# LEARNING MORE FROM GROUND STONE ASSEMBLAGES: RESULTS FROM A NORTHERN CALIFORNIA STUDY

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*Using an in-depth tool analysis, concentrating on kinds and relative amounts of use-wear, this paper reports findings on variation in archaeological ground stone assemblages from several different areas in north-central California. Nuances in the morphology and patterns of tool wear reveal differences across and between ground stone assemblages, identifying important temporal and spatial trends in north-central California.*

Relative to flaked stone assemblages, ground stone implements have generally been subject to less intensive examination and interpretation. Presented here are some of the results from my thesis (Noble 2011). Using an in-depth analysis that concentrates on kinds and relative amounts of use-wear, this study examined variation in archaeological assemblages from several different areas in north-central California: the northern Sierra Nevada, Lake Oroville and the Feather River Drainage, the Sacramento Valley, and the southern North Coast Ranges.

The more than 22 attributes examined in this study were aimed at capturing variation within and between artifact categories in different environments. More insight can be gained from studying the kind of wear that is most prevalent – reflecting what the tool was used for – rather than just the presence or absence of a tool form itself. Also, it cannot be assumed that a tool form found in one environment was used for the same purpose everywhere, especially if different resources were available. It is likewise a mistake to assume that certain types of use-wear reflect only one kind of processing activity, with similar polish or other kinds of wear often produced by different uses.

## DUAL VS. SECONDARY USE

One aspect that proved particularly informative was that of dual versus secondary use. Rather than counting hand stones or pestles and using this information to infer the resources used, a more reliable interpretation can be made when tools are organized into more exacting categories. This kind of artifact use-life examination is also helpful when interpreting use-wear and how it pertains to the product (and not just the resource) being used, as well as such behavioral issues as investment in technologies.

An ideal, or optimal, hand stone has specific attributes that are different from an optimal pestle. In this study the term “muller” is used to refer to tools that show both hand stone and pestle forms of wear but lack the optimal attributes of either, and may have been used for grinding and pounding on concave milling slabs. Both kinds of processing must have been of nearly equal importance, such that a dual-use tool, less than ideal for each purpose, was selected.

On whole or nearly complete bifacial and dual-ended tools, the amount of area available for hand stone and pestle use was compared to the total area actually used, to produce a ratio (Figure 1). The closer the ratio is to 1:1, the more it can be assumed the tool is truly “dual-use.”

## TOOLSTONE CHOICE

Behavioral choices embedded in toolstone selection are informative about constraints. Characteristics of different toolstones influence the effectiveness of tools for particular tasks. Differences in toolstone hardness, grain size, suitability for resurfacing, etc., are all factors, or variables that affect a tool and the way it is used.

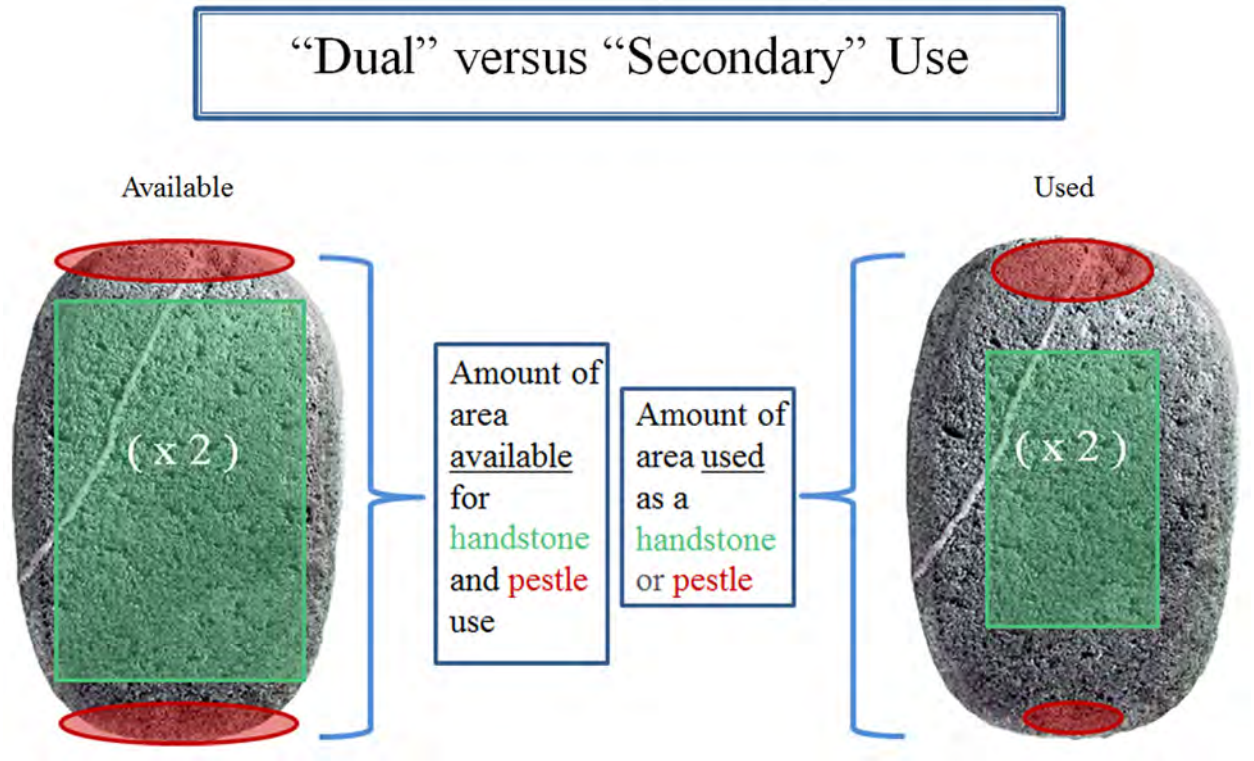


*Figure 1. Dual versus secondary use.*

This is especially true for subsistence-related ground stone, where grain size, structure and friability, hardness, density, and "impressionability" are important and informative characteristics. Grain size affects the roughness of the surface, density affects weight, hardness affects durability and resurfaceability, etc. For this study, grain size and the analytical notion of "impressionability" were employed. Impressionability was relatively coded as: 1 – impressionable, where the ground surface is very distinguishable from an un-ground surface, as with a large-grained granite, 2 – semi-impressionable, where the difference between ground and un-ground surfaces is less distinguishable, and 3 – resistant to impression, where it is difficult to distinguish ground from natural surfaces, on harder materials like metasedimentary stone. These characteristics provide more detailed information about actual – versus visible – levels of use-wear.

Below, some results are summarized. Some generally accepted trends in tool characteristics were upheld by this study, while others were challenged.

## MAJOR TRENDS IN GROUND STONE VARIATION

Both a chi-square statistic and an analysis of adjusted residuals were used to reveal how variables affect tool characteristics, in order to determine what influences artifact form and condition.

Based on these statistics, it is evident that across all tool categories, environments, and time periods, the impressionability of a material has an overwhelming influence on several attributes. Across all artifact groupings, soft or highly impressionable materials are more commonly shaped, show higher amounts of use, are resurfaced more regularly, are more often unifacial, and are burned equally as often as not. Medium, or semi-impressionable, materials are more often unshaped, exhibit medium to low amounts of use, are less often resurfaced, are bifacial or unifacial almost equally, and are the most frequently burned. Hard, or impression-resistant, materials, are usually unshaped, show low amounts of use, are not resurfaced, are usually bifacial, and are rarely burned.

The frequency of shaping is most intriguing, as this attribute is often believed to be related to other factors such as curation and amount of use. While these surely have some influence, the ease with which a tool can be shaped seems also to play a part. Tools that are curated are likely shaped more often than those that are not; however, these data suggest that artifacts made on a softer material might be shaped sooner or more often, given their malleability. The high investment needed to shape a hard material may only be worthwhile in rare contexts where it is essential.

As expected, the amount of use-wear visible on a tool is affected by the hardness of the material, softer stone showing wear more quickly and more dramatically than harder materials. This leads to biased estimates of use-wear levels. Related to this, softer materials need more frequent resurfacing since their abrasive grains are worn down more easily.

The relative amounts of bifacial use are also of interest. Unifacial use is overrepresented among the soft tools; bifacial use, among the hard tools. This may relate to factors of durability associated with harder, usually finer-grained materials. The harder the material, the longer a tool will last, and the greater the chance that both sides or ends will acquire use. Because the hard tools are represented almost entirely by pestles, the high amount of bifacial use, in this case, is in the form of dual-ends.

Burning appears most often on tools with medium impressionability. This may be due to preferred heating properties of stone of this grain-size and density range. Softer tools were burned as often as not, perhaps proving too friable upon excessive heating. Burning is rare among the hard tools, given the increased chances of such fine-grained, dense materials exploding when heated.

**Hand Stones**

Hand stones are secondarily modified more often than pestles. This fits the general notion that hand stones often represent a more generalized tool form, whereas pestles tend to be more specialized. Such secondary modification occasionally occurs in the form of pecked depressions, implying use as anvils, but it most often occurs as pestle-like wear from being pounded on a stone nether surface. The typical morphology of a hand stone means that if the ends are battered, they were likely used on a dished or bowl-shaped surface such as is found on some bedrock mortars or on basined or dished milling slabs. They could not be used with the formal, shaped bowl mortars, given their length and width. An increase in pestle use later in time likely relates to the need for a more functionally interchangeable artifact. With an increase in diet breadth, more resources were processed, using a wider array of techniques per tool.

The most interesting pattern revealed by the present study of hand stones is that shaping does not appear to vary much between the different regions or by time. Shaped hand stones are often assumed to be older than unshaped, seemingly more expedient versions. Instead, as discussed in relation to impressionability, the malleability of the toolstone seems to be the most influential variable. It can still be argued that shaping is a common trait of curated and well-used tools, though tools requiring less time and effort to shape will generally exhibit more shaping. By implication, tools of a harder material that are shaped were probably highly curated, given the investment.

**Pestles**

The pestles in this study are usually dual-ended. This must relate, at least in part, to the durability of the usually hard material, which allows for extensive use, and employs both ends, if appropriate. Many pestles in this study have ends with differing kinds of wear, implying multiple modes of processing with one tool. Many dual-ended pestles exhibit wear consistent with stone mortar use on one end and wooden mortar use on the other, and the single-ended pestles appear to have been used in both materials alternately. In one case, this was likely necessary due to seasonal inundation of bedrock mortars, and the resulting need to use the same tools in wooden versions. Also, hard-shelled nuts can cause a rougher texture when being hulled, whereas seeds tend to polish stone surfaces, and fibrous roots or moist nutmeats can leave a combination of the two.

Also affected, in part, by the nature of the nether surface employed is pestle shaping. In areas where portable mortars are commonly employed, pestles are more frequently shaped. This likely follows from a need to manufacture pestles to fit the mortars. Where bedrock mortars, block mortars, or basined and dished milling slabs are used, pestles need not be shaped. This notion is supported by the fact that earlier pestles were generally more extensively shaped, part of a toolset that was more highly formalized and curated than in late prehistoric times.

**Mullers**

Mullers tend to vary little across time and space, and the required characteristics of these tools override most environmental and temporal influences. This standardized tool is most often made of abrasive material, though typically not as abrasive as the stone selected for hand stones. Cobbles selected for manufacture of mullers often represent a combination of the abrasive qualities inherent in an ideal hand stone, and the durable, hardness qualities intrinsic to an ideal pestle. These "combination" tools are almost always shaped and formal in appearance, suggesting that they are highly curated.

There is no evidence that these mullers were used in conjunction with wooden mortars. Their wide, often loaf-shaped form would make use in a bowl mortar difficult or impossible. Most mullers in this study appear to have been used with shallow bedrock or block mortars, or on basined or dished milling slabs, since the step-fractures around the edges of the margins are likely from being use on a flatter surface. Edges of these scars are still sharp and have not been blunted from contact with the sides of a mortar.

Across all environmental settings, mullers appear to be a later tool form, statistically postdating A.D. 750 (1200 B.P.). As mentioned, such tools apparently sufficed for both grinding and pounding purposes, which was evidently cost-efficient overall. With this in mind, mullers seem to be more of a hybridization of multiple forms of resource processing, rather than a "transitional" tool. The production of mullers as a form of toolstone conservation, trying to extend the utility of a cobble, is not likely, since there were very few found in areas with little to no local toolstone.

Mullers were probably highly curated based on their formality, degree of shaping, and use, and were likely part of a toolkit ready to process whatever kind of plant foods could be procured at a given time.

**Milling Slabs**

For milling slabs, alterations to form by removing excess material from the perimeter to reduce mass and perhaps increase portability is considered a functional shaping endeavor. There are also more formal, possibly aesthetic, types of shaping (i.e., pecking around the perimeter) that were used to improve the shape of a milling slab. Formal shaping does not appear to be dependent on time, though functional size-reduction shaping does. An increase in size-reduced milling slabs in later components may reflect less need for larger grinding surface areas. Such size-reduced slabs could also signal a more portable tool that could be carried around while moving from one resource patch to another.

There is an intriguing pattern of dual-sided slabs with one dished side and one flat side, especially among artifacts from the southern North Coast Ranges. There is, of course, the possibility that these represent intentional dual-use tools that were used to process different resources or in conjunction with varying processing techniques. It seems more likely, based on other observations, that these represent very well used tools that were merely worn until they were dished from using a reciprocal-rocking motion with the hand stones (which is by far the most common stroke evident, based on surface shape and striations). They were then flipped over and used on the other side of the tabular form. This is not to imply that the dished side was no longer employed, merely that it was not shaped as such for a predetermined purpose. Supporting this inference is the observation that there is a lower incidence of dished or concave surfaces at localities with abundant raw material. Relative concavity increases in contexts where toolstone is rare and large, nether stone-sized pieces are harder to obtain.

Most milling slabs were manufactured of abrasive material, though this tendency was reduced later in time when harder, more fine-grained materials were desired. Possibly this is attributable to the need for milling slabs during later periods to be able to withstand pounding from a stone muller, pestle, or hand stone more often.

## CONCLUSIONS

Some generally accepted trends in tool characteristics were upheld by this study, while others were challenged. A transition in plant processing technology from a focus on milling slabs and hand stones to one on mortars and pestles appears to be supported. Both technologies were employed during most time periods, but the relative reliance on one or the other varied over time and space. This shift is represented not only in changing ratios of tool forms in an assemblage, but also in the kinds and amounts of secondary modification, toolstone choice, use-wear, and other attributes. Later in time, likely in response to a general increase in the array of resources procured, tools started to be used in more than one way. Hand stones show evidence of being used as pestles, and vice-versa. Mullers become an almost axiomatic part of this trend, demonstrating the ability to act sufficiently in more than one way. Milling slabs show signs of having been used with mullers and as hopper mortars. Changes in toolstone choice represent these increasing needs for variable use. Materials chosen for both hand stones and milling slabs became less abrasive, finer-grained, and harder over time, presumably reflecting a need for increased durability to withstand pounding in later time periods.

The concept that toolstone availability affects ground stone characteristics is supported. Even apart from the need to recycle tools as hearthstones where non-tool stone is scarcer, material profiles and related attributes (i.e., amount of resurfacing needed, amount of apparent use-wear, degree of shaping, etc.) are influenced as well.

The generally accepted notion that hand stones were more shaped and formalized in earlier temporal intervals is not upheld by results of this study. Instead, as discussed above, the presence of shaping appears to be the result of a more complicated set of requirements in some areas. The time and effort needed to shape a tool seems to be the strongest factor influencing whether or not it is shaped. This does not challenge the idea that more curated artifacts are usually more shaped; it merely suggests that those easier to shape were perhaps done so sooner and more extensively.

Some of these results have shed more light on a few larger ground stone questions for California, and further research can be accomplished both with these data and with data collected from other assemblages. If ground stone tools in existing collections were examined more thoroughly, the body of information amassed could be invaluable.

## REFERENCE CITED

Noble, Michelle D.

2011 An Examination of Variability in Northern California Ground Stone Technologies. Unpublished Master's thesis, Department of Anthropology, California State University, Sacramento.