# THE RELIABILITY OF MICROSCOPIC USE-WEAR ANALYSIS ON MONTEREY CHERT TOOLS

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*Archaeologists have long debated the effectiveness of microscopic use-wear analysis in studies of tool function, due to questions about its reliability and repeatability. Our research used a blind test to study the reliability of microscopic use-wear analysis on replica tools made of Monterey chert, a widely used material type in coastal California. Results confirm that microscopic use-wear can be an effective and reliable means of determining tool function, particularly with regards to tool action and contact material (e.g., wood, leather, antler).*

Use wear analysis has long been used in the functional analysis of archaeological stone tools, and, in recent years, microscopic use-wear studies have been increasingly used in place of macroscopic studies of tool edge damage. Microscopic use-wear attempts to functionally analyze tools by observing utilized edges under magnification. While recent use-wear studies have emphasized advanced imaging techniques (e.g., Evans and Donahue 2008), using normal stereomicroscopes, it is possible to view and analyze two primary sources of information on tool edge use: edge damage and polish. Among the basic types of edge damage are micro-flake scars, snap fractures, step fractures, and edge rounding (Figure 1), the presence of which varies depending on the specifics of tool use (see Tringham et. al. 1974). Polishes also form on the edges of flakes as a result of edge use. Variation in the presence, invasiveness, and appearance of polishes can also be used to distinguish between contact materials and tool motions, although the exact mechanism of polish formation is still unknown (see Keeley 1980; Odell 2001). By combining data from both sources, it is possible to identify the manner in which a tool was used.

Despite the great potential for microscopic use-wear analysis in understanding tool functions, applications of the technique have been fairly limited in California, in spite of demonstrations of the method's promise in the region (e.g., Bamforth 1986; Lebow et al. 2007). In order to demonstrate the effectiveness of use-wear analysis on common California toolstone, this research used Monterey chert replica tools to test the accuracy of predictions regarding the identification of utilized edge, contact material, and tool motion

## METHODS

### Production of Replica Tools

The basic experimental procedure was a blind test similar to those used in previous use-wear studies to judge the accuracy of the methods (e.g,, Odell and Odell-Vereeken 1980). To begin, a number of Monterey chert flakes were knapped using hard-hammer percussion, and 10 unmodified flakes were selected by each researcher to be used on various contact materials in the experiment. Researchers worked independently of each other, so as not to divulge any information about the use of specific flakes. Procedural rules were established with regards to the manner in which flakes could be utilized, in order to standardize the experimental procedure and produce more consistent, reliable data to answer the research questions. These rules reduce variability in the data, so as to focus specifically on the reliability of microscopic use-wear analysis in distinguishing specifically between different contact materials and tool motions.

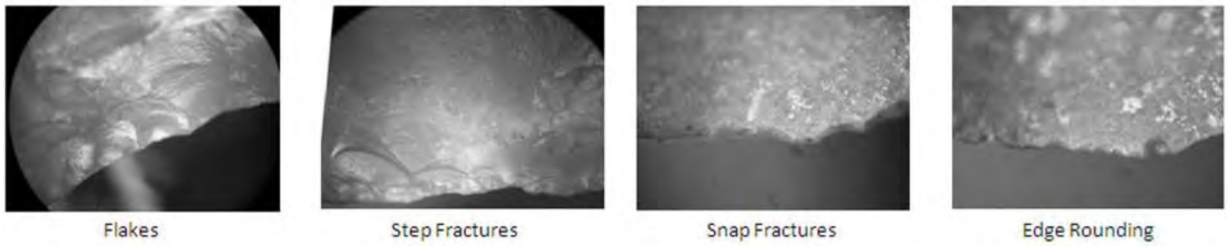



*Figure 1. Edge damage examples.*

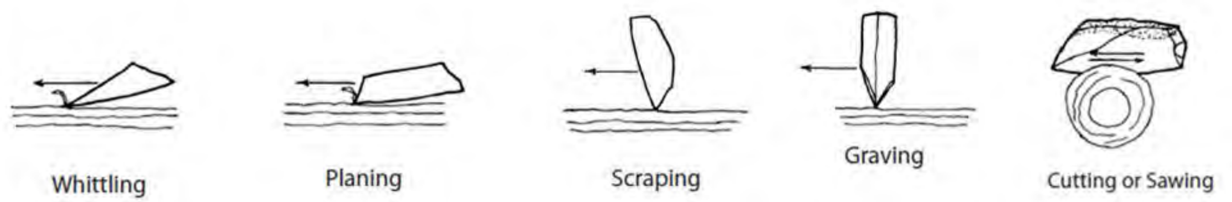



*Figure 2. Tool motions (adapted from Keeley 1980).*

*Table 1: Material type and tool motion restrictions.*

| MATERIAL CATEGORY | TOOL MOTION |
|---|---|
| Hard Material:<br>Wood, Antler | Scraping/Whittling/Planing<br>Graving |
| Soft Material:<br>Leather, Meat, Soft Plants | Cutting<br>Scraping (Leather Only) |

First, it was decided that each of the utilized flakes was to be used on only one edge, on one material type, with one tool motion, for at least 30 minutes. Second, tool motions were limited to simple ways of using the edge of a flake to work a given contact material: scraping/planing/whittling, graving, and cutting or sawing (see Figure 2). It should be noted that, although whittling, planing, and scraping are technically distinct motions, they all remove contact material with the edge oriented perpendicular to the direction of motion, and the resulting wear on the tool edges is very similar. Consequently, it was decided that the three motions could justifiably be grouped together as a single type of motion, which will henceforth be referred to simply as scraping. It was also decided that, when scraping, only the ventral side of the flake should make contact with the material type, as another means of reducing variability by standardizing experimental practices, thereby improving the quality of the data.

The material types used included wood, antler, leather, meat, and soft plants (such as tule, grass, or cattails). The contact materials were also categorized as either hard materials or soft materials, according to the material's inherent properties (Table 1). Tool motions for flakes were constrained according to the category and properties of the contact material being worked, as seen in Figure 2. The restrictions are not entirely arbitrarily imposed; rather, they reflect a simplification of observed tendencies and ensured that unnecessary variation in the data did not arise as a result of unrealistic use of the tools.

Sketches were drawn of the dorsal and ventral sides of each flake along with notes regarding the utilized edge and indicators of any breakage of the flake that occurred during use. The sketches also included the locations of any edges that had been dulled for backing during use. Additional data, including tool motion and direction, and contact material, were also recorded for each flake. The tools were cleaned using a soft brush and water followed by a bath in a weak (5 percent) hydrochloric acid solution to remove any residues before being given to the other researcher for analysis.

## Use Wear Analysis

After all the tools were used and the appropriate data were recorded, the researchers traded flakes for analysis, but did not trade the recorded data about the flakes. A reference collection, consisting of documented, utilized replica Monterey chert flakes, was studied prior to conducting analysis on the experimental flakes. The reference collection was necessary in order to learn the differences between the polishes generated by the various contact materials during use, as well as the differences in polish and edge damage that are the result of different tool motions. Flakes were analyzed using a low-power stereoscopic microscope. Flakes were viewed at 20X, 60X, and 100X magnification. Lighting apparatus were set up such that flakes could be held at the focal point of the microscope by hand to allow for the manipulation of the flake when viewing its edges. Before viewing the edges of flakes under the microscope, the flakes were wiped with alcohol in order to remove any oils or residues that could be mistaken for polish.

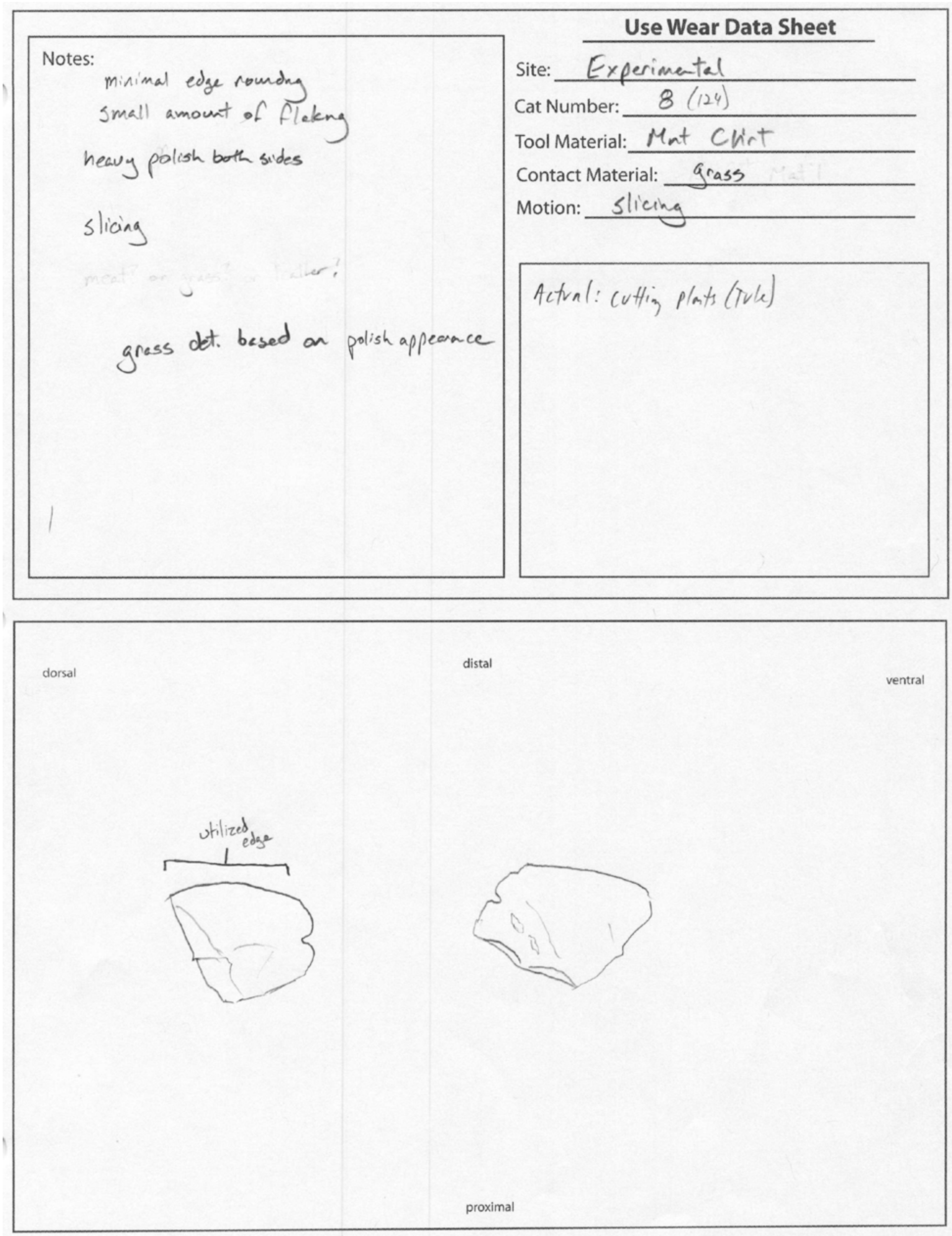
After gaining experience with the reference collection, analysis began on the experimental flakes. Before being viewed under the microscope, each of the flakes was sketched in order to record notes about potentially utilized edges. The edges of each flake were examined for signs of polish or edge damage. When use-wear was detected on an edge, several variables were recorded, including: edge angle; edge shape; the presence or absence of micro-flake scars, step fractures, and snap fractures; polish presence; and polish invasiveness. These data were recorded for both the ventral and dorsal sides of the flakes to aid in predicting tool motion. Drawings were made on the sketches to indicate the utilized edge, and notes were recorded about any distinguishing features of the polish appearance (see Figure 3).

After analysis, final predictions were made for each flake, specifying the location of the utilized edge, the contact material, and the tool motion used. These predictions were then compared with the data recorded during use, in order to test the accuracy of the microscopic use-wear analysis.

# RESULTS

In order to determine the reliability of microscopic use-wear analysis on Monterey chert, it was necessary to analyze the accuracy of the technique's predictive power in a way that incorporated the primary research objectives. The accuracy of the predictions was scored by awarding points for correct predictions in three critical areas: utilized edge location, contact material type, and tool motion. If the utilized edge of a flake was predicted accurately, one point was awarded. However, if the edge was incorrectly predicted, one point was deducted and no more points could be awarded for other predictions about that flake. For contact material, one point was awarded for each correct prediction, and one-half point was awarded if the predicted contact material was in the same material category (hardness) as the actual material type. An additional one point was awarded for correctly predicting tool motion. Flakes that were correctly guessed as unused were awarded three points. Wrong answers for utilized edge prediction were penalized because of their high degree of inaccuracy. The results of this scoring system are shown in Table 2.

Using this scoring system, the total accuracy of each set of predictions is calculated as the sum of the scores for all 10 flakes divided by 30, the maximum number of points. Combined accuracy in the experiment is the average of the two individual accuracies. With individual accuracies of 91.7 percent and 68.3 percent, the experiment averaged a combined accuracy of 80 percent. This degree of accuracy indicates that microscopic use-wear is an effective means of analyzing Monterey chert flake tools. Additional summary statistics of predictions also showed a high degree of accuracy with respect to specific variables (Table 3).



**Use Wear Data Sheet**

Notes:
minimal edge rounding
small amount of flaking
heavy polish both sides

slicing

grass det. based on polish appearance

Site: Experimental
Cat Number: 8 (124)
Tool Material: Mnt Chrt
Contact Material: grass
Motion: slicing

Actual: cutting plants (Tule)

dorsal

distal

ventral

utilized edge

proximal

*Figure 3. Data collection sheet.*

*Table 2: Prediction results.*

HANTEN

| ACTUAL | OBSERVED | EDGE | MATERIAL | ACTION | TOTAL |
|---|---|---|---|---|---|
| Unused | Unused | 1 | 1 | 1 | 3 |
| Unused | Unused | 1 | 1 | 1 | 3 |
| leather, cutting | leather, cutting | 1 | 1 | 1 | 3 |
| leather, scraping | antler, scraping | 1 | 0 | 1 | 2 |
| meat, cutting | meat, cutting | 1 | 1 | 1 | 3 |
| antler, scraping | wood, scraping | 1 | 0.5 | 1 | 2.5 |
| antler, scraping | antler, scraping | 1 | 1 | 1 | 3 |
| plants, cutting | plants, cutting | 1 | 1 | 1 | 3 |
| wood, scraping | leather, scraping | 1 | 0 | 1 | 2 |
| wood, scraping | wood, scraping | 1 | 1 | 1 | 3 |
| | | 10 | 7.5 | 10 | 27.5 |

STEVENS

| ACTUAL | OBSERVED | EDGE | MATERIAL | ACTION | TOTAL |
|---|---|---|---|---|---|
| Unused | Unused | 1 | 1 | 1 | 3 |
| Unused | Unused | 1 | 1 | 1 | 3 |
| antler, scraping | antler, scraping | 1 | 1 | 1 | 3 |
| antler, scraping | antler, scraping | 1 | 1 | 1 | 3 |
| wood, scraping | leather, scraping | 1 | 0 | 1 | 2 |
| wood, scraping | wood, scraping | 1 | 1 | 1 | 3 |
| wood, scraping | plants, cutting | 1 | 0 | 0 | 1 |
| leather, scraping | meat, cutting | 1 | 0.5 | 0 | 1.5 |
| leather, scraping | leather, cutting | 1 | 1 | 0 | 2 |
| meat, cutting | wood, scraping | -1 | 0 | 0 | -1 |
| | | 8 | 6.5 | 6 | 20.5 |

*Table 3: Additional accuracy statistics.*

| | SCORE | % |
|---|---|---|
| Total edges correctly identified: | 19 | 95 |
| *Total materials correctly identified: | 14 | 74 |
| *Total actions correctly identified: | 16 | 84 |
| Tools correctly identified as used: | 15 | 94 |
| Tools correctly identified as unused: | 4 | 100 |

Note: * indicate statistics include only flakes with correctly identified edges

Of the statistics calculated, predictions were least successful at identifying specific contact material. Of the 19 correctly identified edges, material type was predicted correctly for 14 tools, an accuracy of 74 percent. Nevertheless, 74 percent accuracy demonstrates a great deal of reliability and is likely sufficient for many archaeological applications. Additional data indicate that microscopic use-wear can make even more accurate predictions when considering utilized edge and tool action specifically (see Table 2). Predictions accurately detected edge modification on 19 of the 20 flakes. Of those 19 flakes, the tool action was also predicted correctly in 16 cases (84 percent) (Table 3). This degree of accuracy demonstrates that microscopic use-wear has a high degree of reliability for applications involving the identification of utilized edges, contact material, and tool action in the analysis of Monterey chert tools.

## CONCLUSION

The data gathered in this experiment show that microscopic use-wear can be an effective means of analysis for Monterey chert tools, which are ubiquitous at many California coastal sites. In addition to the accuracy of the technique, there are numerous additional benefits that make the method particularly apt for use in California archaeology. First, the technique is both relatively fast and inexpensive, requiring only a stereoscopic microscope, a good-quality fiber optic illuminator, and training. Also, the basic setup used in this experiment appears to be sufficient to identify many tools that would otherwise be classed as debitage (because they have no obvious macroscopic signs of use). Likewise, items that look like tools, but are actually due to trampling, excavation damage, etc., can be culled from the tool sample.

Future directions for research include further experiments with more contact materials and less stringent rules. These experiments would further test the reliability of the test in a way that better simulates real-world tool use. Also, microscopic analysis of archaeological samples for comparison with experimental samples would be a useful area of research in order to determine the technique's effectiveness on archaeological samples.

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