“Wear It’s At” (or Isn’t): An Experimental Program and Functional Re-Analysis of an Oneota Lithic Assemblage Towards Evaluating Error Rates of Expedient Tool Identification

Christian A. Driver

Faculty Sponsor: Robert Boszhardt, Department of Sociology/Archaeology

ABSTRACT

Established in the 1950’s, use-wear analysis has been successfully applied to prehistoric lithic assemblages to determine the probable uses of formal stone tools. Some studies also included analyzing non-formal tools, but these were ancillary, not a focused effort towards identifying expedient tools. The study of use-wear itself calls into question the traditional system by which archaeologists evaluate whether a flake may be a tool or not via morphological traits and macroscopic inspection for traces of use. Sixty stone flakes manufactured from locally available chert were investigated under a microscopically after utilization in probable tasks performed by peoples of the late prehistoric Oneota (A.D. 1200-1650). After subjecting the experimental flakes ton a blind-test, a microscopic re-analysis of a previously studied flake assemblage from an Oneota component in the La Crosse locality was performed. This effort provides a framework for evaluating potential error rates in the identification of expedient tools used by the Oneota in the upper Mississippi River Valley.

INTRODUCTION

With their inception, stone tools became the first recognizable human technology. Chipped stone tool manufacture requires stone that has crystalline structure such as flint or obsidian. The “flint-stone” is then subjected to a process called “flint knapping” (Odell 2004), where numerous flakes (lithic debris) are driven off in a predictable fashion via percussive forces (Cotterell and Kamminga 1979) in order to produce formal tools such as knives, hide-scrapers, axes, and projectile points. By their nature, flakes have very sharp edges and are potential expedient or “casual” tools (Walker 1978). In sum, nearly all prehistoric lithic assemblages (groups of artifacts from a single context/area) contain both formal tools and unmodified flakes.

Stone tools and the associated flake debris constitute the greatest amount of artifacts recovered from most prehistoric archaeological sites, Indeed, they are sometimes the only preserved remains that archaeologists can use to learn about past activities from specific contexts, and numerous methods have been developed to understand how stone tools were manufactured and used. One such set of techniques are “functional analyses”, which focus on analyzing evidence of damage to the tool edge, known as use-wear. Use-wear ranges from scarring on the edge of a stone tool (visible with the naked eye, hand lens, or low powered magnification), to microscopically visible traces of abrasion, damage or polish that are observable only under magnification.

Since the 1970’s, use-wear analysis has been used to deduce probable tool uses, and the probable materials (bone, meat, wood, etc.) they modified (Kamminga 1981, Keeley 1982, Odell 1979, 1980a, 1980b, 1981, and Tringham et al. 1974). However, these analyses are expensive and time consuming, and few archaeologists are trained in them. Today, most stone tool analysis is done using morphological (form) attributes or a hand lens looking to identify signs of edge damage.

Unfortunately, macroscopic identification of edge damage is often unreliable and can lead to misidentified damage from factors other than use as use-wear (Bamforth et al. 1988, Mc Brearty et al. 1996). Non-use damage can occur from natural factors such as trampling or post-depositional actions such as plowing (Odell 2004), and even excavation techniques such as shoveling, troweling and screening. These secondary modifications presumably can be recognized through use-wear analysis (Tringham et al. 1974, Odell 1980a), but few laboratory technicians have the training necessary to distinguish modern and post-depositional damage from prehistoric utilization.

Use-wear analysis has also revealed that classifications based on morphology alone are questionable. A study by Odell (1981) showed that of tools classified as projectile points at a site in west-central Illinois, only 12.5% showed signs of actual use as projectiles; instead, the majority showed signs of use in other activities, such as cutting, drilling, and sawing.

The common method for analyzing archaeological flake assemblages is macroscopic identification alone. Unless correctly identified under magnification, flake-tools risk being classified as “unmodified” or “non-utilized” flakes, part of the waste generated by stone tool production. The main purpose of this paper is to produce a use-wear method that is easily replicable for all archaeologists to better document the archaeological record in an effort to recover as much information about the full range of stone tools present in all assemblages. By going beyond macroscopic identification, flake tools can be recognized as such, rather than being classified as mere lithic debris.

The Oneota Culture

From about A.D. 1200 to 1650 the Oneota culture inhabited the Midwest region of the United States (Theler and Boszhardt 2003). This culture inhabited a range of sites, documented in such places as Redwing Minnesota, the La Crosse locality of Wisconsin, eastern Wisconsin, lower lake Michigan, Central Missouri, and southeastern Nebraska (Henning 1995). The Oneota exploited a wide range of resources from diverse eco-niches. These included Mississippi River wetland resources, and the Plains regions of Minnesota as evidenced by the presence of bison-scapula hoes in the La Crosse locality (Theler and Boszhardt 2003). Also signified by the hoes, the presence of ridged field systems at the Sand Lake site in La Crosse County (Sasso et al. 1985), it is evident that Oneota peoples were reliant on corn, bean and squash agriculture. It is possible that the agricultural reliance was seasonal; perhaps exploited as a stored food resource for early spring, but its importance in the Oneota local economy has been established through floral remains analysis (Arzigian 1989). Other markers of Oneota culture, include artifacts such as sandstone abraders, circular manos, celts, a high occurrence of scraping tools, and lastly, globular shell-tempered ceramic vessels (Theler and Boszhardt 2003).

Ceramics are the most time-sensitive markers of Oneota culture and it is through an understanding of ceramic styles and coinciding radiocarbon dates that a three-phase typology has been developed for the La Crosse locality (Boszhardt 1994; Boszhardt et al. 1995). At La Crosse, these phases are Brice Prairie (A.D. 1300-1400), Pammel Creek (A.D. 1400-1500), and Valley View (A.D. 1500-1625) (Boszhardt 1994).

Oneota culture in the La Crosse locality ends with the Valley View phase at the Valley View site (47LC34). This has been interpreted as a short-term occupation site, interesting for its placement away from the river and floodplain, most likely for defensive reasons, marked by palisaded fortifications at the site (Stevenson 1994). The Oneota are

Then thought to have moved west across the Mississippi where they were encountered by French Explorers as the Ioway (Theler and Boszhardt 2003).

MATERIAL AND METHODOLOGY

Because of its common occurrence on Oneota sites in the La Crosse locality, the material selected for study and therefore experimentation was locally availible Prairie Du Chien Chert (PDC). Material for the experiment was gathered from a known workshop complex in southeast La Crosse County. Speccificly, PDC samples were collected from a small gully approximately 23.1 miles from La Crosse, Wisconsin, located next to a modern rock-quarry. The area was confirmed to be a PDC source for native peoples by the presence of pieces of chert that had been modified by humans.

The acquired PDC was knapped with the aim of producing unmodified flakes. Sixty flakes for the experiment were picked out of the debris piles based on criteria such as suitable size, edge angle, morphology, and minimally damaged edges.

All sixty flakes were numbered and had their attributes recorded onto a standardized data recording form that was developed for this project (Appendix B). Each flake was placed on an 8-polar coordinate grid (Odell 1979) dorsal side up and proximal end facing the user. The edge or area to be utilized was taken note of and a plan view was drawn of the flake in that position at the top of the sheet. The area to be used was marked by a series of dots.

A pair of calipers was then used to measure in millimeters the maximum length and width of the flake and the edge thickness five millimeters from the contact edge.

The edge angle was then recorded with a Gonimeter, a protractor with an arm-like attachment to facilitate proper measurement of three-dimensional objects. Several measurements were taken, and in the event they were all the same, a single value was noted. In the instances of variable edge angles along the working edge, the points were recorded on the plan view and the average taken as the “edge angle” of the working edge. The edge was then evaluated by the edge outline and edge profile (Ahler 1979) to determine macroscopically if any of the flakes were previously damaged prior to their use as experimental tools. Finally, all flakes had both their ventral and dorsal plan-views photographed on a copy-stand, once again, in the same 8-polar position as they had been recorded before.

The next phase of the pre-experiment recordation involved microscopic analysis. Because of the high reflectivity of the PDC, the edge to be examined was dipped in black India ink and blotted by a piece of paper towel to remove any excess.

The ink was allowed to dry and the tool mounted in plasticene; the edge was then oriented parallel to the stage-surface of the microscope.

Of the sixty flakes, the first 15 were marked with a pencil every five millimeters along the intended working edge. Every second five-millimeter area on both the dorsal and ventral sides was then selected as sample areas to be evaluated. For the remaining 45 flakes, one centimeter on both sides was selected for analysis and also marked. Regardless of sampling method, all flakes then had their sampled edges photographed under a magnification of 26x to create an edge plan-view of each side's sampled areas.

All photographs were taken with a Micrometrics DCM 130 digital microscope camera. This camera was mounted in one of the binocular eyepieces and ran directly to a computer system to take live video and store digital photos. The camera had a 20x lens and a resolution of 1280x124 pixels per inch

After the 26x photograph, the flake was then oriented at about 45 degrees to better utilize side lighting to bring out flake scars on the edge. The working edge was then scanned at magnifications between 60x-160x for evidence of pre-experimental damage. Any damage discovered was recorded by a photograph and, these photographs were imported into Photoshop and the damage highlighted in red with the computer paintbrush tool. All photographs were saved in a Photoshop file format that allows a layer with any markings to be rendered invisible to view the damaged area unobstructed. The photograph's file name was then created, containing references to the type of damage (Hayden 1979), the magnification of the photograph, and a number or letter coinciding with the placement of a corresponding number or letter placed on the 26x plan-view photograph to keep track of damaged areas.

After the initial recordation, the flakes were ready for use. As stated above, flakes were selected for experimentation based on edge-angle. The criteria is based on Wilmsen's (1968) article on suitable edge angles for different tasks. Flakes with an edge angle between 26 and 40 degrees (class A) were selected for "light cutting tasks", and flakes with and edge angle between 46 and 55 degrees (class B) were selected for "heavy cutting tasks". A third category was created for flakes with suitable Burin type (flakes with a sharp right angle protrusion suitable for engraving) points (class C). There were 20 flakes in each class. Ten more flakes were then selected out of the spoil pile and left unused and unrecorded. These flakes were to be used as controls in a subsequent blind-test.

The first 15 flakes (that were initially recorded differently) were subjected to screening. The flakes were placed in a "soil" re-created from silt from the MVAC float tank, and leftover material from 1/4" sorting of heavy fraction. The "soil" was then allowed to dry and then screened in a rocker screen until the flakes were released from the soil. They were then re-bagged and subjected to normal laboratory processing by a student volunteer who washed the flakes with water and a tooth brush, after which they were laid out to dry.

The remaining flakes were utilized for different tasks detailed below for intervals of 1, 2, 4, 8, and 15 minutes. In instances where there were less than five flakes available per task, the flake use time was increased so that the last flake was always used for 15 minutes (example: if there were 3 flakes, they were used for 4, 8, and 15 minutes respectively).

Four different mechanical tasks (sawing, graving, cutting, and butchering) were selected for experimentation, and these were thought to have been performed by the Oneota.

Sawing is defined as a bi-directional action longitudinal to the working edge. The tool is most often oriented 90 degrees to the material and moved back and forth while force is applied downward to create a progressively deeper cut into the material.

Graving is defined by both the action and tool morphology. The action can only be effectively performed by a "burin-bit" type spur, a corner with a sharp 90-degree point. The tool is oriented between 25 and 90 degrees to the material and is either pushed or pulled in a unidirectional motion to create a long cut in the material.

Cutting/shaving and butchering are both multidirectional and unidirectional actions, depending on the material. Both also have a variable tool orientation in reference to the worked material between 15 and 90 degrees. Butchering, however, is more specialized, referring to removal of meat from a bone, and dismembering, separating limbs, in this case, a deer-leg.

Whittling refers to a unidirectional action performed on wood, in nature, either towards or away from the user. Primarily used to remove bark or thin and shape a piece of wood, the tool is held at an angle between about 15 and 45 degrees in relation to the wood and produces thin strips of material as waste. Such actions were also performed on bone and antler in other studies (Kamminga 1981, Keeley 1982), but those materials were deemed too hard to make the application of the action worthwhile in this particular experiment.

Modern materials for experimentation were also collected. A deer hide was acquired from a local hunter and several deer legs from a road-kill. Both were frozen. Twenty-four hours prior to experimentation, the hide and legs were removed from the freezer and allowed to thaw. It should be noted that the butchering task was designed to remove the meat from the leg, and the meat-cutting portion of the experiment was conducted on that same removed meat.

Three types of wood were used for cutting sawing and graving (fresh yellow birch, dry black walnut (aged 1 year), and both fresh and dry red cedar). These were placed in a vise-grip during working to hold them steady.

Bone and antler were processed before use in order to soften them. The antler was boiled for 5 hours in water before cutting, sawing, and graving, and the bone for one hour before cutting. During cutting, it was determined the antler was still very hard. Consequently, it was boiled for another 2 hours before being sawed and graved. The bone and antler were also place in the vise-grip during experimentation.

Table 1 gives a break-down of the different tasks, exactly how many flakes were used for each, what types of flakes were used, and if the action was unidirectional or multidirectional.

Table. 1. Experimental program breakdown.

Task	*Flake class & number used*	*Uni/multi-directional*
Cut wood=cw	3A, 2B	Unidirectional
Saw wood=sw	3B	Multidirectional
Grave wood=wg	5C	Unidirectional
Cut hide=ch	4A	Multidirectional
Butcher=b	3A, 2B	Multidirectional
Cut meat=cm	5A	Multidirectional
Cut bone=cb	1B	Unidirectional
Saw bone=bs	3B	Multidirectional
Grave bone=bg	5C	Unidirectional
Saw antler=sa	3B	Multidirectional
Grave antler=ag	5C	Unidirectional

After the experiment, all sixty flakes were cleaned with a toothbrush and water, the standard procedure for lithic artifacts at the Mississippi Valley Archaeology Center (MVAC). Brushing was done from the center of the tool towards the lateral edge on both surfaces. By brushing off of instead of into the flake edge, the possibility of producing false micro-scarring was minimized. Experimentation and washing removed the India ink, so before re-analysis, India ink was re-applied in the same manner as before. Any new damage was photographed and compared to the original pictures of the sampled area. New damage was recorded in the same way as before on the original 26x plan-view photograph in a in green to differentiate new from old damage. The photos remained in the same format as before so that the overlaying markings could be removed to view an unaltered image if so desired.

All fractures were typified and quantified based on Ahler (1979) Hayden (1979) articles, and then compared to the results of 6 use-wear studies (Kamminga 1981, Keeley 1982, Odell 1980a, 1980b, Tringham et al.1974, Vaughan 1984). These are classic studies in the field of use-wear, and the synthesis of their varied and sometimes vividly contrasted results has much to offer the discipline in general, and this study in particular.

New fractures on the experimental flakes were quantified and entered into Excel worksheets, which were used to generate quantitative and statistical data for comparison to the previous use-wear studies. Qualitative analysis was also undertaken because of degree to which the studies were based on qualitative evaluations.

After re-evaluation, a sample of the sixty flakes in addition to the ten unused flakes was submitted to two MVAC staff members and a student worker for a blind test. This test evaluated the usefulness of macroscopic identification of expedient tools versus use-wear analysis. Each participant was given a sample and as much time as needed to evaluate whether the flake had been utilized or not. The participant then filled out a card detailing their evaluation and the reasons for their decision. Results were compared to the actual use or non-use of the flake, towards determining the effectiveness of macroscopic evaluation of expedient tools.

After the blind test, 14 artifacts from The Sanford Archeological District (SAD) Locality 32 (47 LC 394-32, Feature 205, Zone D Quarter section 3), an Oneota site located in the city of La Crosse, Wisconsin, were re-analyzed by the author. The effort employed low-medium powered use-wear analysis to again evaluate whether macroscopic identification is effective for identifying expediently used tools.

The SAD (47 LC 394) is a multi component Oneota site located in the Sanford Archaeology District in the City of La Crosse, Wisconsin. The largest feature of the Locality 32 site is Feature 205. Feature 205 took two years to excavate and reached an estimated depth of one and a half to two meters deep. Feature 205 seems to be a unique feature in both its size and shape. Thought to be a natural feature such as a gully in-filled by garbage, it differs from other garbage pits in that most garbage pits are smaller disused storage pits (Holtz-Leith, personal communication, 2006). The feature was dated to the Brice Prairie phase (A.D. 1300-1400) by ceramic styles and seems to represent a short-term disposal episode from around the site as evidenced by bone in relatively good shape with few appearing to have been gnawed by animals and almost no bleaching, both the presence of which would signal bone that had been left out of a garbage pit for some time (Holtz-Leith personal communication 2006). The significant amount of lithic material recovered, the presence of worked bone and antler, and the interpretation of the feature as representing a large portion of garbage from around the site, makes it a good candidate for use-wear analysis investigating previously classified debitage for signs of expedient tool use.

The SAD materials were excavated from mixed context during the 2004 field season. The soil was skim-shoveled and screened using ¼" mesh. The material was then bagged and sent to MVAC's laboratory facility where they were washed, dried, and catalogued as per the MVAC cataloguing procedure (Mississippi Valley Archaeology Center 2002).

Flake selection was based on size, material, and attributes. A selected flake (and/or "burin") had to exhibit a useable edge/bit for cutting/ sawing/graving actions between 26-55 degrees (Wilmsen 1968). Flakes under an inch long were evaluated for snapped areas, reasoning that a flake that small would not be utilized for a task long enough to produce micro-fractures unique from the flint-knapping process, if at all. Only un-heat-treated PDC could be investigated as heat-treating alters the structure and flaking qualities of flint-stone(Winfield 1978). The selected flakes were recorded on the same recording sheets used for the experimental tools and subsequently investigated microscopically in the same fashion

The SAD flakes were subjected to a non-damaging "smoking process" using vaporized ammonium chloride to coat the artifact with a matte-white finish (Buikstra and Ubelaker 1994). This served the same function of the India ink on the experimental tools, which could not be used on actual artifacts because of permanency issues.

Diagnostic damage was photographed and marked on another 26x plan-view image and quantified. The damage was then compared to the use-wear generated during the experimental phase and the conclusions drawn from the analysis of the experimental data.

DISCUSSION OF RESULTS

Introduction

Oneota lithic studies have been standard fare in the literature of reports for the last several decades, and a consideration of expedient stone tools has been present throughout. Expedient tools thus far have been defined as non-formal tools such as modified and utilized flakes (Withrow 1983), now defined by the MVAC cataloguing scheme (Mississippi Valley Archaeology Center 2002). Some reports even consider use-wear as an option of further analysis but time and budget constraints have not leant themselves towards practice of the technique (Withrow 1983).

Understanding of the Oneota in the La-Crosse area has greatly increased since the establishment of MVAC in 1982 by Dr. Jim Gallagher, whose dissertation was on lithic tools in Africa. Dr. Gallagher brought old-world perceptions to early work on lithics in the La Crosse area. The second Report Of Investigations (ROI) by MVAC (Gallagher et al. 1982) focuses on the Olson site (47LC76). A surface collection of over 23,000 artifacts followed by the excavation of several units yielded many lithics including "irregularly modified pieces" that would now be classified as retouched flakes. With these irregularly modified pieces, thought to represent other expedient tools were also noted.

The Olson site yielded a numerous retouched and utilized flakes. Of these flakes, 325 were classified as retouched and 96 as exhibiting worn/utilized edges (Gallagher et al. 1982). Even some simple burins or engravers were identified, which seem not to exist formally in Oneota assemblages (Holtz-Leith, personal communication 2006). Gallagher's work did not focus on expedient tools, but this early MVAC ROI (Gallagher et al. 1982) shows that expedient technology was considered from the beginnings of Oneota study in the La Crosse locality.

Withrow's (1983) study of Valley View (47LC34) lithics was also prior to the development of a standardized lithic tool cataloguing system by MVAC. Withrow classified retouched and utilized flakes as "unmodified artifacts", and applied an understanding of edge damage and "un-patterned retouch" to his classification of what he understood to be expedient tools (Withrow 1983).

Withrow (1983) cites Ruth Tringham et al.'s (1974) use-wear research and bemoaned the fact that it could not be performed on his assemblage due to the amount of time and specialization necessary. However, all debitage over a quarter-inch was sorted under a 10x microscope for traces of macroscopic wear-traces, and he was even able to make tentative functional analyses for 26 unmodified artifacts based on Tringham's (1974) classification of manner of usage, finding that 14 were used in a transverse motion, 11 in a longitudinal fashion, and 1 for boring (Withrow 1983: 116).

An interesting aspect of the expedient tools used in the Valley View assemblage, this pattern is the high number of expedient tools made of exotic materials. This pattern was seen as reflecting an intensification of use of quality exotic materials because debitage was more consistently being used for tools most likely to maximize its use-potential (Withrow 1983). Withrow's study was also not focused on expedient tools, instead, he was concerned with raw material selection on the basis of technological factors, which he found not to be the case.

The MVAC cataloguing system was in-place by 1989, and Rodell's (1989) study of the Pammel Creek (47LC61) lithics applied the MVAC typology. Concerned primarily with raw material usage and tool typology (Rodell 1989), Rodell determined that the Pammel Creek assemblage reflected the whole range of lithic reduction, especially among tools and debitage made of locally available PDC.

Though Rodell cited the MVAC cataloguing system, he only included utilized and not retouched flakes in his quantifications (Rodell 1989). It is unclear if there were flakes determined to be utilized, or if the retouched flakes all displayed utilization.

A Phase III excavation at the Tremaine Site (47LC95) was undertaken by MVAC in 1992 (Gallagher et al. 1992), and the lithic analysis completed by Charles Moffat. Moffat used the MVAC cataloguing system, and in two feature groupings identified a number of "modified flakes" that he considered informal or expedient tools. Moffat found that a high proportion of the formal tools were made of exotic materials while most of the unmodified debitage consisted of local materials, again showing the importance of quality exotic material.

Another Phase III excavation at the Tremaine (47LC95) site (O'Gorman 1995) completed by the Museum Archaeology Project (MAP) did not use MVAC's cataloguing system, but one developed by the State Historical Society of Wisconsin (xxxx). Retouched flakes were characterized as those with retouch on the edge not extending onto the body, and utilized flakes as exhibiting macroscopic use-wear. The MAP analysis also was not focused on expedient technology, but rather on the procurement of raw materials and the determining of which stages of tool production took place at the site.

The State Road Coulee project (Boszhardt et al. 1984) yielded a very large assemblage consisting of 70,026 lithic artifacts alone. Of this large number only 1,556 or 2.22% were classified as tools, the rest as debitage. Boszhardt used the standard MVAC cataloguing process and therefore the standard classification of modified and utilized flakes took place, classifying them as a subset of the tool category. Modified and utilized flakes made up 38.76% of the tool assemblage or 603 of the 1,556 tools (Boszhardt et al.1995). Once again, expedient tool use was considered but not intensively studied in Boszhardt's work.

Previous Studies

In the six prior use-wear studies referenced, there is a significant difference of opinion between two main camps. On one side are Ruth Ann Tringham and George Odell, the so-called "Harvard Group", who assert that micro-fractures are diagnostic for determining the hardness of materials the tool was used on and for determining the directionality of tool use (Odell 1980a, 1980b, 1981, Tringham et al. 1974). Many of the determinations made by Odell (1980a, 1980b) and Tringham (1974) and her colleagues are based on material hardness and directionality, often not going as far as to infer specific materials but rather the placement of the tool used on a scale of soft to hard worked materials and transverse or longitudinal action. Odell and Tringham also assert, that the low-power (10x-80x) approach is adequate for this type of analysis. Recently, Odell (2001) has acknowledged limitations to this method, but still considers it useful.

On the other side of the debate are Johan Kamminga, Lawrence Keeley, and Patrick Vaughan (Kamminga 1981, Keeley 1982, Vaughan 1984). These practitioners utilized the high-powered approach (100x-1000'sx), focusing their analyses on polish, striations, and edge rounding not usually visible under low power, and frequently employed the use of electron scanning microscopes. All three conducted research on fracture formation during their experiments, and all three came to the conclusion that micro-fractures are not diagnostic, and that conclusive use-wear studies can only be performed by investigating abrasion, polish, and striations. Kamminga, Keeley, and Vaughan also went beyond the hard to soft scale of materials and transverse versus longitudinal actions to interpreting particular tasks performed on specific materials in their analyses. The high-powered approach was suitable for distinguishing differences, but the analysis of micro-fractures was not. This problem may be based on the application of qualitative rather than quantitative methods. Most of the past use-wear literature (Keeley 1982, Tringham et al. 1974, Odell 1980a 1980b) applied qualitative evaluations to understand characteristics of use-wear, whereas others (Vaughan 1984) evaluated those conclusions using quantitative methods and found them to be somewhat lacking. Through application of the low-medium (26x-160x) powered approach, combined with quantitative evaluations, it is hoped that a reliable method of analyzing micro fractures can be assembled that would be useful to the archaeological community, therefore hopefully at least minimizing Vaughan's (1984) bleak view of the analysis of micro-fractures alone.

The application of a low-medium power approach was applied to this study in an effort to possibly take the middle way between the low and high power approaches. It should be noted that the methods of coating and inking the flakes during the experimental and analysis phases obscured any evidence of polish and striations that may have been present. All three advocates of the high-power method assert that most edge polish, abrasion, and striation is only visible under high-powered magnifications. Therefore, the only subjects of analysis were micro-flake scars visible up to 160x.

Fracture typology

At this juncture it becomes necessary to introduce a typology of fracture types so that the reader may become familiar with the different types of fractures that will be discussed. Table 2 is adapted from The Ho Ho Classification and Nomenclature Committee Report in *Lithic Analysis* (Hayden 1979). Fracture initiation types, the beginnings of fractures at the tool edge, are arranged on the left side of the table, whereas terminations, the end of the fracture on the body of the tool itself are along the top. Table 2 shows that it is possible for a termination to have multiple initiations and vice versa. This is the classification primarily used throughout the entire paper.

Table 2. Fracture types adapted from the Ho Ho fracture classification in Lithic Analysis (Hayden 1979).

	Feather	Step	Hinge	Snap
Indeterminate or absent				N/A
Cone				N/A
Bending				

RESULTS OF THE EXPERIMENTAL PROGRAM

Task Evaluation

The evaluation of the experimental results takes place in two parts. First, the results are compared by task to the results of the studies noted above (Kamminga 1981, Keeley 1982, Tringham et al. 1974, Odell 1980a 1980b, Vaughan 1984). Not all tasks performed were represented in the literature, but some of those that were investigated are evaluated here. Those tasks not evaluated specifically by the literature are evaluated in the section dealing with material hardness, as each task exists somewhere along the continuum of soft-hard worked materials. Next, the results are then evaluated in and of themselves in order to determine if any new information has been learned.

Whittling

One attribute of whittling tools that Tringham (1974) and her colleagues observed was the removal of a larger proportion of flakes from the upper, non-contact surface of the tool edge. In this experiment however, only two of five tools displayed more scars on the opposite non-contact surface than the surface in direct contact with the material.

Odell (1980a) also holds that actions transverse to the working edge will produce exclusive, or close to exclusive unifacial scarring, and that whittling will produce a contiguous row of feather terminated fractures on the lower surface of the tool contacting the material, “less abundant” hinge-fractures on the upper surface, and many bending and step fractures were thought to occur with “shaving” actions (Odell 1980b).

Results

No flake exhibited exclusively unifacial scarring and only one tool displayed scarring on one side of the tool that accounted for 90% of total scars. All other tools used for this task had higher proportions of scarring on one edge or the other ranging from 50%-60%, therefore invalidating the unifacial-scarring claim.

Hinges on the upper, non-contact surface are almost non-evaluable. Because of the India ink coating method used, hinge and step fractures were obscured to a point where differentiation became almost impossible. Therefore, step and hinge terminated fractures were considered as one type (step/hinge) and were analyzed as such. Regardless, whether considering those classified as just hinges or those as either step/hinge fractures on the upper surface, the evaluation was found to be in error. Some tools displayed no step or hinge fractures at all and those that did seldom displayed them in a fashion that favored the upper, non-contact surface of the tool, tending more towards a bifacial distribution of the fracture types.

In the case of many bend and step fractures (or in this case, bend, step, and hinge fractures) being a marker of whittling tools, the trend is decidedly against the assertion. Of the five tools, only two tools display over 50% of either bending initiations or step/hinge terminations. The other three flakes used express bending initiations and step/hinge termination frequencies of not above 30%, an insignificant frequency.

As for the claim for contiguous fractures on the lower surface, only one of the five tools displayed this tendency within the sample area. Since the sample areas were selected based on the likelihood of contact, this is not a biased sample, most scarring appeared scattered and not all was feather terminated.

Though Keeley (1982) puts little stock in the low power approach, he did notice a tendency for “half-moon breakages” to occur on lower edge angles during whittling tasks. These half-moon breakages have been determined to be bending snap fractures. When a correlation between bending initiations and edge angle was run on the tools used for whittling, a correlation of .18 was produced signaling no association. However, this may be due to either small sample size and/or to the fact that tools were selected for tasks based on edge angle (Wilmsen 1968), therefore biasing the sample.

Sawing Wood

Odell (1980b) noted that feather terminated and cone initiated fractures were common on tools used to saw hard materials. All sawing on wood performed for this experiment was done on a piece of black walnut, dried for a full year, so the wood sawing action is thought to be in the hard range of the material hardness scale.

Of the three tools used to saw the wood, only one of the three displayed more that 60% cone initiations, and of those fractures only 42% were feather terminated. Once again, sample size may be the issue here but in light of the data at hand, feather terminations with cone initiations do not appear to be a hallmark of sawing wood.

Cutting Hide

Of the six studies, the only one to specifically evaluate cutting hide was Johan Kamminga (1981). As mentioned previously, Kamminga was one of the group that found the low power approach lacking but he did notice the tendency of hide cutting to be characterized by feather-terminated fractures.

In the experiment, feather fractures did occur on all three tools used to cut hide. However, feather fractures were not exclusive and only one of the tools produced more than 50% feather fractures overall. It is unclear if Kamminga is noting only the occurrence of feather fractures or their dominance, however he is still clear that it was only a tendency reflected by his data, and not an attribute to be conclusively relied upon.

Butchering

Specific damage done by butchering was covered satisfactorily only by Keeley (1982) and Kamminga (1981). Both Keeley and Kamminga note that most of the scarring is scattered and many are produced by contact with the bone during removal of the meat. On the subject of the influence of edge angle is where they differ, Keeley found no association with the number of scars and the edge angle of the tool; whereas, Kamminga detected what he thought to be a tendency of higher angled tools exhibiting less scarring on the tool edge.

Qualitatively, contact with the bone was noticeable during the experiment, larger scars on the edge of the tool seeming to coincide with such contact. There was no-way to quantify this however, and many of the scars appeared outside of the sampled area, reflecting the scattered pattern expected.

In reference to edge angle, Keeley (1982) seems to have been correct. When a correlation was run on the five tools for edge angle and total number of fractures, only a figure of .57 was produced, well below the minimum 70% -80% confidence level preferred for this study.

The range of edge angles for the five tools is somewhat small, ranging from 37 to 52 degrees based on the selection of tools for their tasks based on Wilmsen (1968), but it is not believed that the sample size is too small. Further analysis below will shed more light on the correlation between edge angle and the quantity of scars that occur on tools.

Sawing Bone

Kamminga (1981), Odell (1980a, 1980b), and Keeley (1982) all attribute a higher instance of bending initiations to sawing-type actions, which will be discussed further below. However, Kamminga (1981) and Keeley (1982) were the only ones to concentrate on sawing bone as an action itself. Kamminga found that there was a tendency for bending initiations and feathered terminated fractures to occur with sawing bone, while Keeley found a high proportion of micro-step scars occurring in comparison to sawing wood where he found that no micro-step scars occurred.

The results of the experimental program do not confirm a trend towards bending initiated feather fractures. Of three flakes used to saw bone, only one flake displayed a single feather-terminated scar with a bending initiation. This would seem to invalidate the claim but the consideration of the sample size must be taken into account. On the other hand, as will be seen below, the number of bending initiations in general seemed appreciable, even on just three tools and the absence of this type of scarring may be dependent more on the length of time used more than anything else.

On the other hand, Keeley's (1982) theory appears to be partly true. While step/hinge-scarring does occur on flakes used to saw wood, significantly more does occur on bone. This may be a function of material hardness, but step/hinge fractures will be shown later to have little if no correlation with material hardness, therefore leading to the conclusion that step/hinge scars may be significant in determining a tool used to saw bone.

Graving

Odell (1980b) was the only one who discussed graving in a way that could be evaluated. Even so, Odell did not differentiate between different materials graved.

Odell expects “cutting type wear” on graving bits and for the scarring to be bifacial with reference to the bit. As will be discussed, there is no diagnostic “cutting” wear that is discernible by looking at fractures alone. As for the idea that scarring is bifacial, the evidence supports only a weak correlation.

For the evaluation of graving, those tools that were used on wood were not considered because of the fact that four of the five tools broke before they could be used for more than one minute. Of the ten remaining tools, bifacial scarring occurred, but in a lopsided fashion. Only two flakes have a close to equal distribution on both dorsal and ventral aspects of the bit whereas two of the tools exhibit scarring on either just the dorsal or ventral aspect of the bit, and the remaining six exhibit much more scarring on one side or the other. Also, Odell (1980b) does not mention scarring that occurs on the face of the burin bit, but in this experiment, a fair amount of scarring, while not in diagnostic frequencies, still occurred on the face of the bit itself.

Sawing Antler

Sawing antler is another task that was only covered adequately by Keeley (1982), who noticed a tendency towards small step-terminated fractures and “half-moon breakages”, defined here as bending initiated snap fractures. Once again it is worth mentioning that Keeley saw these as tendencies, as he felt the low-power approach to be unreliable.

As mentioned above, step scarring will be addressed below in the section *Hard and soft worked materials*. Bending initiation causes will also be discussed more fully, but suffice it to mention in this section that many believe them to be a byproduct of sawing-type actions. These bending initiated fractures did occur with appreciable frequency on the experimental tools. Though the sample size was only three flakes, the average number of bending fractures was seven per tool compared to an average of 1.86 bending initiated fractures on all other tools. Compared to sawing wood, another three-flake task, the average is higher again, the flakes used to saw wood generating an average of five bending initiations per tool. This average is close, and can perhaps be explained by noting that all wood sawing actions were performed on dry wood, a hard material.

Non-Use Damage

The consideration of non-use damage applied here is that created by Odell (1980a). Odell considers a range of post-depositional and taphanomic factors that could affect the edge of the tool from prehistoric to modern factors. In general, Odell says that non-use damage has a random distribution, a great variety of scar types, irregularly spaced crushed edges, notches, and scars that are mostly unifacial. Odell also feels that retouch is easily discernible based on size.

This experiment has two notable differences from Odell's. First, only one type of non-use damage was considered, the impact of screening and lab processing on unmodified flakes. Second, whereas Odell looked at the entire margins of his tools, those that were screened were examined on one edge only (albeit differently from the other experimental flakes, but not nearly as extensively). Therefore, it is possible that these types of damage occur elsewhere on the tool, but the experiment was unable to evaluate that possibility.

In general, the flakes that were screened had very random patterning of scars, however, the frequency of scarring was very small and would have been indiscernible from the scars present already on the stone had the recordation process not taken place. There was no notch-type scars, nor was there crushing in any of the areas sampled, neither were the scars unifacial in nature.

The conclusions to be drawn from this will be discussed more fully below; however, comparison to Odell's work must be made. The only agreement is in the random distributional patterning. The low number of scars; and lack of crushing are attributed to screening and lab processing not being very hard on the artifacts, whereas, the lack of unifacial distribution seems to be a function of the tool rolling around in the screen. Once again, these results must be taken more on their own rather than in direct comparison to Odell's more extensive study.

Hard and Soft Worked Materials

As previously noted, not all tasks performed for this experiment were specifically addressed to a satisfactory extent in the extant literature. Those that were have been summarized already and the remainder will be discussed here.

Odell (1980a) divided all workable materials into a single scheme operating on a scale of soft to hard. Even though Odell feels that different actions form different types of scarring, he also states that some fracture types are indicative of softer or harder materials. The scale is divided into four sections; soft, soft-medium, hard medium, and hard.

Soft materials include animal products like skin, meat, and fat, and vegetal products like tubers. The kinds of fractures produced by these materials are described as small and feather terminated, or sometimes no scarring, the only sign being a “roughening” of the edge.

Soft-medium materials are softer and fresher woods such as conifers, or things like fresh stalks. Odell (1980a_ states that because of greater penetration, the scarring is larger, especially on un-retouched edges with low edge angle value, and fractures are mostly feather terminations with poorly defined borders.

Hard-medium characterizes harder woods, along with fresh and soaked antler and bone. According to Odell (1980a), scarring is medium and large in size, and characterized by hinge terminations.

Finally, hard materials include bone, antler, and very hard and dry woods. Odell (1980b) notes that comparisons between fresh antler and dry bone may offer difficulties, but overall, scarring is characterized by extensive step-terminations of medium to large size.

Table 3 summarizes all the actions performed for this experiment with the softest material at the top and the hardest at the bottom. Within each material category, actions were also taken into account, for instance, graving was not thought of as being as destructive to the tool edge as sawing, Therefore, graving is always listed first, and sawing last.

Table 3: Actions on Odell's (1980) material-hardness scale.

Scale location	***Action***	***Abbreviation***	***Material hardness number***
N/A	Screen	S	1
Soft	Cut meat	Cm	2
Soft	Cut hide	Ch	3
Soft	Butcher	B	4
Soft-med	Wood grave	Wg	5
Hard-med	Bark/whittle	b/w	6
Hard-med	Wood saw	Ws	7
Hard-med	Bone grave	Bg	8
Hard	Cut bone	Cb	9
Hard	Bone saw	Bs	10
Hard	Antler grave	Ag	11
Hard	Cut antler	Ca	12
Hard	Antler saw	As	13

It is clear throughout Odell's (1980a) treatment of the materials hardness scale that feather fractures are much more common on softer materials and that hinge and step fractures increase as materials become harder. The experimental program did not confirm this. As Figure 1 shows, a graphing of the percentage of feather-terminated fractures versus step/hinge terminated fractures and snap-terminated fractures per tool using the scale of soft to hard materials moving left to right, step/hinge fractures are found to appear in high frequencies across the entire scale, whereas feather fractures generally seem to occur as lower frequencies relative to step/hinge fractures. Snap fractures always occur in low frequencies. Random patterning is evident, and shows that there does not seem to be a general trend towards a decrease in feather fractures and an increase in step/hinge fractures as materials move up the hardness scale. Another interesting thing to note are the flakes screened and lab-processed (S). These tools do not seem to exhibit any difference in the relative occurrence of termination types from the tools that were actually used.

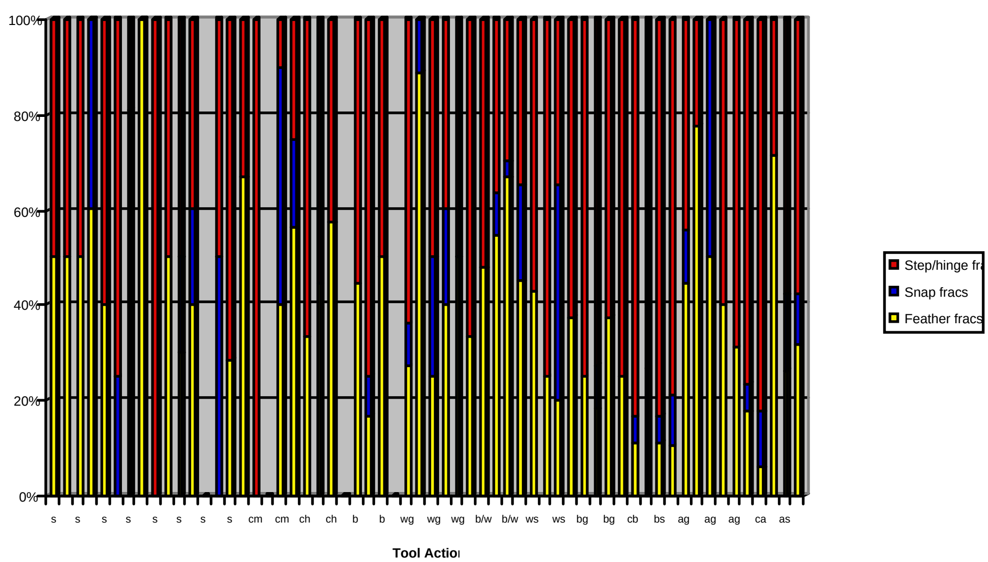

Figure 1. Relative proportions of fracture terminations per tool arranged from soft to hard materials.

As for the other attributes mentioned by Odell (1980a), size and the definition quality of scars were not considered in this experiment. Future work would do well to evaluate these traits, but in the effort to provide a system useable by most archaeologists, such criteria were deemed too time-consuming to consider.

Directionality

One of the most basic determinations of the "Harvard Group" is that of directionality with respect to the edge of the tool utilized. Odell (1980a) states that unidirectional and multidirectional actions oriented longitudinally will have the scars oriented obliquely to the utilized edge, and will allow the analyst to deduce tool action. Trigham (et al.1974) says these actions will produce uneven bifacial scarring dependent on the utilization angle.

Tringham (et al. 1974) say actions oriented transverse to the tool edge, such as whittling or planning, will produce scars on the opposite surface from that which is contacting the material. These scars will also be directional in the fact that they will be oriented perpendicular to the edge (Odell 1980a, 1980b). Odell (1980b) takes a slightly different stance on transverse actions saying that contiguous rows of feather fractures will be present on the contact surface of the tool near the edge, with less abundant hinges on the opposite surface.

Vaughan's (1984) results seem to directly contradict some of these assertations. In his tests, only 65% of his experimental tools exhibited bifacial scarring on tools used longitudinally, and 46% of his tools used in a transverse fashion showed bifacial scarring or scarring on the contact surface. These results contradicted Tringham et al.(1974). Also in contradiction is that only 52% of scarring on transverse edges was "dense". On the other hand, 66% of his longitudinal tools exhibited discontinuous scarring.

The current experimental program supports the results obtained by Vaughan (1984). In-fact, when the number of directional fractures and those that would offer an interpretation of an opposite direction of use were each averaged, the frequencies were exactly even. A correlation of the two attributes showed absolutely no relationship.

Directional scarring may be affected by a number of factors. On tools used longitudinally, non-directional fractures would be those oriented perpendicular to the edge and vice versa on those used transversely. As Keeley (1982) notes, native peoples, much less us as experimenters, would find it impossible to hold the tool at a constant angle, resulting in strange fractures outside of what would be expected. In sawing and cutting especially, fractures oriented perpendicular to the edge should be expected as to effectively cut or saw, force must be applied downward to penetrate the material. This force demonstratably has produced scars oriented perpendicular to the edge on tools used longitudinally.

One caveat in this study is that in order to save time, fracture size was not considered. The smaller scars analyzed may have skewed statistical analysis. Odell (1980a) states that hard materials especially produce larger fractures and soft materials smaller ones. Vaughan (1984) found that to be the case on 63% and 25% respectively on his experimental tools, reflecting only tendencies towards a correlation between material and fracture size. Future studies should apply a method of size analysis to flake-scars; however, this may not be the most time effective method and was therefore not used in this study.

Another consideration is that of scraping actions on things like hide and wood. Such actions were not performed in this experiment due to the Oneota possessing such a high number of what has been interpreted as hafted end-scrapers combined with the difficulty of finding a suitable unmodified edge angle and proper sized flake for un-hafted scraping. Hafted tools are considered modified and would therefore not fit the definition of expedient used for this paper. Hafting would also allow a greater amount of force to be applied that would be difficult to replicate by hand holding alone

Time

One assumption that even non-use-wear analysts might hold is a positive relationship between time and the number of fractures on a tool. In running correlations on the entire assemblage, a correlation of very close to zero was produced. However, when the experimental tools were each correlated by action performed, 4/12 actions, graving antler, sawing wood, sawing antler, cutting hide and cutting meat all produced correlations above 0.85. At first glance, this does not seem dependent on material hardness as both tools used on hard and soft materials produced both positive and negative correlations with the majority being negative. Several factors that may be at work here are sample size, material hardness, and fracture size.

As noted above, a correlation of time versus the number of fractures applied globally on all tools produced a figure of almost exactly zero, or no relationship. It was determined that high variability in actions and therefore fractures may be a possible cause. Correlations were run on each action type (minus screening) and positive correlations were found. As can be seen in Table 1, the highest number of tools used on a material was ten, five if the tools used in screening are omitted. This small sampling strategy was used to facilitate rapid analysis while still covering a wide range of probable tasks. Therefore, the low sample size may affect the correlation of tools by task whereas high variability may affect the global correlation.

The specter of fracture size again becomes an issue in considerations of the number of fractures versus time. If considered combined with factors of material hardness or use of the tool discussed below, it may be possible for larger fractures to form that eliminate previous smaller fractures in the same area. In that case, there is no way to evaluate the relation of time and the total number of fractures on a tool unless those analyzed are tools that are used on softer materials that may not produce large fractures.

Bending fractures and tool use

Odell (1980a, 1980b), Keeley (1982) and Kamminga (1981) all agree that cutting, whittling, and sawing actions produce more bending and snap fractures that other actions relative to the hardness of the material worked. This is a factor because a human individual cannot perform longitudinal actions at a constant angle. Coupled with downward force used to penetrate the material, these constant variations in the tool edge relative to the worked material have a tendency to produce snap terminations and bending initiations as the edge of the tool is caught and force applied perpendicularly as the angle of use is changed. This tendency is thought to manifest itself most clearly in actions like sawing and cutting, where penetration of the material is achieved.

The results of the experimental program for this evaluation are mixed. In Figure 2, all the flakes not used for graving are arranged from left to right from no particular use orientation or transverse use orientation (screening and whittling respectively) to more intensive longitudinal actions (cutting is less intense of a longitudinal action than sawing, therefore it is located closer on the left end of the scale).

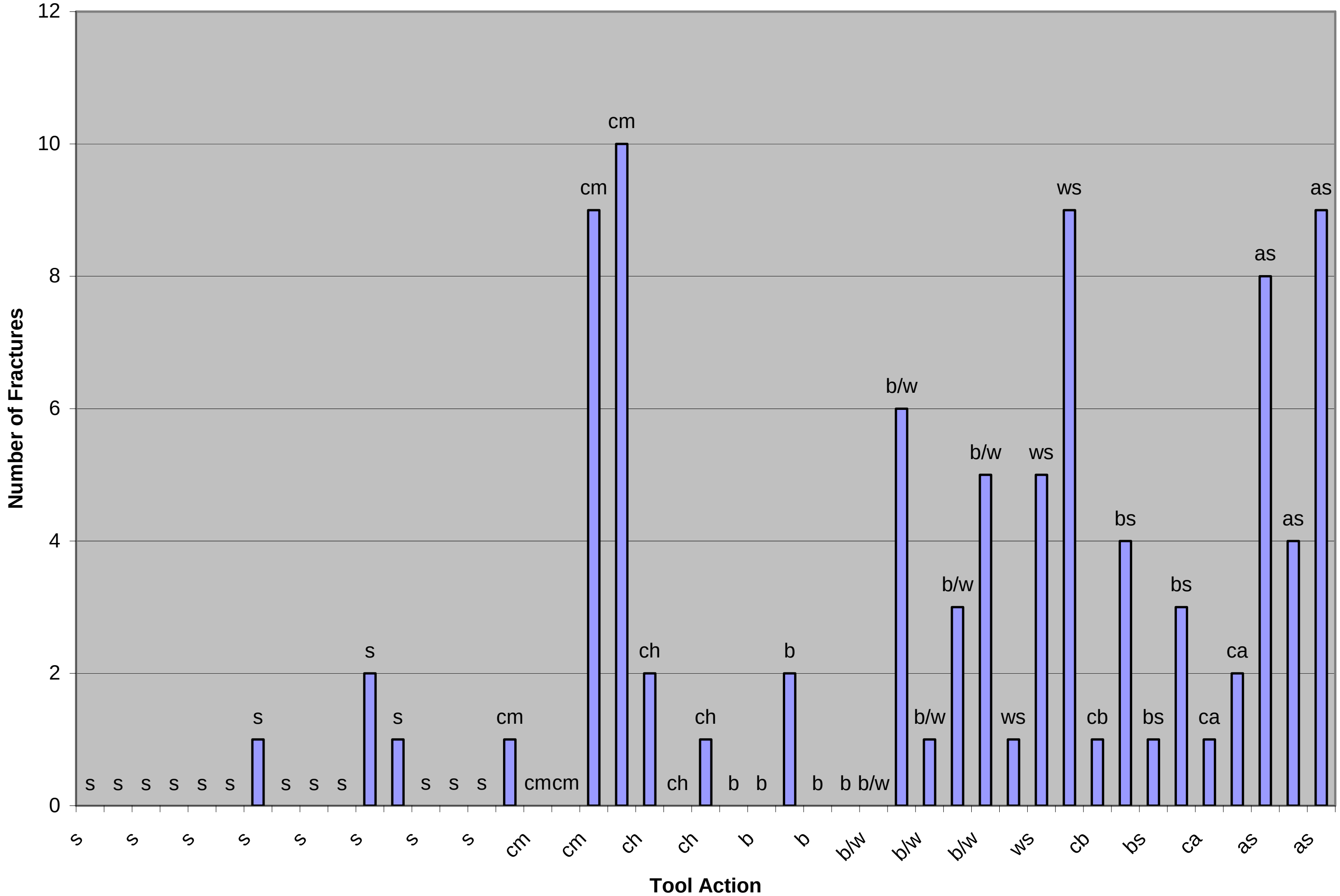

Figure 2. Bending initiations and longitudinal action per tool arranged from soft to hard materials.

Figure 2 shows that besides a few anomalies, bending fractures appear to increase as one moves to the right of the scale into more intensive longitudinal actions, spiking on the far right as harder materials such as dried wood and antler are sawed. However the anomalies must also be considered.

Whittling is a transverse action, and should (according to Kamminga 1981, Keeley (1982), and Odell (1980a)), at the very least, have less bending fractures than tools used in a longitudinal fashion. This is not the case. Four of the five tools used for whittling exhibit more bending fractures than most of the tools to the right end of the scale, even going so far as to register in the second highest grouping of peaks in two instances.

Also anomalous, but explainable, is the peak in cutting meat. As stated above, penetration is a key factor in bending fracture formation, and softer materials like meat, while offering what seems, at least in two of five of the flakes, to be a sufficient amount of resistance to create bending initiations on flakes with lower edge angles.

The important thing to note for bending initiations is that they reflect a tendency. Figure 2 shows almost no bending initiations on the left end of the scale and more on the right, with explainable peaks in some actions.

On the other hand, Figure 3, shows that except for the two of five flakes used for meat cutting, other fractures often greatly outnumber bending initiations, to an extent that they may be un-noticeable. Exceptions occur on the right side of the graph where a fair amount of the bending fractures on three tools challenges the others for supremacy, but these appear to be anomalous and it seems that bending fractures are not a good indicator of longitudinal action.

Edge angle and fracture number

Keeley (1982) and Kamminga (1981), both found that edge angle and the number of fractures formed were closely related. Keeley found what he called “half-moon breakages” on tools used for whittling and sawing wood, and low angled edges as did Kamminga. Both found that high angled edges had a lower number of flake-scars, and Kamminga found that especially true for those used on softer materials.

Wilmsen (1968) found edge angle important dependent on the task performed, his assessment of lower edge angles for tools used on softer materials and higher angles for harder materials was used to assign tools to particular tasks in this study and, therefore, it would not be statistically valid to run correlations of number of fractures versus edge angle per action performed.

Correlations were run on fracture type, the number of bending initiations, and the total number of fractures on a tool all versus edge angle. In all of these tests, no association was found between edge angle and the total number of fractures.

Once again, fracture size may be a factor in this also, as diagnostic fractures may be over a certain size whereas all fractures visible between 26x-160x were given equal weight in this study. Further work on fracture size may be able to resolve this issue but, for now, edge angle does not seem to be related to the total number of fractures.

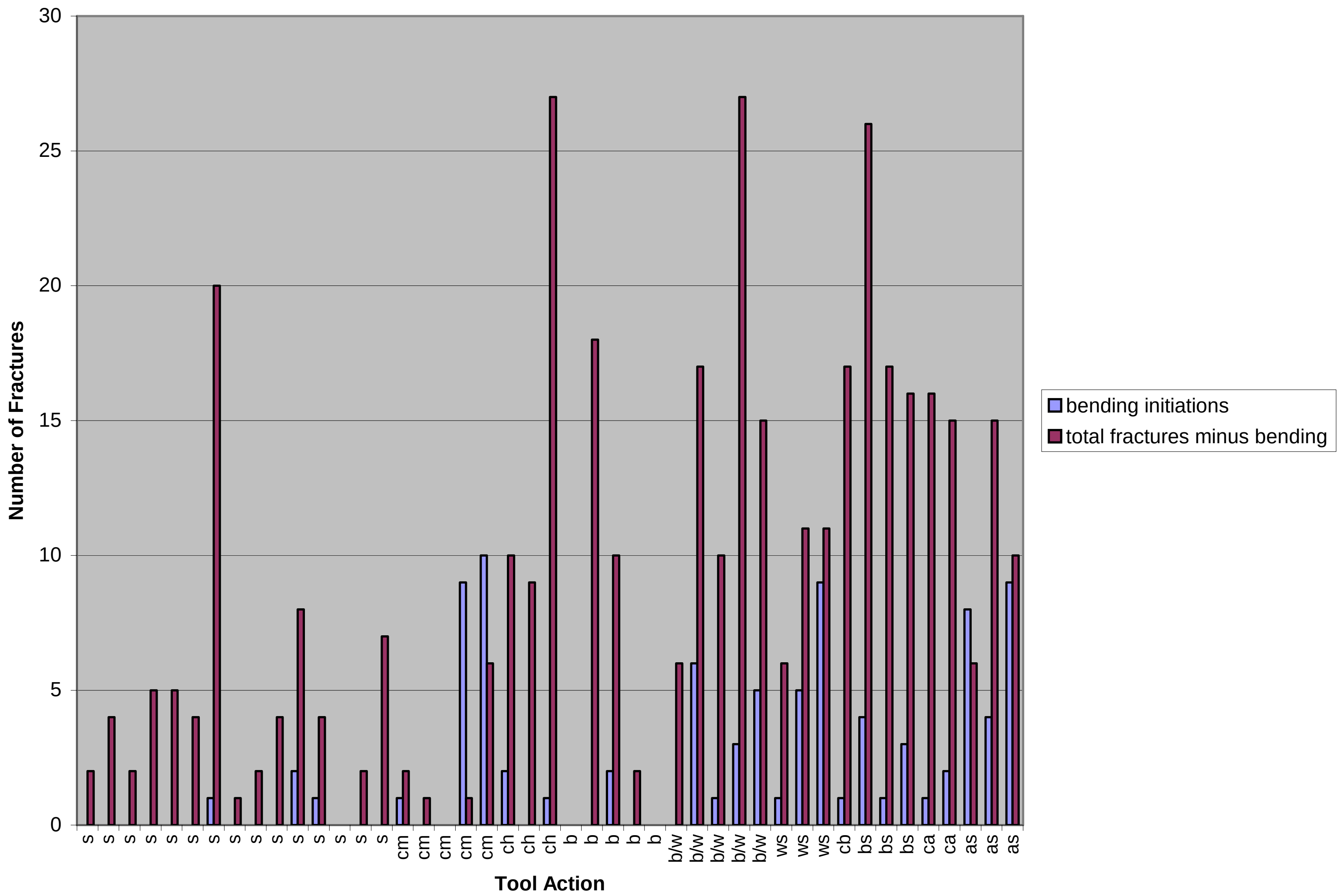

Figure 3. Bending initiations compared to other fractures in longitudinal action per tool arranged from soft to hard materials.

Fracture Continuity

Tringham et al. (1974), and Odell (1980a, 1980b) assigned the attribute of contiguous fracturing to tools used on harder materials. Whether used transversely or longitudinally, this qualitative evaluation is based on the idea that consistent contact with the edge will produce regularly spaced or at least contiguous lines of fractures at the contact area. It is during longitudinal action however that Tringham's (1974)group expects discontinuous scarring on either edge as the angle between the worked material and the tool changes.

All tools used longitudinally and transversely were scanned to evaluate the above qualitative statement. The scanning took place at 26x-60x, the limit of the low power approach that Odell (1980a, 1980b, 1981) and Tringham et al. (1974) applied. For the most part, on tools that had been used on hard-medium hard materials, the assessment turned out to be correct. Tools used longitudinally did display discontinuous scarring that seemed to be related to changes in use-angle. The whittling tools used transversely also displayed contiguous scarring.

Both types' actions produced the expected scarring patterns along the entire tool edge. This was attributed to the use of the entire edge to complete the task. While the area selected for sampling was one that was expected to be impacted the most, the whole tool edge was used on almost all cases in an effort to use the tool for the set time that it was supposed to be. When the utilized area became inefficient, another part of the edge was often used especially in whittling and sawing. This may mirror prehistoric activity in the sense that prehistoric peoples may have wanted to get the most work out of their expedient tools before throwing them away, and may have utilized the entire suitable part of the edge before disposing of them. Localized edge damage may reflect a high edge angle that would have been sharper for longer, or a task that did not take a very long time where significant edge damage would not have necessitated a new tool or throwing the current one away. It is this dynamic that makes determination of use based on whether scarring is localized or contiguous useless.

While comparisons to previous studies are important, each new study should make an effort to add its own conclusions to the discussion of the topic at hand. The results specific to this experiment are reported below, and if nothing else, should, in the author's opinion, guide future research.

Total fractures as related to material hardness

One assumption to evaluate is that the total number of fractures will increase with the hardness of the materials worked. Figure 4 is a graph of the total number of fractures once again arranged from left to right based on Odell's (1980a) material hardness scale.

Figure 4 shows that as material hardness increases, the general trend is toward larger amounts of fractures as material hardness increases, but there are many spikes and anomalies, some easily explainable.

The first explainable spike is related to the task of butchering (b), two of five tools exhibit high numbers of fractures in relation to the other three tools used for butchering. The high number of fractures can possibly be related to bone contact as noted before in the butchering section.

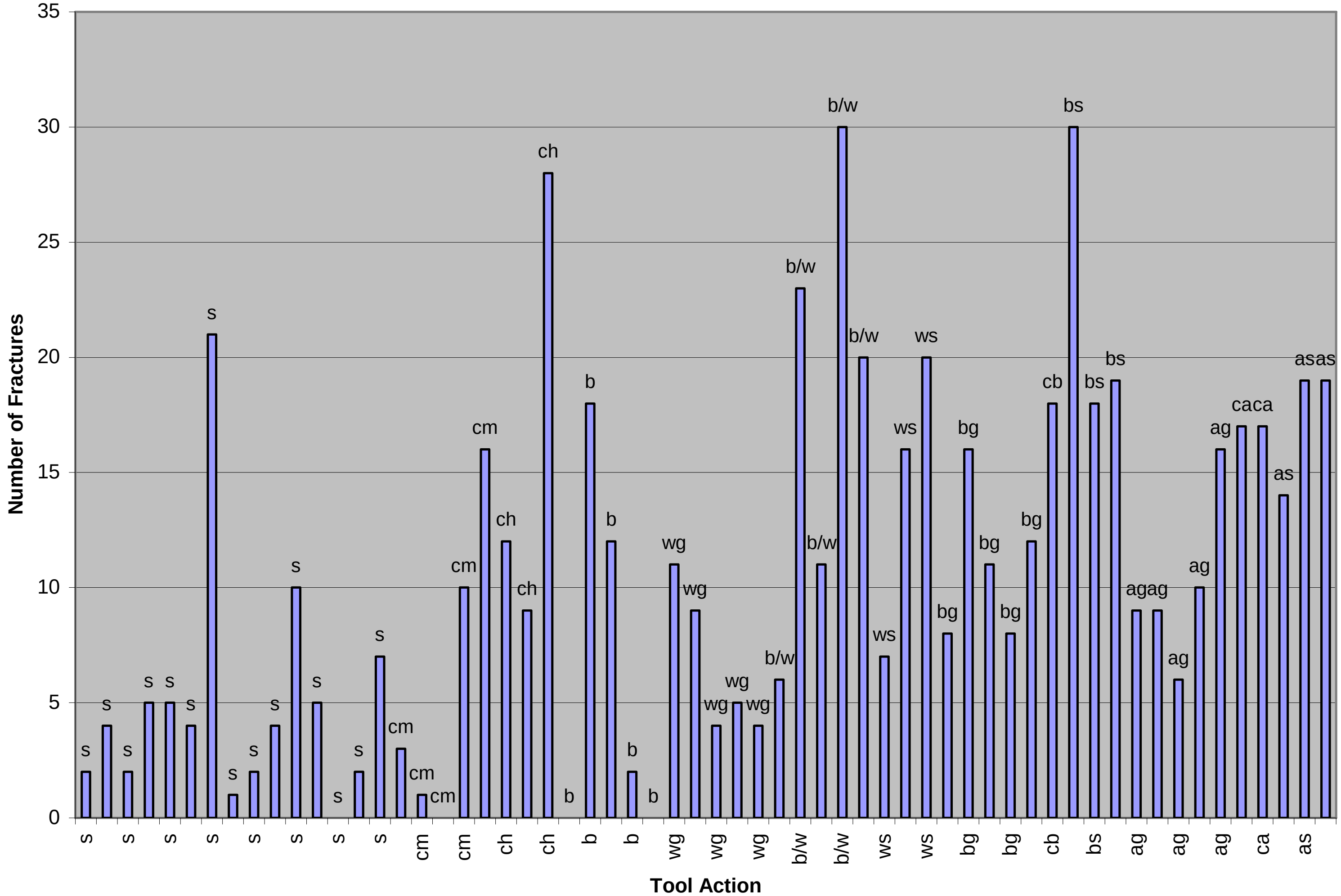

Figure 4. Total fractures and material hardness per tool arranged from soft to hard materials.

The second explainable set of spikes is the tools used for sawing bone, antler, and wood. It was evident that sawing was a very high impact action on tool edges and sawing bone and antler especially seemed to produce spikes in almost all data sets looking at scar-quantity.

As shown by Figure 5, if graving tools are removed from consideration, taking into account their generally low susceptibility to scarring and small area for fractures to form on, the graph seems to equalize out more and the trend toward more fractures as related to material hardness becomes more obvious. Figure 5 seems to indicate that there does seem to be a trend towards more scars with the increase in the hardness of materials.

One interesting thing to note, however, is the cluster of those tools used for cutting hide (ch). All tools used for this purpose, unlike those used for butchering and cutting meat, display higher fractures on average. Such an evaluation may indicate that perhaps cutting hide is not as low-impact a task as has been previously thought. Implications of this may result in an increased rate of recognition of skinning knives in the archaeological record, something thought to be, due to the small amount of strokes and time skinning takes, relative to other tasks.

Lastly, whittling (b/w) also appears to be a higher impact action on a flake than previously assumed. Though wood is a softer material compared to bone and antler, it can be hypothesized that when other figures are taken into account, whittling may cause more damage to a tool even though the worked material is relatively soft. Such an evaluation must remain a hypothesis, because only two actions were performed on wood and graving was not considered because, as noted above, all the tools broke before they could be used for more than a minute. Future work on wood should focus on more tasks and longer periods of time to evaluate if wood itself is harder than previously thought, or if the action of whittling is truly more high-impact than previously thought.

Step/hinge Terminations and Tool Action

Earlier, the idea that step/hinge fractures increase with material hardness was disproved as a general hypothesis. However, there are some interesting things that the experimental program brought to light. Figure 6 is a graph of step/hinge fractures and all other fractures along Odell's (1980a, 1980b) material hardness scale. For most of the graph, step and hinge fractures are neither more nor less than other fractures, mirroring their general high presence shown in Figure 1. However, two peaks are noteworthy, the peak grouped around sawing and cutting bone (bs, cb) and the peak at cutting antler (ca). Since these peaks cannot be reliant on material hardness alone as was shown earlier, another factor may be at work here.

In reference to all other tools and the appearance of step/hinge fractures, there appears to be no relation and random patterning is quite evident. In all other cases, the amount of step /hinge fractures is not a good indicator of materials worked, and the positive results reviewed above, while interesting, are nothing more than interesting tendencies without more work and larger sample sizes.

Cone Initiations and Task

Analysis of cone initiations did not seem to reveal any patterning with relation to material hardness. This was shown by both mostly random patterning and a tendency for all other fractures to number more than cone initiated fractures sufficiently as to obscure them. Figure 7 shows a possible relationship between cone initiations and some actions, namely screening (s), butchering (b), whittling (b/w), and cutting antler (ca).

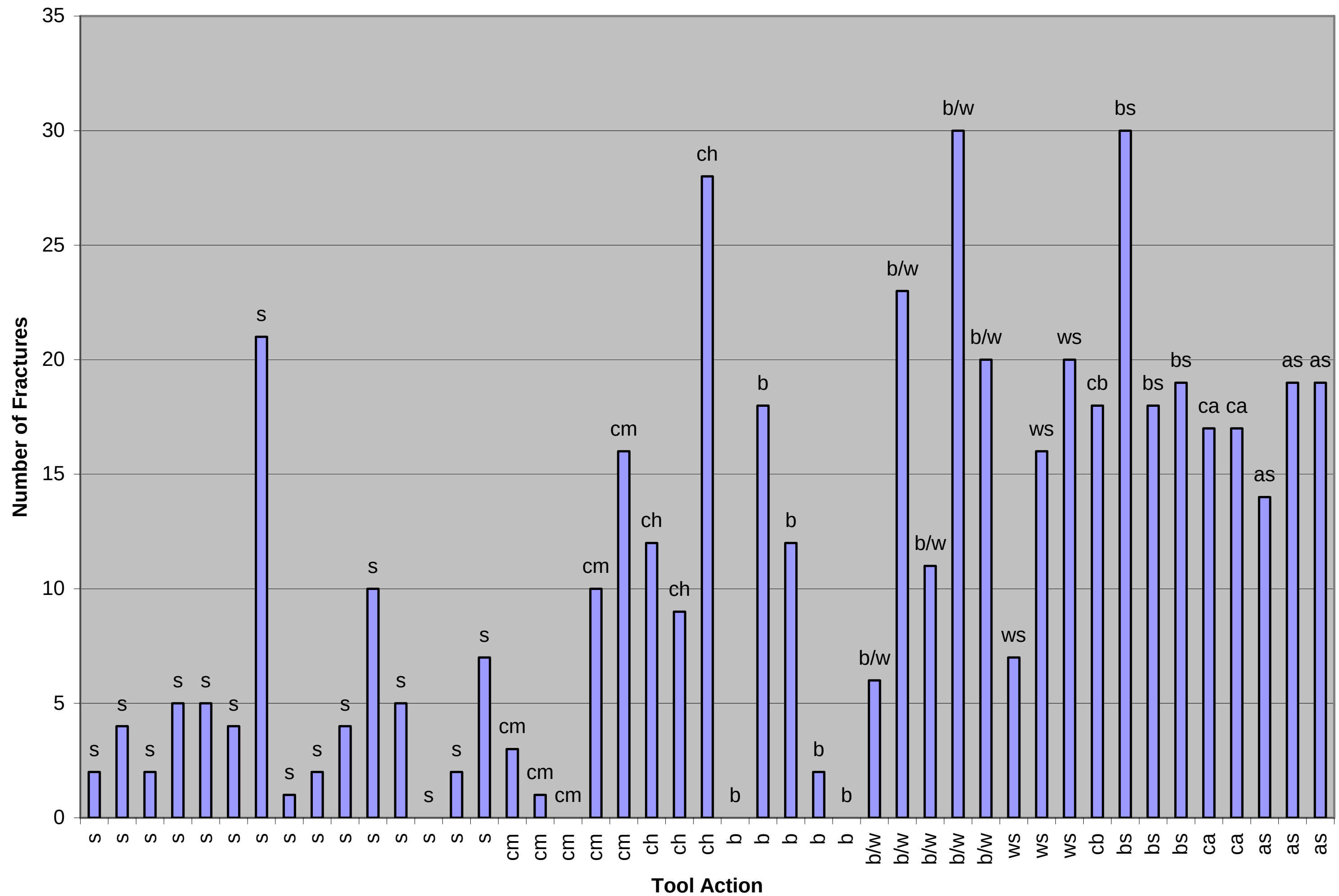

Figure 5. Total fractures on tools except gravers v.s. material hardness per tool arranged from soft to hard materials.

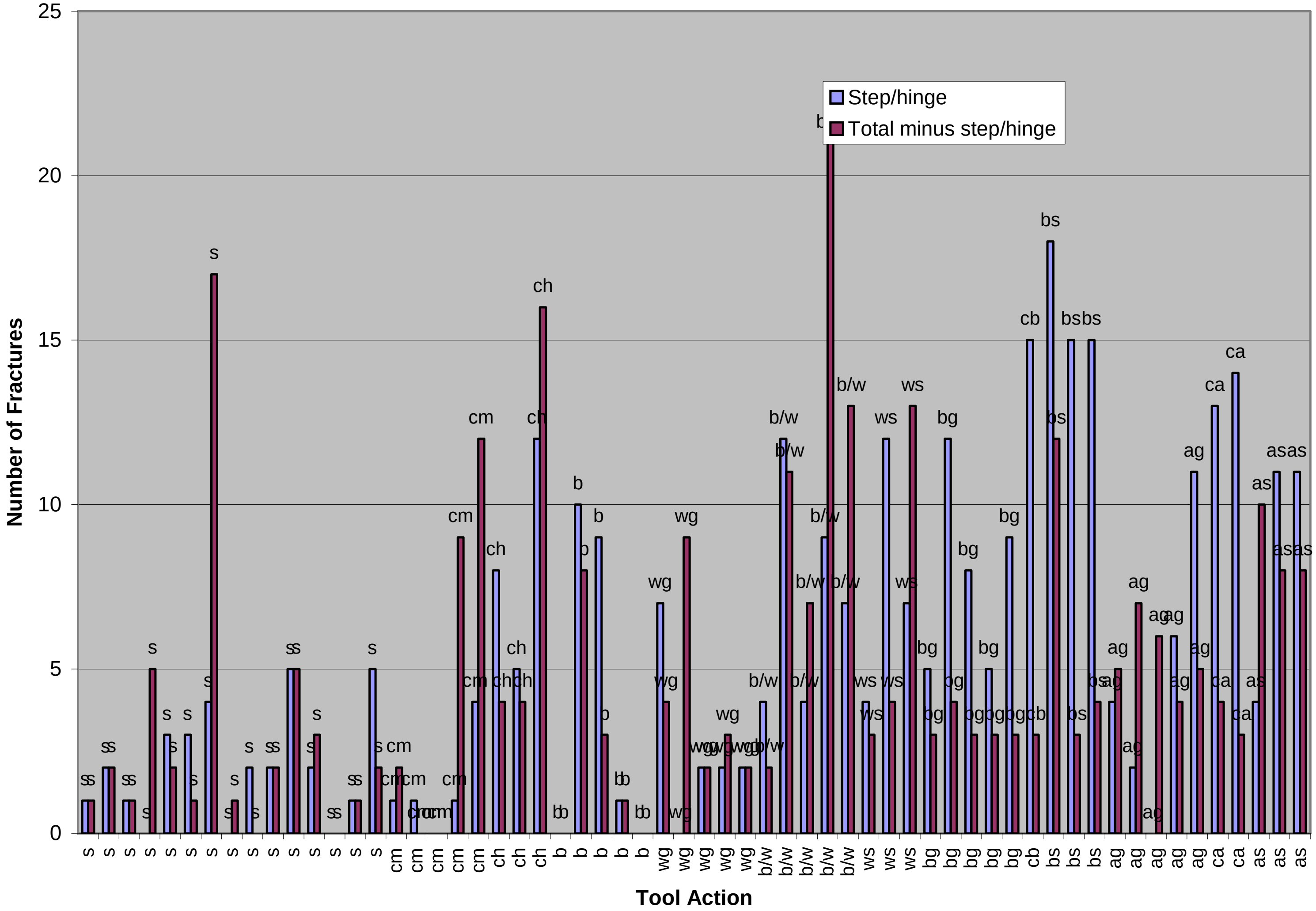

Figure 6. Step/hinge versus tool action.

Possible causes for screened flakes and those used for butchering to display a higher number of cone initiations related to other types of initiations is the nature of contact the tool had with the materials. In both cases, contact with either the screen or bone in both tasks would have been sharp percussive instances, much like the application of percussive force in flint-knapping. Most often cone initiations are formed by this type of action due to the physics of force at work on the flint-stone. Therefore, it is plausible that the high instances of cone initiations are related to this type of percussive force applied to the flake edges.

The physics at work in cutting antler and whittling are less clear. Unlike the other two actions described above, more or less constant pressure is applied in whittling wood and cutting bone, therefore a high incidence of cone initiations is puzzling especially in relation to the same kinds of actions on other materials that do not seem to produce high numbers of cone initiated fractures. It is possible also that the high incidence of cone initiations is related to small sample size, however, the high number on flakes used for whittling remains inexplicable at this juncture. All that can be noted at this point is the general increase in cone initiations.

Macroscopic Evaluation

Keeping in mind that I, the experimenter, have had an intimate knowledge of all flakes and what they were used for, something must be said for macroscopic traces of use. Out of all 60 flakes analyzed, nine displayed macroscopic traces of use, what traditionally one would use to define a "utilized flake" (Mississippi Valley Archaeology Center 2002). The flakes were all of those used for cutting and sawing bone and antler. Of the remaining 51 flakes, only a few displayed such damage and none showed the extent of damage recognizable on the nine flakes used on the hardest of materials.

The conclusion to be drawn here is perhaps that most tools recognized as utilized flakes are those used to process the hardest of materials and possibly those employed as scrapers on softer materials. As a result, those flakes that are under represented in the archaeological assemblages are those informal tools used on softer materials for tasks like cutting, whittling, sawing, and graving of both soft and hard materials.

SUMMARY OF EXPERIMENTAL RESULTS

As previously discussed, Vaughan (1984) believed that the results obtained by Odell (1980a, 1980b), and Tringham et al. (1974) reflected tendencies rather than concrete assertions of micro-fractures in relation to use-action and material hardness. The current experimental program, while attempting to quantify results on individual tools and tasks, seems to agree with Vaughan that the variability found in the analysis of micro-fractures alone is too much and that, aside from a few tendencies found in looking at certain actions and fracture types, micro-fractures alone are unusable as markers for proper functional analysis. Combined with the variability seen in processing damage, and the expected damage from post-depositional processes, the low-medium powered method has proved unreliable for the evaluation of expedient tools in the archaeological record.

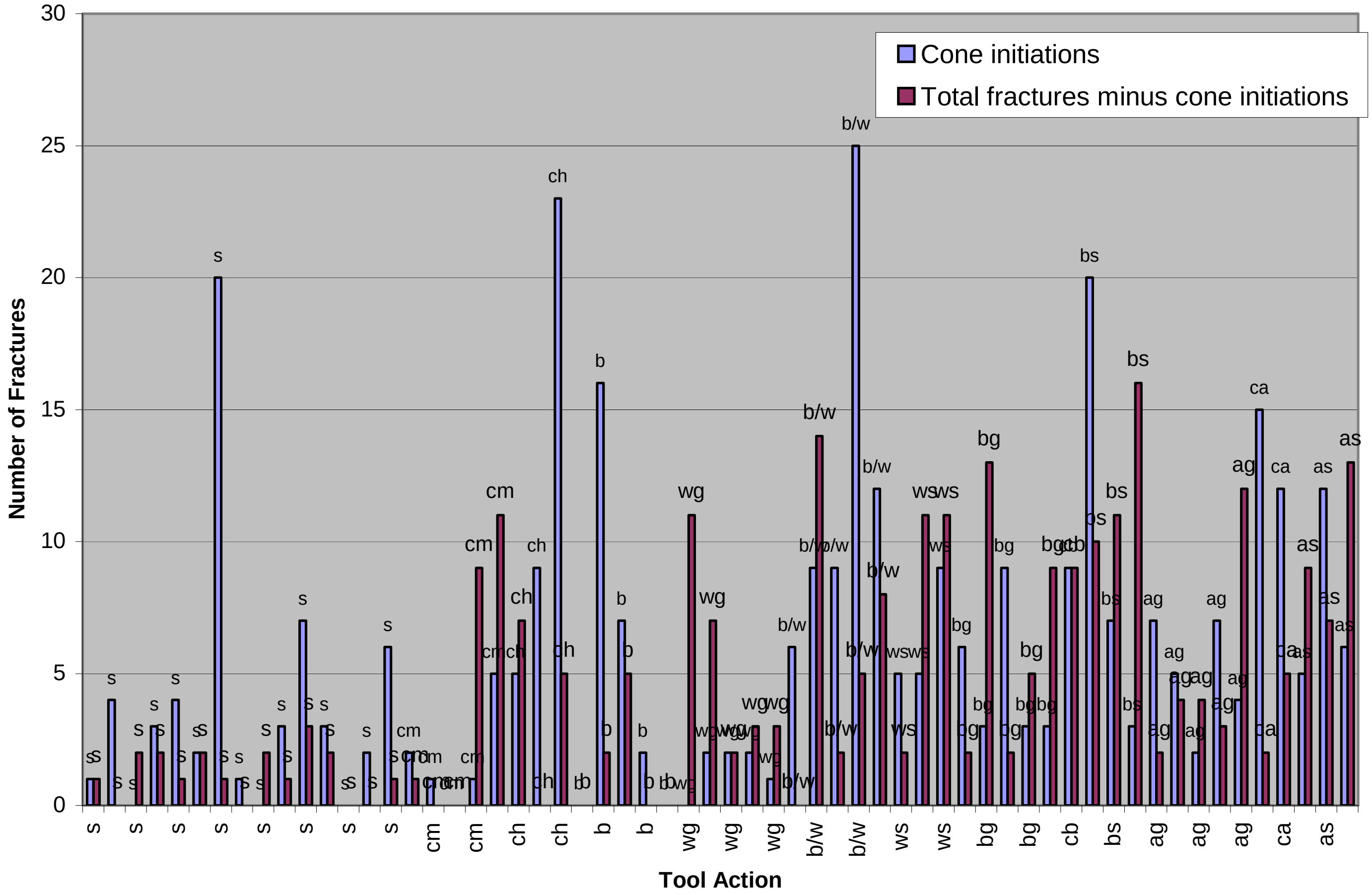

Figure 7. Cone initiations versus tool action.

Aside from the graphs, results were also generated by running correlations both globally and by each task. Positive correlations over 0.70 were deemed significant for further investigation of the raw data itself. Aside from the graphs and correlations mentioned above, all others generated exhibited a high level of variability or correlations over the 0.70 threshold and were deemed unrelated and/or insignificant.

Several factors mentioned that might have affected results were sample size, and not classifying fractures by size. Both of these are factors of time allowed to complete the experiment and analysis to create a replicable and usable method for the archaeological community. Future studies should focus on retaining this goal, if they so choose, to delve deeper into the issue of micro-fractures as markers of use.

Future studies should also focus on a wider range of activities, making sure to include scraping, an important task, especially to Oneota peoples. It may be that hafted flakes shall have to be employed, but extensive testing of un-hafted flakes should also be undertaken to evaluate if such flakes of a certain size are useful in the scraping process on different materials.

Heat-treating is another factor that should also be tested. Because of a lack in adequate facilities conducive to the large fire that would be needed for heat-treating, this project's scope was limited to only analysis of un-heat-treated PDC which became extremely limiting in the selection of flakes to analyze from the SAD (47LC394-32) assemblage. Future studies should focus on heat-treated materials to see if fracturing is different on heat-treated versus un-heat-treated flakes during use.

THE BLIND TEST

To evaluate the ability of archaeologists to recognize expedient tools in the archaeological record, a blind test was performed. Twenty flakes were given to two MVAC (Trials 1 and 3) staff-persons and one student lab-worker (Trial 2) to evaluate both their ability to select used tools, but also reject tools that had not been used. Table 4 summarizes the results.

The fist column lists if the flake was used in the experiment. Only ten utilized flakes were selected, and the other ten were flakes from the debris pile that had not been utilized. Column 2 states what action, if any, the flake was used to perform. Column three is the assigned blind-test number. The next two columns are repeated three times, one for each trial, showing which trial it is, the total number of flakes selected as being "used" per trial, which actual flake was

Table 4. Blind-test (Those that are highlighted mark flakes selected in all three trials) selected, and if the correct area was identified as having being used on a flake selected as having been utilized.

Experiment Flake #	*Action*	*Blind Test #*	*Trial 1 Selected?*	*# Selected:11 Correct Area?*	*Trial 2 Selected?*	*# Selected:13 Correct Area?*	*Trial 3 Selected?*	*# Selected:7 Correct Area?*
N/A		1						
N/A		2						
37	cm	3	N		N		Y	Y
N/A		4						
59	bg	5	N		N		N	
N/A		6						
58	ch	7	Y	N	Y	Y	N	
N/A		8						
N/A		9						
56	ag	10	Y	Y	N		Y	Y
N/A		11						
44	b	12	N		Y	Y	N	
N/A		13						
47	ch	14	N		Y	N	N	
N/A		15						
51	bs	16	Y	Y	Y	Y	Y	Y
N/A		17						
53	ca	18	Y	Y	Y	Y	Y	Y
31	sw	19	n		Y	N	N	
18	cm	20						

The results are as follows: trial one: 8/20 correct, trial 2: 9/20 correct and trial 3: 10/20 correct. The results indicate a close to 50% chance of success in recognizing both if a flake has been used, and the correct area of use, or if a flake is unused.

The highlighted portion marks two tools that were correctly identified as used and the correct used areas identified during all three tests. These are two of the flakes mentioned above in the section on macroscopic evaluation two used on the hardest materials that exhibited macroscopic damage to their edges. The results of the blind test confirm that those flakes used on the hardest of materials are those that are commonly recognized as “utilized flakes”. The results validate the current method of macroscopic identification for these tools. As previously noted, flake tools that are probably underrepresented in the archaeological record are those that were used on softer materials. Also, when evaluating unmodified flakes for utilization damage, it is possible that a fair amount of post-depositional damage is being recognized as utilization damage. However, only 2 of the three trials (Trials 1 and 2) seem to reflect this in that large portions of flakes selected as utilized were actuality un-used flakes.

The Valley-View (47LC34) assemblage

In 1983, Randall Withrow applied Tringham (1974) and her colleague’s experimental analysis to 26 “unmodified implements” that displayed macroscopic damage for his Master’s thesis on the lithics of the Valley View Site (47LC34) (Withrow 1983). All 26 were subjected to analysis under 10x magnification and by using Tringham’s results, Withrow assigned longitudinal or transverse use-wear classifications to the tools.

Of these 26 tools, four PDC tools were selected for re-analysis during this study. The flakes were smoked with ammonium chloride, recorded on an Excel spreadsheet, photographed, and analyzed the same way as the experimental and Feature 205 assemblages.

Of the four tools analyzed (Table 5) two had been classified under longitudinal use, and two as transverse. Three of these four also seemed to agree with Tringham (1974) and her colleague’s assessments, but one (1979.823.22) which was classified as being used longitudinally had most of the scarring on only one side.

Table 5. Four flakes Re-analyzed from the 47LC34 assemblage (withrow 1983).

Site #	***Year excavated***	
47LC34	1979	
Acquisition #	***Feature***	***Use (Withrow 1983)***
79.362.01	37	Transverse
79.541.07	42	Transverse
79.823.22	84	Longitudinal
79.806.05	82	Longitudinal

Two of the four also exhibited obvious retouch and one (1979.362.01), which was evidently a scraper, exhibited what MVAC (Mississippi Valley Archeology Center 2002) would classify as thinning flakes that extended far from the edge.

In sum, three of the four flakes matched Tringham et al. (1974) results very well, however, based on the results of the current experimental program, only one of the four flakes (1979.362.01) could be classified by use action, and one tool (1979.823.22) may or may not represent a possible expedient tool.

RESULTS OF THE ASSEMBLAGE RE-ANALYSIS

Of the SAD material, the lithic debris from nine levels of Feature 205, Zone D, Quarter-section 3 were sorted for unmodified non-heat-treated PDC flakes. Seventeen flakes were found to match the criteria, and 14 were re-analyzed looking for the presence of expedient stone tools that were previously classified as lithic debris.

Of the 14 tools re-evaluated from Feature 205, only two of the 14 can be classified as even “possible” tools, and one is obviously retouched (Table 6). Almost all flake scars were visible at 26x and most between 26x and 80x. The evaluation was hampered by the use of the ammonium chloride, which in some instances had collected rather thickly and was sometime very granular. At magnifications above 80x, identification of specific fracture types became difficult. The ammonium chloride was needed to reduce the reflectivity of the stone, without which many shallow fractures would have gone unidentified. However, this technique may not be the best for future studies that venture beyond 80 magnifications.

Table 6. Tools selected for analysis from Feature 205 Zone D Quartersection 3.

Site #	***Year excavated***			
47LC394-32	2004			
Acquisition #	***Feature***	***Level***	***Reduction stage (MVAC 2002)***	***Used? Y/n/?***
2004.630.209	F.205 ZD Q3	2	Chunk	N
2004.630.48	F.205 ZD Q3	2	Tertiary flake	N
2004.630.49	F.205 ZD Q3	2	Tertiary flake	N
2004.630.50	F.205 ZD Q3	2	Tertiary flake	N
2004.630.51	F.205 ZD Q3	2	Tertiary flake	N
2004.630.52	F.205 ZD Q3	2	Tertiary flake	N
2004.630.53	F.205 ZD Q3	2	Tertiary flake	N
2004.630.22	F.205 ZD Q3	2	Secondary flake	N
2004.630.23	F.205 ZD Q3	2	Secondary flake	N
2004.700.223	F.205 ZD Q3	3	Chunk	N
2004.700.24	F.205 ZD Q3	3	Secondary flake	?,"scraper"
2004.700.25	F.205 ZD Q3	3	Secondary flake	N, retouch
2004.687.08	F.205 ZD Q3	4	Secondary flake	N
2004.676.347	F.205 ZD Q3	5	Chunk	?, "possible tool"

One of the identified "possible" tools may be a scraper fragment (2004.700.24). It appears to have a high edge angle, retouch, and a significant amount of heavy damage to the tool edge. Snap and step fractures are common and the edge appears to be slightly rounded. Whether this tool was used as a scraper or some kind of plane or whittling tool is unclear.

The second "possible" tool is a thin, short chunk (2004.676.347). One edge is very heavily scarred with feather and step types on the dorsal aspect, with few scars on the ventral surface. This small flake was snapped, therefore it is possible that only a piece of the tool remains, however, the flake's edge angle of 26 degrees would make it unsuitable for transverse actions other than light whittling or very light scraping (Wilmsen 1968).

Once again, the failure of the experimental program to produce a use-wear classification to be applied to Oneota PDC unmodified flake use-wear hampered the Re-analysis of the unmodified flakes from the SAD feature contexts. Though only two possible tools were located, assignation beyond "possible" tools could not be made.

CONCLUSIONS

Generally, low-medium power use wear analysis appears to be inappropriate for accurate interpretation of actions and use materials to stone flakes. Very few aspects of fracture terminations, fracture initiations, and correlations between different variables produced results that would show direct relationships. Instead, variability in micro-fractures seems to be much too high to create any meaningful classification system for analyzing unmodified flakes in the search for expedient tools, even through quantitative analysis.

Consideration of certain variables such as fracture size, coupled with larger sample sizes and a wider range of experimental tasks may yield more positive results, but it is my opinion that variability will still remain too high to provide an accurate classification system, and that any system involving the consideration of fracture size would be too specialized and time-consuming to be of use to the majority of the archaeological community.

The blind-test also exposed a close to 50% chance that archaeologists, when analyzing unmodified flake assemblages, may either incorrectly identify utilized flakes or misidentify un-used flakes as utilized. Flakes used on hard materials, regardless of length of time used, seem to exhibit damage recognizable macroscopically, while those used on softer materials seem to have a much lower chance of being recognized as expedient tools. Therefore, the current methods of macroscopic analysis, while presumably identifying a high number of expedient tools used on hard materials in the archaeological record, is most-likely under representing those expedient tools used on softer materials. High powered micro-wear analysis may be the answer to this dilemma, but its high costs in time, money, and specialization put it out of reach of most archaeologists who would be unable to apply it to a large assemblage of the unmodified lithic debris present on a site in order to more fully document the tool culture of the people in question.

Based on Tringham et al. (1974), Withrow's (1983) classifications of the modified flake assemblage from the Valley View Site (47LC34) seem to be valid, but an analysis of the method has shown many of her team's determinations to be incorrect. Therefore, Withrow's classifications of directionality of use are in doubt because of the unreliability of the data.

The SAD (47LC394-32) assemblage yielded only two "possible" tools, and these also tentative classifications because the experimental program failed to provide information that would lead to the recognizing of expedient tools in the archaeological record beyond the method of macroscopic analysis. Based on the data, use will often provide no reliable patterning on stone tools that could be recognized as anything other than incidental damage.

The failure of this project to locate a large amount of expedient stone tools in the SAD (47 LC 394-32) assemblage does not signal a lack of expedient tools in the archaeological assemblage. No-doubt a number of these tools do exist in Feature 205, but their identification remains in-doubt until such time that a low-medium powered method is perfected or until a high-powered analysis is employed on the unmodified lithic assemblage of the feature. As stated earlier, most tools used on hard materials are recognizable on a macroscopic level, and presumably this is true for the utilized flakes already recognized in Feature 205. However, those tools used on softer materials in an expedient fashion presumably remain under represented and are most likely classified as nothing more than lithic debris.

ACKNOWLEDGEMENTS

Jessica Woods for her continued love and support through my grumpiness and periodic fits of rage and madness.

The Mississippi Valley Archaeology Center for the experience of the past two years in preparation for this important time in my life and for use of facilities and equipment.

Ernie Boszhardt for his continual support and faculty advising through all stages of the project.

Dr. Constance Arzigian for valuable advice and help with manipulation of statistical data.

Wendy Holtz-Leith for her assistance concerning artifacts and information from Feature 205.

Dr. Tim Mc-Andrews and Vicki Twinde-Javner for reading this paper and advice throughout its evolution.

Dr. Joseph Tiffany for useful advice and suggestions on methods.

Kathleen Brosius for help with collections and identification.

Rick Woods for the acquisition of a Deer-hide for experimentation.

Monty Rogers for feats of strength and the skills of a hunter concerning road-kill.

Lindsay Maas for help throughout this process when a second pair of hands were better than one, especially in the experimental portion.

Dr. Abler, P.H.D. biology, for help procuring and using chemicals necessary.

Miranda Alexander for continuous help with almost all aspects of the project, especially concerning issues dealing with "Real Science."

The UWL Undergraduate Research Committee, especially Bill Gresens, for the award and opportunities concerned with the procurement of an Undergraduate Research Award and presentation.

To the entire spring 2006 senior thesis class and James Theler for review and support of this project. And finally to the band Underworld, whose music helped me get through, not only this project, but four years of high-school, five years of college, and an addiction.

REFERENCES CITED

Ahler, Stanley A.

1979 Functional Analysis of Nonobsidian Chippd Stone Artifacts: Terms, Variables, and Quantification. In *Lithic Use-Wear Analysis,* edited by Brian Hayden, Academic Press, New York.

Arzigian, Constance M.

1989 The Pammel Creek Site Floral Remains. *The Wisconsin Archeologist*, Vol. 70 The Wisconsin Archeological Society.
Arzigian, Constance M., Robert Boszhardt, Holly Halverson, Douglas Connell, James L. Theler, and Michael Scott.
1993 The Gundersen Site: An Oneota Village and Cemetery in La Crosse, Wisconsin. Reports of Investigation no. 155, Mississippi Valley Archaeology Center, University of Wisconsin La Crosse
Bamforth, Douglas B.; George R. Burns and Craig Woodman
1988 Ambiguous Use Traces and Blind Test Results: New Data. *Journal of Archaeological Science* 17:413-430.
Boszhardt, Robert F
1985 Final Cultural resources Investigations Along CTH 'SN' in La Crosse county, Wisconsin. *Report Of Investigations* No. 33, Mississippi Valley Archaeology center at the University of Wisconsin La Crosse.
1992 Phase II Archaeological Mitigation at the Trane Site (47 LC 447) La Crosse Wisconsin. *Report Of Investigations* No. 138, Mississippi Valley Archaeology center at the University of Wisconsin La Crosse.
1994 Oneota Group Continuity at La Crosse: The Brice Prairie, Pammel Creek, and Valley View Phases. *The Wisconsin Archeologist*, Vol 75, The Wisconsin Archeological Society.
Boszhardt, Robert F., James P. Gallagher, James L. Theler, Thomas Bailey, Arthur Bettis, Dean Thompson
1984 Additional Cultural Resources Investigations at Selected Portions of the State Road Coulee—Pammel Creek Flood Control Project at La Crosse, WI. *Report Of Investigations* No. 27, Mississippi Valley Archaeology center at the University of Wisconsin La Crosse.
Boszhardt, Robert F., Wendy Holtz, and Jeremy Nienow
1995 A Compilation of Oneota Radiocarbon Dates as of 1995. In *Oneota Archaeology, Past, Present, and Future.* Edited by William Green, Report 20 , Office of the State Archaeologist, the university of Iowa, Iowa City.
Buikstra, Jane E. and Douglas H. Ubelaker
1994 *Standards for Data Collection From Human Skeletal Remains.* Number 44, Arkansas Archaeological Survey, Fayetteville
Cotterell, Brian and Johan Kamminga
1979 The Mechanics of flaking. In *Lithic Use-Wear Analysis*, edited by Brian Hayden, Academic Press, New York.
Hayden, Brian
1979 The Ho Ho Classification and Nomenclature Committee Report. In *Lithic Use-Wear Analysis*, edited by Brian Hayden, Academic Press, New York.
Henning, Dale R.
1995 Oneota Evolution and Interactions: A Perspective from the Wever Terrace, Southeast Iowa. In *Oneota Archaeology, Past, Present, and Future.* Edited by William Green, Report 20 , Office of the State Archaeologist, the university of Iowa, Iowa City.
Gallagher, James P, Constance M. Arzigian, Robert F. Boszhardt, Charles R. Moffat, James L. Theler
1992 Phase III Excavation at the Tremaine Site 47 LC 95, The Midvale Interceptor Report. *Report Of Investigations* No. 133, Mississippi Valley Archaeology center at the University of Wisconsin La Crosse.
Gallagher, James P., Roland Rodell, Katherine Stevenson
1982 The 1980-1982 La Crosse Area Archeological Survey. *Report Of Investigations* No. 2, Mississippi Valley Archaeology center at the University of Wisconsin La Crosse.
Kamminga, Johan
1981 *Over the Edge: Functional Analysis of Australian Stone Tools*. Anthropology Museum, University of Queensland, Occasional Papers in Anthropology, No.12.
Keeley, Lawrence H.
1982 *Experimental Determination of Stone Tool Uses: A Microwear Analysis*. The University of Chicago Press, Chicago.
McBrearty, Sally; Laura Bishop, Thomas Plummer, Robert Dewar, Nicholas Conrad
1996 Tools Underfoot: Human Trampling as an Agent of Lithic Artifact Edge Modification. *American Antiquity* 61:108-129.
Mississippi Valley Archaeology Center

2002 *MVAC Manual on Cataloguing Procedures 2002*. Mississippi Valley Archaeology center at the University of Wisconsin La Crosse.
Odell, George H.
1979 A new and Improved System for the Retrieval of functional Information from Microscopic Observations of Chipped Stone Tools. In *Lithic Use-Wear Analysis,* edited by Brian Hayden, pp. 329-345. . Academic Press, New York.
1980a Verifying the Reliability of Lithic Use-Wear Assessments by 'Blind Tests': The Low-Power approach. *Journal of Field Archaeology* 7:87-120
1980b The Mechanics of use Breakage of Stone Tools: Some Testable Hypotheses. *Journal of Field Archaeology* 8:197-209.
1981 Functional Analysis of Lithic Artifacts in West-Central Illinois: Experiments and Systems used. Center for American Archaeology , Contract Archaeology Program. Report of investigations No.129
2004 Lithic Analysis. Kluwer Academic/Plenum Publishers, New York.
O' Gorman, Jodie
1995 The Tremaine Site Complex: Oneota Occupation in the La Crosse Locality, WI, Vol:3: The Tremaine Site 47 LC 95. Museum Archeology Program, State Historical Society of Wisconsin.
Rodell, Roland L.
1989 The Lithic Artifacts at the Pammel Creek Site. *The Wisconsin Archeologist*, Vol. 70, The Wisconsin Archeological Society.
Sasso, Robert F., Robert F. Boszhardt, James C. knox, James L. Theler, James P. Gallagher, Katherine Stevenson, Cyntia Stiles-hanson
1985 Prehistoric Ridged Field Agriculture in the Upper Mississippi Valley. *Report Of Investigations* No. 38, Mississippi Valley Archaeology center at the University of Wisconsin La Crosse.
Stevenson, Katherine
1985 *Oneota Subsistence-Related Behavior in the Driftless Area: A Study of the Valley View Site Near La Crosse Wisconsin.* Unpublished P.H.D. Dissertation, Department of Anthropology, University of Wisconsin, Madison.
1994 Chronological and Settlement Aspects of the Valley View Site. *The Wisconsin Archeologist*, Vol 75, The Wisconsin Archeological Society.
Theler, James L. and Robert F. Boszhardt
2003 *Twelve Millenia: Archaeology of the Upper Mississippi River Valley.* University of Iowa Press, Iowa City
Tringham, Ruth; Glen Cooper, George H. Odell, Barbara Voytek, Anne Whitman
1974 Experiments in the Formation of Edge damage: A New Approach to Lithic Analysis. *Journal of Field Archaeology* 1:171-196.
Vaughan, Patrick C.
1984 Use-Wear Analysis of Flaked Stone Tools. *University of Arizona press,* Tuscon.
Walker, Phillip L.
1978 Butchering and Stone tool Function. *American Antiquity* 43:710-715
Wilmsen, Edwin N.
1968 Functional Analysis of Flaked Stone Artifacts. *American Antiquity* 33: 156-161.
Withrow, Randall M.
1983 *An analysis of Lithic Resource Selection and Processing at the Valley View site (47 LC 34).* Unpublished Master's thesis. Department of Anthropology, University of Minnesota.