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EXPERIMENTAL DETERMINATION OF USE WEAR ON SILCRETE BLADES

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INTRODUCTION

Over the past three decades use wear analysis has become respected as a viable method of ascertaining the uses to which prehistoric lithic implements were put. Since its nascence in the late 1950s in the former Soviet Union a wide variety of analytical techniques have developed and several related studies such as blood residue analysis as well as patina and gloss analysis have been spawned (Bahn 1987; Anderson 1980; Briver 1977; Keeley and Newcomer 1977; Keeley 1980; Loy 1983; Unger-Hamilton 1984; Vaughan 1985).

The reliability of the results of use wear analysis and the high rate of success among researchers (Ibid, 1977, 1980, 1983, 1985, 1987) predicting the types of material worked by lithic implements through the study of edge damage prompted the present research. The possibility of applying the techniques of edge wear analysis to implements made from orthoquartzite or silcrete, as it is commonly called, are explored.

A limited number of studies in the field of use wear analysis have been undertaken in New Zealand and even fewer of these involved silcrete implements (Kooyman 1985; Bain 1979; Schmidt 1993). Kooyman's research on silcrete involved twenty experiments which were aimed at defining micro chipping and use polish. It was found that use wear was not evident on silcrete implements used on softer materials such as meat, vegetation and hides (Kooyman 1985). The silcrete implements in the current research were used exclusively on harder materials; bone and wood. The resulting damage to the edges of the manufactured silcrete blades was quantified and the morphology of the chips was considered as well as the changes in the quantity and morphology over extended periods of use.

The objectives of this experiment are to investigate the possibility that the prehistoric use of silcrete blades could be discerned. It was hoped that these conclusions would be reached based upon the edge damage caused by using the blades on different materials. Other variables include, angles of use, actions and time. Consistencies in edge damage are highlighted by this experiment and the results are compared to randomly selected archaeologically excavated blades from Shag River Mouth (S155/5) in Otago. They are also compared with ten separate blades in a blind test designed to validate the findings of the primary experiment. The objective of the latter part of the experiment being, the elucidation of comparable damage on archaeological blades with one or a number of the experimentally determined categories.

OPERATIONAL PROCEDURES

The silcrete used in this experiment was obtained from the Nenthorn Valley, near Macraes Flat west of Dunback, Central Otago. Blocks of silcrete are readily obtainable from the roadside without having to venture onto the Nenthorn quarry site (S145/1). This quarry is the nearest source of silcrete to the Shag River Mouth archaeological site which contained a wide range of silcrete blades. The proximity of the Nenthorn quarry to the Shag River was one of the primary reasons for selecting this source.

Three, 2-3 kilogram blocks were removed from the roadside and inspected for quality. Samples which were particularly large grained or 'sugary' were discarded and only those which exhibited a grain similar to silcrete found in prehistoric tool assemblages were retained.

These blocks were reduced using a granite hammerstone, to produce 40, sharp edged implements, each having about a five centimetre cutting surface. The knapping was done over an earthen enclosure in order to reduce the chances of edge damage in blade production.

The 40 experimental blades were then assigned a letter and a numeral, being divided into groups of five from A to H at random. Each blade was marked twice with an indelible pen on the cutting edge, each mark being two centimetres apart, these delineated the area of use. In order to differentiate between chips on the cutting edge caused by manufacture and chips caused by use, the unutilised experimental blades were photographed using a Nikon SMZ-U zoom 1:10 photomicroscope, using 25 ASA Agfa film.

A standardised form was prepared and the experimental blades were individually examined for chips which occurred during manufacture. These were noted and the depth and width of each chip was recorded using a standard metric callipers.

The experimental blades were then subjected to use on different materials using different actions. Cattle bone was selected as a substitute for the types of bone found in prehistoric contexts due to problems of availability. A native New Zealand wood, Broadleaf, (*Grisilinia littoralis*) was used to simulate woodworking with silcrete. Blades A1-5 were used on the wood using a sawing action at a 45° angle. Blades B1-5 were used with the same action at a 90° angle. Blades C1-5 were used on wood at a 45° angle with a scraping action and blades D1-5 were used on the wood scraping at 90°.

Specimens E1-5 were used on the bone, sawing at a 45° angle. F1-5 were also used in a sawing motion but at a 90° angle. Blades G1-5 were used in a scraping action at a 45° angle. H1-5 were utilised in a scraping action at a 90° angle.

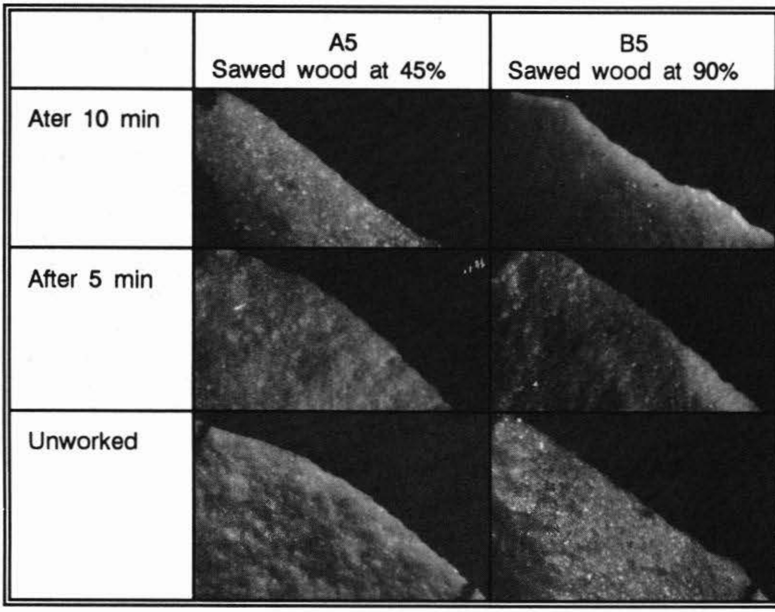
For the first application of the silcrete blades to the experimental material each blade was used for a five minute period, averaging one stroke per second. The blades were then cleaned in an ultrasonic bath for five minutes to remove any bone or wood residue adhering to the stone. The blades were then photographed with the Nikon photomicroscope and examined for edge damage. Chips which occurred in the designated two centimetre area were measured for depth and width and these figures were recorded. The process was then repeated, blades A-D used on wood again and blades E-H used on bone, the same action and angles being retained for each blade. The purpose of this second application was to register any damage due to cumulative or extended use of silcrete blades. The experimental blades were utilised for a further five minute period. The blades were washed again in the ultrasonic bath for five minutes and then photographed. Each blade was examined for chips occurring within the two centimetre area.

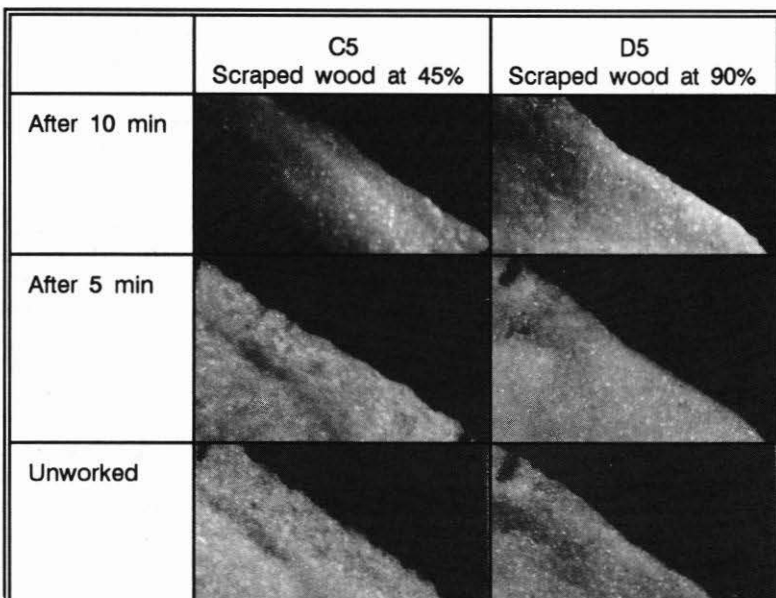
RESULTS

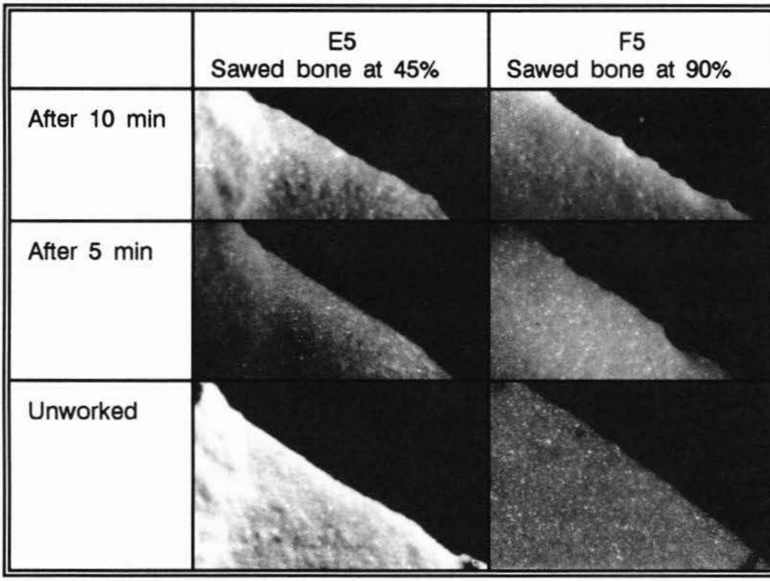
The results of different use actions, angle and duration were tabulated for each blade. The number depth and width of the chips present in the demarcated area were recorded. Chips resulting from the manufacture of the blades showed no overall consistency, as would be expected. The depth of the chips produced in manufacture did not exceed 0.04mm on average. The width of the chips produced during the manufacture of blades exhibited greater values, ranging from 0.235mm - 0.052mm on average. One group of blades, H1-5 did not exhibit any edge damage as a result of the manufacturing process.

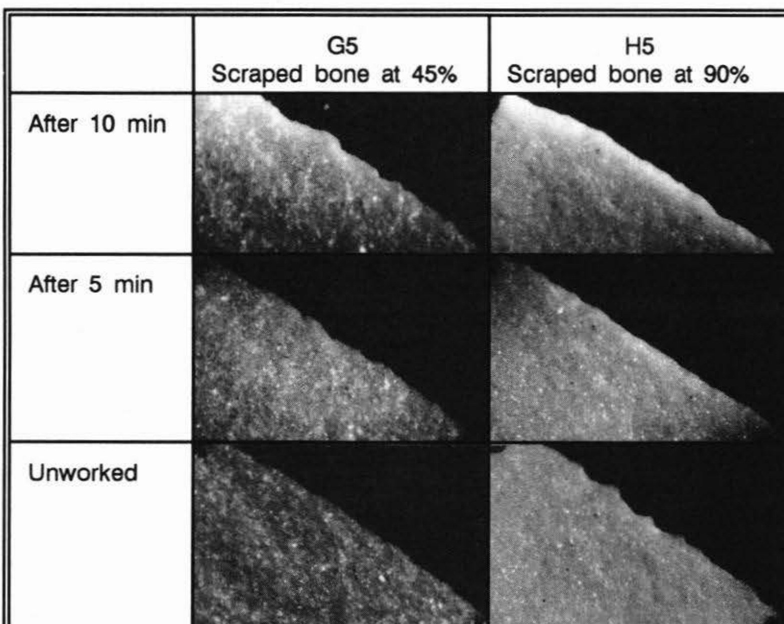
Due to the nature of silcrete, which has a hexagonal crystal structure, tending to fracture conchoidally, chips are readily formed when smaller pieces are severed from a core (Roberts, Rapp, Weber 1974). This trait is usually described as hackly which denotes a propensity for the mineral to produce an uneven edge when broken.

The experimental blades registered considerable edge damage after five minutes of use. A good deal of differentiation in depth of chips was observed between the different actions and angles used on wood (a range of 0.078mm). Sawing at a 45° angle caused an average chip depth of 0.101mm. Scraping at a 45° angle caused the next greatest amount of damage, chip averaging 0.089mm. Sawing at a 90° angle resulted in an average depth of 0.069mm on the blades while the least damage was incurred by scraping on the wood at a 90° angle.


A5
Sawed wood at 45%
B5
Sawed wood at 90%
Ater 10 min
After 5 min
Unworked


C5
Scraped wood at 45%
D5
Scraped wood at 90%
After 10 min
After 5 min
Unworked


E5
Sawed bone at 45%
F5
Sawed bone at 90%
After 10 min
After 5 min
Unworked


G5
Scraped bone at 45%
H5
Scraped bone at 90%
After 10 min
After 5 min
Unworked

The width of chips caused by five minutes of use on the Broadleaf was considerable. The greatest average width of chips was caused by scraping at 45° (0.276mm) and by sawing at 90° (0.276mm). There is a sizeable difference in the average width of chips on blades which were used in a scraping action at 90° (0.103mm) and chips on blades sawing at 45° (0.081mm).

After a period of five minutes use on bone, the silcrete blades (E-H) showed considerably less damage than those used on wood. Sawing at 90° caused the greatest degree of damage as far as average depth was concerned (0.05mm), followed by sawing at 45° (0.046mm). Scraping caused less damage at 90°, an average depth of 0.034mm was recorded and at 45° the average depth of chips was 0.023mm.

The width of the chips on the experimental blades after five minutes use showed some consistency. Sawing at 90° and scraping at 90° resulted in an average width of 0.125mm. Sawing at 45° resulted in an average width of 0.116 mm. The least amount of damage occurred on blades used in a scraping action at 45°, the average width being 0.064mm. Chips which were present on unutilised blades disappeared and only two new chips appeared on one blade.

All of the experimental blades were reused for an additional five minute period, totalling ten minutes of use for each blade preforming the identical tasks. The blades which were used on the Broadleaf changed considerably, many chips being worn down completely and often new ones appearing. The average depth did not change drastically in the ten minute sample, although in every action and angle category the average depth did decrease. Sawing at a 45° angle resulted in an average depth of 0.069mm, a decrease of 0.032mm. Sawing at 90° resulted in an average depth of 0.059mm, decreasing 0.01mm from the preceding five minute sample. The result of scraping at 45° was also a decrease in average depth from 0.089mm in the five minute sample to 0.034mm: a total drop of 0.055mm. Scraping at 90° resulted in a decrease of 0.012mm in the average depth resting at 0.011mm.

The average width of chips after ten minutes use, remained the same on blades used in a sawing action at 45° and dropped only slightly on those used at 90° (from 0.270mm to 0.249mm). There was however a notable decrease in the width of chips on blades used with a scraping action. At 45°, chip width was reduced to 0.120mm and at 90° it dropped to 0.023mm. This last sample included only one blade with two chips on it, so many chips had been reduced to a flat surface after ten minutes of use.

The chip morphology of experimental blades utilised on bone for ten minutes remained remarkably constant, especially where depth was concerned. Sawing at 45° resulted in an average depth of 0.046mm, no change from the five minute sample. Sawing at 90° resulted in an average depth of 0.046mm, a drop of just 0.03mm from the five minute sample. Scraping at 45° resulted in the appearance of three new chips on a previously undamaged blade, which served to increase the average depth to 0.029mm. Scraping at 90° however reduced the number of chips on the blades which resulted in an average depth of 0.017mm.

The same results were observed concerning the width of the chips on the experimental blades after ten minutes of use. There was a slight increase in chip width on blades used in a sawing action at 45° to 0.146mm. Sawing at 90° also resulted in an increase in the average width to 0.164mm. Scraping at 45° resulted in an increase as well, but not as marked, only rising to 0.07mm. There was a decrease in the average width of chips which were used in a scraping action at 90° dropping 0.043mm to 0.082mm.

Looking to the total number of chips on blades per group ie: A1-5, revealed very little increase from unworked blades to blades worked for five minutes on wood.

BLADES	UNWORKED TOTAL CHIPS	BLADES USED FOR 5 MIN. ON WOOD-TOTAL NO. OF CHIPS
A1-5	6	8
B1-5	6	7
C1-5	12	12
D1-5	6	5

Experimental blades used on the bone showed a significant increase in the total number of chips per group.

BLADES	UNWORKED TOTAL CHIPS	BLADES USED FOR 5 MIN. ON BONE-TOTAL NO. OF CHIPS
E1-5	1	11
F1-5	1	9
G1-5	3	3
H1-5	0	5

Groups E and F registered the highest increase in total chip number, these blades were used in a sawing action at 45° and 90° respectively. Groups G and H sustained comparatively little chipping damage although scraping at 90° did cause five chips where there were none before on the unutilised experimental blades. After ten minutes of use on wood the experimental blades showed an overall reduction in the total number of chips.

BLADES USED FOR TEN MIN. ON WOOD	TOTAL NO. OF CHIPS
A1-5 (SAW 45°)	4
B1-5 (SAW 90°)	11
C1-5 (SCRAPE 45°)	9
D1-5 (SCRAPE 90°)	2

Only sawing at a 90° angle registered an increased number of chips on the blades, rising by four. The blades that were used on bone were examined after ten minutes of use, an overall decline in the number of chips was recorded.

BLADES USED FOR TEN MIN. ON BONE	TOTAL NO. OF CHIPS
E1-5 (SAW 45°)	8
F1-5 (SAW 90°)	7
G1-5 (SCRAPE 45°)	6
H1-5 (SCRAPE 90°)	2

Again only one of the groups displayed an increase in the total number of chips, G1-5 scraping at 45° rose in number by four.

DISCUSSION

Blades Used for Five Minutes

Wood

Experimental blades used on wood for five minutes revealed conclusively that the depth of chips is directly affected by the angle the tool is used at. Those tools employed in both sawing and scraping at a 45° angle registered the greatest average depth of chips. Chip depth was next most affected by the action the tool was used in, sawing causing deeper chips than the scraping on average when employed on Broadleaf wood.

The width of chips resulting from five minutes of use on wood was not as conclusive as the results found for depth. No consistent increase in width may be associated with either use-angle or action.

Bone

Experimental blades used on cattle bone for five minutes were not as heavily damaged as those used on wood. It was possible however, to discern that the sawing action had the most effect on chip depth.

The width of chips was effected mainly by the angle of use, right angles causing the greatest widths. Sawing at a 45° degree angle was the next greatest cause of damage followed lastly by scraping at 90° which was also the least effective method for removing material from the bone. It would therefore be very difficult to detect use wear on silcrete tools used as scrapers on bone for short periods of time.

Blades Used for Ten Minutes

Wood

The experimental blades which were utilised on wood for ten minutes showed a decrease in depth across all the angle and action categories. Extended use of silcrete blades serves to dull them, as may be expected. The action used seemed to affect the width of chips on the blade edge. Scraping was especially effective at reducing the width while the sawing motion seemed to have little effect on this aspect. The sawing action reinforced the serrations which were formed after five minutes of use.

Bone

Little change was registered for chip depth after ten minutes use on the bone regardless of angle of action. It is possible that the solid consistency of the material played a part in the constancy of chip depth.

The average width of chips of blades used on bone remained constant. The blades used in a sawing action registered an increase in width but it was not dramatic. Contrary to the other samples the blades used in a scraping action at 90° showed a decrease in the average depth. These results are probably attributable to the consistency of the bone. It tended to develop a very glossy appearance after the first five minute session. The reduced gripping ability of the material being worked would tend to preserve the morphology of the chips on the cutting edge. The fibrous nature of wood tends to constantly alter the morphology of the cutting edge. No gloss is built up on wood but an uneven surface is created which is bound to affect the depth and width of chips as they are continually dragged across the fibrous bundles.

The total number of chips found on the blade was a good overall indicator of damage due to action, angle and duration. The number of chips peaked after the first session of use and dropped off after the additional five minutes. It is interesting to note the different effects of bone and wood on total chip numbers. Across all of the groups of blades used on wood for five minutes the increases were minimal. A decrease was noted in one instance from the unutilised level.

Total chip numbers on blades used on bone increased dramatically compared to those used on wood after five minutes. Only one group (G1-5) remained static. Sawing on bone was definitely the greatest cause of chipping at both angles in the initial use session. The hardness of the bone and the downward pressure exerted by the user would account for the greater number of chips especially as it is much more difficult to begin to cut bone than wood and the initial force action needs to be greater.

The total number of chips after ten minutes use on both bone and wood was seen to decrease in most samples. It appears that extended use on both materials results in an increase in the wear, thereby reducing the overall number of processes. After five minutes use the extremely sharp and thin edge of the blade becomes more rounded and is thicker and therefore more resistant to chipping. The surviving processes are further worn down after the second five minutes of use.

In comparing the action used at similar angles, one may conclude that sawing at 45° on wood is less damaging than scraping at 45°. After ten minutes use the same results were noted, with a greater number of total chips caused by the scraping at 45°. The width of chips on blades used in scraping at 45° are consistently greater than those on the blades used in a sawing motion, the depth however is not as great. Sawing at 90° caused a greater number of total chips than scraping at the same angle after five minutes on both bone and wood. The average depth and width were also considerably less on blades used in a scraping manner at 90°.

The combination of time, action and material which produced the greatest number of chips on blade edges overall was sawing on wood at 90°. The morphology of the chips was wide and shallow. This combination of factors served to increase the total number of chips on the blades. It was noted during the experiment that this was the most effective method of cutting through the wood, although after ten minutes of use the blade edge had rounded considerably and was far less effective than the new blade. Retouching the blade would have renewed the cutting ability but this would need to be done very frequently.

Edge damage that is caused during the manufacture of silcrete blades has continued to be visible throughout the experiment. Fourteen of the unworked blades had chips on the edges. Ten of these blades still retained the chips caused in manufacture after five minutes of use. After ten minutes of use six of the blades retained chips caused in manufacture. It is clear that damage caused in manufacture is a significant contributor to the number of chips present on blades although the significance drops after extended use.

BLIND TEST

A blind test was executed in order to assess the value of measuring chip morphology as it pertains to the identification of the type of material silcrete blades were utilised on. Ten silcrete blades were manufactured for this purpose, following the procedure described above. These ten blades were utilised on both bone and wood at either 45° or 90° for varying amounts of time by independent volunteers. The blades were then examined for edge damage and the width and depth of the chips was recorded by the experimenter. The action, time, material and angle was not revealed until the results were compared with the sample of experimental blades (A-H). In order to avoid confusion the blind test blades were labelled J-S.

Results of the Blind Test

The success rate for identifying the type of material worked was high. The rate of accurate assessment for action, angle and time however was considerably lower. The correct time, angle, action and material worked was among the possible choices five times out of ten. In other words, in half of the comparisons a perfect match was found. This is not as encouraging as it sounds however. Blind test blade J for example, was very similar to six experimental blades, one of which was the near duplicate in terms of action, angle, time and material worked. It would therefore be difficult to assess the angle, action and time on archaeological silcrete blades based on this type of comparison.

The material worked was much easier to ascertain. In seven of the ten instances the material worked was accurately predicted. Using blind test blade J as an example once again, of the six experimental blades it was most similar to, five of them were used on the same material as blade J.

The results of the comparison between the experimental blades and those prepared for the blind test were subjected to a two tailed T-test. The results of this test confirmed the accuracy of this method of identifying material worked. While none of the blind test blades were statistically different from the experimental ones, the blades which were most similar had the lowest values in the results of the T-test.

ARCHAEOLOGICAL BLADES

Having established that silcrete blades register no edge damage when employed on softer materials or animal flesh (Kooyman 1985) it must be assumed then, that blades found in archaeological assemblages which demonstrate use wear, were used on harder materials. The Maori employed wood, bone and shell widely in the manufacture of ornaments, tools and weapons, which are the materials most likely to cause edge damage on silcrete blades. Blades with evidence of use wear are common at butchering sites in New Zealand from which we may further assume that they were used in the disarticulation of fauna.

To examine the possibility of establishing the types of materials archaeological blades were used upon, ten silcrete blades were selected at random from the University of Otago collection of Shag River Mouth artefacts. The Shag Mouth site (s155/5), a large prehistoric village, is located on the south bank of the Shag river. All of the blades selected were seen to have use wear. No retouch was apparent and the blades examined were all broken. It is likely that the blades were broken during use and discarded.

Each blade from the selected Shag Mouth collection was compared to the overall results obtained with the experimental blades. Each archaeological blade was compared with group A 1-5 and with each of the remaining groups. The type of material the blade was used upon was then deduced from this comparison which should be fairly accurate if the results of the blind test are considered. The results are tabulated below.

ARCHAEO-LOGICAL BLADES	CLOSEST EXPERIMENTAL BLADES 5 MINUTES	CLOSEST EXPERIMENTAL BLADES 10 MINUTES	PROBABLE USE MATERIAL
AB3151	D1-5	C1-5	WOOD
AB3119	D1-5	C1-5	WOOD
AB3127	D1-5	C1-5	WOOD
AB3134	C1-5/D1-5	H1-5	?
AB2037	C1-5/D1-5	E1-5/H1-5	?
AB3133	D1-5	B1-5/C1-5	WOOD
AB3149	C1-5/D1-5	E1-5/F1-5	?
AB3122	C1-5/D1-5	F1-5/H1-5	?
AB3120	C1-5/D1-5	B1-5/C1-5	WOOD
AB3150	C1-5/D1-5	B1-5/C1-5	WOOD

The provenance of these blades in the archaeological context however does not conclusively support the findings presented above. All of the archaeological specimens were excavated from units which contained worked bone and prepared fish hook tabs as well as finished hook remains. The only blade which was not found in association with bone was AB3127. It is quite possible that the blades could have been associated with worked wooden artefacts but due to differential taphonomy these were not recovered.

CONCLUSION

The stated objective of this experiment was to identify the patterns left on silcrete blades after using them on different materials at different angles with variant actions. A high rate of success was achieved in the first objective.

Through an examination of the edge damage on the experimental blades it was possible to identify with a good deal of accuracy what material the blade was used upon. The other variables however were much harder to identify and there was no way in which this could be done with any confidence. The results of the comparison with the archaeological sample were not as conclusive as the blind test results, as all the blades selected had come from contexts which contained worked bone. The association of blades with the bone does not obviate the possibility that they were used to work wood.

Although there was a high rate of success in establishing the material upon which silcrete blade was employed, the use of this type of empiric method in establishing the function of silcrete blades in archaeological contexts would be uneconomic.

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