on the valley from the mountain ranges to the west of the valley.

Certain areas may have had available high concentrations of naturally shaped boulders suitable for stone mortars, but other areas (see Fig. 1) depended on rare occasional finds of suitable boulders. In other cases, exterior shaping (by percussion) of irregular or blocky materials was necessary before a central mortar hole was created (see Figs. 2 and 3).

Experimental replication has allowed us to understand that creating a mortar or bowl by pecking alone is extremely time-consuming and tiring. Other, more efficient methods of stoneworking were available and sometimes were used. Specimens described here indicate at least one of those methods. An unwanted segment of stone could first be isolated and then removed with a single blow.

Although archaeological or experimental evidence has not been presented here, there may have been another method of removing large portions of unwanted stone: intentional heat fracture. Thermal fracture occurs when rapid alteration in temperature causes expansion or contraction of the surface of a rock and when that rapid alteration is not matched in interior materials. A “potlid” fracture might result; a phenomenon that would create a somewhat circular shallow concavity in the surface of a rock. Coles and Higgs (1969:58) discussed potlid fracture: “...there is no evidence that man ever used this method to fracture rock, because there is no way of controlling the fracture as there is by percussion of one form or another.” Historical accounts and ethnographic observations, however, indicate that heat was sometimes used to purposefully create fractures in rock (e.g., Binford and O’Connell 1984:418). The pecked-groove undercutting technique described above would facilitate control of heat fracture when heat was selectively applied to the isolated portion of the stone.

Conclusions

Portable stone mortars and bowls have a wide archaeological distribution in both the Old World and New World. They are more common in some cultures, geological/geographical regions, and chronological contexts than in others and their functions probably varied greatly. Stoneworking techniques other than, or in addition to, slow and laborious pecking were used in their production. We propose that prehistoric stoneworkers pecked grooves to isolate and undercut unwanted portions of stone. Once the unwanted portion was isolated, it was removed by a single percussion blow (or by the alternative possibility of selective application of heat). The isolation technique was used because it was both a reliable and energy-efficient method of shaping.

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