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<td>Spearpoints &amp; barbs</td>
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<td>wood</td>
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INTRODUCTION

The mechanics of flaking are of interest to anthropologists and fracture mechanists alike. The anthropologist seeks to understand the mechanics of flaking in order to identify manufacturing techniques and elucidate the nature of use-fracturing. The fracture mechanist sees flaking as a specialized form of fracture, the study of which can contribute to a general understanding of fracture mechanics. This paper is a crystallization of discussions on flaking held by the authors over a number of years.

Much pioneering work on the subject has already been done, and in our opinion among the most significant are the studies carried out by Crabtree (1968; 1972; Bordes and Crabtree, 1969), Kerkhoff and Müller-Beck (1969), and Faulkner (1972; 1973). It is on the foundation of these works that this present paper stands. Our purpose is to use mainstream fracture mechanics to give a clearer understanding of the processes involving in flaking, and in particular to explain the basis of the Ho Ho Committee's use-fracture classification.

FRACTURE MECHANICS: BACKGROUND

Classical fracture mechanics can be used to explain the mechanics of flaking in brittle materials. When a brittle body is broken in half, the total energy is increased by the surface energy of the new fracture surfaces. All materials have an energy associated with their surface, because the atoms at the surface are not balanced by adjacent atoms.

* Department of Mechanical Engineering, University of Sydney, Sydney, N.S.W. 2006
They therefore possess a higher energy than those in the interior of the body.

If it were possible to produce a body with no flaws then it would have extreme strength. The theoretical strength of glass is of the order 10,000 MPa whereas ordinary window glass usually breaks at about 100 MPa (Cottrell 1964:343). Griffith (1920; 1921) postulated that this discrepancy in strength was due to flaws which, in man-made glass, are largest at the surface. Under a normal tensile stress a flaw or crack reduces the potential energy of a body by an amount which is proportional to the square of its length. Griffith (1920) introduced the hypothesis that fracture can only occur in a brittle material if the potential energy released by the growth of the crack is greater than, or equal to, the surface energy of the new fracture surfaces. Using the theoretical reduction in potential energy caused by a flaw, he was able to account for the discrepancy in strength on the basis of flaws of the order of 1 um deep, that are observable in the surface of glass.

In practice no material is absolutely brittle. Even in glass there will be a slight permanent deformation near the tip of a flaw or crack. A reassessment of Griffith's ideas (Orowan 1952; Irwin 1948) produced the hypothesis that in brittle materials the energy required to create a unit area of fracture surface is a material constant, which for very brittle materials is the surface energy.

A fracture can propagate in a fast unstable manner, as happens when a car windscreen shatters, or in a slow stable manner, which can occur when an object is fractured in compression. The stability of the fracture propagation depends on whether the potential energy released increases or decreases with fracture growth under the loading condition. If, as in fracture under tension, the potential energy increases with fracture growth, there will be an excess of potential energy over the energy required to create the fracture surfaces. This surplus energy is converted into kinetic energy as the fracture rapidly accelerates. The acceleration is not without limit. Theoretically it is not possible for a fracture to propagate faster than the velocity of Rayleigh waves (Cotterell 1964) because, at this velocity, all the potential energy released is converted into kinetic energy leaving none available for the creation of the fracture surfaces. However, well before the velocity
of Rayleigh waves is reached, the fracture branches because of directional instability (Cotterell 1965 (a)) and the branching velocity represents a practical limit to the velocity of fracture propagation. In lithic materials the branching velocity is of the order of 1,000ms⁻¹ (approximately half the velocity of Rayleigh waves) which is a far greater propagation velocity than that normally associated with flaking. If the stress in a brittle body is primarily tensile the fracture will be unstable and can propagate using the strain energy stored in the body. Under a primary compressive field, fracture is stable and can only grow if the load is increased. A metastable state exists in a body where the stresses are primarily due to bending.

A crack under a general load can be represented by the combination of three basic modes of crack surface displacement (Paris and Sih 1965:31) as shown in fig. 1*. Mode I is associated with local displacements in which the crack opens by the surfaces moving directly apart. Modes II and III involve displacements in which the crack surfaces slide over one another. In Mode II they slide in a direction normal to the crack front, and in Mode III they slide parallel to the crack front. For all modes of crack surface displacement the stresses in the immediate vicinity of the fracture front diminish in proportion to the inverse square root of the distance from the fracture front. For Mode I the stress acting across the prolongation of the fracture (see fig. 2) is given by Paris and Sih (1965:32) as:

\[ \sigma_y = \frac{K_I}{(2\pi x)^{1/2}} \]

where \( K_I \) is called the Mode I stress intensity factor.

An ideal fracture in an isotropic homogeneous elastic brittle body will follow such a path that the crack surface displacement is always Mode I, which implies that the prolongation of the crack is a principal stress trajectory (Cotterell 1965(b)). However, in a real material

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* All figures referred to in appendix B are located at the end of the text within the appendix.
there are always local inhomogeneities that cause the fracture to deviate from the ideal path. The nature of the stress field adjacent to the fracture front determines whether the fracture returns to its ideal path or continues to deviate (Cotterell 1965(b); 1966; 1970; Finnie and Saith 1973). The stress field adjacent to the fracture front can be expressed as a power series where the first term is given by equation (1) and the dominant stresses are:

\[
\sigma_x = \frac{K_1}{(2\pi x)} + A + Bx + Cx + \ldots
\]

\[
\sigma_y = \frac{K_1}{(2\pi x)^{1/2}} + Bx^{1/2} + \ldots
\]

It is the sign of the second term \(A\) in the expression for \(\sigma_x\) that determines the directional stability of the fracture. If this term is negative, which represents a compressive stress, then the path is stable and predictable. The sign of this second term can be determined from the principle stress trajectories at the fracture front (Cotterell n.d.). If the principal stress trajectory, which is a continuation of the fracture, is in the direction of the minimum principal stress, then the second term \(A\) in equations (2) is negative and the fracture has directional stability. Some understanding of the effect of stress trajectories on the directional stability of fracture surfaces can be gained from study of the shape of the trajectories in the immediate vicinity of the fracture front (see fig. 3). When the minimum principal stress is in the direction of the fracture, the trajectories on either side of the fracture converge on the trajectory that is a prolongation of the fracture. If the fracture deviates, it is directed back towards its ideal path, whereas if the maximum principal stress is in the direction of the fracture, the adjacent trajectories diverge from the ideal path and any deviation of the fracture path causes still further deviation until the fracture changes to follow the direction of the minimum principal stress. It should be emphasized that the prediction of the shape of the principal stress trajectories only holds for the immediate vicinity of the fracture front; Faulkner's (1972:117) diagrams of the stress trajectories in blade flake manufacture do not give enough detail of the fracture front to confirm the theory given above.
Flaking, whether during flake manufacture or tool use, is accomplished with a compressive force applied by pressure or percussion. Fracture in a brittle body, however, only occurs under tensile stress. The necessary tensile stress can be created by bending if the angle of the line of force $\phi$, is small enough (see fig. 4(a)). Tsirk (1968) has calculated a critical value $\phi^*$ at which the primary stress becomes compressive. If $\phi$ is less than this critical value there are tensile stresses along the upper surface, but if $\phi$ is greater, then the stress system is primarily compressive (see fig. 4(b)). Tsirk's calculations were made for a wedge with a point load. Although this idealization is adequate for calculation of the stresses away from the loaded tip of the wedge, the stresses near the actual loaded contact zone are different and contain secondary tensile stresses that enable a fracture to initiate, even if the primary stresses are compressive.

A purely compressive stress system is difficult to achieve even under careful laboratory conditions and fracture occurs under the action of secondary tensile stresses. In flaking, the secondary tensile stresses are produced at the edge of the contact area either between the cone and the hammerstone or punch in the case of tool manufacture, or between the tool and the worked material in the case of tool use. Such a stress system is very similar to that produced by an indenter pressing into a plane surface (Frank and Lawn 1967:292). In a brittle solid these tensile stresses cause a cone-like crack to develop from a surface flaw (Frank and Lawn 167:291). There is general agreement that the stresses under a pressure tool, punch or hammerstone are similar to Hertzian stresses (Kerkhoff and Müller-Beck 1969:443,444; Speth 1972:37-40; Faulkner 1972: 124-129). However, the magnitude of the stresses only becomes comparable to Hertzian stresses if the size of the contact area is small compared with the distance to a free surface (Faulkner 1972:112-115). The maximum stress is greatly increased if the indenter is oblique to the surface (Lawn 1967:308).

There is no clear evidence that flakes produced by pressure flaking are essentially different from those produced by percussion flaking (Faulkner 1972:135; Sollberger and Patterson 1976:531) and Mewhinney (1957:56-59; 1964:203-205) suggests that skill more than method determines
the characteristics of a flake. Crabtree (1972:15) states that flakes
detached by hand-held pressure technique may exceed two inches in length
and are often mistaken for percussion flakes. The only distinctions
Crabtree (1968:457) makes between pressure and percussion flakes are in
the prominence of the bulbs of force and the absence of eraillure scars
on pressure flakes. Faulkner (1972:159,137) however, denies the latter
observation and is led to the conclusion that from the similarity of
the flake forms, it is reasonable to assume that pressure and percussion
flaking involve similar fracture mechanisms. Although this appears to
be true, it may be possible to distinguish the two manufacturing techniques
in blade flaking by overall blade shape and by measuring the amount of
platform crushing (Chandler and Ware 1976).

Pressure and percussion produces similar Hertzian cone fractures,
because the stress distributions are similar, provided that the percussive
impact lasts long in comparison with the time in which elastic waves
travel across the highly stressed contact area (Roesler 1956:56). The two
solutions are similar, because the spherical waves which propagate from the
impact, decay in inverse proportion to the square of the distance from
the point of impact. The same decay occurs for a static point load
(Timoshenko and Goodier 1973:398-402). When the load is placed near a
free surface, as in the case of primary flaking, the spherical waves
become cylindrical waves which decay in inverse proportion to the distance
from the load point - the same decay as in the static case. Thus Faulkner's
(1972:137) assumption that the stress fields under percussion and pressure
flaking are similar appears reasonable. However Speth (1972:42) suggests
that percussion flaking is a variety of spalling fracture with the
necessary tensile stress being created by oblique reflection of compres­
sive waves at the free surface of the core. His subsequent experiments
on percussion flaking (Speth 1974; 1975) do not convince us that percus­
sion flaking is due to spalling and that the stress system is essentially
different to that which occurs in pressure flaking.

FRACTURE INITIATION IN FLAKING

In blade manufacture, control of the fracture initiation is
essential. With proper core preparation the fracture will initiate at
the edge of the contact zone between the core and the flaking tool where
Hertzian type tensile stresses exist. The possibility of such initiation is enhanced if the primary stresses are compressive (see fig.4). If the striking platform is large enough, the fracture forms a partial Hertzian cone, termed 'a bulb of percussion', whereas, if the contact zone is near the edge, the bulb will be slight or non-existent. Bulbs formed by pressure flaking may be more diffuse and flatter than those formed by percussion (Crabtree 1968:457). However, Mewhinney (1964) argues that there is no direct correlation between the flake scar and the flaking technique. Cone initiation (see fig.8(a)) can occur in use, especially if the force is directed into the body of the tool (see fig.4(b)).

Another form of initiation in tool-use occurs when there is significant bending produced on the tool's edge (see fig.4(a)). In this situation the fracture can initiate in the upper surface of the tool away from the edge, under the action of tensile bending stresses. The maximum tensile stress occurs at the point of loading, but frequently the initiation of the fracture occurs at some distance from this point, as fracture occurs where the stress intensity factor reaches a critical value, and not where the stress is greatest. If the surface flaw has a size \( a \) then the stress intensity factor is approximately given by:

\[
K = \sigma \sqrt{a}
\]

Although the stress decreases with distance from the tool's edge, the chance of encountering a large flaw increases, and therefore the maximum value of the stress intensity factor may occur away from the tool's edge. Fractures initiated away from the point of loading have no bulbs of percussion and are perpendicular to the initiation surface.

During tool-use, bending stresses occur on edges that have acute cross-sectional angles - usually no more than around 40°. In fact most use-fractures on such edges are of the bending variety. While the tool's edge angle is clearly predominant in determining the form of use-fracture initiations on acutely angled working edges, as the angle increases, the nature of the material being worked becomes more important. For example, flakes with edge angles greater than 45°, employed to saw a relatively hard material such as bone, can suffer quite severe snap fracturing, such damage increasing the thickness of the working edge to as much as a millimetre or more.
The stable direction for fracture propagation is the direction of the minimum principal stress, with the maximum principal stresses acting across the fracture surface. In some cases the growth of the fracture does not essentially alter the principal stress trajectories. Faulkner's photoelastic experiments on glass plates produced blades which are extremely similar in shape to the principal stress trajectories (Faulkner 1972:99,103,117). The reason why the principal stress trajectories are not altered significantly in this case is because the fracture is not produced by the primary stress distribution which is compressive, but by the secondary tensile stresses which are appreciable only near the tip of the propagating fracture. Since the primary compressive stress is parallel to the free surface, with the secondary tensile stress normal to the surface, the directional stability of the fracture is assured. The stress distribution in blade flaking is similar to that existing in uniaxial compression tests. Flakes extremely similar to blade flakes (see fig.5) have been obtained in compression tests on glass (Cotterell 1972). These flakes were detached in a slow stable manner as the load was increased. The difference between the principal stresses in the uniaxial compression test is so extreme that it is very difficult to deflect the fracture from its ideal path parallel to the free surface. Gramberg (1965:47-48) demonstrated the dominance of this particular stress field over the fracture path by experiments on single crystals of sodium chloride which have highly preferred crystallographic cleavage planes. He cut a cylindrical specimen so that the cleavage planes were inclined at 36° to the axis of the cylinder. However, when the cylinder was fractured under compression, the fracture still followed the stress determined path along the cylinder axis.

The fracture paths of use-fractures depend on the primary stress system and the initiation mechanism. The principal stress trajectories shown in fig.6 for partial fractures in use-fracture situations were based on trajectories obtained with perspex sheet models coated with a brittle lacquer. If the force is directed essentially into the body of the tool a primary compressive stress is produced (fig.4(b)) which is similar to that obtained in blade flaking. Although the principal stress trajectories near the tip of an advancing fracture are distorted, they are not radically different from the principal stress trajectories that exist before fracture initiation (compare fig.6(a) and fig.4(b)). The prolongation of the flake is the direction of the minimum principal stress
and therefore the direction of the fracture is stable and the flake tends to be long.

If there is significant bending during the formation of a flake initiated at the edge of the contact zone (see fig.6(b)) the advancing fracture radically alters the principal stress trajectories. Only the maximum principal stress trajectory passes through the tip of the fracture and the direction of the fracture is not stable while its subsequent path is uncertain, but usually leads to an abrupt termination at the free surface. Directional stability of such fractures can be achieved if sufficiently large compressive stresses exist which are orientated in the direction of the fracture (Benbow and Roesler 1957). Such compressive stresses can be achieved by increasing the angle $\phi$ of the line of force until the situation returns to that shown in fig.6(a) by reducing the effective bending, as might occur in adzing, where the wood forms a cushion for the underside of the tool. In pressure flaking blades the finger tips are sometimes used to reduce the amount of bending (Crabtree 1968:472).

When a fracture initiates away from the contact zone, under bending stresses, the principal stress trajectories are not radically altered (see fig.6(c)). Since the prolongation of the fracture is also the direction of minimum principal stress, the direction of the fracture is stable. If the angle of the force $\phi$ is large but less than $\phi^*$, then the compressive stresses near the lower surface are considerably larger than the tensile stresses near the upper surface, and these compressive stresses turn the principal stress trajectory (that is the prolongation of the fracture) so abruptly that it runs essentially parallel to the lower surface. The fracture follows and also runs parallel to the lower surface. The principal stress trajectory is not turned sharply if the angle of force $\phi$ is small and the fracture can run almost straight across the tool to form a snap fracture.

So far we have discussed only the profile of the fracture path. We agree with Faulkner (1972) that the essential features of the fracture path can be discovered from a two dimensional model. The plan of the fracture path is determined more by the topography of the surface about to be flaked than the flaking method used in detaching it. If a flake is removed from a flat surface, it spreads sideways from the initiation.
at the edge of the contact zone (see fig.8(a)). The principal stress parallel to the surface is intermediate between the maximum and minimum and plays no part in determining the fracture path. The plane across which the maximum principal stress acts is parallel to the free surface and causes the sideways spread of the fracture, an expansion that can be inhibited or controlled by the presence of a ridge on the dorsal surface (Crabtree 1972:15). Therefore in use-fracture studies most emphasis should be placed on the profile of the flake scar rather than its plan.

**FLAKE TERMINATIONS**

In the previous sections we discussed how the fracture path is affected by the direction of the flaking force. The most readily distinguished feature of the fracture path is the manner in which it terminates. The Ho Ho Classifications and Nomenclature Committee has recognised the importance of flake termination and has introduced a provisional standard classification.

In use-fracture, when the fracture profile is without discontinuities in its slope, there are two basic terminations: the feather (Crabtree 1972:64) and the hinge (Crabtree 1972:68) (see figs. 7(a), (d), 8(a)). In our discussion on fracture paths we stated that feather terminations are more likely to occur if the line of the force is directed into the body of the tool, and that hinge terminations are more likely if the line of the force is directed to give a larger bending component. Crabtree (1968:465-466) gives some confirmation of the above observation stating that in blade flaking an excessive outward pressure produces a hinge termination. There are two subtypes in the hinge fracture which some workers consider important. We do not believe that these two subtypes represent any fundamental difference in loading, but admit that we do not fully understand the retroflexed hinge which some workers consider to be the only true hinge termination (Tixier 1974:15; Sollberger 1972). A possible explanation for the difference may lie in the velocity of fracture propagation. One of the authors has observed that fractures propagating at high velocities frequently turn as they are about to meet a free surface at right angles and run parallel to it for a short distance before terminating. (Cotterell 1965(a):228).
A flake or flake scar which terminates abruptly in a break that is essentially at right angles to the previous fracture path is termed 'a step fracture' (Crabtree 1972:93) (see fig. 7(b), (c), 8(a)). There are two subtypes: in the first, there is a plain break (fig. 7(b)), and in the second, the primary fracture continues past the break (fig. 7(c)), leaving a partial flake still attached to the tool, a remnant that can often be picked off. The first subtype is described by Crabtree (1968: 466) in the context of blade flaking, as one where the pressure is insufficient to cause the flake to be removed from the core. To form this type of termination the fracture must come to rest and be reinitiated, although the duration of the rest may be as short as a microsecond. A possible cause of the halt, other than that described by Crabtree (1968: 466), could be the primary fracture encountering a flaw. There are always large tensile stresses in the direction of fracture growth as well as normal to the fracture surface, and if the fracture is stopped by a flaw it may reinitiate under these stresses (such a crack stopping mechanism has been suggested by Gordon 1968:114), although it is more likely that reinitiation occurs after the bending component of the force has increased. Possibly in use-fracture a step termination of the second subtype may be reinitiated to give a step termination of the first subtype.

The step termination of the second subtype occurs if the flake is thin and bends or buckle under the flaking force which results in the flake snapping. The continuing fracture is often revealed by the reflection of light from the fracture surfaces which are separated by microscopic debris. Crabtree (1968:475) gives an excellent series of high speed photographs depicting the formation of this subtype of step termination.

The Ho Ho Nomenclature Committee decided to include both these subtypes of step terminations in one class because the stress systems producing both terminations are the same (the force directed essentially into the body of the tool producing a primary compressive stress system), and also because the second subtype can be converted into the first subtype during subsequent use of the tool.

In blade flaking another possible termination which has a continuous fracture profile is the plunging termination (Crabtree 1968:466), where the fracture plunges to the opposite side of the core. Crabtree (1968:466) considers that these fractures are caused by positioning the pressure
tool too far from the edge of the core, an observation that is confirmed by Faulkner (1972:118). Such terminations are unlikely to be of interest to use-wear analysts.

MORPHOLOGY OF THE FRACTURE SURFACE

The discussion up to this point has been concerned with the gross features of flakes and flake scars - their initiation, path and termination. But the markings that appear on the fracture surfaces of large flakes and blades can also appear on microfractures and therefore can conceivably be employed as bench marks in use-wear studies. Microscopic undulations and lances can be seen in one of the use-fractures depicted in fig. 8.

A plethora of terms are used to describe fracture markings, both in scientific and anthropological writings, and undoubtedly a second Ho Ho committee is needed to introduce a standard terminology for anthropologists.

Smoothness of the fracture surface

In brittle materials the smoothness of the fracture surface is closely related to propagation speed. Glass has a mirror smooth fracture surface at low propagating velocities and only becomes rough at high velocity. The development of a rough fracture surface is shown in fig. 9 for a glass plate broken under tension. The mirror surface, characteristic of low velocity fracture propagation, changes to a rougher stippled surface referred to as 'mist' (Holloway 1973:185-186) or 'frost' (Ponclet 1951:19) which develops into a 'hackle' zone. Finally, if the fracture propagation reaches a velocity of approximately 1,500 ms$^{-1}$ it will branch. However, the mist-like surface on glass will only develop if the velocity of fracture propagation is above 1,000 ms$^{-1}$ (Holloway 1973:185), whereas the velocities measured in flaking experiments, whether percussion (Goodman 1944) or pressure (Crabtree 1968; Faulkner 1972) are in the range 200-300 ms$^{-1}$.

* Not to be confused with lances which are described later.
Therefore, it is unlikely that mist or hackle regions are present on flake implements. The example given by Faulkner (1972:146) is of a block of glass broken by a jack hammer - he stresses the rarity of the event in normal flaking.

Undulations and Wallner Lines

Undulations (Faulkner 1972:152) are the commonest markings on pressure and percussion flake surfaces (see fig. 8(b)). They have many other names: ripples (Leach 1969:49; Bordaz 1970:25; Crabtree 1968:458; Muto 1971:115), compression rings (Crabtree 1968:454), waves of compression (Bordes and Crabtree 1969:8), and rib marks (Murgatroyd 1942:156). These markings, which indicate the actual profile of the fracture front, are formed by a change in stress field causing the direction of maximum principal stress just ahead of the fracture front to rotate about an axis parallel to it (Faulkner 1972:153). The markings can represent an arrest of the fracture, as in the case of the glass flake shown in fig. 5 where on continuation of the fracture growth, changes have occurred in the stress field which have caused the fracture to grow at a slight angle to the previous surface. However, more frequently there is no arrest of fracture and the undulation represents the passage of a shear wave propagating perpendicularly to the fracture surface, so that the entire fracture front is almost instantaneously subjected to the change in stress field (Holloway 1973:183).

Undulations are common on flakes manufactured from a wide variety of materials. Wallner lines (Wallner 1939) are much more delicate ripples in the fracture surface and are only present in the most homogeneous materials such as glass and obsidian. Classic Wallner lines are shown in fig. 10, which is a photograph of a tension fracture in glass under normal incident light with the surface slightly out of focus to make the Wallner lines clearer. A usual characteristic of Wallner lines is two sets of intersecting lines, with a convex orientation towards the direction of fracture propagation. Neither of these two sets of lines indicates the actual profile of the fracture front. Wallner lines are caused by the interaction of the fracture front with a shear wave generated by the fracture front itself as it passes an irregularity. There are usually two sets of lines because the shear waves are reflected at the free
surface of the specimen. A schematic diagram of the formation of Wallner lines is shown in fig.11. It is assumed that a shear wave is generated by the fracture front at position 0. The shear waves propagate radially from 0 at velocity \( v_2 \) and travel faster than the fracture front. In fig.11 the velocity of propagation of the fracture is 0.42\( v_2 \) which is close to the maximum fracture velocity (Schardin 1959) and is much faster than the velocity of fracture observed in flaking, but it has been chosen to make the development of Wallner lines clearer. When the fracture front reaches AA', the shear wave reaches a free surface and is reflected to form the complimentary Wallner line. Examination of fig.11 shows that the fracture front approximately bisects the angle between the two sets of Wallner lines and allows a simple calculation of the fracture velocity.

In fig.12 the fracture front is approximated by a straight line which bisects the angle between two sets of Wallner lines which are also represented by straight lines. While the fracture advances from 00' to A, the shear wave has travelled a distance OA and the velocity of fracture propagation is given approximately by:

\[
v_f = v_2 \sin \theta
\]

By measuring the angle between the sets of Wallner lines shown in fig.10 it is found that the fracture propagated at approximately 0.45 \( v_2 \). In flaking, the velocity of fracture propagation is much smaller. Faulkner (1972:121) has measured a maximum of 280 ms\(^{-1}\) which would make the angle between the two sets of Wallner lines 12\(^{\circ}\), assuming that the velocity of propagation of shear waves is \( v_2 = 2,500 \) ms\(^{-1}\) (Schardin 1959). A fracture surface of an obsidian blade flake from Lipari (in the collection of the Nicholson Museum, University of Sydney) shown in fig.13, has sets of Wallner lines that make an angle of 21\(^{\circ}\), which indicates a velocity of fracture propagation of 0.18 \( v_2 \).

The slower the velocity of fracture propagation the smaller is the angle between Wallner lines. Thus for slow moving fractures the Wallner lines and the fracture front are almost coincident, and it may not be possible to distinguish them from undulations. The only distinction between what the authors consider true Wallner lines and undulations when only one set exists, is the depth of the marking. True Wallner lines arise from stress waves generated by the fracture front itself and
as a consequence are extremely shallow whereas undulations are comparatively deep.

Wallner lines are usually only detected by examination of the surface under low magnification with normal incident light, and are present only in the most homogeneous materials. We suspect that they are comparatively rare since many blades had to be examined before we found the example shown in fig.13. Undulations are common.

Lances

Lances (Smekal 1973) are usually seen in conjunction with undulations (see figs.8(b), (c)) and as with undulations, they go under a variety of names. While Crabtree (1968) and Leach (1969) prefer the term fissures, other names are: striations (Faulkner 1972) tear lines (MacDonald 1969), grooved shatter lines (Muto 1971), fracture steps (Lawn and Wilshaw 1975) and, most confusing of all, hackle marks (Schardin 1954; Bateson 1950; Murgatroyd 1942). Lances are always formed in the direction of fracture propagation and are normal to undulations (see fig. 8(b)). The mechanics of the formation of lances have been described by Sommer (1969). Lances form when the axis of the maximum principal stress is rotated in a plane perpendicular to the direction of propagation. The fracture cannot adjust to this change in stress field by continuously rotating the fracture plane, and the original fracture front breaks up into small separate fronts. Schardin (1954:87) remarks that when lances appear, the velocity of fracture propagation always decreases from its normal value to a very low one, because the simultaneous formation of lances and undulations requires more energy. However, Kerkhoff and Muller-Beck (1969:446) show a fracture surface containing lances and Wallner lines where the velocity of fracture propagation is estimated by us to be 0.21 v₂. Lances are common to both pressure and percussion flakes.

Eraillure

A characteristic scar, usually known as an eraillure appears on the surface of many bulbs of percussion, especially if the artifact material is fine textured (Bordes 1947:18; Faulkner 1972:159). According to Crabtree (1968:457) the eraillure scar is absent on pressure flakes, but Faulkner (1972:159; 1973) who has made a special study of the eraillure flake, states that they are a common feature in pressure flaking.
The eraillure flake forms a scar on the ventral surface of the flake. There is no corresponding scar on the surface of the core, but the eraillure flake frequently remains attached to the core by a small bridge of material. Faulkner (1973:4) has given a convincing explanation of the mechanism by which an eraillure flake is formed. Lances form on both sides of the bulbar surface where the change in fracture plane is greatest. The middle of the bulbar surface is free from lances, because the surface is already perpendicular to the maximum principal stress. The eraillure flake is formed by an extension of a lance tongue across the face of the bulb.

The morphology of the fracture surface is extremely interesting, but at present does not appear to tell us very much about how a flake was detached. Even if it is possible to measure velocity of fracture propagation through the study of Wallner lines, we still do not know whether the flake was detached by percussion or pressure. If the fracture initiation is of the bending type we know the kind of loading that must have produced it, but if there is initiation at the edge of the contact zone the type of loading is less certain. At present there is debate as to whether the presence of a bulbar scar indicates whether percussion was used (Crabtree 1968:57; Mewhinney 1964) but the work of Frank and Lawn (1967) and many others on Hertzian fractures indicates that such a distinction is unlikely.

CONCLUDING REMARKS

Use-fracture patterns are a valuable aid in determining the functions of certain types of prehistoric tools but more sophisticated experimentation than that which has already been carried out is necessary before the full potential of use-fracture patterning can be realised. To achieve this objective researchers must have a viable use-fracture classification and we believe it is only through the study of flaking mechanics that a meaningful basis for such a classification can be found.

The features of a use-fracture that appear to be relevant are its form of initiation and termination. Fracture surface markings do not at this stage provide any useful criteria for classification. It is the profile rather than the plan of the fracture that seems to more accurately reflect the load conditions under which the fracture was
created. Fracture size may be an important variable as in some cases it reflects the magnitude of the load. These are, of course, the conclusions of the Ho Ho committee and a provisional classification has been formulated.

The mechanics of flaking indicate that the direction of loading and the specific and wedge angles of the working edge are the chief determining factors for the form of initiation and fracture termination but controlled mechanical use-fracture experiments employing polished glass wedges are essential in confirming the mechanical basis of the provisional classification.

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TIXIER, JACQUES

TSIRK, ARE

WALLNER, H.
I OPENING MODE

II SHEARING MODE

III ANTI-PLANE SHEARING MODE

FIG. 1 THE BASIC MODES OF CRACK SURFACE DISPLACEMENT

FIG. 2 STRESS COMPONENTS NEAR A FRACTURE FRONT
a. DIRECTIONALLY STABLE

b. DIRECTIONALLY UNSTABLE

FIG. 3 PRINCIPAL STRESS TRAJECTORIES NEAR FRACTURE FRONT
NEUTRAL AXIS

\[ \phi < \phi^* \]

a. PRIMARY STRESS BENDING

\[ \phi > \phi^* \]

b. PRIMARY COMPRESSIVE STRESSES ONLY TENSILE STRESS ONLY PRODUCED BY SECONDARY EFFECTS

--- DIRECTION OF MAXIMUM PRINCIPAL STRESS

--- DIRECTION OF MINIMUM PRINCIPAL STRESS

FIG. 4 EFFECTS OF DIRECTION OF FORCE ON STRESS DISTRIBUTION
Fig. 5

Glass flake obtained from compression test.
a. PRIMARY STRESS DISTRIBUTION COMRESSIVE - CONE INITIATION

b. PRIMARY STRESS DISTRIBUTION BENDING - CONE INITIATION

c. PRIMARY STRESS DISTRIBUTION BENDING - BENDING INITIATION

DIRECTION OF MINIMUM PRINCIPAL STRESS
DIRECTION OF MAXIMUM PRINCIPAL STRESS

FIG. 6 SCHEMATIC PRINCIPAL STRESS TRAJECTORY BASED ON PERSPEX MODELS WITH BRITTLE LACQUER COATINGS
a. FEATHER TERMINATION

b. STEP TERMINATION

Type 1

c. STEP TERMINATION

Type 2

d. HINGE TERMINATION

FIG. 7 FLAKE TERMINATIONS
Fig. 8a

A step (left) and feather fracture (right) on the abraded and bevelled working edge of an experimental obsidian scraper used to work dense wood. Both fractures have cone initiations and expand onto a flat surface.

Width of field: 2mm X50

Fig. 8b

Detail of the fracture floors and terminations of the step and feather scars depicted in Fig. 8a. The lines running parallel with the termination of the feather fracture are undulations. The scraper lines that intersect the undulations at around 90° are lances.

Width of field: 670um X150
Fig. 8c
Detailed view of the lances depicted in Fig. 8b.
Width of field: 200um X500

Fig. 9
Fracture surface of glass (mirror = mist = hackle).
Fig. 9

Fracture surface of glass (mirror - mist - hackle).
Fig. 10

Wallner lines on the fracture surface of glass.
Fracture Front

Shear Wave Front

Wallner Line

Fig. 11 Formation of Wallner Lines

\[ V_f = 0.42 V_2 \]

Fig. 12 Straight Line Approximation to Wallner Line Development
Fig. 13

Blade flake from Lipari showing Wallner lines.
### APPENDIX C

**RAW FIGURES FOR EXPERIMENTAL ACCIDENTAL FRACTURE DAMAGE**

Each line lists the damage on a single edge. The first figure denotes the edge angle at midpoint. The second figure denotes the length of the edge. The remaining figure list the fracture types: 1 = step; 2 = retroflexed hinge; 3 = feather/hinge; 4 = snap. Each of these figures are followed in brackets by the width of the scar, and the frequency on the right hand side of the bracketted figure (e.g. 4(0.2)3 means three snap fractures, 0.2 mm wide.

#### Fracture Damage from Trampling

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<th>Fracture Type &amp; Frequency</th>
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<td>25</td>
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</tr>
<tr>
<td>30</td>
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<td>37</td>
<td>25</td>
<td>3b(.5)2</td>
</tr>
<tr>
<td>43</td>
<td>34</td>
<td>1(&lt;.2)5; 3(&lt;.2)5/ nil</td>
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<tr>
<td>45</td>
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</tr>
<tr>
<td>66</td>
<td>33</td>
<td>no fractures</td>
</tr>
<tr>
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<tr>
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**Obsidian**

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### Fracture Damage from Sieving

#### Flint

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### Volcanic Tuff

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### Obsidian

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### Silcrete

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Fracture Damage from Bag Transportation

**Flint**

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**36° - 65° 133 mm combined lengths**

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**66° - 90° 60 mm combined lengths**

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**Volcanic Tuff**

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### APPENDIX D

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**Silcrete**

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APPENDIX D

PETROLOGICAL REPORT NO. 75/27

By T.P. Zlotkowski

(revised by Johan Kamminga)

Geological Survey of New South Wales
Department of Mines

Accompanying plans:

1:250,000

Wollongong SI/56-9 9028-I
Bathurst SI/55-8 8831-I-V, 8630-I
Ulladulla SI/56-13 9027-IV, 8927-I
Dubbo SI/55-4 8832-II
Newcastle SI/56-2 9332-I
Sydney SI/56-5 8930-I

1:50,000

Wollongong SI/56-9
Bathurst SI/55-8
Ulladulla SI/56-13
Dubbo SI/55-4
Newcastle SI/56-2
Sydney SI/56-5

All thin sections are lodged with the Geological Survey of New South Wales. Quote the T numbers for retrieval.
Bombo Basalt Quarry

Basalt, altered

The hand specimen consists of aligned euhedral plagioclase (0.5 - 10.0 mm, 6%) which are set in a basaltic matrix. In thin section the rock consists of plagioclase phenocrysts, chlorite filled amygdules (1.0 - 2.0 mm, 2%), euhedral olivine with alteration in fractures (0.4 mm, 2%), clinopyroxene (0.3 mm, 2%), opaques (0.02 mm and larger grains 0.6 mm, 5%) which are set in an unfoliated matrix of plagioclase microlites (0.09 mm, 60%), opaques and leucoxene. Although the phenocrysts are aligned in hand specimen the rock is otherwise massive and breaks with a hackley fracture.

Mount Tomah, Blue Mountains

Olivine Basalt, altered

The hand specimen consists of euhedral plagioclase (0.5 - 2.0 mm, 5%) in a basaltic matrix. In thin section the matrix consists of trachytic plagioclase microlites (0.15 by 0.03 mm, 50%), opaques, and augite + olivine (0.03 mm, 10%). Phenocrysts consist of euhedral plagioclase (0.15 - 2.0 mm, 15%, some embayed and altered to sericite) and euhedral olivine (0.03 - 1.1 mm, 15%). The rock fractures with a hackley surface but the phenocrysts are soft.
Bathurst SI/55-8

203-844 8630-I T28856

Dam on the Belabula River
Andesitic Basalt, foliated, altered

The hand specimen fractures unevenly giving a sugary surface consisting of feldspar phenocrysts. In thin section the rock consists of sericitized feldspar laths (1.0 mm, 55%) showing no preferred orientation mixed with chlorite (5%) in patches (0.2 mm) and after pyroxene (0.3 mm) with tremolite. Euhedral clinopyroxene (0.05 - 0.06 mm, 35%) is evenly distributed throughout. Small patches (0.1 - 0.7 mm) of granular rutile (0.006 mm, 5%) occur.

Newcastle SI/56-2

481-930 9332-I T28852

Nobbys Head, Newcastle
Volcanic Tuff, bedded

The hand specimen consists of well bedded, fine grained material with small patches of clay. In thin section the rock consists of microcrystalline quartz (0.005 mm, 95%). The larger patches seen in hand specimen did not survive the thin sectioning process. The rock fractures conchoidally.

Bathurst SI/55-8

264-911 8831-IV T28848

Gravel from Turon River, Sofala
Rhyodacitic Volcanic, foliated

Evenly distributed subaligned crystals of ovoid biotite (0.06 mm, 25%) and muscovite (0.025 mm, 5%) are set in a matrix of subaligned anhedral quartz (0.005 - 0.03 mm, 70%) + leucoxene (0.002 mm, 1%). Although the specimen shows a strong primary lineation in thin section it fractures subconchoidally. The format of biotite, muscovite and matrix quartz suggests that the rock is a rhyodacitic volcanic.
The hand specimen consists of fine grained quartz with occasional lithic fragments. In thin section it consists of a fine grained angular matrix with a range of quartz (0.03 - 0.5 mm, 75%) grain sizes. Some relic textures after feldspar (?) exist but are now replaced with quartz, and some lithic fragments (0.5 - 1.5 mm, 2%) occur. Detrital tourmaline also occurs (0.06 mm, 1%). Cavities filled with opal (up to 0.5 mm, 5%) are present.

The rock consists of quartz grains with slight iron staining. In thin section it consists of quartz grains (0.15 mm, 99%) all of very similar size showing secondary growth and undulose extinction. Some grains are microcrystalline quartz (1%) and there are patches of iron oxide (0.15 mm, 1%). A slight lineation is caused by the moderate elongation of the grains. The rock exhibits a hackley fracture and the grains are well cemented.

The hand specimen of this rock is massive and fine grained. In thin section it consists of fitted patches of microcrystalline quartz (0.03 mm, 100%) with areas of radiatic opal (0.3 mm) probably filling in previous cavities. No lineation is present. The hand specimen fractures conchoidally to evenly.
Western Desert (in the area north of Haasts Bluff)

Chaledony

The hand specimen is a fine grained siliceous rock showing no lineation. In thin section it is seen to consist of fitted microcrystalline quartz (99%), some of which occurs as fibrous elongate patches (0.3 mm) possibly formed by the infilling of cavities. The centre of the cavities often contain small amounts of limonite. The rock breaks with a subconchoidal fracture.

Warrumbungles Mountains

Chert, bedded, opal filling cavities

The hand specimen is very fine grained siliceous material which in thin section consists of well bedded iron stained microcrystalline fitted fibrous patches of quartz (0.01 mm, 95%) with larger patches of radiating material (0.1 - 0.4 mm, 5%) filling previous cavities. The hand specimen fractures conchoidally.

Gascoyne Junction, Western Australia

Chert, radiolarian (see plate 250)

The hand specimen is a fine grained cherty rock that fractures conchoidally showing a poor bedding lineation. In thin section it is seen to consist of iron stained microcrystalline quartz which shows distinct bedding and a rich content of well preserved radiolarian. Microfractures occur parallel to the bedding (0.1 - 0.8 mm apart, 2 mm long) but do not seem to affect the direction of fractures of the hand specimen.
The hand specimen is a hard, very fine grained rock which fractures conchoidally. In thin section it is seen to consist of microcrystalline quartz and a high abundance of fossil material mostly replaced by silica although some fragments still retain carbonate material. Fossils present include at least three species of Bryzoa, sea urchin spines, sea cucumber spicules and possibly Ostracodes and Foraminifera (J.W. Pickett, pers. comm.). The biological content of this specimen would make correlation between it and other specimens from the area reasonably easy although flint derived from carbonate rock of the same age spreads along most of the southern coast of Australia.

The hand specimen is massive fine grained calcite with abundant fractures (1 mm wide) filled with iron stained calcite. In thin section the rock consists of evenly fine grained calcite (0.02 mm, 99%) with patches of quartz (0.15 mm, 1%). The rock fractures extensively and randomly when struck along blunted areas.

We acknowledge and appreciate the assistance and advice provided by Ken Blackwood, Department of Mining Engineering, University of U.S.A. The equipment that was used belonged to the School of Earth Sciences, Macquarie University.
APPENDIX E

THE MODIFIED LOS ANGELES ABRASIVE WEAR TEST (see fig. 3.3)

by Thomas J. Hudson* and Johan Kamminga

A modified Los Angeles Abrasion Test (see T-96 in AASHTO 1970) was conducted on thirty rock samples taken from a wide range of stone resources, some of which are known to have been used for making stone implements. Ordinarily this test procedure calls for 5000 - 10000 g samples placed in a metal cylinder containing seven to twelve steel balls and rotated for 500 revolutions. However, it was difficult to obtain a significant number of 5000 g samples for these tests. At the University of Idaho in 1975, a modified T-96 was designed to deal with the difficulty of obtaining large quantities of stone. This modified T-96 was followed almost exactly, with the exception of sieve sizes, for the abrasion tests conducted as part of this research.**

In the modified test, samples were composed of 500 g of rock material. Two 22 mm diameter steel balls were placed in the Standard Los Angeles Abrasive Wear Machine with each sample, and the drum was revolved 500 times.

Prior to testing, the majority of the stone to be analysed was in the form of +500 g pieces. It was therefore necessary to break the test material into smaller pieces that would pass through the 2.54 cm standard gradation sieve. Actual samples were obtained by a short, simple method which, while providing a natural composition of the sample from varied sized fragments, was not nearly as time consuming as the standard sample procurement method (see 2# below). After the oversized pieces of stone were broken up in a mortar-pestle fashion with an iron rod, the fragments were sieved through 2.54 cm,

* University of Idaho, Moscow, U.S.A.
** We acknowledge and appreciate the assistance and advice provided by Ross Blackwood, Department of Mining Engineering, University of N.S.W. The equipment that was used belonged to the School of Earth Sciences, Macquarie University.
1.90 cm, 1.30 cm, 9.53 mm, 3.18 mm (=1", 3/4", 1/2", 3/8". 1/8") standard gradation sieves. All fragments passed through the 2.54 cm sieve. Weights were noted for material retained on each sieve, then totalled (see tables), and the 500 g sample derived as follows:

\[
\text{Initial Weight (500 g) - Final Weight} = \text{Loss}
\]

\[
\% \text{Wear} = \frac{\text{Loss}}{\text{Initial Weight}} \times 100
\]

**L.A. Test Results**

Numbers are grid sizes: 1 = 1.90 cm, 2 = 1.30 cm, 3 = 9.53 mm,
4 = 3.18 mm, 5 = 12#; column I refers to the pre-test weights, column II refers to the post-test weights. All weights are expressed in grams.

### Altered basalt

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Loss = 56.3 g

L.A. value 11.2

### Olivine basalt

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Loss = 60.0 g

L.A. value 12.0

### Andesitic basalt

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Loss = 48.8 g

L.A. value 11.2
4. Volcanic Tuff

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5. Rhyodacitic volcanic

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<td>L.A. value 13.6*</td>
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*This figure is highly suspect but it was not possible to repeat the test because there was a shortage of the material.

6. Silcrete

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7. **Orthoquartzite**

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Loss = 57.5 g  
L.A. value 11.5

---

8. **Olary Chalcedony**

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Loss = 59.7 g  
L.A. value 12.0

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9. **Cundeelee Chalcedony**

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Loss = 60.3 g  
L.A. value 12.0

---

L.A. figures for these samples should be slightly less because rock fragments had some cortex attached.
10. **Chert**

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Loss = 90.0 g  
L.A. value 18.0

11. **Radiolarian chert**

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Loss = 53.2 g  
L.A. value 10.8

12. **Flint**

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Loss = 56.0 g  
L.A. value 11.2

Loss = 52.2 g  
L.A. value 10.4
### 13. Obsidian

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Loss = 114.6 g  
L.A. value 23.0

### 14. Obsidian

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Loss = 143.2 g  
L.A. value 28.6

### 15. Quartz crystal

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Loss = 126.9 g  
L.A. value 25.4
APPENDIX F

1. REFERENCES FOR FIGURE 3.5.

DISTRIBUTION OF SKIN CLOAKS, BAGS, RUGS, APPAREL AND ORNAMENTS IN AUSTRALIA

A. Unspecified Skin Cloaks

Reference
Aiston 1920/25:97
Bennett 1834/1I:175-176
Bennett 1927/410
Curr 1886/1I:190
Field 1825:432
McKiernan 1911:886
Mathews and Everitt 1900:277
Tindale 1939:11

Aiston 1920/25/I:17
Bates 1922
Curr 1886/111:270
Curr 1886/1I:306
Curr 1886/1I:340
Curr 1886/1I:375
Curr 1886/1:395
Curr 1886/1:401
Grey 1841/1I:56, 265
Richards 1925:250
Schulze 1891:229
Warner 1958:475

Area
Port Lincoln to Fowlers Bay, Tarcoola, S.A.
Yass area, N.S.W.
Flinders River to Cameron Downs, Lattamour Tablelands, Q'land.
Burke and Darling Rivers, N.S.W.
Blue Mountains, N.S.W.
Raymond Terrace, N.S.W.
South-East Coastal Australia
Point McLeay, Murray River, Vict.

B. Specific Absence of Cloaks

Aiston 1920/25/1:17
Bates 1922
Curr 1886/111:270
Curr 1886/1I:306
Curr 1886/1I:340
Curr 1886/1I:375
Curr 1886/1:395
Curr 1886/1:401
Grey 1841/1I:56, 265
Richards 1925:250
Schulze 1891:229
Warner 1958:475

Central Australia
Ooldea, S.A.
Paroo and Warrego Rivers, north of lat. 27° 30'
Mouth of Norman River and Gulf of Carpentaria Q'land.
Flinders and Cloncurry Rivers, Q'land.
Junction of Thomson and Barcoo Rivers, N.S.W.
Point Culver, W.A.
Eucla, W.A.
Coastal region north of lat. 29° S, W.A.
Mt. Mulligan, Q'land.
Upper and Middle Finke Rivers
Blue Mud Bay, N.T.
## DISTRIBUTION OF POSSUM SKIN PRODUCTS IN AUSTRALIA

<table>
<thead>
<tr>
<th>Reference</th>
<th>Area</th>
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</thead>
<tbody>
<tr>
<td>Angus 1850:85</td>
<td>Mt. Barker and Adelaide Plains, S.A.</td>
</tr>
<tr>
<td>Barrington 1802:23</td>
<td>Sydney-Parramatta, N.S.W.</td>
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<tr>
<td>Bennett 1834/II:175-6,181</td>
<td>Yass area, N.S.W.</td>
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<tr>
<td>Bennett 1834/II:275</td>
<td>Bogong Mts., N.S.W.</td>
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<tr>
<td>Bennett 1834/I:322</td>
<td>Blue Mts., N.S.W.</td>
</tr>
<tr>
<td>Beveridge 1889:27, 1883:26</td>
<td>Swan Hill area, Lower Murray, Vict.</td>
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<tr>
<td>Blackman 1901:31</td>
<td>Parramatta, N.S.W.</td>
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<tr>
<td>Bunce 1859:75</td>
<td>Western Port Ranges and Yarra River, Vict.</td>
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<tr>
<td>Bundock 1898:3</td>
<td>Richmond River, N.S.W.</td>
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<tr>
<td>Byrne 1931/2:183</td>
<td>Mornington Peninsula, Vict.</td>
</tr>
<tr>
<td>Cawthorne 1885; 1925/6:19</td>
<td>Adelaide, S.A.</td>
</tr>
<tr>
<td>Curr 1883/286</td>
<td>Junction of Goulbourne and Yarra Rivers to Tongala, N.S.W.</td>
</tr>
<tr>
<td>Curr 1886/II:36</td>
<td>Bulloo River, N.S.W.</td>
</tr>
<tr>
<td>Curr 1886/II:143</td>
<td>Yorke Peninsula, S.A.</td>
</tr>
<tr>
<td>Curr 1886/II:158,178</td>
<td>N.W. Corner of N.S.W.</td>
</tr>
<tr>
<td>Curr 1886/II:182</td>
<td>Lower Paroo River, N.S.W.</td>
</tr>
<tr>
<td>Curr 1886/II:432</td>
<td>Headwaters of Burdekin River, Q'land.</td>
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<tr>
<td>Curr 1886/II:471</td>
<td>Cape River, Q'land.</td>
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<tr>
<td>Curr 1886/III:19</td>
<td>Region bounded by Belyando and Cape Rivers, Q'land.</td>
</tr>
<tr>
<td>Curr 1886/III:64</td>
<td>Area around Tambo, Q'land.</td>
</tr>
<tr>
<td></td>
<td>(Peak and Logan Downs no longer exist).</td>
</tr>
<tr>
<td>Curr 1886/III:96</td>
<td>Headwaters of Comet River, Q'land.</td>
</tr>
<tr>
<td>Curr 1886/III:114</td>
<td>Keppel Bay, Calliope River, Curtis Island, Q'land.</td>
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<tr>
<td>Curr 1886/III:122</td>
<td>Boyne River, Q'land.</td>
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<tr>
<td>Curr 1886/III:155</td>
<td>Mary River, Q'land.</td>
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<tr>
<td>Curr 1886/III:304</td>
<td>Gwyder River, Q'land.</td>
</tr>
<tr>
<td>Curr 1886/III:352</td>
<td>Hunter River, N.S.W.</td>
</tr>
<tr>
<td>Dawson 1881:9</td>
<td>Western Victoria</td>
</tr>
<tr>
<td>Dawson 1935:23</td>
<td>New England region, N.S.W.</td>
</tr>
<tr>
<td>Dunbar 1943:142</td>
<td>Central Darling River, N.S.W.</td>
</tr>
<tr>
<td>Graham 1863:111,121</td>
<td>Bathurst plain, N.S.W.</td>
</tr>
</tbody>
</table>
Area

Broken Bay, N.S.W.
Snowy River, N.S.W.
Shoalhaven River; Braidwood; Twofold Bay, N.S.W.
Gippsland, Vict.
Sutton River, Q'land.
Coastal Central, Q'land.
Bathurst Plain, N.S.W.
Port Phillip Bay, Vict.
South-east coastal N.S.W. and Vict.
Echuca, Vict., Flinders Ranges, S.A., Hunter River, N.S.W.
100 miles from Brewarrina, N.S.W.
Wombat, Mt. Gambier, Vict. - S.A.
3. REFERENCES FOR FIGURE 3.7.

DISTRIBUTION OF MACROPODIDAE SKIN CLOAKS, BAGS, APPAREL AND ORNAMENTS.

Reference                      Area
Angus 1850:85                  Mt. Barker and Adelaide, S.A.
Barrington 1802:23             Sydney-Parramatta, N.S.W.
Bates 1938:60, n.d. (b):20     South-west of Western Australia
Browne 1856:261, 264           King Georges Sound, W.A.
Cawthorne 1885; 1925/6:19      Adelaide, S.A.
Curr 1886/I:328                Perth, W.A.
Curr 1886/I:336                York District, A.W.
Curr 1886/II:143               Yorke Peninsula, S.A.
Curr 1886/III:304              Gwyder River, Q'land.
Dawson 1881:9                  Western Australia.
Curr 1943:142                 Central Darling River, N.S.W.
D'Urville 1833:plate 24        King George Sound, W.A.
Grey 1841/II:56, 265           Lat. 29°S on coast of W.A.
Hassell and Davidson 1936:679  Bremer Bay and Esperence Bay and inland, W.A.
Helms 1896:397                 Snowy River region, N.S.W.
Henn 1945:366                  W.A.
King 1827:4, 122, 129, 139-140, 143
Ling Roth 1899:128            Twofold Bay, N.S.W.
Mountford 1963:526             Tasmania
Nind 1831:25                   Jarramungup, W.A.
Peron 1809:60, 75, 175, 217    King Georges Sound, W.A.
Pyke 1892:42, 45               Cape Geographe, W.A. Maria Island, South-West Cape, Tasmania.
Plomley (Robinson) 1966:137, 154, 531, 564
Roth 1904:11; 1910 (b):51      Port Phillip, Vict.
Schürmann 1879:210             Tasmania
Spencer 1915:46                Brisbane area, Q'land.
Taplin 1879 (b):41            Port Lincoln, W.A.
Wilhelmi 1860:3                Bunbury and York District, W.A.; Lake Fromme, S.A.
                                 Coorong, S.A.
                                 Port Lincoln, S.A.
4. REFERENCES FOR FIGURE 3.8.

DISTRIBUTION OF SKIN WATER BAGS

<table>
<thead>
<tr>
<th>Reference</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aiston 1928:131</td>
<td>East and north-east of Lake Eyre, S.A.</td>
</tr>
<tr>
<td>Berndt and Berndt</td>
<td>Ooldea, S.A.</td>
</tr>
<tr>
<td>1945:298</td>
<td></td>
</tr>
<tr>
<td>Beveridge 1889:27</td>
<td>Swan Hill, Vict.</td>
</tr>
<tr>
<td>Curr 1886/II:158-159</td>
<td>N.W. corner of N.S.W. and directly north of Swan Hill.</td>
</tr>
<tr>
<td>Curr 1886/II:322</td>
<td>Gregory and Leichhardt Rivers, Q'land.</td>
</tr>
<tr>
<td>Davidson 1937:198</td>
<td>Tennant Creek, MacDonald Ranges, Coopers Creek area, N.T.,</td>
</tr>
<tr>
<td></td>
<td>Lachlan - Macquarie Rivers District, N.S.W.</td>
</tr>
<tr>
<td>Dunbar 1944:174</td>
<td>Central Darling River, N.S.W.</td>
</tr>
<tr>
<td>Mathews 1901:79</td>
<td>Victoria and Roper Rivers, N.T.</td>
</tr>
<tr>
<td>Meston 1895:81</td>
<td>Bourke River, Q'land.</td>
</tr>
<tr>
<td>Parker 1905:125</td>
<td>100 miles north of Brewarrina, N.S.W.</td>
</tr>
<tr>
<td>Roth 1897:102</td>
<td>Leichhardt, Selwyn Ranges, Boulia District, Q'land.</td>
</tr>
<tr>
<td>Roth Collection, Aust.</td>
<td>Museum, E 13363 E 13364 E 13365</td>
</tr>
<tr>
<td>Sturt 1849/I:296</td>
<td>North-west, N.S.W.</td>
</tr>
</tbody>
</table>

Area

East and north-east of Lake Eyre, S.A.

Ooldea, S.A.

Swan Hill, Vict.

N.W. corner of N.S.W. and directly north of Swan Hill.

Gregory and Leichhardt Rivers, Q'land.

Tennant Creek, MacDonald Ranges, Coopers Creek area, N.T., Lachlan - Macquarie Rivers District, N.S.W.

Central Darling River, N.S.W.

Wilson's Bluff, S.A.-W.A. border.

Victoria and Roper Rivers, N.T.

Bourke River, Q'land.

100 miles north of Brewarrina, N.S.W.

Leichhardt, Selwyn Ranges, Boulia District, Q'land.

Camooweal and Urandangie, Q'land.

North-west, N.S.W.

The density figures listed in this appendix were compiled from Bolza and Kloot (1963), Causey, et al. (1974), Division of Wood Technology (1960), Kingston and Rideout (1961), and the files of the Division of Wood Technology, Forestry Commission of New South Wales. Timber density is expressed in kilograms per cubic metre and the means by which these figures are determined are described in the publications cited above. But I briefly point out that density varies within and between species, the greatest variation being due to changes in moisture content. It is probable that the density figures given for some arid or semi-arid timbers utilised to make
1. TIMBER SPECIES EXPLOITED BY THE AUSTRALIAN ABORIGINES FOR THE MANUFACTURE OF WOODEN ARTIFACTS

Although the purpose of this survey was to collate a comprehensive list of timbers used by Aborigines, for the purpose of accuracy, colloquial names for trees, when they appeared in the literature, were ignored. A single tree species may have up to four or five common names in the area of its distribution, while not uncommonly different species can share a single common name: the early settlers were not concerned with the details of taxonomy.

This compilation of 141 species comprises almost all the properly documented references in the literature. When there were minor errors in nomenclature (spelling, omission of the botanist's name after the species name) I have made the correction without notification. I appreciate the assistance provided by the staff at the National Herbarium of New South Wales in correcting the nomenclature given in the ethnographic literature.

Distribution refers only to the specified locality where the observation was made and not to the species itself. The procedure for listing the artifacts is straightforward except that 'throwing stick' is included with 'club', even though in some cases the observer was referring to the woomera or some other artifact.

The density figures listed in this appendix were compiled from Bolza and Kloot (1963), Cause, et al. (1974), Division of Wood Technology (1960), Kingston and Ridson (1961), and the files of the Division of Wood Technology, Forestry Commission of New South Wales. Timber density is expressed in kilograms per cubic metre and the means by which these figures are determined are described in the publications cited above. But I briefly point out that density varies within and between species, the greatest variation being due to changes in moisture content. It is probable that the density figures given for some arid or semi-arid timbers utilised to make
spears and spearshafts are likely to be slightly high. This is because in certain instances the wood was taken from the root and not the branch or trunk (see Thomson 1964:420), and root wood is often a less dense part of the tree, there being little functional advantage in stronger cell walls (J.W. Lanyon, pers. comm.).
<table>
<thead>
<tr>
<th>#</th>
<th>Species</th>
<th>Area</th>
<th>Artifacts:</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Acacia acuminata</em> Benth.</td>
<td>South-west of Western Aust.</td>
<td>boomerang:</td>
<td>Bates n.d. (d):16</td>
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<tr>
<td>2</td>
<td><em>Acacia aneura</em> F. Muell.</td>
<td>Gibson, Western &amp; Central Deserts; Inland Q'land</td>
<td>spear:</td>
<td>Basedow 1914:63;</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gould 1970:10;</td>
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<td></td>
<td>Johnston &amp; Cleland</td>
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<td></td>
<td>1942:98, 1943:164</td>
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<td></td>
<td></td>
<td>Maiden 1889:349;</td>
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<td>Roth 1897:147;</td>
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<td>Schulze 1891:227;</td>
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<td>Stirling 1896:87;</td>
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<td>Thomson 1964:407</td>
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<td></td>
<td>spearthrower: Mountford 1941:312;</td>
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<td></td>
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<td>De Graaf 1968:86;</td>
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<td>Johnston &amp; Cleland</td>
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<td></td>
<td></td>
<td>spearpoint: Basedow 1914:63;</td>
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<td>Johnston &amp; Cleland</td>
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<td></td>
<td>1943:163;</td>
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<td></td>
<td></td>
<td>Maiden 1889:349;</td>
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<td>digging stick: Cleland 1957:161;</td>
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<td>Johnston &amp; Cleland</td>
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<td>1942:98, 1943:161,164</td>
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<td>Maiden 1889:349;</td>
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<td>Thomson 1964:407</td>
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<td></td>
<td>boomerang: Johnston &amp; Cleland</td>
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<td></td>
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<td>1942:98; 1943:163-164,170;</td>
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<td>Thomson 1964:407</td>
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<td></td>
<td>Maiden 1889:349;</td>
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<td></td>
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<td>Roth 1897:42</td>
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<tr>
<td>4</td>
<td><em>Acacia auricoma</em> A. Cunn. ex</td>
<td>Wellesley Islands, North Queensland</td>
<td>spear:</td>
<td>Basedow 1914:63;</td>
</tr>
<tr>
<td>5</td>
<td>Benth.</td>
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<td>Johnston &amp; Cleland</td>
</tr>
<tr>
<td>6</td>
<td><em>Acacia candelabri</em> F. Muell. ex Benth.</td>
<td>North-east of South Australia</td>
<td>spear:</td>
<td>Basedow 1914:63;</td>
</tr>
<tr>
<td>7</td>
<td>Benth.</td>
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<td></td>
<td>Johnston &amp; Cleland</td>
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<td></td>
<td></td>
<td></td>
<td>1942:98; 1943:163-164,170;</td>
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<td>Thomson 1964:407</td>
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<td>Maiden 1889:349;</td>
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<td>Roth 1897:42</td>
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Density (kg/m³): 1040, 1089, 1260
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<th>Area</th>
<th>Artifacts: References</th>
<th>Density kg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Acacia aulacorpa A. Cunn. ex Benth.</td>
<td>Wellesley Islands, North Queensland</td>
<td>club: Johnston &amp; Cleland 1942:98; 1943:164</td>
<td>1260</td>
</tr>
<tr>
<td>5</td>
<td>Acacia cambagei R.T. Bak. F. Muell. ex Benth.</td>
<td>North-east of South Aust.</td>
<td>spear: Johnston &amp; Cleland 1943:170</td>
<td>1260</td>
</tr>
<tr>
<td>6</td>
<td>Acacia cyperophylla F. Muell. ex Benth.</td>
<td>North-east of South Australia</td>
<td>boomerang: Johnston &amp; Cleland 1943:170</td>
<td>1260</td>
</tr>
<tr>
<td>#</td>
<td>Species</td>
<td>Area</td>
<td>Artifacts: References</td>
<td>Density kg/m</td>
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<tr>
<td>8</td>
<td><strong>Acacia doratoxylon</strong> A. Cunn.</td>
<td>Central Australia South-west of Western Australia</td>
<td>spear: Bates n.d. (d):16; Maiden 1889:354; Stirling 1896:88</td>
<td>1346</td>
</tr>
<tr>
<td>9</td>
<td><strong>Acacia excelsa</strong> Benth.</td>
<td>North Queensland</td>
<td>spearthrower: Roth 1897:149 boomerang: Lumholtz 1908:49</td>
<td>1150</td>
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<tr>
<td>10</td>
<td><strong>Acacia farnesiana</strong></td>
<td>North Queensland</td>
<td>spearpoint: Roth 1897:146</td>
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</tr>
<tr>
<td>12</td>
<td><strong>Acacia harpophylla</strong> F. Muell. ex Benth.</td>
<td>Rockhampton &amp; Dawson regions, North Q'land</td>
<td>adze stick: Roth 1904</td>
<td>905</td>
</tr>
<tr>
<td>13</td>
<td><strong>Acacia holocarpa</strong> Benth.</td>
<td>North Queensland</td>
<td>spear: Roth 1909:104,192</td>
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</tr>
<tr>
<td>#</td>
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<td>Area</td>
<td>Artifacts: References</td>
<td>Density $\frac{kg}{m^3}$</td>
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<tr>
<td>14</td>
<td><strong>Acacia homalophylla</strong> F. Muell. (inc. A. homalophylla A. Cunn.)</td>
<td>Gibson Desert; Central and North Queensland; Central Australia to Swan Hill, Victoria</td>
<td>spearshaft: Gould 1969:210; Maiden 1889:357; Palmer 1883:108; Roth 1897:146,147</td>
<td>1346</td>
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<tr>
<td>19</td>
<td><strong>Acacia kempeana</strong> F. Muell. ex Benth. (2)</td>
<td>Cundeelee; Finke River, Central Australia</td>
<td>spearthrower: Roth 1897:148,149; boomerang: Beveridge 1889:59; Palmer 1883:59; Roth 1897:142,145</td>
<td>745</td>
</tr>
<tr>
<td>20</td>
<td><strong>Acacia leiophylla</strong> Benth. (1) (inc. A. notabilis)</td>
<td>Frazer Range, Central Australia</td>
<td>club: Roth 1897:146,147; 1904:34; 1909:207</td>
<td>615</td>
</tr>
<tr>
<td>21</td>
<td><strong>Acacia mearnsii</strong> B. R. Br. (A. robusta Benth.)</td>
<td>Lake Makay, Roulinda &amp; Walter James Ranges, Central-West Australia</td>
<td>adze stock: Roth 1904:20; mesh stick: Spencer 1915:58</td>
<td>314</td>
</tr>
<tr>
<td>26</td>
<td><strong>Acacia pandura</strong> A. Cunn. (inc. A. laurina Linn.)</td>
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<tr>
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<td>Area</td>
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<td>Density kg/m</td>
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<tr>
<td>18</td>
<td><em>Acacia lysiphloia</em> F. Muell. (inc. <em>A. lysiphoea</em> F. Muell.)</td>
<td>Endeavour and Normanby Rivers</td>
<td>spear: Roth 1909:194</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td><em>Acacia mearnsii</em> de Wild (A. mollissima)</td>
<td>Kimberleys, W. Australia &amp; Victoria</td>
<td>spear: Hardman 1899:62</td>
<td>745</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>shield: Blackman 1904:178</td>
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<td>Smyth 1878:330</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td><em>Acacia melanoxylon</em> R. Br. (A. arcuata Sieb.)</td>
<td>Victoria</td>
<td>spearthrower: Smyth 1878:310,314</td>
<td>615</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>shield: Maiden 1889:359</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td><em>Acacia monticola</em> J.M. Black</td>
<td>Lake Makay, Rawlinson &amp; Walter James Ranges, Central-West Australia</td>
<td>speartbarb: Thomson 1964:406,415</td>
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<td>speartthrower hook: Thomson 1964:415</td>
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<td>spear (hunting &amp; fighting) 1964:415</td>
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<td>22</td>
<td><em>Acacia murrayana</em> F. Muell. ex Benth. (2)</td>
<td>West-Central Australia</td>
<td>spear: Long 1971:269</td>
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<td>23</td>
<td><em>Acacia notabilis</em> F. Muell. (inc. <em>A. notalis</em>)</td>
<td>Central-Western Australia</td>
<td>spear: Gould 1970:10</td>
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<td>24</td>
<td><em>Acacia oswaldi</em> F. Muell.</td>
<td>Central Australia</td>
<td>boomerang: Johnston &amp; Cleland 1942:98</td>
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<td></td>
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<td>club: Maiden 1889:363</td>
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<td>25</td>
<td><em>Acacia pendula</em> A. Cunn. ex G. Don. (A. leucophylla Lindl.)</td>
<td>North Queensland</td>
<td>boomerang: Bennett 1860:289; Lumboltz 1908:49; Maiden 1889:363</td>
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<td>Density $kg/m^3$</td>
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<td>26</td>
<td>Acacia rigens A. Cunn. ex Don.</td>
<td>Unspecified</td>
<td>unspecified: Maiden 1889:365</td>
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<tr>
<td>27</td>
<td>Acacia rothii F. M. Bail.</td>
<td>North Queensland</td>
<td>spear: Roth 1909:190</td>
<td>400</td>
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<td>spearpoint: Thomson 1939:210</td>
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<td>throwing stick: Roth 1909:197</td>
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<td>digging stick: Roth 1904:24</td>
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<td>28</td>
<td>Acacia salicina Lindl. (3)</td>
<td>Unspecified</td>
<td>boomerang: Maiden 1889:365</td>
<td>769</td>
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<td>29</td>
<td>Acacia sowdenii Maiden</td>
<td>Ooldea, S. Australia</td>
<td>spear: Johnston &amp; Cleland 1942:97</td>
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<td>club:</td>
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<td>30</td>
<td>Acacia tetragonophylla F.Muell.</td>
<td>North-East of South Australia</td>
<td>spear: Johnston &amp; Cleland 1943:152,154</td>
<td>900</td>
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<td>small ceremonial stick: Johnston &amp; Cleland 1942:99; 1943:164</td>
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<td>31</td>
<td>Acacia torulosa Benth.</td>
<td>Arnhem Land</td>
<td>spear: Specht 1958:490</td>
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<td>32</td>
<td>Acacia victoriae Benth. (A. sentis)</td>
<td>North Queensland</td>
<td>knife handle: Etheridge 1891:31</td>
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<td>33</td>
<td>Aglaia elaegmoidea Benth.</td>
<td>North Queensland</td>
<td>spearthrower: Roth 1909:197</td>
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<td>34</td>
<td>Alstonia actinophylla (A. Cunn.) K. Schum.</td>
<td>Arnhem Land</td>
<td>dugout canoe: Roth 1910c:53; Specht 1958:498</td>
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<td></td>
<td>(A. verticulosa F. Muell.)</td>
<td>Endeavour River, North Queensland</td>
<td>ceremonial pole: Specht 1958:498</td>
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<td>35</td>
<td>Archontophoenix alexandrae (F. Muell.) H. Wendl. et Drude</td>
<td>North Queensland</td>
<td>spear: Roth 1909:195</td>
<td>960</td>
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<td>36</td>
<td>Avicennia marina (Forsk.) (4) Vierh. var. A. australasica (Walp.) Mold.</td>
<td>Port Macquarie, N.S.W.</td>
<td>shield: Dick 1915:282; Goddard 1934:192</td>
<td>845</td>
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<td>37</td>
<td>Bombax ceiba L. (B. malabararium DC.)</td>
<td>Endeavour River, North Queensland</td>
<td>dugout canoe: Roth 1910b:40</td>
<td>415</td>
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<td>38</td>
<td>Bruguiera parviflora (Roxb.) Wight et Arn.</td>
<td>Arnhem Land</td>
<td>canoe paddle: White 1949:55</td>
<td>900</td>
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<td>39</td>
<td>Bruguiera rheedii Blume (=) B. gymnorrhiza (L) Lam.</td>
<td>Gulf Coast of North Q'land.</td>
<td>canoe paddle: Roth 1910a:9</td>
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<td>40</td>
<td>Bursaria spinosa Cav.</td>
<td>Tasmania</td>
<td>club: Ling Roth 1899:71</td>
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<td>41</td>
<td>Callitris glauca B. Br. ex R.T. Bak. et H.G. Sm. (nom. illegal) (5)</td>
<td>Central Australia</td>
<td>churinga: Spencer &amp; Gillen 1899:144</td>
<td>690</td>
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<td>spearpoint: White 1967:96</td>
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<td>speartrower: Tindale 1925/6:99</td>
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<td>message stick: White 1967:96</td>
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<td></td>
<td>canoe paddle: Specht 1958:383; Tindale 1925/6:89</td>
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<td>ceremonial objects: Tindale 1925/6:99</td>
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<td>43</td>
<td>Canarium australasicum (F.M.Bail.) Leenhouts</td>
<td>Cape Bedford, North Q'land.</td>
<td>dugout canoe: Roth 1910b:20</td>
<td>565</td>
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<td>44</td>
<td>Cassia eremophila A. Cunn. ex Vogel</td>
<td>Central Australia</td>
<td>spearbarb: Stirling 1896:87</td>
<td>260</td>
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<td>45</td>
<td>Casuarina decaisneana F. Muell.</td>
<td>Central Australia</td>
<td>spear: Spencer &amp; Gillen 1889:578; Stirling 1896:89</td>
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<td>46</td>
<td>Casuarina equisetifolia L.</td>
<td>Arnhem Land</td>
<td>spearr: Specht 1958:487</td>
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<td>47</td>
<td>Casuarina littoralis Salisb. (C. suberosa Otto et Dietr.)</td>
<td>Tasmania</td>
<td>club: Ling Roth 1899:71</td>
<td>715</td>
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<td>48</td>
<td><em>Casuarina stricta</em> Ait. (?)</td>
<td>South-east of South Australia</td>
<td>boomerang:</td>
<td>Luebbers 1975:39</td>
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<td>49</td>
<td><em>Ceriops tagal</em> Perr. (C.B. Robinson) =</td>
<td>Gulf Coast of Queensland</td>
<td>canoe paddle:</td>
<td>Roth 1910a:9</td>
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<td></td>
<td><em>Ceriops candolleana</em> Arn.</td>
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<td>50</td>
<td><em>Clerodendrum inerme</em> R.Br.</td>
<td>North Queensland</td>
<td>spear:</td>
<td>Roth 1909:193</td>
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<td>Arnhem Land</td>
<td>spearthrower peg:</td>
<td>Meehan pers. comm. via J.</td>
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<td>Bahmann</td>
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<td>52</td>
<td><em>Croton triacros</em> F. Muell.</td>
<td>North Queensland</td>
<td>spear:</td>
<td>Roth 1909:191</td>
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<tr>
<td></td>
<td><em>(Laportea gigas Wedd.)</em></td>
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<td>54</td>
<td><em>Desmodium umbellatum</em> (L.) DC.</td>
<td>North Queensland</td>
<td>spear:</td>
<td>Roth 1909:191</td>
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<td><em>(D. alata R. Br. ex DC.)</em></td>
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<td>56</td>
<td><em>Diospyros ferrea</em> var. humilus (Maba</td>
<td>Groote Eylandt</td>
<td>European smoking pipe:</td>
<td>Specht 1958:498</td>
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<td></td>
<td><em>humilis</em> B. Br.)*</td>
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<td>57</td>
<td><em>Dodonaea triquetra</em> Wendl.</td>
<td>Stradbroke and Morton Islands, Queensland</td>
<td>spear:</td>
<td>Watkins 1891:46</td>
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<td>58</td>
<td><em>Eremophila longifolia</em> (R.Br.) F. Muell.</td>
<td>North-east of South Australia</td>
<td>nose peg: Johnston &amp; Cleland 1943:158</td>
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<td>59</td>
<td><em>Erythrina vespertilio</em> Benth.</td>
<td>Widely distributed in Queensland and inland Australia</td>
<td>tooth evulsion stick:</td>
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<td>60</td>
<td><em>Erythrophleum chlorostachys</em> (F.Muell.) Hennings ex Taub. (E. chlorostachyus F. Muell. Bail.; E. laboucherii F.Muell.; Laboucheria chlorostachys F.Muell.)</td>
<td>Arnhem Land; North Queensland</td>
<td>spearbutt: Roth 1897:147</td>
<td>241</td>
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<td>shield: Blackman 1904:178; Johnstion &amp; Cleland 1943:166; Lumholtz 1908:332; Palmer 1883:109; Roth 1909:204-5; Schulze 1891:228; Spencer &amp; Gillen 1899:586</td>
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<td>61</td>
<td><em>Eucalyptus coccifera</em> F. Muell.</td>
<td>Brisbane, Queensland</td>
<td>carrying vessel: Cleland 1957:161; Hayden:n.d.; Roth 1897:149; 1904:29; Spencer 1915:42; Spencer &amp; Gillen 1899:586</td>
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<td>62</td>
<td><em>Eucalyptus doroabiana</em> F. Muell.</td>
<td>South-west of Western Australia</td>
<td>spear: Palmer 1883:109; Roth 1909:193,197</td>
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<td>64</td>
<td><em>Eucalyptus pauciflora</em> A. Cunn. ex Schultes</td>
<td>Daintree, Queensland</td>
<td>spearpoint &amp; prong: Palmer 1883:109; 1884:323; Tindale 1925:6:90</td>
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<td>66</td>
<td><em>Eucalyptus grandiflora</em> Maiden</td>
<td>Central-coastal Queensland</td>
<td>digging stick: Thomson 1939:plate 12</td>
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<td>67</td>
<td><em>Eucalyptus gunnii</em> F. Muell.</td>
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<td>club: Blackman 1904:185; Spencer 1928:490</td>
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<td>68</td>
<td><em>Eucalyptus maculata</em> Maiden</td>
<td></td>
<td>mallet: Thomson 1936:72</td>
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<td>69</td>
<td><em>Eucalyptus melanophloia</em> Maiden</td>
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<td>handle for hafted elouera: Setzler &amp; McCarthy 1950:72</td>
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<td>70</td>
<td><em>Eucalyptus niphophila</em> Maiden</td>
<td></td>
<td>throwing stick: Palmer 1884:323</td>
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<td>Artifacts: References</td>
<td>Density kg/m³</td>
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<td>61</td>
<td><em>Eucalyptus brownii</em> Maiden et Cambage (7)</td>
<td>North Queensland</td>
<td>carrying vessel: Roth 1904:31</td>
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<td>62</td>
<td><em>Eucalyptus camaldulensis</em> Dehnh. (E. rostrata Schlecht.)</td>
<td>Yarra River, Victoria; Central Australia; Margaret Ranges</td>
<td>club: Smyth 1878:299; carrying vessel: Love 1942:215; Spencer &amp; Gillen 1899:608</td>
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<td>63</td>
<td><em>Eucalyptus crebra</em> F. Muell.</td>
<td>Brisbane, Queensland</td>
<td>spear: Petrie 1932:102; Roth 1909:195</td>
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<td>64</td>
<td><em>Eucalyptus doratoxylon</em> F. Muell.</td>
<td>South-west of Western Australia</td>
<td>spear: Maiden 1889:447</td>
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<td>65</td>
<td><em>Eucalyptus dumosa</em> A. Cunn. ex Schau.</td>
<td>Swan Hill, Victoria</td>
<td>spear: Beveridge 1889:59-60</td>
<td>105</td>
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<td>66</td>
<td><em>Eucalyptus eremphila</em> (Diels) Maiden var. grandiflora Maiden</td>
<td>Cundeelee</td>
<td>shield: Beveridge 1889:66; boomerang: Beveridge 1889:59; club: Beveridge 1889:59-60; carrying vessel:</td>
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<td>69</td>
<td><em>Eucalyptus foecunda</em> Schauer (E. polybractea F. Muell.)</td>
<td>South-west of Western Australia</td>
<td>spear: Maiden 1889:448</td>
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<td>70</td>
<td><em>Eucalyptus gomphocephala</em> A. DC.</td>
<td>Western Australia</td>
<td>carrying vessel: Spencer 1915:42</td>
<td>1039</td>
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<td>71</td>
<td><em>Eucalyptus incrassata</em> Labill.</td>
<td>Oldean, South Australia</td>
<td>spear: Johnston &amp; Cleland 1942:99</td>
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<td>spearthrower: Johnston &amp; Cleland 1942:100</td>
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<td>mesh stick: Johnston &amp; Cleland 1942:99</td>
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<td>72</td>
<td><em>Eucalyptus leucoxylon</em> F. Muell. var. E. macrocarpa J.E. Brown</td>
<td>Victoria</td>
<td>carrying vessel: Thomson 1964:407</td>
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<td>73</td>
<td><em>Eucalyptus marginata</em> Donn ex Sm.</td>
<td>South-west of Western Australia</td>
<td>spearthrower: Smyth 1878:314,330; Spencer 1915:12</td>
<td>1007</td>
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<td>carrying vessel: 1915:42</td>
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<td>digging stick: Johnston &amp; Cleland 1943:160</td>
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<td>75</td>
<td><strong>Eucalyptus microtheca</strong>&lt;br&gt;<strong>F. Muell. var.</strong>&lt;br&gt;<strong>E. cymbaliformis Blakely et Jacobs</strong></td>
<td>Central Darling River</td>
<td>emu decoy horn: Dunbar 1944:175</td>
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<td>76</td>
<td><strong>Eucalyptus obliqua L'Herit.</strong>&lt;br&gt;(<strong>E. fissilis F. Muell.</strong>)</td>
<td>Victoria;&lt;br&gt;Twofold Bay, N.S.W.</td>
<td>spear: Smyth 1878:304</td>
<td>shield: Oldfield 1868:263</td>
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<td>77</td>
<td><strong>Eucalyptus oleosa</strong>&lt;br&gt;<strong>F. Muell. ex Mig.</strong></td>
<td>Western Desert;&lt;br&gt;Ooldea, S. Australia</td>
<td>spear: Gould 1970:7;</td>
<td>digging stick: Johnston &amp; Cleland 1942:99</td>
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<tr>
<td>78</td>
<td><strong>Eucalyptus papuana F. Muell.</strong></td>
<td>Western-central Australia</td>
<td>carrying vessel: Thomson 1964:407</td>
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<td>79</td>
<td><strong>Eucalyptus pellita F. Muell.</strong>&lt;br&gt;(9)</td>
<td>Middle Palmer River,&lt;br&gt;North Queensland</td>
<td>man's fighting pole: Roth 1909:209</td>
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<td>80</td>
<td><strong>Eucalyptus polycarpa F. Muell.</strong></td>
<td>Arnhem Land</td>
<td>spear: Specht 1958:496</td>
<td>spearthrower peg:</td>
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<td>canoe paddle:</td>
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<td>drone tube:</td>
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<td>81</td>
<td>Eucalyptus pyriformis Turcz. F. Muell.</td>
<td>Ooldea, South Australia</td>
<td>spear: Johnston &amp; Cleland 1942:99</td>
<td>&quot;</td>
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<td>carrying vessel: &quot;</td>
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<td>82</td>
<td>Eucalyptus redunca Schau.</td>
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<td>digging stick: Bates n.d.(d):16</td>
<td>boomerang: &quot;</td>
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<td>83</td>
<td>Eucalyptus salmonophloia F. Muell.</td>
<td>Western Desert</td>
<td>spear: Gould 1970:7</td>
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<td>84</td>
<td>Eucalyptus setosa</td>
<td>Wellesley Islands, Gulf of Carpentaria</td>
<td>play boomerang: Woolston 1973:101</td>
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<td>86</td>
<td>Eucalyptus terminalis F. Muell. (E. terminalis Sieb.)</td>
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<td>speartrower: Roth 1909:197</td>
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<td>87</td>
<td>Eucalyptus tessellaris F. Muell.</td>
<td>North Queensland</td>
<td>speartrower: Malone 1889:534;</td>
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<td>88</td>
<td><em>Eucalyptus tetrodonta</em> F. Muell.</td>
<td>Arnhem Land</td>
<td>spear: Specht 1958:497</td>
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<td>spear(?)point: White 1967:96</td>
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<td>grave post: Specht 1958:497</td>
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<td>canoe paddle: &quot;</td>
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<td>music stick &quot;</td>
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<td>drone tube: &quot;</td>
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<td>stem of European smoking pipe: &quot;</td>
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<td>hollow, cylindrical drum: &quot;</td>
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<td>bullroarer: Specht 1957:497; Warner 1937:492</td>
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<td>89</td>
<td><em>Eucalyptus viminalis</em> Labill.</td>
<td>Victoria</td>
<td>shield: Smyth 1878:332</td>
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<td>90</td>
<td><em>Eupomatia laurina</em> R. Br.</td>
<td>North Queensland</td>
<td>proximal end of spear: Roth 1909:195</td>
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<td>91</td>
<td><em>Excoecaria agallocha</em> L.</td>
<td>Endeavour River, North Queensland</td>
<td>dugout canoe: Roth 1910b:30</td>
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<td>92</td>
<td><em>Exocarpos cupressiformis</em> R. Br.</td>
<td>Yarra River, Victoria</td>
<td>spearthrower: Maiden 1889:534; Smyth 1878:310</td>
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<td>93</td>
<td><em>Ficus chretioides</em> F. Muell.</td>
<td>Lower Tully River, North Queensland</td>
<td>shield: Roth 1909:204</td>
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<tr>
<td>94</td>
<td><em>Flagellaria indica</em> Linn.</td>
<td>Brisbane</td>
<td>gunwale overcast for bark canoe: Roth 1910a:17</td>
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<tr>
<td>95</td>
<td><em>Gmelina macrophylla</em> (R. Br.) Benth.</td>
<td>Cape Bedford, North Queensland</td>
<td>dugout canoe: Roth 1910b:40</td>
<td>515</td>
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<tr>
<td>96</td>
<td><em>Hakea leucoptera</em> R. Br.</td>
<td>North-east of South Australia</td>
<td>point: Johnston &amp; Cleland 1943:165</td>
<td>881</td>
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<td>97</td>
<td><em>Heterodendrum oleifolium</em> Desf.</td>
<td>Ooldea, South Australia</td>
<td>boomerang: Johnston &amp; Cleland 1942:99; shield:</td>
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<td>98</td>
<td><em>Hibiscus brachysiphonius</em> F. Muell.</td>
<td>North Queensland</td>
<td>spear: Roth 1909:191</td>
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<tr>
<td>99</td>
<td><em>Hibiscus tiliaceus</em> L.</td>
<td>Arnhem Land; North Queensland</td>
<td>spear: Roth 1909:192; Specht 1958:494;</td>
<td>495</td>
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<td>100</td>
<td><em>Leptospermum lanigerum</em> Smith</td>
<td>Tasmania; Victoria; Port Lincoln, South Australia</td>
<td>spear: Ling Roth 1899:69,70; Maiden 1889:56; Smyth 1878:30</td>
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<td>101</td>
<td>Leptospermum phyllicoides (A. Cunn. ex Schau.) Cheel (Kunzea peduncilaris F. Muell.)</td>
<td>Victoria</td>
<td>spear: Maiden 1889:560</td>
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<tr>
<td>102</td>
<td>Livistona australis (R. Br.) Mart. (Corypha australis B. Br.)</td>
<td>North Queensland</td>
<td>spearhead: Palmer 1883:108,109; Roth 1909:194</td>
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<td></td>
<td>Lysiphyllum sp. (Bauhinia carronii F. Muell.) (10)</td>
<td>North-east of South Australia (traded from western Q'land.)</td>
<td>shield: Johnston &amp; Cleland 1943:162</td>
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<tr>
<td>104</td>
<td>Macaranga tanarius (L.) F. Muell.</td>
<td>Arnhem Land, North Queensland</td>
<td>but of spear: Specht 1958:492; Roth 1909:191</td>
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<tr>
<td>105</td>
<td>Malaisia scandens Lour. (Planch.) = M. tortuosa Blanco</td>
<td>Brisbane</td>
<td>bark canoe gunwale</td>
<td>runner: Roth 1910a:16</td>
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<tr>
<td>106</td>
<td>Melaleuca glomerata F. Muell.</td>
<td>Musgrave Ranges, Central Australia</td>
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<tr>
<td>107</td>
<td>Melaleuca leucadendron L. sens lat.</td>
<td>Arnhem Land</td>
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Artifacts: References
- spear: Maiden 1889:560
- boomerang: "
- club: "
- Smyth 1878:299
- shield: Johnston & Cleland 1943:162
- but of spear: Specht 1958:492; Roth 1909:191
- bark canoe gunwale runner: Roth 1910a:16
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<tr>
<td>116</td>
<td><em>Pandorea pandorana</em> (Andr.) Steen. (Tecoma australis; Pandorea doratoxyylon; Tecoma doratoxyylon)</td>
<td>Inland desert Australia</td>
<td>spear:</td>
<td>Basedow 1904:24-25; Cleland 1925:195; Cleland 1957:161; Cleland &amp; Johnston 1937:211; Cleland &amp; Tindale 1954:85; Schulze 1891:227; Spencer &amp; Gillen 1889:577; Stirling 1896:87</td>
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<td>118</td>
<td><em>Petalostigma quadriloculare</em> F. Muell.</td>
<td>North Queensland</td>
<td>spearthrower peg:</td>
<td>Roth 1909:199</td>
<td>1105</td>
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<td>119</td>
<td><em>Pittosporum bicolor</em> Hook.</td>
<td>Tasmania</td>
<td>club:</td>
<td>Ling Roth 1899:70-71; Maiden 1889:588</td>
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<td>120</td>
<td><em>Pittosporum phylliraeoides</em> DC.</td>
<td>Cundeelee, Central Australia</td>
<td>shield:</td>
<td>Hayden 1971:13</td>
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<td>121</td>
<td><em>Pluchea indica</em> (L.) Less.</td>
<td>North Queensland</td>
<td>spear:</td>
<td>Roth 1909:191</td>
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<td>123</td>
<td><em>Pongamia pinnata</em> (L.) Pierre. (13)</td>
<td>North Queensland</td>
<td>haft for pounding stone: Thomson 1936:71</td>
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<td>124</td>
<td><em>Premna dallachyma</em> Benth.</td>
<td>North Queensland</td>
<td>spear:</td>
<td>Roth 1909:193</td>
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<td>125</td>
<td><em>Premna obtusifolia</em> R. Br.</td>
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<td>spear: Roth 1909:192</td>
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<td>126</td>
<td><em>Ptychosperma elegans</em> (R. Br.) Blume</td>
<td>South-east Cape York</td>
<td>distal end of spear: Roth 1909:195</td>
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<td>127</td>
<td><em>Rhizophora mucronata</em> Lam.</td>
<td>Arnhem Land;</td>
<td>club: Roth 1904:24; Warner 1937:489</td>
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<td>North Queensland</td>
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<td>129</td>
<td><em>Rhodomyrtus macrocarpa</em> Benth.</td>
<td>North Queensland</td>
<td>boomerang: Roth 1909:201</td>
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<td>130</td>
<td><em>Scyphiphora hydrophyllacea</em> Gaertn.</td>
<td>Endeavour River, North Queensland</td>
<td>digging stick: Roth 1904:24</td>
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<td>131</td>
<td><em>Seyphilora hydrallacea</em> Gaertn.</td>
<td>Endeavour River, North Queensland</td>
<td>digging stick: Roth 1904:24</td>
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<td>132</td>
<td><em>Sonneratia acida</em> L.</td>
<td>Endeavour River, North Queensland</td>
<td>dugout canoe: Roth 1910b:40</td>
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<td>133</td>
<td><em>Syncarpia glomulifera</em> (Sm.) Niedenzu (Syncarpia laurifolia Ten.)</td>
<td>Wild Bay, Queensland</td>
<td>canoe: Maiden 1899:18</td>
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<td>134</td>
<td><em>Syzgium</em> sp. (inc. <em>Eugenia carissoides</em> F. Muell.)</td>
<td>Pennefather River, North Queensland</td>
<td>club: Roth 1904:33</td>
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<td>137</td>
<td><em>Thryptomene oligandra</em> F. Muell.</td>
<td>North-west Cape York, Cooktown to Saxby River, Queensland</td>
<td>point and end of spear:</td>
<td>Roth 1909:192; Palmer 1883:110;</td>
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<td>138</td>
<td><em>Tristania sauveolens</em> (Soland ex Gaertn.) Sm.</td>
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<td>proximal portion of spear:</td>
<td>Roth 1909:192</td>
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<td>139</td>
<td><em>Unona wardiana</em> F.M. Bail.</td>
<td>Pennefather River, North Queensland</td>
<td>digging stick: Roth 1904:24</td>
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<td>140</td>
<td><em>Xylocarpus granatum</em> Koen. (X. moluccensis (Lam.) M. Roem. et Carappa moluccensis Lam.)</td>
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<td>proximal portion of spear:</td>
<td>Roth 1909:192</td>
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<td>141</td>
<td><em>Xylomelum pyriforme</em></td>
<td>Myall Lakes, N.S.W.</td>
<td>canoe paddle: Enright 1932</td>
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<td>109</td>
<td><em>Mimusops elengi</em> L. sens lat. (11)</td>
<td>North Queensland</td>
<td>speartrowner: Roth 1909:197</td>
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<td>Arnhem Land</td>
<td>B. Meehan, pers. comm., via J. Buhmann</td>
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<td>canoe paddle:</td>
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<td>112</td>
<td><em>Myrtus exaltata</em> Bail. (12)</td>
<td>South-east Cape York; Middle Palmer River, North Queensland</td>
<td>spear: Roth 1909:195</td>
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<td>sword: Roth 1909:210</td>
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<td>113</td>
<td><em>Nauclea orientalis</em> (L.) L. (= <em>Sarcocephalus cordatus</em> Miq.)</td>
<td>Arnhem Land</td>
<td>dugout canoe: Tindale 1925/6:103</td>
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<td>114</td>
<td><em>Normanbya normanbyi</em> (W. Hill et F. Muell., L.H.Bail. (Drymophloeus normanbyi F. Muell.)</td>
<td>South-east Cape York</td>
<td>spear: Roth 1909:192</td>
<td>1025</td>
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</table>
NOTES

1. This is probably a misidentification as the species does not occur in Central Australia.

2. Long is very likely to be confused with Acacia murrayana.

3. Although Acacia salicina; Lindl., is closely allied to Acacia ligulata A. Cunn., and is definitely not synon­

4. Both Goddard and Dick used the superseded botanical title Avicennia officinalis Linn., misspelling it as

5. The present status of this species is in some confusion. I follow Hall, Johnston and Chippendale (1970:296)

6. The species recorded in ethnographies was Callitris intratropica (F. Muell. ex Benth.). (=Callitris
collumellaris F. Muell.). I have chosen the revision preferred by Hall, et al. (1970:300).

7. Roth confused E. brownii with E. Bicolor A. Cunn., which is a closely related species but occurs only in south­
eastern Australia (see Hall, et al. 1970:228).

8. Johnston and Cleland may have misidentified this species as the known occurrence of E. microcarpa is only in
the Flinders Ranges of South Australia.

9. Roth confused E. resinifera Sm., with a closely related species, E. pellita F. Muell. The former inhabits the
central-east Australian coast (see Hall, et al. 1970:64).

10. This species is now placed in the genus Lysiphyllum but the combination L. carronii has not been published.

11. Mimusops parvifolia R. Br. is probably part of M. elengi L. sens lat.

12. A peculiar identification as no true Myrtus occurs in Australia.

13. Thomson used the illegitimate title, Pongamia glabra.
APPENDIX G

2. EXTRACT FROM WOOD IDENTIFICATION OF SPEARthrowERS IN THE QUEENSLAND MUSEUM

Compiled by
Jan Buhmann, Richard Robins and Myron Cause

This list pertains only to species which are not listed in Appendix G (1) or for which the artifact or district was not previously recorded.

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<th>Species</th>
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<tbody>
<tr>
<td>Acacia cambagei R.T. Bak.</td>
<td>Idamere, Queensland</td>
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<tr>
<td>Acacia excelsa Benth.</td>
<td>Kamma, Queensland</td>
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<tr>
<td>Acacia hodoxylon</td>
<td>Boulia; Gulf of Carpentaria</td>
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<tr>
<td>Araucaria cunninghamii Ait. ex D. Don.</td>
<td>Cardwell, Queensland</td>
<td>448</td>
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<tr>
<td>Backhousia bancroftii</td>
<td>Queensland (area not specified)</td>
<td>929</td>
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<tr>
<td>Backhousia hughesii C.T. White</td>
<td>Cardwell, Queensland</td>
<td>1009</td>
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<tr>
<td>Bombax ceiba L.</td>
<td>Yirrkala, Arnhem Land</td>
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<tr>
<td>Bruguiera gymnorrhiza</td>
<td>Yirrkala</td>
<td>977</td>
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<tr>
<td>Castanospermum australae</td>
<td>Cairns, Laura River, Q'land.</td>
<td>769</td>
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<tr>
<td>Duboisia myoporoides</td>
<td>Mornington Island &amp; Q’land.</td>
<td>449</td>
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<tr>
<td>Erythrina vespertilio Benth.</td>
<td>Daly River, Darwin, N.T.</td>
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<tr>
<td>Eucalyptus abergiana</td>
<td>Cardwell, Queensland</td>
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</tr>
<tr>
<td>Eucalyptus citriodora</td>
<td>Northwest Queensland/ Northern Territory (area not specified)</td>
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<tr>
<td>(Euc. maculata var. citriodora)</td>
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<td>Eucalyptus dichromophloia F. Muell.</td>
<td>Atherton, Cardwell, Gulf of Carpentaria, Kamma, Mapoon, Queensland</td>
<td>995</td>
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<td>Eucalyptus pellita F. Muell.</td>
<td>Kamma, Queensland</td>
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</tr>
<tr>
<td><em>Mimusops elengi</em> L. sens lat.</td>
<td>Yirrkala, Arnhem Land</td>
<td>1010</td>
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<tr>
<td><em>Flindersia ifflaiana</em></td>
<td>Kamma, Queensland</td>
<td>929</td>
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<tr>
<td><em>Lysicarpus angustifolius</em></td>
<td>Queensland (area not specified)</td>
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</tr>
<tr>
<td><em>Polyalthia nitidissima</em></td>
<td>Cape York?</td>
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</tr>
<tr>
<td><em>Pseudoweinmannia lachnocarpa</em></td>
<td>Central Queensland</td>
<td>881</td>
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<tr>
<td><em>Santalum lanceolatum</em></td>
<td>Gulf of Carpentaria</td>
<td>929</td>
</tr>
<tr>
<td><em>Xanthostemon whitei</em></td>
<td>Kamma, Queensland</td>
<td>1121</td>
</tr>
<tr>
<td><em>Eucalyptus intermedia</em> R.T. Baker</td>
<td>Spearthrower Mapoon Mission, Q'land.</td>
<td>1009</td>
</tr>
<tr>
<td><em>(Eucalyptus corymbosa)</em></td>
<td>Ref: Q'land Museum files. J. Bahmann</td>
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<tr>
<td><em>Intsia bijuga</em> (Colebr.) O. Ktze</td>
<td>Spearthrower peg. Anbarra territory, Arnhem Land</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ref: Q'land Museum files. Betty Meehan, Rhys Jones</td>
<td></td>
</tr>
<tr>
<td><em>Lumnitzera racemosa</em> Willd.</td>
<td>Spearthrower peg. Mt. Bartle Frere, Q'land.</td>
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<td></td>
<td>Ref: Q'land Museum files. Meston 1889</td>
<td></td>
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<tr>
<td><em>Cordia subcordata</em> Lamk.</td>
<td>Spear Pennefather River. Roth 1908</td>
<td>464</td>
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<tr>
<td><em>Ficus colossea</em> F. Muell. ex Benth.</td>
<td>Shield Mt. Bartle Frere, Q'land.</td>
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<td>Ref: Q'land Museum files. Meston 1889</td>
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<tr>
<td><em>Thespesia populnea</em> Corr.</td>
<td>Hunting spear Pennefather River. Roth 1908</td>
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<td><em>Wedelia biflora</em> D.C.</td>
<td>Spear Pennefather River Roth 1908</td>
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APPENDIX H

USE-WEAR ON ADZING, CHISELING AND GRAVING IMPLEMENTS FIXED ON WOOMERAS AND STICK HAFTS

Hafted adzes and chisels curated in two Australian museums were examined for use-wear. By far the majority of surviving specimens are lodged in the South Australian Museum and the Western Australian Museum, and in all cases they were collected in desert Australia. I did not attempt to locate all the hafted woodworking tools curated in Australia but those I list and describe constitute the majority of those not in the Australian museum. There are specimens scattered in other Australian and overseas museums, and in private hands. Catalogue numbers are those given in the museum registers.

The specimens were examined under a low powered binocular microscope (Wild M5) and they were not cleaned before inspection. The frequency, size and type of fractures positioned on the working edges of the tools are listed. However, their positions along the working edges of the tools are not depicted; this information is recorded on diagrams which I have retained. Fractures recorded were in nearly all cases only those on the underside margin as upper faces were retouched. The code for the fracture list is as follows:

- 1 = step;
- 2 = retroflexed hinge;
- 3 = feather/hinge;
- 4 = snap.

Each of these figures is followed in brackets by the width of the fracture which in turn is followed by the frequency of the fracture type and their sizes.

The edge angle cited represents only the measurement at midpoint of exposed working edge. Identification of stone materials is not always accurate.

TULA
South Australian Museum.

A4254 Collected in the vicinity of Cooper Creek, S.A. Fine grained quartzite. Quite a large flake with an exposed circumference of 100 mm. Wood fibres are compacted into the edge fractures. The wooden shaft was fashioned with a metal tool.

65° 1(4)1, (1.5)1, (1.2)1, (1)1; 3(3)1, (1.5)1, (0.5)3
A4273 Collected somewhere in Central Australia. Chert. The wood shaft was shaped with a metal tool.

39° 1(4)1, (2)1, (0.5)2; 3(0.5)2

A4277 Collected at Daly Waters, N.T. Chert. As well as use-fractures, there is an area of smoothing on the undersurface, measuring 7 mm across and 5 mm long. It is located on the most projecting part of the bulb. Within this smoothed area are striations angled at about 85°. Most are faint but one is long and well defined. There is very moderate edge rounding on spurs between retouch fractures.

72° 2(2)1; 3(0.5)2, (0.2)1; 4(2)1

A4279 Collected along the Katherine River, N.T. Chert. Prominences along the edge are rounded and small pieces of wood fibre are compacted into edge fractures.

42° 1(5)1; 3(1)1, (0.2)1

A4284 Collected in the Gascoyne District, W.A. Chert or chalcedony. One flake in a double ended adze. The dorsal margin is only lightly retouched.

52° 1(1)2, (0.4)1, (0.2)2; 3(1)2

A4284 The opposite tula flake in the double ended adze.

50° 1(1.3)1, (0.5)1

A17535 Made by 'Sam' last of the old Diere men at Cooper Creek in 1932. Quartzite, 87°. No use-wear was identified and the tool was probably never actually used.

A31131 Collected at Barrow Creek, N.T. Chert with a vitreous texture and lustre. Circumference measure 30 mm.

88° 1(1)1; 3(2)1, (1)1, (0.2)2

A34048 Collected in the Cooper Creek District, S.A. Quartzite. From the Aiston collection.

74° 1(1)2; 3(1)1

A34084 Unprovenanced from the Aiston Collection; probably around Lake Eyre. Unspecified material. The circumference of the edge is 32 mm. Moderate rounding was observed along much of the working edge.

74° 1(1.5)1; 3(2)1, (1.5)1, (1)1
A35334 Collected somewhere along the Diamantina. Chalcedony. Smoothing on some of the ridges for a distance of 2 mm from the working edge on the upper retouched face. To the same extent, smoothing occurs on the underside margin but it is not so noticeable. Prominences along the edge are sometimes rounded.

$53^\circ$  
1(3)1, 3(3)1, (2)3, (0.5)1, (0.2)1

A39401 Collected at Jadliaura Station (Wooltana) in the North Flinders Ranges, S.A. Fine grained quartzite. The wooden shaft is made with a metal tool. Even though this was a tula flake the exposed underside is not convex but flat.

$43^\circ$  
1(4)1, (3)1, (2)1, (1.5)3, (1)1; 3(5)1, (2)1, (1.5)3

A41394 Collected by J. Harris Browne on the second Sturt expedition. Chalcedony. The working edge is blunted and a film of resin gives the impression of use-polish. The edge is irregular in plan.

$89^\circ$  
1(8)1, (2)1; 3(7)1, (5)1, (2)2, (1.5)4; (1.5)3 undetached flakes.

A52755 Collected on Anna Creek Station, S.A. A tooth engraver is attached to the opposite end of the adzestock. Chert with a vitreous texture. Fragments of wood fibre are compacted into the fractures along the working edge.

$45^\circ$  
1(1.5), (1)1, (0.5)4; 3(3)1, (1.5)1, (0.5)1

A53532 Collected in 1961 on Myrtle Springs Station, N.T. Chert? Film of resin on the retouched upper margin gives the impression of use-polish.

$80^\circ$  
3(2)4, (1.5)2, (1)1, (0.2)9

A54726 Collected at Lake Christopher, W.A. in 1963 by N.B. Tindale. This artifact is illustrated by Tindale (1965: fig.13; pages 134-5), who informs us that it was made by Tjupurula, a Ngadadjara tribesman, and subsequently used to fashion a dense wood adze or chisel handle. Tindale's description suggests that the tool functioned as a chisel (scraper). It was resharpened during use. Wood fibres are compacted into the fractures on the retouched face.

$85^\circ$  
3(0.5)2
No catalogue number. A loose tula flake broken from the resin haft.

Chert. Circumference of working edge is 90 mm. About 30 mm of this edge is rounded with use-polish extending inward approximately 0.3 mm on both margins.

75° 1(1)2, (0.5)2; 3(1)3, (0.5)4

Western Australian Museum

AL4766 Provenance unknown (1963). Chalcedony (?). The wooden shaft appears to have been fashioned with a metal tool.

75° 1(2)1 A recent fracture that was almost certainly not caused by tool-use.


77° 1(1)2, (0.5)1; 3(1)1, (1)1, (0.2)1

E805 Collected at Geraldton, W.A. in 1900. A chert tula set in an incised woomera. Wood pulp is compacted into the fractures on both margins of the edge. The edge is blunted and moderately polished or smoothed.

65° 1(4)1, (3)2, (1)2, (0.5)2; 3(1)2, (0.5)7

A4139 Unprovenanced (1911). Chert, 62°. The wooden shaft was fashioned with a metal tool. All fractures appear to be 'fresh' and probably were not derived from tool use.

A17054 Collected in the Murchison District, W.A. in 1900. Chert, 75°. No possible use-fractures or other forms of wear detected.

A11458 Collected at Halls Creek, W.A. (1946). A chert tula set in an incised woomera. The surfaces were coated with a film of resin and any possible smoothing or polish could therefore not be detected.

78° 1(1.5)1, (1)1; 3(2)1

796 Collected at Geraldton (1900). Flint (?) tula hafted onto an incised woomera. The edge is rounded. On the underside a light polish extends 0.3 mm from the edge and on the upper retouched face the prominences just on the edge are polished. An 0.8 mm section of the edge next to the step fracture is striated at an angle of 80°.

68° 1(1)1; 3(0.5)1

74° 1(7)1, (5)1; 3(0.5)4

NON-TULA OR UNIDENTIFIABLE FORM

South Australian Museum.


A4268 Collected at Tenipe Downs. Chert or chalcedony of very fine quality. The working edge has an irregular profile. There is very moderate edge rounding which may not be identifiable on a prehistoric tool. Rounding also occurred along the back wall of the 7 mm step fracture. This rounding was 0.5 mm wide and extended for 3 mm. It was accompanied by striation angled at 90° to the edge. Striation angled at 85° - 90° was observed along the area behind the remaining step fracture.

69° 1(7 x 2)1, (5 x 1.5)1, 3(1)1, (1)1

A16217 Collected at Hermannsburg, N.T. Quartzite; edge angle not measured. The working edge is well rounded and the underside is bevelled. The upper face is not retouched and use-fractures do not occur.

A31141 Collected at Hermannsburg, N.T. Granular quartzite with an included angle (wedge angle) of 21° and a specific edge angle of 82°. There is no retouch but the edge is snap fractured and the spurs between these fractures are fractured off. The quartzite is too granular to detect small fractures and no other type of use-wear was observed.

A31146 Unprovenanced. Quartzite; included, 55°; specific 60°. The wooden stock was made with a metal tool. Small fragments of wood fibre are compacted into the retouch scars. Also, for a distance of 1 mm from the edge, there is moderate polish on the ridges of these scars. On the underside margin there is a polish or smoothing that extends for 15 mm along the working edge and up to 1 mm inward. Fractures on the underside could not be identified because of the quartzites granularity.
A31149  Unprovenanced. Fine grained quartzite. The edge appears to be freshly retouched.  
82° 1(2)1

A31150  Unprovenanced. Fine grained quartzite, possibly a tula. Wood fibre particles are compacted into some of the fractures. There is also a small patch of wood fibre on the underside of the hafting resin.  
84° 1(2)1, (1.5)1; 4(1.5)1

A34041  Collected by George Aiston in the Cooper Creek District, S.A. A stick adze with a pirri point hafted onto one end. Chert? 
Prominences on the working edge were moderately rounded.  
54° 1(5) numerous overlapping, (1.5)2; 2(2)1; 3(1)2

A34047  Collected by George Aiston in the Lake Eyre region, S.A. Fine quality chert or chalcedony. The circumference of the working edge is 65 mm.  
68° 1(1)1, (1)4; 3(1.5)1, (1)2, (1)6, (0.5)2; 4(1.5)1

A34050  Collected by George Aiston in the Cooper Creek District, S.A. A stick adze with a pirri point hafted at one end. Chert, possibly a tula; 76°. A thick film of resin extends from the main body right onto the working edge where this resin is smoothed and striated, undoubtedly through tool-use. This film does however, obscure the use-fractures. Prominences between retouch scars are moderately rounded in such a way as to suggest that the last retouching was directed at rejuvenating the rounded edge.

A34052  Collected by George Aiston at Cooper Creek. Fine quartzite; 50°. Smoothing extends along the entire 20 mm length of the working edge on the underside. It was not well developed and was restricted to a zone 0.3 mm wide. No fractures were noted.

A34057  Collected by George Aiston in the Cooper Creek District. Quartzite; 65°. Edge fractures cannot be positively identified because the material is too granular. Wood fibre particles are compacted into depressions.
A39436 Collected at McDonald Downs, Central Australia (Iliaura tribe). Double ended adze. Clear chalcedony flake with an irregular profile to the working edge. All the prominences on the edge are blunted or very moderately rounded.

\[
\theta = 78^\circ, 1(0.5)2; 3(0.5)2; 3(0.5)4, (0.5)4
\]

A39436 A chalcedony flake hafted at the opposite end of the stick adze.

\[
\theta = 51^\circ, 1(1.5)1, (0.5)2; 3(0.5)7, (0.5)1
\]

A51347 Collected in Central Australia. Unretouched fine grained quartzite flake which has a circumference of 35 mm.

\[
\theta = 55^\circ, 3(1)1, (1)4/1(1)1; 3(1.5)1, (1)2; 4(1)1
\]

A54723 Collected by N.B. Tindale and P. Aitken at Gill Pinnacle (Kudjuntari), W.A., in Ngadjurra territory. 1963. A very fine grained quartzite or chert (?) in a double ended adze. The flake has an uneven curvature. Wood fibre is compacted into the edge fractures. A 2 mm length of the edge is moderately rounded and an area 3 mm long by 1 mm wide, situated at one end of the edge, is striated at an angle of 50°.

\[
\theta = 82^\circ, 1(5) overlapping fractures, (1.5)3, (3)1
\]

A54723 Fine grained quartzite or chert flake hafted at the opposite end of the adze described above. The edge is not retouched. Compact wood fibres have obscured some of the fracturing on the underside. There are no fractures on the upper margin.

\[
\theta = 60^\circ, 1(1.5)2, (1)1; 3(3)1, (2)4; 4(4)1, (3)1, (2)1, (1.5)1
\]

A54758 Collected by N.B. Tindale at Mt. Davies, S.A., in 1963. Chalcedony flake with working edge curving up at one end. This adze is illustrated by Tindale (1965:136,fig.3). The working edge is moderately rounded.

\[
\theta = 79^\circ, 1(2)1
\]

A54759 Collected by N.B. Tindale at Mamutjara, south-west of Bell Rock Road, W.A. It was made by a Nakako tribesman in 1963. Chalcedony; included angle, 42°, specific angle, 75°. Wood fibre is compacted on both lateral margins of the edge. A film of resin gives the impression of polish but there are no identifiable traces of wear.
A54760 Collected by N.B. Tindale at Mamutjara, W.A., in 1963. Irregularly shaped chalcedony flake; $50^\circ$. The edge is probably not retouched and fractures on the upper margin may result from tool-use. These fractures were not recorded. Wood fibre is compacted onto the edge and small fractures on the underside margin may be obscured. An apparent polish can be seen along most of the underside of the working edge. For the first 10 mm it extends 0.5 mm inwards, and then on the adjoining 15 mm, polish on ridges extends inward for up to 4 mm. Within this latter polished area very faint striations angled at $85^\circ-90^\circ$, can be detected.

A54761 Collected by N.B. Tindale at Malupiti, Mt. Davis, S.A. The adze was made by a Pitjandjara tribesman. Chalcedony. The flake is minimally snap fractured and is probably untetouched. Wood fibre adhering to the resin haft appears to be from a light wood.

A54762 Collected by N.B. Tindale at Malupiti, Mt. Davies, S.A., in 1963. Chalcedony flake is not retouched and the working edge is uplifted at one end. All fractures are of the bending variety.

A54763 Collected by N.B. Tindale at Walpa, just north of Wilson, S.A. Chert. Polish or smoothing appears on 15 mm of the underside margin to an extent of 3 mm from the working edge. This modification appears on microscopic prominences and on the edges of flake scars.

A54764 Collected by N.B. Tindale at Mamutjara, S.W. of Bell Rock Range, W.A., in Nakako territory, 1963. Chalcedony. There is a considerable amount of wood fibre on the edge especially in the overlapping step fractures.

Western Australian Museum

A116 Collected at Geraldton, W.A. Chalcedony flaked hafted onto the butt end of a woomera. The resin haft is deformed. At one end of the edge the underside is moderately polished or smoothed for a length of
3 mm and width of 1 mm.

A225  Collected on the De Grey River, W.A. Chalcedony flake hafted onto an incised woomera. The prominences on the edge are very moderately rounded.

A248  Collected at Ashburton River, W.A. Silcrete (?) flake hafted on the butt end of an incised woomera. The edge of the flake is fairly sharp and the single scar on the underside is fresh.

A8088 Unprovenanced (1920). A fine chert or chalcedony flake hafted onto an incised woomera.

A8917 Unprovenanced (1925). A fine quality chert flake hafted on the butt end of a woomera.

A10665 Unprovenanced (1940). A fine quality chert or chalcedony flake hafted onto an incised spearthrower. The resin haft is deformed and the flake is exposed.

A11242 Collected at the Ashburton River, W.A. A chert flake hafted onto an incised woomera. The flakes bulb of percussion is exposed. On the upper margin there is medium rounding and smoothing of the margins of retouch scars that are within 2 mm of the edge. On the underside there is faint smoothing or polish extending no more than 1 mm from the edge. This polish is more pronounced on the exposed bulb of percussion that forms part of the underside face.

A11243 Collected at the Ashburton River, W.A. A fine quality chert hafted onto an incised woomera. The working edge of the tool has an irregular profile. It is very difficult to detect polish or smoothing on this naturally reflective material.
Al5418 Unprovenanced. Chalcedony flake hafted onto a woomera; 83°. The tool was not examined as the edge was coated with a film of resin derived from the resin haft.

Al6438 Collected by R.A. Gould at Warburton, W.A., in 1967. Notation: 'Beating stick (kupulu) with hafted stone adze flake, made by Tommy Reed, a Ngatatjara man.' The edge of this chalcedony flake has an irregular profile. Wood fibre is compacted on the edge. 56° 3(1)2, (0.5)2; 4(1)2

Hafted Stone Graving Tools in the South Australian Museum

A4262 Cooper Creek, S.A. Fine quartzite pirri; edge angle 56° - 64°. Hafted onto a stick adze. The stock was probably fashioned with a metal tool. Smoothing and rounding occurs on prominent parts of both faces of this point (see sketch diagram).

A34041 Collected by George Aiston in the Cooper Creek area, S.A. Chert pirri protrudes 12 mm from the resin haft. The tip is snapped and the lateral edges are blunted.

A34050 Collected by George Aiston in the Cooper Creek area, S.A. Fine quartzite pirri. The pirri is exposed for 15 mm of its length but there is a thick resin film extending across one face and this obscures some of the retouch. The film is smoothed, and striated in line with the length axis of the tool. Small remnants of the edge and spurs between the retouch scars are blunt on one edge and rounded on the other indicating that the retouch was probably for the purpose of rejuvenating
the edges. The very tip of the point has been snapped off but this may be accidental fracture, possibly shelf damage.

A34055  Collected by George Aiston in the Lake Eyre district, S.A. Pirri. The lateral edge are rounded at the tip of the pirri.

A34056  Collected by George Aiston in the Lake Eyre district, S.A. Pirri. The tip has been snapped off.

A34084  Collected by George Aiston in the Lake Eyre district, S.A. The stone point was probably a pirri but the retouched face is smoothed into three facets following the original fracture facets.

# SHORT LIST OF BARKS USED BY AUSTRALIAN ABORIGINES TO MAKE ARTIFACTS

<table>
<thead>
<tr>
<th>#</th>
<th>Species</th>
<th>Area</th>
<th>Artifacts</th>
<th>References</th>
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<tr>
<td>1</td>
<td><strong>Eucalyptus acmenioides</strong> Schau.</td>
<td>Stradbroke Island, Q'land.</td>
<td>canoe:</td>
<td>Petrie 1904:97, 318</td>
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<td>2</td>
<td><strong>Eucalyptus agglomerata</strong> Maiden</td>
<td>central coastal N.S.W.</td>
<td>canoe hull:</td>
<td>Lampert and Sanders 1973:108</td>
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<td><strong>Eucalyptus botryoides</strong> Sm.</td>
<td>central coastal N.S.W.</td>
<td>canoe hull:</td>
<td>Lampert and Sanders 1973:108</td>
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<td><strong>Eucalyptus miniata</strong> A. Cunn. ex. Schau.</td>
<td>Bathurst Island</td>
<td>canoe hull:</td>
<td>Basedow 1913:303</td>
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<td>5</td>
<td><strong>Eucalyptus papuana</strong> F. Muel</td>
<td>Walter James Range, Central Australia</td>
<td>carrying vessel:</td>
<td>Thomson 1964:409</td>
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<td><strong>Eucalyptus rostrata</strong> Schlecht. syn. <strong>E. camaldulensis</strong> Dehnh.</td>
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<td>canoe hull:</td>
<td>Brigham 1905:225; Dunbar 1944:174</td>
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<td>8</td>
<td><strong>Callophyllum tomentosum</strong> Wright</td>
<td>Tully River, North Q'land.</td>
<td>canoe hull:</td>
<td>Roth 1910a:6</td>
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<td>9</td>
<td><strong>Erythrophleum chlorostachys</strong> (F. Muell.) Hennings et Taub.</td>
<td>North Q'land</td>
<td>hut:</td>
<td>Roth 1910c:65</td>
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<td>Artifacts</td>
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<td>Eucalyptus tetradonta</td>
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<td>carry vessel</td>
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<td>F. Muell.</td>
<td>Arnhem Land, North Q'land.</td>
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<td>Spencer 1914:386;</td>
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<td></td>
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<td>canoe hull</td>
<td>Tindale 1925/6:101.</td>
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<td>Roth 1910a:9;</td>
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<td>Thomson 1939:217;</td>
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<td></td>
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<td>hut</td>
<td>Warner 1937:490.</td>
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<td></td>
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<td>belt</td>
<td>Roth 1910c:61, 65;</td>
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<td>bark dress</td>
<td>Warner 1937:504</td>
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<td>bark painting (hut?)</td>
<td>Mountford 1956:13;</td>
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<td>Warner 1937:505</td>
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<td>Petrie 1904:97, 318</td>
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<td>Tristani a sauveolens</td>
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APPENDIX J

DESCRIPTIONS OF THE TOOL-USE EXPERIMENTS

Procedures For Recording Use-Wear and Cleaning Experimental Tools

The working edges of experimental tools were carefully examined prior to use to ensure that they were completely free of any form of wear or damage. During the experiments every effort was made to keep the worked materials and stone tools free of extraneous dust or sand. Skins which were experimentally scraped, incised and cut were laid out on polythene sheets before work commenced.

Progression and change in the formation and appearance of use-wear were microscopically observed and noted, work being interrupted for this purpose, but schematic diagrams of the use-wear (mainly the fracturing) were normally drawn only after tool-use had finished. All use-fractures over 0.2 mm wide were recorded, it being very difficult with a conventional microscope to identify fractures that were smaller than this. On coarsely-textured stone materials, use-fractures around 0.5 mm and less could not be distinguished from the natural undulations and flawing of the surface.

I considered it important to record the widths of all use-fractures detected so that wear patterns could be described in more detail. Another advantage is that other researchers can order this data according to their own fracture size categories. While Hayden (Hayden and Kamminga 1973) employed a tripartite fracture size scheme (0.05 mm, 0.05 - 2 mm, 2 - 7 mm) to describe the use-fracturing on ethnographic Western Desert stone tools, Gould (1973:11) has correctly pointed out that these categories are too broad and may obscure small but significant variations. However, no standard fracture-size categories have been proposed and at this stage in the development of use-wear studies it is unlikely that there would be any agreement on such a scheme.
I did not measure fracture length (i.e. 90° axis to the working edge) as I considered the width measurement to be sufficient in conveying an idea of fracture size. When a fracture was unusually long this information was incorporated into the diagramatic representation of the use-fracturing.

All the experimental tools were examined with the Wild M5 microscope before and after they were cleaned of adhering residues, and sometimes also before the tool-use operation was completed. It was after completion of work that wear was photographed. Of course not all use-wear was photogenic or conveyed relevant information in a photographic form and therefore the subjects were carefully selected.

Tools were not photographed before use commenced.

After the experimental operations were completed care was taken to ensure that the tools were not damaged. They were labelled and packed in small paper bags which were then wrapped in cotton wool and packed into cardboard boxes.

CLEANING

During tool-use, residues from the worked materials tended to adhere to the contact surfaces of experimental tools. These residues included crushed wood fibre (Ahler 1971:82-83; Bordes 1971:70; Crabtree and Davis 1968:428; Kamminga 1971:73), resin, fat, shell and bone carbonate, and skin protein (plates 103,110,116,119,120,133,179). Of these residues, wood fibre and resin, compacted into small fractures, and resin in the form of a surface film can be particularly difficult to dislodge (see plates 142-144,154,160).

It is very important that experimental tools are adequately cleaned, even though it can be delicate and difficult task. Wood resin and even grease from the operators' hands can mimic use-polish and striations and when tools have been carefully cleaned the analyst must still be cautious about the identification of polish when microscopically examining experimental tools.

Researchers have employed a number of chemical preparations for cleaning residues from stone tools and these have included hot soapy water (Semenov 1964:24; Phillipson and Phillipson 1970:41), carbon-
tetrachloride, sodium hydroxide, hydrochloride acid solution (Brose 1975:93), hydroperoxide and dilute nitric acid (Bordes 1971:70).

To clean my experimental tools I first washed them in hot water and Teepol, a non-biodegradable detergent. The tools were then rinsed in cold running water. This was often sufficient. Sometimes, during microscopic examination the contact surfaces of tools were cleaned again with cotton wool dipped in acetone.

If after this cleaning process residue still adhered to the tool, obscuring (see plates 79,80) or mimicking use-wear, it was immersed in a weak sodium hydroxide solution (2 - 10%) or a dilute hydrochloride acid solution until the resin, wood fibre, carbonate or protein residue was dissolved.*

KEY TO DESCRIPTIONS OF USE-WEAR

Directly below the experiment number and artifact material is the angle category (in roman numerals) followed after a colon by the length of the working edge in millimetres. If the length of the edge was significantly reduced or increased by use-fracturing the new reading is set out in brackets directly after the pre-use reading.

For example: II:35 mm (38 mm)

If no diagram accompanies the description of wear the edge angle readings are bracketted in after the angle category. If all these readings taken along the working edge (both ends and centre) are the same only one figure is given.

For example: II(28°):35 mm

or

II(28°,29°,26°):35 mm

When accurate readings could not be made because the surfaces of the experimental tool were too rough (as with some orthoquartzite tools) the range of angles was indicated, or if they clustered around one reading, the approximate reading was given.

For example: II(25° - 29°):35 mm

or

II(27° approx.):35 mm

* Researchers should be cautious when employing powerful cleaning agents such as acids, as they must be certain that these cleansers do not react with the stone tool itself. The composition of the stone artifact materials must be determined before cleaning the tools as they are not always 100% silica and may react with acids or alkalis. Certainly more detailed investigation of prospective cleaning processes is in order.
Particulars relating to the morphology of the working edge are given on the third line. The first letter (straight abbreviated as 's') or word in this line indicates the plan-view profile. If the edge is convex or concave the degree of convexity was calculated* by drawing an imaginary line from one end of the working edge to the other end and measuring from the midsection of this line to the midsection of the working edge.

For example:

\[
\text{convexity} = 10 \text{ mm} \quad \text{concavity} = 4 \text{ mm}
\]

Plan-view profile is followed by the cross-section profiles, the first word or letter (straight abbreviated as 's') relating to the upper surface of the diagram and the second word or letter relating to the lower surface or the underside of the tool. The following word or letter indicates the end-view profile. If the end-view profile of the working edge is 'concave' the lower surface or undersurface (as indicated in the schematic diagrams) curves up at the ends; if the end-view profile is 'convex' the ends curve down. The degree of curvature is expressed in the same way as it is for plan curvature.

Whether a sand abrasive was intentionally present on the tool, or more commonly the worked material, and if so the amount, is given after the coded description of end-view profile.

The following line is an example of the coding for a hypothetical tool:

\[
(1) \quad (2) \quad (3) \quad (4)
\]

\[
\text{convex (10 mm), s/s, s, 10 g}
\]

\[
(1) \quad \text{plan-view profile}
\]

\[
(2) \quad \text{cross-section profile}
\]

\[
(3) \quad \text{end-view profile}
\]

\[
(4) \quad \text{quantity of abrasive present}
\]

* Metrical calculations of working edge were not done for some of the tools used in early experiments.
The illustrations are schematic representations. Fractures, and occasionally other forms of use-wear, are drawn on a straight line which represents the working edge of the experimental tool. An approximation of the form of this working edge is not shown in the diagram but is coded above the descriptions. When tools were not oriented at 90° to the surface of the worked material the area above the line indicates the upper surface of the tool and the area below the line indicates the lower surface, or face presented to the worked materials.

Scale drawings of use-fractures are only accurate along their width axes (i.e. along the working edge). Length of fractures in almost all cases is based on visual estimates. Fractures that are 0.2 mm or less in width may be drawn slightly larger than their measurement indicates. This is done for clarity in the illustration.

As snap fractures are represented on both surfaces of a working edge it should logically be drawn in on both sides of the line representing the working edge. However, to simplify the diagram, snap fractures have been illustrated only on the upper face.

Fracture type and size is indicated for every use-fracture. The bottom number indicates fracture size in millimetres or as a fraction of a millimetre. The top number represents fracture type.

1. step fracture (a = shallow, b = deep)
2. retroflexed hinge
3. feather/hinge (a = feather, b = hinge)
4. snap fracture (all types of bending fractures)
5. cleft

For example: \[ \frac{1.5}{la} \] = shallow step fracture, 0.5 mm wide

The edge angle readings are located below the diagram.
SKINNING KANGAROO CARCASS

#1 Volcanic Tuff

II:21 mm
s, slightly concave/slightly convex, very slightly concave, no abrasive

Fracturing was the only form of use-wear and much of it probably resulted from contact with bone. The tool was still quite efficient when the pelt had been completely cut away from the carcass.

#2 Volcanic Tuff

II:35 mm
convex (10 mm), s/s, s, edge of tool sprinkled with sand periodically during operation

The experiment was uneventful and the information is the same as in the preceding skinning experiments.
#3 Volcanic Tuff

III:40 mm

slightly concave (1.5 mm), s/s, concave (2.5 mm), no abrasive

The experiment was uneventful and the description is the same as in the preceding skinning experiments.

#4 Flint

II:25 mm

s, s/slightly concave, s, no abrasive

The experiment was uneventful and the description is the same as in the preceding skinning experiments.

#5 Flint

II:21 mm

irregular, s/slightly concave, s, no abrasive

The operation was uneventful and the description is the same as in the preceding skinning experiments.
Obsidian
II:35 mm
s, irregular/irregular, no abrasive

This obsidian tool was very efficient and care was necessary to avoid damaging the pelt by cutting through the skin. Fracturing was the only form of use-wear to occur. The tool was still quite effective when the task was completed.

Obsidian
III:32 mm
wavy, concave/convex, wavy, no abrasive

This tool was very efficient and still quite functional when the skin was removed from the carcass. Time: five minutes.

Chert
II:42 mm
concave (3 mm), very slightly concave/convex, s, no abrasive

A very efficient tool - the curvature of the edge seemed to enhance cutting effectiveness. Time: 15 minutes. Use-wear consisted only of small fractures.
This tool was not effective at all. The operation was terminated after two minutes with there being no discernable wear other than one small (1 mm) snap fracture at one end of the edge.

**LIGHT DUTY BUTCHERING**

**#10 Volcanic Tuff**

II:32 mm
convex, s/s, s, no abrasive

Only use-fractures appeared. The tool was still functional when the task was completed.
Only fractures appeared. All the snap fractures were not illustrated because of interpretation problems. The tool was still functional when the job was completed.

The tool became very blunt before the job was finished. Edge fractures were the only form of use-wear.

This was not a good tool as the cutting edge became dull very quickly. Wear comprised one 1.5 mm step fracture and an 0.4 mm feather/hinge fracture. There was no visibly detectable blunting.
Volcanic Tuff

V (85°, 88°, 85°): 52 mm
s, s/s, s, no abrasive

Both forequarters and hindquarters of a kangaroo carcass were boned with this tool in 25 minutes. The use-wear was comprised only of a few scattered fractures.

Flint

II: 45 mm
s, s/convex, concave, no abrasive

The efficiency of the tool was much reduced by the time the job ended. Only fractures appeared on the working edge.

Flint

III: 26 mm
wavy, convex/s, convex, no abrasive

This tool was very efficient for the 12 minutes in which it was used. Only small fractures occurred.
The tool was used efficiently for 15 minutes although it was working less effectively towards the end of the job. Scattered fractures on the underside of the edge were the only wear that developed.

The tool was only moderately efficient at the beginning of the job and less so at the end. A few scattered fractures were detected after use but take no account on this material are not easily recognisable. The diagram represents only the minimum wear.

The tool worked very well but blunted towards the end of the job. This blunting could not be detected visually. Edge fracturing was the only use-wear.
#19 Obsidian

II: 30 mm
slightly convex, convex/s, wavy, no abrasive
The tool performed well. Edge fractures were the only form of use-wear.

#20 Silcrete

III: 40 mm
s, slightly concave/convex, irregular, no abrasive
The tool was only moderately efficient at the beginning of the job and less so at the end. A few scattered fractures were detected after use but as flake scars on this material are not easily recognisable the diagram represents only the minimum number.

#21 Olary Chalcedony

III (46°): 28 mm
concave, slightly concave/slightly convex, s, no abrasive
The only use-wear to appear was a few snap fractures less than 1 mm in size.
#22 Radiolarian Chert III: 35 mm
slightly concave, s/s, s, no abrasive

The tool was quite effective throughout the operation. Only small fractures appeared.

#23 Altered Basalt
II (34°, 34°, 35°): 31 mm
irregular, slightly convex and irregular, s, no abrasive

This tool was not efficient. Some snap fracturing occurred but because the edge was originally so ragged these use-fractures could not all be properly identified. Edge blunting was obvious under the microscope along about 10 mm of the edge. This blunting was poorly defined because the rock material was granular, and consequently this attribute would not normally be recognisable.

#24 Rhyodacitic Volcanic
III: 20 mm
slightly irregular, s/s, s, no abrasive

After disjoining one shank and cutting away 3.7 kg of muscle, the tool was too blunt to continue. This blunting could not be detected under the microscope. Other than this, wear comprised only a few small feather/hinge fractures.
#25 Andesitic Basalt

II: 23 mm
s, s/convex, s, no abrasive

The operation was completed in 20 minutes but cutting meat became very difficult towards the end as the working edge of the tool had dulled. Edge fracturing also occurred.

#26 Othoquartzite

II (35°): 30 mm
irregular, slightly concave/s, irregular, no abrasive

The tool was not suitable for this task. Only one kilogram of flesh was cut away before the working edge of the tool became too dull for work to continue. The use-wear consists of tiny snap fractures around 0.2 mm in size to one 9 mm wide. These fractures however, were ill-defined and difficult to identify.

#27 Quartz

II: 12 mm
s, s/slightly concave, s, no abrasive

Use-wear consisted only of a few minute snap fractures. Use-fractures were very difficult to identify on quartz.
CUTTING FRESH KANGAROO MEAT

#28 Volcanic Tuff
I: 28 mm (33 mm)
s, s/convex, s, no abrasive

Four and a half kilograms of meat was very finely sliced for 15 minutes. The tool was still quite functional when the job was terminated. Snap fracturing was the only form of use-wear.

#29 Volcanic Tuff
I (15°): 75 mm
convex and dentated by retouch, s/s, s, no abrasive

Three kilograms of meat was finely sliced. A few of the fine teeth along the edge were snapped at their points but the tool was still quite effective when the job was finished.

#30 Volcanic Tuff
I: 50 mm
convex (3 mm), s/s, s, no abrasive

Six and six-tenth kilograms of meat was finely sliced for a period of 25 minutes. The tool was still effective at the end of the job but towards the finish it was difficult to cut through the membrane covering the flesh. The snap fracturing developed gradually during the period of use.
#31 Volcanic Tuff

I: 25 mm

s, s/s, convex, the edge of the tool was dipped periodically into sand during the operation and sand sprinkled over the meat. About 4.9 kg of meat was very finely sliced. The tool was very efficient and cut deeply into the meat. Snap fracturing was the only form of use-wear.

#32 Volcanic Tuff

II: 42 mm

s, s/convex, s, no abrasive

4.8 kg of meat was finely sliced and the tool was still perfectly effective when the job was terminated. Snap fracturing was the only form of use-wear.

#33 Volcanic Tuff

III: 35 mm

fairly straight, s/convex, s, no abrasive

4.8 kg of meat was finely sliced for a period of 26 minutes. The tool was still quite effective when work ceased. The fine snap fractures that occurred were on a burr which ran along the righthand side of the edge.
4.6 kg of meat was finely sliced for 15 minutes and the tool was still effective when work ceased. No discernable use-wear appeared during the operation.

#35 Flint

I:30 mm

convex, s/s, slightly wavy, no abrasive

8.6 kg of meat was finely sliced for 12 minutes. The tool was still very serviceable when the job was finished. Snap fracturing was the only form of use-wear.

#36 Obsidian

II:25 mm

convex (3 mm), slightly concave/slightly convex, s, no abrasive

3 kg of meat was finely sliced for 15 minutes. The tool
was quite efficient, and still functional after the job was terminated. Minute snap fracturing was the only form of use-wear.

CUTTING COOKED KANGAROO MEAT

#37 Volcanic Tuff
II: 26 mm
s, s/s, slightly convex, slightly wavy, no abrasive

2.3 kg of cold, cooked meat was finely sliced. The tool was still very effective when work ceased. Snap fracturing was the only form of use-wear.

CUTTING AND CHOPPING FROZEN KANGAROO MEAT

Cutting

#38 Volcanic Tuff
II: 40 mm
slightly convex, s/s, s, 6 grams of sand

1.4 kg of frozen meat was sliced into thin slivers. The tool was still quite effective when work ceased. Only very small
fractures appeared on the working edge.

Chopping

#39 Volcanic Tuff
IV(67°, 74°, 75°): 72 mm convex, s/convex, wavy, weight: 0.6 kg, no abrasive

1.3 kg of frozen meat was chopped for a period of 10 minutes (plate 71). The tool was still quite effective when work ceased. There was no discernable use-wear.

HEAVY DUTY BUTCHERING (CHOPPING KANGAROO TAIL)

#40 Volcanic Tuff
III: 38 mm, 630 grams s, slightly convex/slightly concave, s, no abrasive

The task was completed but the working edge of the tool suffered severe fracture damage. Its efficiency was much reduced by this wear. The edge angle was not broad enough for the working edge to resist this traumatic impact.
#41 Volcanic Tuff

V: 58 mm, 500 grams
s, s/s, s, no abrasive

The edge suffered severe fracture damage, mostly along one margin. However, the tool was still useful when the experiment ended.

#42 Volcanic Tuff

V: 55 mm, 340 grams
s, s/s, slightly convex, s, working edge of the tool was periodically sprinkled with sand

Quite an effective tool. Edge blunting was not pronounced and very small fractures were entirely absent; only large fractures occurred.

#43 Flint

V: 25 mm, 820 grams
s, s/s, s, no abrasive

The tool was still efficient when work ceased. Only edge fractures resulted from this task.
#44 Silcrete

V: 54 mm, 2,600 grams
concave, s/s, s, no abrasive

The tool was extremely efficient. After use the edge was moderately blunted along its entire length. Very small scars were not identifiable as the artifact material was granular.

#45 Olary Chalcedony

III: 25 mm, 840 grams
s, s/s, s, no abrasive

Severe fracturing of the edge occurred during use.
**#46 Altered Basalt**

V: 57 mm, 1,036 grams
s, s/s, s, no abrasive

Severe fracturing of the edge occurred during use.

---

**#47 Olivine Basalt**

IV: 55 mm, 968 grams
slightly concave, s/s, slightly irregular, no abrasive

The tool worked effectively and it was still operational when the job was finished. The edge was blunted and fractured.

---

**#48 Andesitic Basalt**

V: 86 mm, 1,700 grams
s, s/s, s, no abrasive

The tool worked effectively with minimal damage to the working edge. Very small fractures were not identifiable on this material. Individual grains were detached at various places along the edge and the overall result could be
described as modest edge rounding. The edge was widened to as much as 0.5 mm along these degraded areas. This damage would not, however, be readily identifiable as use-wear.

![Diagram](image)

**#49 Rhyodacitic Volcanic**

IV: 45 mm, 1,948 grams

s, s/s, s, no abrasive

An efficient tool which cut through the kangaroo tail in 3 minutes. Only fracture damage appeared.

![Diagram](image)

**#50 Orthoquartzite**

III: 55 mm, 1,800 grams

irregular, irregular/s, concave, no abrasive

Prominent parts of the edge were blunted but edge rounding did not occur. The diagram illustrates only the minimum number of fractures as the granularity of the material made it impossible to identify very small fractures.
#51 Quartz

IV: 40 mm, 454 grams
irregular, irregular/s, slightly irregular, no abrasive

The tool worked reasonably well. Fractures were very difficult to identify on the quartz and the diagram includes only fractures over 1 mm.

SCRAPING FRESH KANGAROO SKIN

#52 Volcanic Tuff

II: 26 mm
slightly wavy, concave/s, concave, no abrasive

Small snap fractures (1 mm or less) appeared along the edge soon after job was started. Subsequently, larger snap fractures appeared. The 3.5 mm snap fracture which is
illustrated in the diagram below, was accidentally caused during the experiment and did not result from scraping skin. The tool was used for 60 minutes to scrape one large kangaroo skin. After termination a very faint and almost unnoticeable smoothing and blunting was detected on the spurs between snap fractures.

The tool was used for 60 minutes to scrape one large kangaroo skin. After termination a very faint and almost unnoticeable smoothing and blunting was detected on the spurs between snap fractures.

**#52a Volcanic Tuff**

II:27 mm

slightly wavy, s/s, s, 5 grams of sand

The tool was used for 60 minutes to scrape an area of skin approximately 600 cm², this mostly being an area of muscle attachment. After work ceased, the tool was still serviceable but not highly efficient. The only form of use-wear was snap fracturing.

**#53 Volcanic Tuff**

III(46°, 48°, 48°):25 mm

slightly irregular, convex/s, s, 80 grams of sand

The tool was used for 35 minutes to scrape an area of approximately 600 cm², mostly cleaning off protein.
membrane with attached trunci muscle. No edge fracturing occurred at all. When work ceased, the edge was blunt but rounding was not advanced. Polish extended along the whole length of the moderately rounded edge, and was as much as 1 mm wide on the underside, and about 0.2 mm wide on the upper face.

#54 Volcanic Tuff

$V(90^\circ): 37 \text{ mm}$

very slightly convex, s/s, s, no abrasive

After 45 minutes only $120 \text{ cm}^2$ of skin had been scraped. At this time the edge was blunt but there were no other traces of use. The broad edge angle made the tool unsuitable for this task.

#55 Volcanic Tuff

$V(85^\circ): 28 \text{ mm}$

s, s/s, s, 6 grams of sand

After 20 minutes an area measuring $75 \text{ cm}^2$ had been scraped. The tool blunted rapidly and after it became inefficient a microscopic examination showed that the working edge was rounded with smoothing 'polish' extending 0.5 mm up both lateral faces. The tool did not do a good job as the edge angle was too broad.

#56 Flint

$I(15^\circ): (25 \text{ mm}) 30 \text{ mm}$

s, s/convex, s, no abrasive

The tool was used for 40 minutes to scrape an area of skin measuring around $400-500 \text{ cm}^2$. During this time the working edge snap fractured along its length, leaving a rather dentated profile. The convexity of the edge was
entirely obliterated by the fracturing. The experiment was terminated because the edge was not cutting effectively but on microscopic inspection, the edge revealed no noticeable blunting.

Micro-serrations (spurra between the snap fractures) may have made the tool more effective but this is speculation. Blunting occurred but it developed very slowly. A total area of 20.70 cm² was scraped clean. At termination there were 3 min. snap fractures along the edge (one of 1 mm, one of 0.3 mm and 38 of 0.1 mm or less).

#57 Flint

III: 25 mm convex, convex/s, slightly wavy, 8 grams of sand

A complete skin was fleshed in 35 minutes. The tool worked very well and was still quite functional when the job was finished. During the operation the working edge sustained small snap fractures and when work ceased blunting was advanced; in some places on the edge there was moderate edge rounding.
#58 Obsidian

II(27°): 21 mm

very slightly concave, s/s, s, no abrasive

While the tool appeared to be ideally suited for skin scraping, it did not perform well, though the operator's inexperience may have contributed in a small way to its inefficiency. Minute (1 mm) snap fractures appeared along the entire length of the working edge (plate 10). From beginning to end of the operation no change in efficiency was noted. Micro-serrations (spurs between the snap fractures) may have made the tool more effective but this is a speculation. Blunting occurred but it developed very slowly. A total area of 3,070 cm² was scraped clean. At termination there were 40 minute snap fractures along the edge (one of 1 mm, one of 0.6 mm and 38 of 0.5 mm or less).

#59 Obsidian

II: 33 mm

s, s/s, convex (2 mm), 2 grams of sand

This tool worked very well at first but its efficiency was reduced at 25 minutes and the job was terminated. The final wear pattern was very interesting. The edge was uniformly rounded along its entire length. The underside of the edge was abraded to a width of 1 mm, this abrasion overlying two small feather fractures. The upper face was finely feather/hinge and snap fractured, with abrasion extending inward for only 0.3 mm (see plates 78-80).
#60 Chert

II: 30 mm
straight with a slight convexity at 28° end, s/s,
straight with slight concavity at 28° end, no abrasive

This tool was very efficient and even after 100 minutes of use it still worked, though only about a quarter as well as when the job was begun. The only use-damage sustained was minute (mostly 1 mm and less) snap fracture. The edge was still sharp where it had not fractured. The job was terminated after 100 minutes.

#61 Chert

III(55°): 17 mm
s, s/s, 10 grams of sand spread over whole skin but only half the skin was fleshed

The tool was used for exactly one hour at the end of which time it was no longer effective. Only half of one kangaroo skin was fleshed - an area of 1,600 cm². When work ceased, the working edge of the tool was rounded to a thickness of 0.2 mm or 0.3 mm. On the underside of the edge smoothing invaded inward as much as 2 mm, and within this altered zone very fine striations, running approximately perpendicular to the edge, were observed. At one end of the edge this smoothing was well developed and in this area two of the striations intersected. Smoothing on the remainder of the edge was not as easy to identify because of the natural reflectivity of the chert. The spurs between some fine snap fractures (1 mm and less) were heavily worn. These snap fractures were shallow and resulted from the removal, during use, of a thin projecting lip of material on the edge.
#62  Altered Basalt

II: 27 mm
very irregular, s/s, s, no abrasive

This was not a good skin fleshing tool although it did successfully scrape the membrane from 600 cm\(^2\) of skin in a period of 50 minutes. Snap fracturing occurred early in use and the edge then stabilised. Subsequently the edge blunted and one spur was rounded.

#63  Andesitic Basalt

III(46\(^\circ\), 55\(^\circ\), 55\(^\circ\)): 35 mm
s, s/convex, straight with convexity at 34\(^\circ\) end, 2 grams of sand

This tool was used for 70 minutes to completely flesh a large kangaroo skin. After the job was finished the working edge of the tool was well rounded and 'polished'. No fractures could be identified.

#64  Silcrete

II(26\(^\circ\)[22\(^\circ\)], 30\(^\circ\)): 20 mm
irregular, irregular/irregular, irregular, no abrasive

Pieces of the edge broke away during use, leaving the edge rather jagged in appearance. The tool's efficiency was reduced within the first 30 minutes but the operation was continued for another 60 minutes, and 3,180 cm\(^2\) of skin was eventually fleshed. Microscopic examination of the spent
tool did not reveal any use-wear which would normally be identifiable. The fractures were unidentifiable and the very modest edge rounding would not be recognised on a prehistoric tool.

The tool was unsuitable and the job was terminated after 10 minutes. Edge wear consisted of ill-defined fractures, and it did not be identifiable on a prehistoric tool.

#65 Silcrete

II: 47 mm

convex, s/convex, concave, 3 grams of sand

This was an efficient tool and was still scraping the skin clean when the job was terminated at 45 minutes and after 850 cm² of skin had been cleaned. Angles at which the tool was held were high - as much as 90°. After the job was finished microscopic examination revealed edge rounding and blunting on the spurs between snap fractures.

#66 Orthoquartzite

II (32°): 51 mm

slightly concave and irregular, s/s, slightly convex, no abrasive

This tool was totally unsuitable and the job was terminated after five minutes. The edge would not scrape the protein membrane off the pelt and the granularity of the edge seemed to have been the cause of the difficulty. The only wear was fracturing which would not be identifiable on a prehistoric tool.
#67 Orthoquartzite

IV(65°): 35 mm
irregular, concave/convex, concave, no abrasive

The tool was unsuitable and the job was terminated after 10 minutes. Edge wear consisted of ill-defined fractures, that would not be identifiable on a prehistoric tool.

#68 Carbonate

II: 45 mm
s, s/convex, concave, 2 grams of sand

An area of 20 cm² was scraped clean in 15 minutes before the tool could no longer scrape properly. It performed poorly. The edge crumbled within the first few strokes and it rapidly blunted. The underside of the edge was polished to a width of about 1 mm at the ends of the working edge and in between the snap fractures. No striations were evident. A light polish 0.5 mm wide was also evident on the upper margin of the edge.

#69 Carbonate

III(52°, 55°, 55°): 32 mm
straight with small irregularities, irregular/irregular, irregular, no abrasive

Surprisingly, the tool worked effectively in this fleshing operation. No noticeable macroscopic breakdown occurred during tool-use. The job was terminated after 52 minutes and 800 cm² of scraping as the edge was blunt. Microscopic examination revealed pronounced rounding of a 12 mm section of the working edge (up to 1 mm thick) and polish/
smoothing extending as much as 3 mm from the working edge on the underside. Some prominences positioned outside this main area were also rounded. The rest of the edge was blunted.

SCRAPING PARTIALLY DRIED KANGAROO SKIN

#70 Volcanic Tuff

III (50°, 52°, 55°): 43 mm

slightly concave in middle, s/s, s, half dried skin sprinkled with wood ash and charcoal

The tool was used for 65 minutes until its efficiency was much reduced. No fracturing at all occurred but the edge was moderately rounded and polished along its entire length (0.5 mm wide on upper face and up to 2 mm wide on the underside). The polish was only detectable under the microscope.

SCRAPING DRIED KANGAROO SKIN

#71 Volcanic Tuff

II: 37 mm

wavy, s/s, s, no abrasive

Snap fracturing occurred almost immediately. After 30 minutes the whole edge was fractured and the tool's efficiency was much reduced. The job was terminated after 35 minutes when an area of 210 cm² had been scraped and the tool was no longer working efficiently. Snap fracturing was the only form of use-wear.
Very small snap fractures appeared within the first few minutes of scraping. At 60 minutes the tool was beginning to blunt and its efficiency was reduced. After another 10 minutes of scraping the job was terminated as the tool was obviously not functioning effectively. At this stage the edge was snap fractured along the underside and smoothed with closely packed but ill-defined striations.

The origin of these fractures was the underside of the edge. Snap fracturing continued until the edge was stable. After 60 minutes of scraping, smoothing on the underside of the edge was noted, a wear form that probably made its appearance sometime earlier. The tool was still functional but its efficiency was reduced. The job was terminated at 60 minutes and a more thorough microscopic examination revealed a smoothed bevel on the underside of the edge which was striated at 90° to a width of 0.8 mm. No smoothing was observed on the upper face.
Volcanic Tuff

II:35 mm

slightly convex, s/slightly convex, s, a very small quantity of sand, probably less than a gram, adhered to the dry skin. Very small snap fractures appeared within the first few minutes of scraping. At 60 minutes the tool was beginning to blunt and its efficiency was reduced. After another 30 minutes the job was terminated as the tool was obviously not working effectively. At this stage the edge was snap fractured along most of its length and the underside was smoothed with closely packed but ill-defined striations angled at 75° - 80° to the edge. There was no smoothing or striations on either of the lateral margins.

Volcanic Tuff

III:37 mm

s, s/s, s, no abrasive

The tool was used for 35 minutes until its efficiency was reduced. During this time only small snap feather/hinge and step fractures appeared along the working edge. Small wrinkles in the dry skin caused at least some of these fractures.
Volcanic Tuff

IV(65°, 67°, 75°): 34 mm
slightly wavy, s/s, s, no abrasive

The tool performed satisfactorily in this task and its efficiency was only slightly reduced after three-quarters of the skin had been scraped. The job was terminated at this point. Microscopic examination revealed smoothing/polish along the underside of the edge but this was only a thin strip some 0.2 mm wide. Polish was concentrated in the middle of the edge. Faint striations or 'trends' were detected running at angles of 85° - 90° to the edge within this polished zone. Blunting was not pronounced and about eight small (1 mm) snap fractures were scattered along the edge.

Flint

II: 32 mm
slightly concave (2.5 mm), s/s, concave, no abrasive

Snap fracturing occurred immediately and continued for about 10 minutes. Edge smoothing/polish then progressively became more pronounced. The job was terminated after 45 minutes of scraping. The tool had performed very well in this experiment and it was still very effective when work ceased. At termination an area 3,000 cm² had been scraped. Snap fractures were prominent and the underside of the edge was moderately bevelled and polished for a width from the edge of 1.5 mm.
Flint II: 18 mm
slightly concave, s/s, s, 4 grams of sand

The edge instantly snap fractured, the scars measuring less than 1 mm (see diagram A). The edge ceased fracturing shortly after and a bevel began to form on the underside. After 30 minutes the tool's efficiency was much reduced and the job was terminated. The area scraped measured approximately 100 cm². At termination the prominences on the working edge were rounded (plate 81), especially the spurs between the snap fractures. The edge rounding was due not so much to microscopic abrasion but rather to minute fracturing. There was a very faint polish on the underside of the edge accompanied by a few scattered 90° striations.

After 30 seconds

During the first seconds of use the edge begins to fracture. One can see the fracture initiates at a point on the working edge. The same time numerous small fractures occur around it. After 40 cm² of skin was scraped clean, it was noticed that two smaller fractures had taken the place of the 2 mm fracture - the new fractures being jagged. The spurs of the fine striations were noticeably blunting although the tool's efficiency at this stage was quite acceptable. As soon as work began on the large plate 2 cm by 0.8 cm broke off the working edge on both sides. The entire working edge on both sides was continuously fractured when the tool was examined at the completion of the scraping. The edge was still functional, the quality of work was good and wear was minimal.

Flint III: 33 mm
slightly convex, s/slightly convex, slightly concave, 5 grams of sand

After about 20 minutes the edge of the tool was noticeably blunting and a restricted faint polish developed on the under-
side. Feather/hinge and snap fractures, all 0.5 mm or less in size, continually appeared on the edge. After 40 minutes this fracturing ceased and edge rounding and polish were becoming more pronounced. The job was terminated at this point as scraping efficiency was reduced. One quarter of a kangaroo skin had been scraped. The final microscopic examination revealed well developed edge rounding interrupted by use-fractures. The rounding was more noticeable on the underside of the edge and here a moderate polish extended inward for approximately 1 mm.

One quarter of a kangaroo skin had been scraped. The final microscopic examination revealed well developed edge rounding interrupted by use-fractures. The rounding was more noticeable on the underside of the edge and here a moderate polish extended inward for approximately 1 mm.

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# 79 Obsidian

II(32°): 23 mm (25 mm)

slightly irregular, s/slightly convex, slightly curved,
no abrasive

During the first seconds of use the edge began to fracture. One feather flake measuring 2 mm wide by 0.9 mm long was pressed off the righthand end of the working edge. At the same time numerous small feather fractures, usually around 1 mm or less, were detached from both sides of the edge giving it a serrated appearance. After 40 cm² of skin was scraped clean, it was noticed that two smaller fractures had taken the place of the 2 mm fracture - the new fractures being jagged. The spurs of the fine serrations were noticeably blunting although the tool's efficiency at this stage was quite acceptable. As soon as work resumed, a large flake 2 mm by 0.9 mm broke off the working edge. After 130 cm², the edge was much blunter and losing its effectiveness. The entire working edge on both sides, was continuously fractured when the tool was examined at the completion of 170 cm² of scraping. The effectiveness of the tool was diminishing rapidly and the edge would not scrape evenly. Though the tool was still functional, the quality of work was poor and therefore
the experiment was terminated. Microscopic examination revealed extremely fine fracturing within and between the larger feather fractures figured below. This comminution variably widened the working edge to as much as 1 mm.

Edge fractures appeared shortly on the upper face during the first few strokes; finally many fractures set also feather/hinge.

The tool was inefficient; it was clean but the edge was unsuitable, therefore the job was terminated. The fractures change in the size and density along the striking edge. The fractures on the underside which are illustrated have been heavily abraded. The fractures on the upper face are retained and are very small. Fractures on the underside which are illustrated have been formed in the last few moments of scraping as these fractures were not abraded.

#80 Obsidian

III:23 mm
s, slightly concave/convex, slightly concave, 4 grams of sand

This tool had to be held at angles about 45°. Small fractures, all about 0.5 mm in size, appeared on the edge after the first stroke across the skin. After a few more strokes more fractures were added including two feather/hinge fractures, each 1 mm wide. The operation was halted after three minutes because the shape of the edge was not suitable for the task. The area of skin which had been scraped was negligible. Abrasion was pronounced on the underside and was concentrated at the righthand end of the edge (plate 82), thinning out to separate striations at the other end (see diagram). The edge was heavily fractured but not blunted or rounded.
**#81 Obsidian**

III:35 mm  
s, s/s, s, 5 grams of sand

Edge fractures appeared mostly on the upper face during the first few strokes; mainly snap fractures but also feather/hinge. The tool was inefficient after only three minutes and therefore the job was terminated. There was very little change in the fracture pattern. The underside of the working edge was heavily abraded for a distance of 0.3 mm inward (plate 83). This abrasion may have obliterated very small fractures. The fractures on the underside which are illustrated must have been formed in the last few moments of scraping as their margins were not abraded.

**#82 Chert**

II:26 mm  
irregular, s/convex, slightly curved, no abrasive

After an area of skin measuring 25 cm² had been scraped it was noted that three large cleft fractures occurred along flaws which met the working edge. By the time 150 cm² had been scraped the underside was bevelling. After 560 cm² of skin had been scraped the edge was blunting, and this process continued until at 1,180 cm² the tool was not effective and the job was terminated. At this time the underside of the edge was slightly bevelled and smoothed. The width of this smoothing was 0.5 mm.
After five minutes of scraping the working edge was bifacially fractured (see illustration). At 14 minutes the job was discontinued. The edge had an irregular profile as a result of the fracturing and because of this it scoured rather than scraped the skin. This chert was very brittle. No use-wear was observed other than edge fracturing.

After five minutes of work the fractures along the working edge of the tool were recorded. The job was discontinued after 15 minutes when an area of 1,900 cm² had been scraped.
The tool was still effective but its efficiency was reduced. The edge was thickened by fracture and an abraded bevel 2 mm was well developed on the underside (plates 85, 86). This use-wear is reminiscent of wear on European palaeolithic end-scrapers (Semenov 1964:87-88).

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**Radiolarian Chert**

III:20 mm

s, s/s, s, 2 grams of sand

Faint sub-parallel striations could be seen along the working edge after a short period had elapsed. These striations were more definite by the time half a skin had been fleshed. At the same time the edge was severely snap fractured, the initiations of these scars being on the lower margin of the tool. After approximately 60 minutes of scraping the tool was working less efficiently and the job was therefore terminated. Microscopic examination revealed that striations were concentrated on the underside of the edge, in an area 10 mm long. Some of these striations, angled between 75° - 90° to the edge, intersected and were scattered rather than being aligned in sets. The working edge was rounded, its width being about 0.3 mm, but the continuity of this rounding along the edge was interrupted by fractures.
Altered Basalt

II (35°): 14 mm
roughly straight with irregularities, s/s, s, no abrasive

After 20 minutes of scraping the wear pattern was established and although the tool was still functional the job was discontinued. The underside of the edge and the lateral face was smoothed to a width of 2 mm. Short poorly defined striations angled at 75° could be seen and these may have been furrows caused by crystals or grains which were broken from the edge and dragged across the surface. One poorly defined feather/hinge fracture (2 mm) was situated near the centre of the edge.

Altered Basalt

III (55°): 40 mm
irregular, irregular/irregular, irregular, 3 grams of sand

Smoothing abrasion began immediately on the underside of the edge. No identifiable fracturing could be seen when the edge was periodically examined. The job was terminated after 12 minutes when an area of 200 cm² had been scraped. The tool was not very efficient, even at the beginning, but it was still functional when work ceased. The underside of the edge was bevelled and smoothed to a width of 2 mm (plate 87). Within this zone there were ill-defined striations, angled at about 80° to the edge.
#88 Orthoquartzite

II (31°): 24 mm

straight but with small irregularities, irregular/irregular, irregular, no abrasive

Within the first five minutes the edge crumbled in a series of snap fractures and then stabilised. Spurs were absent. After this fracturing which thickened the edge, the tool blunted although it was still quite functional. It was used efficiently for 62 minutes to scrape an area of skin measuring 3,000 cm$^2$. One may attribute this success to the stone's granularity and the absence of sharp snap fracture spurs which would cut the skin. The tool acted as a rasp. Final wear examination showed that the edge was snap fractured (up to 3 mm each) with rounding on the underside only, and smoothing on this rounded part of the edge to a width of 0.3 mm. The smoothed area had a frosted appearance. Spurs were degraded.

#89 Orthoquartzite

II (25°, 30°, 30°): 23 mm

irregular, irregular/irregular, s, sand adhering (fixed) to dry skin

Smoothing on the underside of the edge appeared almost immediately and continued to develop. The tool lost its efficiency within 15 minutes and the job was terminated. At completion, the underside of the edge was smoothed to a width of 4.5 mm along most of its length (plate 88). There were no definite striations. Fractures were ill-defined and would not have been identifiable on a prehistoric tool.

#90 Orthoquartzite

IV (65°): 28 mm

very slightly irregular, s/s, s, no abrasive

After five minutes the edge had fractured and taken on a serrated appearance. By 12 minutes smoothing was noticeable
on the underside of the edge. Meanwhile, fracturing was
continuing and small flakes or fragments were still being
pressed off at 100 minutes. The job was terminated at 137
minutes when the tool was not working properly. Use-wear
at this stage consisted of ill-defined fractures giving the
edge an irregular profile; rounding of edge projections,
and smoothing along two areas, each 1.5 mm wide, on the under­
side of the edge. This smoothing had a frosted appearance
typical of an abraded quartzite surface. There were no
striations.

RUBBING DRIED KANGAROO SKIN

#91 Altered Basalt

The flat surfaces, and the 90° edges (each 45 mm long), were
rubbed on a kangaroo skin for a total time of 15 minutes.
The stone was not granular enough for the tool to work well.
All contact edges were somewhat rounded or flattened with
striations running generally in the same direction across
these smoothed edges. Individual striations were not well
defined. Smoothing did not appear on the flat surfaces.

#92 Andesitic Volcanic

One flat surface and an adjoining edge (90° - 95°) was rubbed
over the skin for 10 minutes. This artifact material was not
able to 'rasp' the skin because it was not granular enough
and probably the constituent grains and crystals were too soft.
Through use the edge was worn down almost flat, being widened
to 2 mm and heavily striated (plate 88). These striations,
oriented across the edge, were similar to grinding marks on
intentionally ground artifacts. The flattened, smoothed (almost
polished) edge had a slightly curved profile, probably the
result of a slight horizontal movements in the tool's orienta­
tion to the skin. The flat surface was abraded on the high
areas as can happen in the early stage of intentional grinding.
Dips in the surface were not smoothed.
#93 Olivine Basalt

The flat surface of this tool was the contact area. The tool was used for 5 minutes and its performance could be described as very successful. All high areas on the surface were smoothed flat; a visual contrast to the rough topography in the depressions. There was a curvature in the alignment of these smoothed areas. Within these areas there were heavy, well-defined striations (clearly scratches) up to 10 mm in length, which were sub-parallel and often intersected (see plate 89). This use-wear is very similar to some intentionally abraded surfaces, e.g., an edge-ground axe.

#94 Carbonate

The irregular 70° of the tool was used to rub the skin for 5 minutes. The angles at which the tool was held ranged between 5° and 90°. The carbonate tool was marginally effective in this task. Quite heavy abrasive wear occurred with the development of a flattish bevel 2.5 mm wide on the underside of the edge. Edge rounding was quite well-developed with indistinct striations angled at 90° to the edge.

#95 Orthoquartzite

A 70° edge and a flat surface were employed to rub a skin which did not have any adhering sand. The tool was successful in rasping off the membrane but it was certainly not as effective as a scraper. No use-wear was observed.

#96 Orthoquartzite

The flat surface of this tool was used to rub skin which had sand grains adhering to its surface. After only 5 minutes there was a distinct smoothing polish over much of the area of the tool which had been in contact with the skin. The job was terminated after 10 minutes. The tool was not effective in this job.
ENGRAVING KANGAROO SKIN

#97 Volcanic Tuff

II:30 mm

very slight irregularities, s/s, slightly curved, no abrasive

The first two incisions into the skin caused a few snap fractures. The positions of these fractures were related to the slight irregularities in the edge and it can be assumed that they were caused by differential pressure along the edge. After the job was terminated at around 8,000 cm of incision, the tool's edge exhibited pronounced edge rounding with smoothing along the margins of the early fractures. A few scattered but definite striations with a maximum length of 4 mm ran parallel with the edge (plate 92).

At 40 cm

At 1,170 cm

#98 Volcanic Tuff

II:18 mm

s, s/convex, s, no abrasive

After 2,800 cm of incision the edge was dulled and more pressure had to be applied to keep the tool cutting. However, there was no pronounced rounding although the edge was blunt to the touch. One feather fracture was observed. At 6,000 cm the tool did not work effectively...
and the job was discontinued. At this stage the edge was well rounded to a thickness of approximately 0.25 mm. Most of the scars were smoothed over. Smoothing extended no more than 0.5 mm from the working edge on the lateral faces. Two shallow but definite striations ran parallel to the edge for a distance of about 6 mm; presumably caused by fragments broken from the edge during use of the tool. There was a slight 'polish' no more than 0.2 mm from the edge on the curved lateral face.

![Diagram of edge rounding and striations](image)

**Volcanic Tuff**

III:24 mm
convex, s/s, s, no abrasive

At an incision length of 4,900 cm, edge rounding and modest to developed polish/smoothing could be clearly observed. Some of the snap fractures which had appeared, were smoothed over. The tool was inefficient at 8,240 cm of incision. Microscopically the edge rounding was regular and pronounced. Long parallel striations were observed running parallel with the working edge on both lateral faces. Their extent from the edge was however, only 0.5 mm. Smoothing was concentrated mostly on one lateral face, to a maximum extent of 0.4 mm.
#100 Volcanic Tuff

IV(740):20 mm
convex, convex/s, curved, no abrasive

At 2,100 cm of incision the working edge was very moderately rounded with smoothing on the convex face extending 1.5 mm from the edge. This unifacial smoothing reflects the way the tool was held in the hand - not perfectly horizontally because of the irregular shape of the flake. There were no edge fractures. At 2,800 cm the job was discontinued because the tool was inefficient. At this stage the edge rounding was pronounced and a 'light polish', extending at most 0.6 mm in from the edge, was distributed along the length of the convex face. Long striations ran parallel to the edge within this 'polished' zone (plates 93, 94).

#101 Flint

V(90°):22 mm
s, s/s, s, no abrasive

The incision produced by this tool was wide and shallow which indicated that its edge angle was not suitable for an engraving task. The job was terminated at 2,500 cm of incision. The edge exhibited modest blunting but there were no fractures.

#102 Obsidian

II: 24 mm
s, concave/convex, slightly curved, no abrasive

At 30 cm of incision very small feather/hinge fractures appeared along the entire length of one side of the edge (max. width 1 mm; average 0.6 mm). After 27 cm of incision, minute feather/hinge fractures appeared on the opposite face. The edge appeared serrated at 3,630 cm but it was still engraving very effectively. Only at 6,000 cm did the edge noticeably begin to blunt although
efficiency remained high. Further fracturing occurred at 7,080 cm and some of the smaller fractures merged to form larger ones up to 2 mm wide. Blunting was more pronounced at 8,580 cm and the incision in the skin was widening. After 17,750 cm of engraving blunting was more pronounced and fracturing recurred. The tool was still operating at a reduced but acceptable effectiveness at 29,000 cm of incision and the operation was ended at this point. Microscopic wear observed after this period of use consisted of very fine striations on the convex face up to 1.5 mm from the edge, running parallel with the working edge between use-fractures. Spurs between the fractures were rounded and had a frosted, abraded appearance - no doubt caused by the fragments broken from the edge during use.

At 31,800 cm the tool was still quite efficient although the incisions became increasingly wider. Poorly defined snap fractures were the only use-fracture types and there was moderate rounding on the low spurs between these fractures.
**#103a Chert**

I:21 mm convex (3 mm), s/s, dip at righthand end, no abrasive

An effective tool. At 5,000 cm of engraving a few 1 mm snap fractures occurred. After 18,400 cm of engraving the working edge had lost its effectiveness. It was rounded for a length of 5 mm along the highest point of the convexity.

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**#104 Olary Chalcedony**

III:32 mm wavy, s/convex, slight convex, no abrasive

At 540 cm of engraving the edge of the tool was slightly serrated and irregular from feather/hinge fracturing that had appeared on one face. The edge began to blunt at 2,400 cm, while small fractures still occurred at 4,200 cm. A reduction in efficiency was not noticeable at 16,000 cm and at about this point fracturing stopped and edge rounding became noticeable. The operation was terminated at 31,000 cm of engraving when the tool was no longer effective. Wear consisted of feather/hinge fractures on the straight face along the edge, with edge rounding and smoothing overlying the small fractures. Long striations extending in as much as 0.8 mm ran parallel with the edge.
Radiolarian Chert

II (35°): 28 mm
s, s/s, s, minute quantity of sand grains adhered to skin

Tool used to incise for a length 3,740 cm when it became inefficient. The edge displayed pronounced rounding which thickened it to 0.4 mm and smoothing/polish occurred up to 0.5 mm from the edge on both lateral margins. Three 8 mm striations ran along the edge within the smoothed zone (from foreign grit?). A few minute fractures were too degraded to identify.

Rhyolitic Volcanic

II (25°): 18 mm
s, s/s, s, no abrasive

Snap fracturing began immediately but it was not severe - at 300 cm of engraving only three 1 mm snap fractures were identified. This form of damage continued to occur until the working edge took on a serrated appearance before 1,300 cm of engraving was completed. Blunting was also noticeable at this point. Further snap fracturing did not occur and the edge slowly continued to blunt as the engraving action was continued. The job was terminated at 11,000 cm of engraving at which point it was considered that the tool was producing a poor incision. The microscopic examination revealed that the fractured working edge was rounded and smoothed, the smoothing extending up the lateral surfaces for 0.2 mm.

Two short and poorly defined striations ran parallel to the edge within this smoothed area. More striations might have been present but to see them it would have been necessary to use magnifications higher than 75X with appropriate lighting and perhaps filters, or a scanning electron microscope. The snap fractures were very shallow.
#107 **Rhyodacitic Volcanic**  
IV(75°, 71°, 71°): 25 mm  
very slightly convex, s/s, curved, no abrasive

The tool was not efficient at all and the job was terminated after 4,500 cm of incision. Edge rounding was prominent on the projecting part of the convex edge and one lateral face was smoothed for up to 0.5 mm from the working edge. There were a few small feather/hinge fractures.

#108 **Andesitic Basalt**  
III(54°, 54°, 55°): 26 mm  
slightly concave and irregular, s/s, s, no abrasive

At 300 cm the tool engraved effectively and the pre-use projections on its edge began to wear down. After 900 cm the edge began to blunt and the tool's efficiency was reduced. Most of the projections were worn down. At 1,200 cm the edge was not functional and the job was terminated. At this point the ends of the slightly concave edge were well rounded and smoothing occurred on the working edge only, not the lateral faces. Striations ran along the length of the rounded edge.

#109 **Orthoquartzite**  
II(c.32°): 24 mm  
irregular but roughly straight, irregular/irregular, s, no abrasive

The first signs of wear appeared after 1,120 cm of engraving when the small grain projections began to wear down, macroscopically straightening the profile of the edge. At 1,620 cm the edge fractured. Small (1 mm) fractures gave the edge a more serrated or jagged appearance. After 2,700 cm of incision the edge measured about 0.8 mm across and it still had a jagged appearance. The job was discontinued at 3,170 cm. At no time did the tool incise a clean, thin line and I considered that it was unsuitable as a skin engraving tool. The final examination after the job was finished revealed an
edge which was irregular and jagged without any identifiable wear features.

#110 Orthoquartzite
III(55°):20 mm
slightly irregular because of granularity, s/slightly irregular, s, no abrasive

After 1,080 cm of engraving (5 minutes) the projections of the edge were worn down giving it a fairly straight plan, though still slightly undulating. Blunting was noticeable after 2,680 cm of incision. At 4,430 cm the tool was no longer effective and the job was terminated. The tool was only really effective in the first 750 cm of incising, otherwise a good incision was not obtained. When work ceased, the edge had an irregular plan and there was no identifiable wear.

#111 Orthoquartzite
V(90°):23 mm
roughly straight, irregular/irregular, s, no abrasive

After 500 cm the edge could only cut a broad, shallow incision 0.65 mm across. The edge showed no sign of wear. After 2,100 cm of incision the edge measured 0.9 mm across. The edge was thickened by fracturing and had an irregular appearance. There was no identifiable wear pattern.

#112 Quartz
I:25 mm
irregular, irregular/irregular, s, no abrasive

The edge progressively snap fractured between 400 cm and 1,500 cm of engraving. At 4,380 cm the edge was apparently stable and did not make a clean incision in the skin. The job was terminated at this point.
The working edge dulled very quickly and the tool ceased to function after only a few minutes.

CUTTING KANGAROO SKIN

#114 Volcanic Tuff

I: 26 mm
wavy, s/s, concave, no abrasive

The edge immediately snap fractured along its entire length. The job terminated after cutting a length of 758 mm although tool still quite functional. Its efficiency was reduced and the fracture pattern had stabilised. There was no discernable use-wear other than snap fractures.

Within 10 minutes minor fractures appeared along the working edge (approx. 98% of cutting) at an angle of 15° (approx.). Efficiency at this point was reduced. After 135 minutes of cutting 30% of skin was removed. The efficiency of the tool was approximately halved. Snap fracturing had almost ceased and the edge still had a serrated appearance. The tool had been used for 80% of the test length was 2570 mm. The use-wear consisted only of edge rounding on the spur between snap fractures.

In no instance were fractures larger than long edge tool was still suitable for cutting. It was subsequently used to saw bone.
#115 Volcanic Tuff

II:24 mm  
s, s/s, s, no abrasive

Within 10 minutes small snap fractures appeared along the working edge and after 30 minutes (494 cm of cutting) the edge had a serrated profile. Efficiency at this point was reduced. After 155 minutes of cutting lengths of skin (equivalent to 1,218 cm) the efficiency of the tool was approximately halved. Snap fracturing had almost ceased and the edge still had a serrated appearance. Some further small fracturing occurred before 265 minutes had elapsed. The tool was still effective after 285 minutes when the cutting length was 2,570 cm. The use-wear consisted only of edge rounding on the spurs between snap fractures.

#116 Volcanic Tuff

II:42 mm  
slightly convex, slightly convex/s, s, no abrasive

This tool was very efficient. By the time 346 cm of skin had been cut there was only a modest decrease in the tool's efficiency. Only minor breakdown of the edge occurred – primarily snap fracturing along the whole length of the edge. In no instance were fractures larger than 1 mm. The tool was still useful when the job was terminated at 346 cm of cutting. It was subsequently used to saw bone.
Volcanic Tuff

IV: 25 mm
s, s/s, s, no abrasive

No wear appeared on the edge of the tool by 210 cm of cutting. Some feather/hinge fractures (1 mm) appeared on the side of the edge before 1,210 cm of skin had been cut. The job was terminated at this point. No other form of wear occurred. The tool was still quite functional. Some of the finer snap fractures (0.2 mm and less) were not recorded.

Volcanic Tuff

V(95°): 25 mm
s, s/s, s, no abrasive

The broad edge angle would not permit the tool to cut through the skin. The job was discontinued after only two minutes.

Volcanic Tuff

V(90°): 25 mm
s, s/s, s, no abrasive

The edge angle on this tool was too wide for it to be effective in this task.
Flint

II:17 mm
s, s/s, s, no abrasive

Snap fracturing occurred within the first few minutes and this gave the working edge rather serrated appearance. At 622 cm the job was terminated because of reduced efficiency. The only other form of wear to be observed when work ceased was a slight blunting on the spurs between the snap fractures.
#122 Flint

III(55°):20 mm

slightly concave, s/s, s, no abrasive added but a few sand grains adhered to the dry skin

The working edge rounded and sustained a few scattered fractures approximately 0.5 mm wide. The tool was used to cut through 785 cm of skin before it became inefficient.

#123 Flint

IV(74°, 73°, 75°):20 mm

s, s/s, very slightly curved, no abrasive

After 50 cm of skin had been cut the tool's efficiency was much reduced. The edge angle was unsuitable for the task, and the job was terminated at 250 cm. Two feather fractures (1.6 mm and 2.1 mm) were noted after work ceased.

#124 Flint

V(85°):22 mm

s, s/s, s, no abrasive

While the working edge was sharp its edge angle was too wide and because of this the tool was only barely effective. 31 cm of skin was cut. At termination there was only one retroflexed hinge (0.2 mm) and one feather/hinge (0.2 mm) fracture on one of the lateral margins.

#125 Obsidian

II:10 mm

s, s/s, s, no abrasive

After 361 cm of cutting the quality of the work was reduced, the tool leaving a roughened irregular cut mark. Fine fracturing occurred primarily between 60 - 100 cm of cutting. After this degree of use, fracturing on the edge ceased. Cutting was continued, and the edge grew duller. Although
the tool continued to cut, the quality of the work was poor and so the job was terminated at 500 cm. Microscopic examination revealed fine step (0.2 mm) fracturing between the larger fractures illustrated below. This appeared as roughening or shattering. No rounding was apparent and loss of efficiency was presumably due to the microfracturing.

#126 Chert

II:17 mm

slightly irregular, s/slightly convex, slightly concave, no abrasive

Two large snap fractures (1.5 mm and 2 mm) occurred immediately on commencing work. Smaller snap fractures also occurred. Initially the tool was very effective. At 980 cm the edge had taken on a typical snap fractured profile. These snap fractures continued to refracture into smaller ones, a process that reduced the cutting efficiency of the edge. After 1,570 cm two feather fractures (1 mm) appeared along the edge. At 1,930 cm the final fracture pattern was formed and at 2,050 cm the job was terminated as the edge was no longer cutting effectively. These snap fractures were the only form of wear.
#127 Radiolarian Chert

II (25°, 27°, 27°) : 30 mm
convex, concave/convex, slight curve, no abrasive

This tool was very effective and the edge suffered relatively very little damage. The tool became gradually less efficient during use. By 628 cm the edge was no longer cutting cleanly. At termination the edge wear consisted of some fine feather/hinge fractures, mostly feather or transitional snap-feather about 0.2 mm wide), along the entire length of the edge. Interspersed amongst these was the occasional snap fracture. All fractures were less than 1.5 mm and occurred in roughly equal proportions on both sides of the edge.

#128 Olary Chalcedony

II : 30 mm
s, s/s, slightly concave (1.5 mm), s/s, s, no abrasive

The working edge immediately began to snap fracture and before 100 cm of skin was cut it was very irregular in profile - the serrated appearance typical of a snap fractured edge. After the edge snap fractured the cut marks were not clean and even but were somewhat ragged. The tool cut poorly at 592 cm and the job was terminated. The use-wear consisted only of snap fractures.
The edge immediately began to fracture or crumble. This continued until fracturing ceased at around 146 cm of cutting. Most of the working edge became practically unusable after 483 cm of cutting. The larger part of the working edge became consistently less irregular with use. A large fracture appeared on the edge and this contributed to the deterioration in cutting efficiency. The job was terminated at 483 cm as the tool was no longer effective. At this stage some spurs between snap fractures were blunted while others rounded.

The tool was not suitable for the task. After 100 cm of cutting the tool became totally ineffective and therefore the job was terminated at this time. The final examination revealed blunting and very moderate edge rounding on the snap fractured edge but this use-wear would not normally be identifiable on a prehistoric tool. The edge was granular and smaller fractures than those illustrated could be seen but not accurately identified.
Andesitic Volcanic

II (29°): 25 mm
irregular, irregular/irregular, s, no abrasive

The material from which the tool was made was too granular to permit efficient use. Moderate snap fracturing occurred on the thin edge by 100 cm of cutting. The edge did not cut cleanly. The job was terminated at 100 cm and the wear at this time was well developed edge rounding and smoothing which contrasted with the rough unaltered surfaces of the flake. The rounded edge was 0.3 mm thick. Snap fractures along the edge were as much as 3 mm in width, and these too were rounded.

Andesitic Basalt

III (54°, 53°, 55°): 38 mm
straight but slightly serrated, slightly convex/irregular, s, no abrasive

This tool was not very efficient. Fracturing along the edge during the first 200 cm of cutting gave it an irregular profile. At 332 cm the edge was blunting although the tool could still be used. Blunting continued until 537 cm of skin was cut, and the job was terminated at this point because of the tool's inefficiency. At this time the edge was feather/hinge fractured on both margins and these fractures were smoothed. The edge was well rounded to a thickness of approximately 0.3 mm.
Orthoquartzite

I (15° approx.): 26 mm
irregular, s/s, irregular, no abrasive

The edge immediately began to snap fracture and degrade through grain or grain aggregate detachment. The job was terminated when 235 cm of skin had been cut. The tool was not very efficient and line of cutting was ragged. No identifiable wear was observed as the material was too granular.

Orthoquartzite

II (35°, 35°, 37°): 28 mm
irregular, irregular/irregular, irregular, no abrasive

Snap fractures 1.5 mm and less in size appeared within the first few minutes of use. The job was terminated at 150 cm of cutting as the tool was clearly of unsuitable material. The cut marks on the skin were very ragged. When the job was terminated use-wear comprised small fractures that would not normally be identifiable on a prehistoric tool, and edge rounding on a 1 mm projection.

Orthoquartzite

IV (70°): 12 mm
irregular, irregular/irregular, irregular, no abrasive

After 10 cm of cutting, the irregularities on the working edge were worn away and its profile was now slightly undulating. After another 2 cm of cutting a large 3 mm piece broke off the edge (apparently due to a flaw in the rock). At 22 cm very small irregularities again appeared along the edge. These fractures were mostly less than 1 mm. At 140 cm the tool did not cut properly and the job was terminated. No wear was properly identifiable as such. The tool's effectiveness in this task was very poor.
Quartz

II: 20 mm irregular, s/s, s, no abrasive

The tool was used effectively for 60 cm with minimal edge fracture. Over the next 20 cm, 2 mm fragments broke off the working edge leaving it with a jagged profile. The edge became concave for a length of 10 mm and the smallest fractures were concentrated inside this depression. The tool was ineffective at approximately 100 cm of cutting and the job was terminated.

![Diagram]

Carbonate

II (31° approx.): 26 mm convex and irregular, irregular/irregular, s, no abrasive

The tool was totally unsatisfactory for cutting skin as the artifact material was too soft. Only a 5 cm cut was made before the edge severely snap fractured.
AWLING DRIED KANGAROO SKIN

#138 Volcanic Tuff
31 mm:18 mm

With the first penetration the apex (1 mm length) snapped off. At the 144th penetration 3 mm of the broken tip broke off. The tool was no longer effective and the job was terminated. Microscopically the contact edges along the tip of the awl were visibly dulled.

#139 Volcanic Tuff
54 mm:16 mm

The tool was very effective for 160 penetrations, at which point the tip snapped and the job was a little more difficult. At 369 penetrations the tip snapped again leaving a minute 'burin' spall (plate 99). Job discontinued at 1,000 penetrations of the skin.
The tip snapped off. The job terminated at 1,500 penetrations although the tool was still functional. There was no use-wear other than fracturing along the edges.

At 247 penetrations the tip snapped off less than 1 mm from the apex although the tool was still functional. Job terminated at 500 penetrations. No fracturing along the contact edges but they were very moderately blunted.
At 509 penetrations the tip of the awl snapped. The job was continued to 1,000 penetrations although the final 200 necessitated more effort. The tool was still functional at termination. Although striations were not visible to the naked eye, even after the tool was scrutinised closely, they were detected with a low-powered microscope and properly angled light. Long (up to 8 mm) subparallel striations, of unknown type but all very fine, ran from the snap platform down the three lateral faces. One face in particular was heavily striated (see plate 98). These striations were probably caused by undetected particles of fine sand which had stuck to the skin while it was drying.

### Obsidian

31 mm:5 mm

There was evidence of use-wear on this tool after 500 holes had been made in a range of skin. During the time that the tool was used to punch 500 holes in the skin there was a noticeable decrease in its efficiency. However, at termination no use-wear was detected.
#143 Obsidian

32 mm:12 mm

Two grams of sand

At 215 penetrations the tip snapped 1 mm from the apex. Small fractures appeared on the edges. The job was discontinued at 250 penetrations because it was not working effectively. Abrasion could be seen along the obtuse edge (see illustration and plate 100).

#144 Silcrete

34 mm:5 mm (64°, 92°, 92°)

There was no identifiable use-wear on this tool after 500 holes had been punched in a kangaroo skin.

#145 Olary Chalcedony

32 mm:4 mm

During the time that the tool was used to punch 500 holes in the skin there was a noticeable decrease in its efficiency. However, at termination no use-wear was detected.
#146 Radiolarian Chert

30 mm:5 mm

Fracturing of the tip began almost immediately but ceased after only a short while. After 119 holes had been punched, the tool was deemed to be performing poorly and the job was terminated. Fractures were the only form of use-wear detected.

#147 Chert

29 mm:6 mm Angles: 61°, 45°, 110°

During the first 100 penetrations minute fractures (0.2 mm) occurred along the two acute edges. At 152 penetrations the tip snapped, leaving a triangular stub 1 X 1 X 0.5 mm. Job terminated at 1,000 penetrations although the tool was still functional.

#148 Rhyodacitic Volcanic

40 mm:12 mm

On the second penetration into the skin the apex of the awl snapped off, but this did not inhibit the tool's effectiveness. Microfractures (1 mm) appeared during the first 75 penetrations. After the skin had been pierced 500 times no wear other than fractures had developed and the awl was still quite effective.
#149 Altered Basalt

Angles 43°, 84°, 82°

At 380 penetrations the tool’s efficiency was reduced though it was still effective. At 500 penetrations when the job was terminated the only use-wear observed under the microscope was a shallow step fracture 1.5 mm long at the apex.

#150 Olivine Basalt

Angles: 89°, 59°, 39°

The tool worked well for 32 penetrations but then the tip snapped and the awl could no longer be used. The triangular stub that remained measures 3 x 2 mm.

#151 Andesitic Basalt

Angles: 70°, 80°, 65°

The tip snapped in attempting the first penetration. However, as the tool was still effective the job was continued until 500 penetrations were done. Use-wear was not well developed and there was nothing else besides the snapped tip.
#152 Orthoquartzite

Angles: 78°, 69°, 69°

After 100 punches more effort was needed to properly pierce the skin. At 300 penetrations the tool was inefficient. The job was terminated at 500 penetrations. Use-wear was not identifiable because of the granularity of the rock material.

#153 Volcanic Tuff

43 mm: 7 mm

Angles: 58°, 100°, 48°

On the first penetration the tip snapped off less than 1 mm from its apex. Before 10 penetrations had been effected 4 snap fractures, measuring about 1.5 mm each, appeared on the 48° edge. No further use-wear was sustained during the following 900 penetrations. The tool was still quite functional when work ceased.

#154 Flint

35 mm: 24 mm

Angles: 40°, 50°, 72°

After 1,000 penetrations only a 0.2 mm feather fracture at the apex suggested that the tool had been used at all.

#155 Olary Chalcedony

50 mm: 18 mm

Angles: 62°, 30°, 79°

After 1,000 penetrations the only evidence of use was an 0.1 mm triangular snapped platform on the tip.
SAWING BONE

#156 Volcanic Tuff
II: 22 mm
s, s/s, slightly concave, no abrasive

Within 5 minutes the edge had fractured bimarginally. Blunting of the working edge was noticed before 10 minutes of sawing had elapsed. At 25 minutes the tool was not sawing properly and the job was terminated. No trace of the original concave profile remained. The larger fractures (see diagram) were mostly of the snap and hinge varieties. Within these larger fractures were finer feather, hinge and retroflexed hinge fractures, often overlapping, and situated along the side of the edge from which the larger fractures had been initiated. If the large fractures did not alternate this damage could easily be confused with retouch (see plate 101).

#157 Volcanic Tuff
II: 40 mm (reduced to 37 mm)

serrated by snap fractures 1 mm no more than 1 mm wide, convex/s, s, no abrasive

This tool was used in a skin cutting experiment before being employed to saw bone (see p. 518). All traces of wear resulting from the previous experiment were obliterated by the bone sawing damage. The tool was used for 16 minutes and the job ended before the tool became inefficient. The edge was considerably widened by the snap fracturing - as much as 1.6 mm. The spurs were small.
and their tops were rounded. Small feather/hinge and step fractures 0.2 mm and less in size were located on the walls of the large snap fractures. Usually this involved one edge of the back wall of the large fracture but sometimes both edges were involved. White material (carbonate) from the bone and also possibly residue from the skin was compacted into fractures and depressions.

Volcanic Tuff

III:25 mm (reduced to 22 mm)

s, slightly concave/s, slightly concave, no abrasive

This tool was used to saw grooves 2 mm deep for a period of 40 minutes. At termination the tool's efficiency was greatly reduced. The use-fractures were nearly all hinge with very small step and feather/hinge types within these larger fractures. The fracturing caused the edge to widen to about 1 mm. Spurs between larger fractures were well rounded and some of these rounded projections were indented with fine overlapping step fractures. Fractures were predominantly found on the concave margin of the edge and here the curvature of this side may have been an important influence on the positioning of fractures. Moderate smoothing was observed around the edges of large hinge fractures.
Volcanic Tuff

V: 42 mm
s, s/convex, wavy, no abrasive

This tool could only penetrate about 1.5 mm into the bone because the angle of edge was too great. The width of the cut was about 2 mm. After 30 minutes of sawing the edge was quite irregular and was noticeably more dull than when first used. The tool however, was still effective. The job was terminated after 75 minutes at which time the tool could still saw, but not well. At termination the edge of the tool was examined under a microscope. Step fractures tended to be deep, often with complex terminations (plate 103) - back walls broken into two or three ridges. Spurs between fractures were usually rounded but smoothing was not pronounced. Carbonate material from the bone was compacted into the fractures.

Flint

II: 28 mm
slightly irregular, s/s, s, no abrasive

The edge began to snap fracture and crumble immediately. At 8 minutes major fracturing (2 mm+) had occurred at several points along the edge. Smaller fracturing increased the size of these concavities so that eventually the edge became very uneven. By 54 minutes the tool was no longer efficient and the job was terminated. At this point the edge was widened to about 1.5 mm by snap and feather/hinge fracturing. Smaller fractures were situated on the walls of large snap fractures. These small fractures were compacted with carbonate derived from the bone. Spurs between larger fractures were worn and rounded.
Within 1 minute of rapid sawing 3 flakes (1 mm, 1.1 mm and 2 mm) snapped from the edge. After another 30 seconds the edge began to break up with complex feather/hinge, step and snap fracturing. It was noted that some of the detached fragments lodged in the sawn groove and further damaged the working edge of the tool. After another 5 minutes the spurs were breaking down and the edge was beginning to lose its serrated profile. By 24 minutes the edge width varied from 0.4 mm to 1 mm although it was still quite usable.

Fracturing reinitiated along the working edge by 45 minutes - mostly feather/hinge. At 65 minutes the edge still cut into the bone but not efficiently, so the job was terminated.

The fracturing on the edge was bimarginal, with finer step fracturing on the walls of these larger fractures, usually along the proximal edge. Carbonate from the bone was compacted into these fine fractures. The large fracturing had widened the edge to about 1 mm. Prominences between large fractures were rounded.
Within the first few seconds tiny hinge fractures up to 0.5 mm wide appeared on both sides of the working edge. Fracturing continued so that in only 6 minutes the edge took on a typical 'bone-saw' profile. At 10 minutes of sawing it was noted that the tool, because of its obtuse edge angle, could only cut about 1 mm to 1.5 mm into the bone - not a deep incision at all. The edge ceased to fracture and stabilised at 20 - 30 minutes. Although the tool was still functional the job was terminated at 30 minutes. It was seen under the microscope that the edge was widened in some places by very fine fracturing right on this broadened edge. The edge was wavy.


#163 Obsidian

II: 32 mm (originally 27 mm)
s, s/s, s, no abrasive

Both large and small (1 - 3 mm) fractures appeared on the working edge within 90 seconds of use, giving the edge a very irregular profile. These fragments of the edge were breaking off in the 1 mm deep groove. While the initially fresh, sharp edge cut quickly into the bone the serrated edge could also cut into the bone, although not as efficiently. After 6 minutes had elapsed the edge measured 1 mm across, due to the continued fracturing. Larger or prominent spurs had been worn down by micro-fracturing and the working edge appeared much less serrated. The job was terminated at 10 minutes when the tool ceased to function properly. Severe snap and feather/hinge fracturing had widened the edge to between 1.5 mm and 1.7 mm in places. Within these large fractures there were minute (0.2 mm) step, hinge and retroflexed hinge fractures. The tops of the spurs were degraded by very fine step and what appeared to be hinge fractures. This wear pattern was very well defined and characteristic although the tool was not as efficient as bone saws made from other materials.

#164 Silcrete

II: 18 mm
convex and very irregular, roughly straight/roughly straight, straight, no abrasive

Initially the tool worked well but its performance rapidly deteriorated. Within 5 minutes the edge had snap fractured
and crumbled. These snap fractures increased in size or were replaced with larger fracturing as work proceeded. The tool ceased to work properly at approximately 15 minutes and the job was discontinued. Fracturing was the only identifiable wear form. These fractures were compacted with carbonate which could not be easily cleaned off.

Silcrete

III:20 mm (reduced to 17 mm after use)

s, slightly concave/irregular, slightly curved, no abrasive

The edge did not immediately begin to break down macroscopically; only after 6 minutes did the first snap fractures appear. Over 43 minutes of sawing, approximately six snap and feather/hinge fractures (1 mm+) occurred, and enlarged with crumbling of their edges. Grain detachment on the edge eventually caused the tool to become inefficient. The edge was widened by the fracturing. Minute fractures were observed within one of the clefts and a couple of the other larger fractures. Not all the fractures were identifiable because the silcrete was roughly textured. There was some microcracking on the widened edge and modest edge rounding on projecting parts.
Olary Chalcedony

**II: 12 mm**

- s, s/very slightly convex, wavy, no abrasive

Within a minute after commencing work the tool's edge began to snap fracture. While this fracturing was quite severe, the spurs between fractures were not pronounced. Initiation of these fractures was on the straight margin. The job was terminated at 15 minutes when the tool was no longer functioning. Edge width at termination was about 1 mm but the damage pattern was not distinctive. Fine fracturing was observed in only the 6 mm snap fracture on the righthand end of the working edge.

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Olary Chalcedony

**III: 23 mm**

- convex (3 mm), s/slightly concave, s, no abrasive

Within a minute of sawing the edge snap fractured along most of its length. The fractures were no wider than 1 mm. In 6 minutes the fractures joined up to form snap-like concavities 2 - 5 mm wide. At 20 minutes it was noticed that the spurs were beginning to wear down although the edge was still jagged. These spurs continued to cut into the bone and it was evident that this chalcedony was a suitable material for the task as it produced a clean and even cut. At 35 minutes of use, two flakes (1.5 mm each) were detached from the edge. At 40 minutes the tool failed to cut a new groove cleanly so the job was terminated. The original convexity of the edge was eliminated by the snap fracturing and it ended with a very irregular profile. The width of the edge was increased to as much as 2 mm in places. The snap fractures bordered on transitional snap-feather types and if one did not take account of the irregularity of the edge
they appeared similar to abrupt retouch. Under the microscope it was seen that these fractures were initiated from both lateral margins and there were many step and feather/hinge fractures inside them. Carbonate was compacted into these fine fractures. Blunting and very moderate rounding was detected on the spurs between the large snap fractures.

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**Radiolarian Chert**

II:48 mm

convex, s/s, s, no abrasive

The fine edge began to snap fracture almost immediately and it quickly took on a serrated appearance. Fragments and particles also broke free from the edge when pressure was applied. The tool continued effective sawing for 18 minutes by which time the spurs had worn down and the tool became inefficient. The job was terminated at this point. At termination the edge profile was very irregular and the edge widened to 1.0 mm to 1.5 mm through deep snap fracturing (plate 103). There were numerous fine, shallow and complex step, and the occasional retroflexed hinge fractures situated on the walls of the larger snap fractures (plate 102).
Rhyodacitic Volcanic

III: 53 mm
s, s/s, s, no abrasive

After 2 minutes of use ten hinge fractures each approximately 1 mm wide, were counted on both margins of the working edge. The tool lost its usefulness in this task in 12 minutes and the job was terminated. Widening of the edge through snap feather and hinge fracturing was as great as 1.5 mm. Another feature that occurred and which is typical of bone saws was the waviness of the working edge. As the stone was roughly textured it was difficult to define the finer fractures but it was recognised that some did exist within the large hinge and snap fractures. Carbonate was compacted into the fractures and depressions in the surface of the lateral margins. Some spurs were blunted, others rounded.

Altered Basalt

I (15°): 20 mm
irregular, irregular/irregular, irregular, no abrasive

The edge snap fractured but the scars could not be easily distinguished because of the rough texture of this basalt. Once the edge stabilised the tool could be used reasonably efficiently for a few minutes until all the prominent parts of the edge were well rounded and smoothed. Total time of use was only 6 minutes.
Andesitic Basalt

III:22 mm

straight but slightly jagged, slightly concave/slightly convex, no abrasive

Immediately the edge snap fractured, initiation being on the convex face. This pattern had stabilised when the edge was examined at three minutes. From this point on fracturing ceased and the spurs began to blunt and round. The tool gradually became less efficient until at 12 minutes the job was terminated. A few small fractures were detected in the large snap fractures and these were compacted with carbonate derived from the bone.

Olivine Basalt

II:25 mm

irregular, irregular/irregular, roughly straight, no abrasive

Within 5 minutes the edge fractured along part of its length. Snap fractures became larger, probably because they jointed up through crumbling of some spurs. At 16 minutes sawing efficiency was decreased to some degree but the tool was still fairly acceptable. The job was terminated at 40 minutes when the tool was sawing poorly. Snap and snap-feather or feather fracturing along the edge had increased its width to 1 mm. These fractures were initiated on both margins. The prominent parts of the edge, between major scars, were rounded but this would probably not be identifiable on an equivalent prehistoric tool.
This tool worked for a considerable time and the granularity of the quartzite may have assisted in the sawing. The used edge was irregular because of snap fracturing and detachment of grains or fragments. The job was discontinued at 100 minutes when the tool's efficiency was much reduced. Snap fracturing had widened the edge to 1.2 mm. Spurs were rounded but not smoothed. Fine fractures were not identifiable if they occurred. This tool would not be identifiable as a bone saw if the wear pattern was the sole evidence of its function.

After about 3 minutes of sawing the edge began to lose its sharpness because of use-fracturing. About seven minutes later pieces of edge began breaking away, and in a further four minutes the pieces increased in size to 2 - 3 mm and formed a depression 6 mm long. However, after 8 minutes the tool was broken and the edge measured 31 mm. The cutting edge was almost jagged and the efficiency of the working edge was significantly reduced. About 20 minutes after the first four minutes the edge had been broken out in the 1.5 mm deep groove sawn into the wood. The working edge then
progressively dulled and the spurs wore down. The job was terminated at 45 minutes when the tool was definitely not working effectively. The working edge at this time was 0.5 mm wide and prominences along its length were blunted. Bimarginal snap and feather/hinge fractures were poorly defined. This wear pattern would not be identifiable as bone saw wear on a prehistoric tool.

**#174 Orthoquartzite**

\[ V(85^\circ - 98^\circ):37 \text{ mm} \]

s, s/variable, irregular, no abrasive

The edge of this tool cut a broad groove in the bone - as much as 4 mm wide at the top of the 'V'. It did not saw particularly well; certainly not as well as bone saws with more acute edge angles. Some use-flakes were detached but the scars were not really recognisable on this granular material. These scars were on both sides of the working edge. Reduction of efficiency was noticed quite early and the job was terminated at 12 minutes. The wear pattern would not be identifiable as such on a prehistoric specimen.

**#175 Quartz**

\[ \text{III}(50^\circ):40 \text{ mm} \]

irregular, irregular/s, irregular, no abrasive

After about 3 minutes of sawing the edge began to lose its sharpness because of use-fracturing. About seven minutes later 1 mm pieces of edge began breaking away, and in a further five minutes the pieces increased in size to 2 - 3 mm. The scars merged to form a depression 8 mm long. However, even after this severe damage the cutting edge was almost as effective as when the experiment was begun. At 18 minutes the profile of the working edge was jagged. By 23 minutes the jaggedness was less and the edge measured 1 mm in width. Fragments of quartz broken from the working edge lodged in the groove. The job was terminated at 25 minutes when efficiency was significantly reduced. At termination there
was complex fracturing along the working edge comprising most feather/hinge fractures but also snap and step fractures. These fractures ranged down to less than 0.2 mm in size. Many smaller fractures were seen lying within the large fractures, and these were often compacted with carbonate from the bone. The fractures were too complex to draw accurately.

DRILLING KANGAROO BONE

#176 Volcanic Tuff

(65°, 39°, 85°): no abrasive

The tip fractured but the tool continued to cut into the bone until a hole 3 mm deep had been drilled. A new hole could not be started. The apex was reduced to a ridge covered with overlapping step fractures, mainly remnant termination areas. The edges leading up to this ridge were fractured (step, hinge, feather and retroflexed hinge; see plate 106). Total time of use was 6 minutes.

#177 Volcanic Tuff

(70°, 74°, 84°): no abrasive

The tool was not effective in this operation. The apex of the point progressively fractured and it did not develop cutting edges. The tool's inefficiency could be attributed to the fact that the tip was not sufficiently robust. Total time of use was 4 minutes.

#178 Flint

(49°, 68°, 99°): no abrasive

The tip immediately fractured and within a few moments a stub 5 mm wide had developed. The tool was not at all effective in this operation.
#179 Obsidian

(58°, 58°, 75°): no abrasive

This tool performed very poorly, only one hole to a depth of 1 mm being drilled. The tool was even ineffective in widening an existing hole. Immediately on commencing work the tip of the drill fractured off. At termination the edges leading to the platform that formed the apex sustained dispersed snap and step fractures up to 3 mm wide.

#180 Silcrete

(57°, 78°, 81°): no abrasive

In drilling the first hole the tool could penetrate only 1 mm into the bone in 2½ minutes. The new hole was drilled to a depth of 1.5 mm, an effort that took 18 minutes. The edges leading to the tip were fractured and the tip had become rounded and blunt. After a further 15 minutes of drilling the tool penetrated through to the marrow cavity. Wear in the form of fracturing and blunting continued. In drilling a third hole the tool took 30 minutes to penetrate 2 mm into the bone. The edges leading up to the rounded apex continued to fracture. The job was discontinued although the tool could still be used at this much reduced level of efficiency. At termination the apex of the drill was fractured back to a granular stub. All the fractures were ill-defined but abrasive smoothing was clearly evident on the projections on top of the apex and along its sides. Projections in this area were rounded to as much as 0.3 mm. This wear resulted from much longer than normal usage of the drill.

#181 Olary Chalcedony

(50°, 70°, 78°): no abrasive

The tool was used to drill only one hole 3 mm deep. The operation was considered a success but took 32 minutes, after which time the tool was no longer working effectively. Fracturing of the apex was minimal but further details on the wear are not available.
#182 Radiolarian Chert

(81°, 81°, 81°): no abrasive

Within the first minute the tip was fractured and this damage continued for another 3 minutes. The hole drilled was 7 mm in diameter but only 2 mm deep, and the performance of the tool was judged to be very poor. All three edges leading to the fractured apex were step and feather fractured—mostly very fine step (0.1 mm), but one feather was 4 mm wide.

One of the faces sustained very little fracture damage.

#183 Chert

(35°, 80°, 84°): no abrasive

Within 2 minutes the tip was fractured down to a stub and the tool became ineffective. It had made very little impression on the bone.

#184 Rhyodacitic Volcanic

(35°, 44°, 76°): no abrasive

After 3 minutes the tip shattered depositing small fragments of stone in the small hole that was being drilled. This debris acted as an abrasive for about 5 seconds until the fragments were expelled with the bone shavings. After a further 15 minutes of drilling the apex of the drill was considerably worn, but without achieving a great deal. During this entire period of use a hole only about 1.3 mm was drilled, and towards the end of the job this hole was becoming wider rather than deeper. At termination the apex comprised a ridge with two rounded prominences, each 1 mm wide. Down the two sides of this ridge were step fractures each 1 mm - 1.5 mm wide.
#185 Rhyodacitic Volcanic
(50°, 86°, 91°): no abrasive

After 2 minutes the tip began to break down. A 1 mm flake broke off one edge close to the apex. After another 15 minutes another 1 mm step fracture appeared next to the first. At 30 minutes only 3 holes 1.5 mm deep had been drilled and as the tool was not working well the job was terminated. The apex of the tool was rounded and smoothed to an oblong shape 1 mm X 0.5 mm. Two of the edges leading to the apex were rounded; the 91° edge for 4 mm and the 50° edge for 3 mm. The latter edge was also step fractured on one of its margins within this rounded section and the rounding was pronounced on spurs between these fractures.

#186 Altered Basalt
(66°, 78°, 86°): no abrasive

This tool only began to cut into the bone after the tip was fractured off. It was then able to drill a hole 1.2 mm deep but became ineffective after 3 minutes. At termination the apex comprised a smoothed and rounded ridge, quite stub-like, 1 mm wide and 3 mm long.

#187 Andesitic Basalt
(41°, 78°, 85°): no abrasive

The drill did not work very well, the tip rapidly blunting and rounding. Only one hole 1.2 mm deep was drilled before the tool became ineffective. At termination the stub-like apex was well rounded, measuring 1 mm by 1.5 mm (see plate 107). Rounding extended down the 41° edge for 4 mm.

#188 Olivine Basalt
(47°, 64°, 87°): no abrasive

Rapid breakdown of the drill tip began immediately. The tool did not perform well being only able to drill one hole 2 mm
deep before becoming ineffective. At termination the apex was rounded by moderate smoothing and grain detachment to a stub measuring 1 mm X 2 mm. There were poorly defined step fractures (1 mm) on one face.

#189 Orthoquartzite

(51°, 57°, 104°): no abrasive

This tool was not effective. The tip was reduced by grain fracturing and detachment so rapidly that in 4 minutes the drill was ineffective. At termination the apex was rounded but not polished or smoothed, although there were small patches of 'frosted' smoothing. Fractures were not identifiable.

#190 Quartz

(65°, 68°, 69°): no abrasive

The tool was of no use in beginning a hole but it was moderately effective in enlarging existing ones. The point immediately broke and 'shattered' when an attempt was made to drill a hole. At termination the tip was reduced to a stub, 1 mm wide, rounded by a minute fracturing. A spall 3 mm wide and 15 mm long was initiated from this stub and spread down one of the faces. On two opposing edges, for a distance of 2 mm from the apex of the drill, there were concentrations of overlapping step fractures. This fracturing was bifacial and it gave these parts of the edges very irregular profiles.

#191 Volcanic Tuff

no abrasive

This drill was not very efficient. It began to fracture after one minute of use and could only drill a single hole. However, it was moderately effective in enlarging other pre-
existing holes for 4 minutes before ceasing to be effective even in this task. At termination the edges forming the apex were bifacially fractured, with a complex arrangement of feather and step fractures giving these edges a very irregular profile. Some of the projections in these areas were moderately smoothed and rounded.

"Volcanic Tuff"

(46°, 70°, 75°): no abrasive

The tip of the drill began immediately to fracture and within 15 to 20 seconds only a stub remained. The tool continued to work for six minutes. At termination there were numerous overlapping step fractures along the apex of the drill point and macroscopically this damage resembled that on bipolar cores. A concavity 1 mm deep and 7 mm long was fractured into one of the lateral edges which was angled at about 75° to the stub-like apex (see diagram).

There was moderate rounding (0.1 mm) of some projections on the apex.
The contact faces of the drill immediately began to fracture with fragments broken from the tip lodging in the hole and acting as an abrasive. The tool worked well for 30 minutes. At termination all three edges were bifacially fractured with feather/hinge and step types (some overlapping) and moderate edge rounding on projections between these fractures. One of the large feather/hinge scars had a deep initiation surface that was minutely fractured inside and appeared similar to a retouch scar. The extent of this fracturing from the apex was around 5 mm. The tip of the drill was minutely fractured and reduced to an irregular stub measuring 0.5 mm across. These small fractures were compacted with carbonate.

This tool was not efficient and after only 30 seconds it would not drill effectively. However, fracturing had begun immediately on commencement of work and at 90 seconds this damage had altered the edge sufficiently for it to work again. After 5 minutes the tool was inefficient and the job was terminated. At termination the tip was fractured down to a stub about 1 mm wide (plate 105).
#195 Obsidian

(54°, 62°, 100°): no abrasive

The tip immediately snapped and began to fracture. The tool was not successful as it could not drill a hole completely through the bone. At termination there was complex fracturing on two of the three faces. The tip was completely removed by fracturing.

#196 Silcrete

no abrasive

This tool was extremely efficient and it was used to drill ten holes in the turtle shell. Fracturing of the tip began when the first hole was drilled. By the third hole the edges leading to the apex were noticeably fractured and the apex itself had taken on a rounded profile. By the ninth hole fracturing had ceased and efficiency was noticeably reduced. At termination a ridge on the apex of the drill was smoothed and rounded and a small section of the 69° edge which had not been fractured away was also rounded and smoothed.

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#200 Volcanic Tuff

(55°, 71°, 83°)

Seven holes were drilled in 2 minutes. The first hole took one minute to drill and each successive hole took a progressively longer time to complete. At termination the drill was worn down to a rounded, smoothed shape.

Rounding and smoothing continued along the lateral edges for...
Orary Chalcedony  
(63°, 70°, 70°): no abrasive  

This tool was used to drill a hole through a thick part of the turtle shell so the depth of the hole was 3.5 mm. The tool was not able to start a new hole. At termination the apex consisted of a ridge 2 mm long with a feather scar on each lateral face. There were also a few small feather fractures along one of the edges leading up to the apex.

Altered Basalt  
(69°, 71°, 96°): no abrasive  

This tool was used to drill one hole through the turtle shell. No further drilling could be achieved. At termination the apex of the drill was an irregularly shaped stub with moderate smoothing on its prominent parts. There were also some ill-defined fractures on the edges at the apex.

Orthoquartzite  
(75°, 77°, 85°): no abrasive  

The tool was not able to completely drill a hole and clearly the artifact material was unsuitable. Micro-fractures were ill-defined and not easily identifiable.

Volcanic Tuff  
(55°, 71°, 83°)  

Seven holes were drilled in 20 minutes. The first hole took one minute to drill and each successive hole took a progressively longer time to complete. At termination the apex of the drill was worn down to a rounded, smoothed stub. Rounding and smoothing continued along the lateral edges for...
a distance of 2 mm from the apex. The 55° edge also sustained on both its margins some shallow step fractures, for a distance of 4 mm from the apex.

#201 **Obsidian**

(32°, 42°, 50°)

Severe fracturing began within the first few seconds of use and fracturing continued for at least 15 minutes. Fragments and flakes from the drill tip acted as an abrasive which contributed to the damage on the tool. The job was terminated when on the third hole the tool failed to drill completely through the shell. At termination the apex was somewhat rounded by extremely fine microfracturing (plates 113-115) and the three lateral edges were flattened and highly abraded as they met on the apex. Remnants of hinge and step fractures could be seen along the abraded apex.

#202 **Rhyodacitic Volcanic**

(55°, 80°, 80°)

The tool failed to cut into the shell and the apex simply rounded and smoothed.

#203 **Andesitic Basalt**

(4 lateral edges; all approx. 90°)

The tool failed to initiate a hole. When it was used to widen a hole, the apex rounded and smoothed. This wear continued along the lateral edges for 2 mm from the apex.

#207 **Obsidian**

(50°, 57°, 102°)

One hole was drilled before the tool ceased to work effectively. The apex of the drill was heavily fractured and stub-like.
DRILLING NAUTILUS SHELL

#204 Volcanic Tuff
(63°, 66°, 83°)
The tool failed to initiate a hole and in the attempt the apex of the drill suffered considerable fracture damages. These fractures were confined to the top-most 4 mm and they consisted of complex overlapping step on two faces and a large feather on the third. The apex was rounded to a ridge (0.5 mm wide) spanning two of the lateral edges. Projections on the fractured apex, as well as the ridge were rounded and smoothed.

#205 Flint
(60°, 82°, 96°)
One hole with a diameter of 6 mm was drilled in 12 minutes. After drilling this hole the tool could not initiate a new one. The apex of the drill was fractured (plate 109).

#206 Flint
(54°, 84°, 93°)
The tool was used to drill 6 holes, each 5 mm in diameter. In drilling the first hole the apex was fractured and the drill tip took on the typical stub-like appearance. The experiment ceased when the tool could no longer work. At termination the apex was rounded by complex fracturing. The margins of the use-fractures acted as cutting blades and were compacted with carbonate (plate 110).

#207 Obsidian
(50°, 57°, 103°)
One hole was drilled before the tool ceased to work effectively. The apex of the drill was heavily fractured and stub-like.
Radiolarian Chert

The drill tip immediately began to fracture and it failed to initiate a hole. It was then used to enlarge a pre-existing hole. This use resulted in severe fracturing (plates 111, 112).

This schematic diagram is simplified and does not depict fractures smaller than 1 mm.

Chert

The drill tip immediately fractured to a rounded stub and it failed to initiate a new hole. It was subsequently used to enlarge a pre-existing hole. At termination the apex of the drill was stub-like with flaked concavities along all three lateral edges. There were some very small step fractures on the stub itself.
### Rhyodacitic Volcanic

Three holes were drilled before the tool became ineffective. At termination the apex was rounded as were prominent areas of the lateral edges. Some fractures were difficult to identify because of granularity (Plate 116).

### Orthoquartzite

(48°, 63°, 85°)

After 2 minutes of drilling the tip of the drill broke off leaving a ridge 2 mm long. The drill was not a successful tool as it failed to drill even one hole. At termination the fracture damage was indistinguishable from that which can occur on a fragment detached from a bipolar core. There were small areas of overlapping step fractures terraced down from the ridge but in general fractures were not easily identifiable on this material.
**DRILLING BALER SHELL (HAFTED)**

#212 Volcanic Tuff

(53°, 63°, 85°): no abrasive

Immediately on commencing work the tip of the drill-point snapped off 1 mm from its apex. The tool did not perform very well in initiating a hole but it was effective in widening existing holes. After 3 minutes of this use there were some minute fractures along all three of the lateral edges. By 6 minutes the drill was even inefficient in carrying out this task and the job was terminated. All the edges were step fractured (including one hinge type) for a distance of 6 mm from the apex. Some of these fractures were overlapping. Edge rounding (0.2 - 0.3 mm wide) was well developed between fractures along a 3 mm stretch of the 53° edge. Isolated areas of rounding appeared on the other two lateral edges as well. The apex was a flat snap platform measuring 1.5 mm across. The edges of this platform were moderately rounded (see plate 117).

#213 Flint

no abrasive

The drill failed to penetrate the shell as not enough load could be applied to the shaft. It was therefore used to enlarge an existing hole until the drill point no longer functioned properly. The tip snapped off when the drill was jarred while enlarging a hole.
#214 Olary Chalcedony

\(35^\circ, 67^\circ, 88^\circ\): no abrasive

In attempting to start a hole the tip of the drill snapped off 1 mm from the apex. The drill was then used to deepen a pre-existing 1 mm hole but within 3 minutes its tip had severely fractured and the tool became ineffective. At termination the tip was severely step fractured down one edge. Snap, feather/hinge and step fractures were situated along the top 4 mm of the 35° lateral edge. A rounded ridge ran across the two remaining edges of the apex and this gave it a rounded profile.

#215 Quartz

\(55^\circ, 84^\circ, 100^\circ\): no abrasive

The drill failed to initiate a hole in the shell and in the attempt the tip of the drill suffered considerable fracturing for a distance of 2 mm from the original peak. The drill tip was then used to widen a pre-existing hole but by 4 minutes the tip was severely fractured for a distance of 4 - 5 mm from its apex and it was no longer useable.

#216 Volcanic Tuff

\(68^\circ, 48^\circ, 109^\circ\)

The tool would not bite into the shell. The resultant damage from this attempt at drilling was fracturing which was similar to that on the percussion point on a bipolar core. The tip was snapped off leaving a flat ridge 3 mm long. Step fracturing extended 1 mm down the faces from the ridge.
Flint

The pyramid shaped point was immediately reduced by fracturing to a rather thick blunt stub which surprisingly was able to pierce the shell. A hole 4 mm in diameter through 2 mm of shell was drilled. The tool only began to work when the tip was heavily fractured - the edges of the scars acting as cutting blades. At termination the drill was still functional but its performance was not good.

Obsidian

(76°, 89°, 92°)

The tool was of no use in drilling this shell. Severe fracture damage immediately appeared and less than a minute later, when the tool was no longer effective, its tip was reduced to a stub by heavy compound fracturing. Areas of crushing or abrasion were seen along the broken and jagged ridges on the apex.

Silcrete

(52°, 56°, 62°)

Within the first 2 minutes of use the tip of the drill began to break down. Further fracturing ensued until at 20 minutes the first hole had been completed. Upon penetration of the
shell, when the second hole was being drilled, the point fractured to a rough stub, the apex being formed by the fractures that had previously been further down the edges of the shaft. An unsuccessful attempt was made to begin drilling a third hole. Total time expended in drilling was 37 minutes. At termination the drill tip was fractured down to a moderately rounded and smoothed ridge, 0.3 - 0.5 mm wide (plate 118). The three faces comprising the point were shallow step and feather/hinge fractured for a distance of 8 mm from the apex of the drill. Projections on the lateral edges within 5 mm of the apex were smoothed rounded. Carbonate was compacted into small scars.

#220 Olary Chalcedony
(36°, 55°, 122°)

This tool could not successfully drill in this thick shell so it was used to enlarge a pre-existing hole. At termination the apex was a stub, 1 mm thick. Small remnant fractures on this stub were compacted with carbonate.

#221 Altered Basalt
(72°, 77°, 91°)

The tool was not able to drill into Baler shell or successfully continue a pre-existing depression. The apex of the drill was immediately rounded (1.8 mm wide) and abrasion extended 3 mm down one face. Carbonate was compacted into small depressions in the surface of the drill tip.
Approximately three quarters of a kilogram of sweet potato was completely shredded in this operation. As soon as work began the working edge snap fractured. When work ceased the tool's efficiency was not noticeably reduced.

Approximately 1.8 kg of sweet potato were shredded. Snap fracturing occurred soon after the job was started. The spurs between these snap fractures were very degraded by the time work ceased. Along 5 mm of one end of the working edge there was rounding and the width of the edge along this section was 0.2 mm. The rest of the unfractured edge was moderately abraded and slightly bevelled on one margin but there were no striations.
**Volcanic Tuff**

III\(51^\circ, 48^\circ, 46^\circ\): 20 mm

very slightly convex (1.5 mm), s/straight to slightly convex, s, no abrasive

Two kilograms of sweet potato were shredded and in this time the working edge sustained extremely fine (0.2 mm) snap and feather/hinge fractures. There were no trace of polish at a magnification of 100X. The tool was still efficient when work ceased.

**Obsidian**

I: 40 mm

convex, convex/s, s, no abrasive

Three quarters of a kilogram of sweet potato were shredded. Very small snap and feather/hinge fractures appeared quite rapidly. The tool was still efficient when the job was terminated.

**Olivine Basalt**

II\(32^\circ\): 24 mm

slightly irregular, irregular/irregular, s, 10 grams of sand

Four and a half kilograms of sweet potato were shredded. After the job was terminated brown organic matter was observed adhering in the crevices and depressions on the contact surfaces of the tool. This material, probably mostly starch, was difficult to wash off. Two snap fractures, each 1 mm wide, occurred on the working edge but fractures were difficult to identify on this material. The
projections on the edge were well rounded with smoothing extending for about 1 mm in from the working edge. The edge was rounded to approximately a thickness of 0.2 - 0.3 mm.

#227 Rhodacitic Volcanic

I:35 mm
s, s/s, s, 8 grams of sand

Half a kilogram of sweet potato was shredded. Almost immediately the edge snap fractured along its entire length (average width 3 mm). Sand adhered to the wet shredding of potato and was consequently rapidly removed from contact with the tool.

#228 Carbonate

III:27 mm
s, slightly concave/s, slightly curved, no abrasive

One kilogram of sweet potato was shredded. Snap fracturing of the edge occurred during scraping of the first 0.5 kg. Fracture ceased and subsequently edge rounding and smoothing began developing. The tool was still functional when the job was discontinued.
SLICING SWEET POTATO

#229 Volcanic Tuff

I: 22 mm
slightly convex (2 mm), concave/convex, curved,
10 grams of abrasive added

The quantity of sweet potato sliced was 3 kg. Immediately on commencing work the fragile working edge snap fractured, especially when the flake was twisted during use. No edge blunting was discernable but I expect that with prolonged use, blunting could occur and it might even develop into rounding. The tool was still effective when the work ceased.

#230 Volcanic Tuff

IV(70°, 65°, 68°): 34 mm
convex (2 mm), s/slightly concave, slightly concave (1.5 mm), no abrasive

Two kilograms of sweet potato were sliced. The only use-wear was 2 feather fractures 0.5 mm in width.

#231 Obsidian

III(45°, 50°, 45°): 30 mm
wavy, s/s, s, 25 grams of sand

One kilogram of sweet potato was sliced. The sand was quickly removed from contact with the tool as it adhered to the slithers of potato. The use-wear consisted only of two fractures, a feather/hinge and a step, both less than 0.2 mm in size.
IV: 34 mm
s, s/very slightly convex, s, 30 grams of sand

Two kilograms of sweet potato were sliced. Minute feather/hinge fractures, each no larger than 0.25 mm appeared on one margin of the working edge. On the opposite margin the edge was heavily abraded and slightly bevelled to a width of about 0.2 - 0.3 mm. The working edge was otherwise rounded for its full extent and both coarse and fine striations (furrows and sleeks) extended back for up to 10 mm. These striations were not matched in sets and were angled from 90° to around 45° to the edge. Many of them intersected (see plates 123-128).

SPOONING BAKED SWEET POTATO

II (30°): 15 mm
s, s/s, s, 14 grams of sand

Seven and a half kilograms of sweet potato were spooned from their jackets. The soft sooked material offered no resistance to the tool and use-wear did not develop on its working edge.
CHOPPING GREEN LIGHT WOOD ACROSS THE GRAIN

#234 Volcanic Tuff

IV(75°, variable): 79 mm, 936 g
s, s/slightly convex, slightly curved, no abrasive

By 36 minutes the tool's efficiency was only slightly decreased and there was no fracture damage. As the chopping continued it was necessary to ensure that the angle of use was strictly around 90° as the tool would occasionally slide if the angle was at 75° or thereabouts. This was because the working edge was dulled. The tool was used to chop wood for 4 hours and 6 minutes at which point the operation was discontinued. The chopping tool was still perfectly serviceable. Edge blunting was evident during use because of reduced efficiency but not visible microscopically. Five very fine step fractures, all less than 0.3 mm in width, were scattered along the working edge but they may have been missed in the pre-use examination of the edge.

#235 Obsidian

III: 50 mm, 820 g
s, s/s, s, no abrasive

Almost immediately after commencing work the edge began to fracture and fragments of obsidian which had broken off the edge, lodged in the wood. These fragments may have contributed to subsequent damage to the working edge. There was no abrasion or striation. The fracture pattern was recorded at 5 minutes of use (diagram A). The operation was terminated at 15 minutes although the tool could still function reasonably well. The pieces or chips of wood detached from the wooden beam by blows with the chopping tool were much smaller than when the operation commenced. The fracture damage was severe.
The experiment was uneventful and it was terminated at 15 minutes of chopping although the tool was still perfectly efficient. The working edge was not blunt but given enough time this wear form would undoubtedly develop. The only use-damage noted after close microscopic examination was a few scattered hinge, feather and step fractures, all less than 1 mm wide. Some of these fractures have complex topographies at their areas of initiation.
Obsidian

V: 112 mm, 1077 g
s, s/s, s, 30 grams of sand

This tool was used in #236. Most of the sand was quickly shed from the wood because the wooden beam vibrated when the chopping tool struck it and also because the sand adhered the wood chips as they were removed. The tool sustained heavy abrasion during the 38 minutes in which it was used. By the end of this time the tool was bruising the wood out rather than cutting cleanly. It still however removed wood. The abraded surfaces extended along the whole length of the working edge and up one lateral face for about 10 mm and 4 mm on the other. The face with more extensive abrasion was on the side of the tool which had most contact with the wood (see plate 134-137). Demarcation between abrasion and striation on the less abraded face was quite clear, the transitional zone being only about 1 mm wide. Many of these striations were curved (plates 134-136). On the more highly abraded face definite striations first appeared just 1 mm to 2 mm above the working edge. Above the 10 mm wide abraded area there were many 'stray' striations (plate 135). Angles of the striations on both faces varied between 75° - 90° and many intersected or were curved around. Fractures from the previous operations were obliterated by abrasion (plate 138) and no new fractures were observed. The working edge was evenly rounded to a width of 0.5 mm.

Altered Basalt

IV(75°): 70 mm, 2015 g.
irregular, irregular/irregular, irregular, no abrasive

The chopping tool was effective in removing wood and there was no noticeable reduction in efficiency when the job was terminated at 40 minutes. The tool was then examined under the microscope. Fractures were not identifiable because of the irregularity of the edge and the coarse texture of the basalt. Edge rounding was quite definite but it was discontinuous, being restricted to prominences. The width
of rounded areas was 0.75 mm. Smoothing was found only on rounded areas. With continued use it is likely that rounding of the working edge would have become more extensive.

#239 Altered Basalt
IV(78°, variable): 80 mm, 1814 g.

fairly straight but roughly textured, s/s (one surface is a cleavage plane), roughly straight, 20 grams of sand

The tool came into contact with only a portion of the sand. It was used for 25 minutes by which time it was still functional. The working edge of the tool was rounded and smoothed along its entire length. The width of this rounded edge varied from 0.2 mm to 1.5 mm.

#240 Olivine Basalt
V(86°, variable): 51 mm, 3063 g.

irregular, irregular/irregular, slightly curved, no abrasive

The tool was used for 30 minutes until it bruised the wood rather than cut through it. It was not a very effective tool and I regarded the artifact material as generally unsuitable for this function. There were no identifiable fractures on the working edge and no other discernable traces of wear.

#241 Olivine Basalt
IV(72°, variable): 70 mm, 2779 g

concave and irregular, variable/variable, roughly straight, 20 grams of sand

The tool was used for 12 minutes during which time it did not perform particularly well. At termination use-fractures were not identifiable because of the rough texture of the basalt. It is probable that there were few use-fractures, if any. Edge blunting was pronounced and the width of the worn edge
was approximately 0.5 mm. Edge rounding was variable because the edge was irregular before tool use commenced. Where the edge was rounded there was also smoothing which extended up the lateral margins for as much as 3 mm (plate 133). No striations could be detected within this smoothing. Smoothing was most pronounced on the prominent parts of the edge and depressions were not abraded or smoothed.

**#242 Orthoquartzite**

\[ V(85^\circ - 95^\circ): 60 \text{ mm, } 710 \text{ g} \]

irregular, irregular/irregular, irregular, no abrasive

A heavier chopper would have been more effective although for the 65 minutes it was used the tool proved to be quite a serviceable chopping tool, and it could have been used for a much longer time. Under the microscope the working edge appeared moderately ragged but no definite use-fractures could be identified. A magnified side-on view of the working edge suggested that grains had been torn out. Edge blunting was evident and projecting areas on the edge were slightly rounded. With continued use, rounding would undoubtedly have developed further.

**#243 Orthoquartzite**

\[ V(85^\circ - 95^\circ): 60 \text{ mm, } 710 \text{ g} \]

irregular, irregular/irregular, 30 grams of sand

Prior to this experiment the chopper had been used in #242. This operation lasted 40 minutes during which time there was some reduction in the tool's efficiency. The tool could have been used for a much longer period, perhaps hours. Sand was quickly dispersed from the area of wood in which the chopping tool was continually striking. When work ceased, wear was difficult to identify. There were no distinct fractures - if they had occurred they were obscured by the granularity of the stone. The profile of the working edge was irregular but there was variable discontinuous edge blunting and rounding, and a moderate abrasive smoothing on portions of both lateral margins and especially on edge projections. The maximum width of the 'frosted' abrasive modification was 4 mm. The boundaries
of smoothed areas were ill-defined because of surface granularity, giving the smoothing a patchy appearance.

**#244 Carbonate**

&IV(68°):30 mm, 1588 g
irregular, s/convex, slightly curved, no abrasive

Quite unexpectedly this chopping tool during the first 10 minutes of use cut into the wood reasonably well although its efficiency did not approach that displayed by a volcanic tuff chopper. By 14 minutes the edge was reduced and rounded so that it ceased to cut properly and the wood fibre was being bruised out quite slowly. When work ceased there was edge rounding on a prominent 15 mm section of the working edge. Elsewhere, points of crushing and edge blunting could be seen. Some parts of the edge had crumbled away increasing its width in these areas to as much as 2 mm.

**#245 Carbonate**

&III(50°, variable):100 mm, 1010 g
irregular, irregular/irregular, wavy, 20 grams of sand

The tool was used for 15 minutes by which time it was battering out wood fibre rather than cutting it out. The edge had worn down before this time. When work ceased, edge rounding was very pronounced and the width of this worn edge varied between 1 mm - 2 mm. The lateral faces were smoothed: one face to a distance of 22 mm from the edge and the other for as much as 10 mm and as little as 4 mm. Striations were commonly aligned in sets and they were restricted to these smoothed surfaces. Angles of striations to the working edge varied from almost parallel to 75°. Some individual or sets of striations intersected.
CHOPPING MEDIUM LIGHT WOOD ALONG THE GRAIN

#246 Volcanic Tuff

\[ V(86^\circ, 87^\circ, 86^\circ) : 93 \text{ mm}, 795 \text{ g} \]

s, s/s, s, no abrasive

This tool was very efficient for the 65 minutes in which it was used and it could have continued in use for a considerable time. Edge blunting was almost imperceptible but with extremely long use rounding would undoubtedly develop. The working edge did not fracture. A brown film extended the full length of both lateral faces and clearly marked the area of the contact surfaces which had not been regularly in contact with the wood during chopping. Repeated high pressure contact with the wood removed any particles and moisture from the surface in the proximity of the working edge and the film was a distance from the working edge of 8 mm on one face and 10 mm on the other.

#247 Carbonate

\[ IV(65^\circ - 78^\circ, \text{variable}) : 30 \text{ mm}, 1248 \text{ g} \]

irregular, irregular/irregular, irregular, no abrasive

After 9 minutes of work the tool began bruising the wood rather than cutting through it. The tool only worked properly for the first 5 minutes. The only wear form on the tool was edge rounding 1.5 mm wide.

CHOPPING DENSE WOOD ACROSS THE GRAIN

#248 Volcanic Tuff

\[ IV(66^\circ) : 90 \text{ mm}, 1702 \text{ g} \]

convex (8 mm) straight to convex/convex, s, no abrasive

Severe fracturing of the straight face began almost immediately, and continued for four minutes, while at the same time the fractures that were appearing on the convex face increased in size. The total time of use was only six minutes. Fracturing had not ceased when the job was
discontinued, but it was evident that the tool's edge angle was unsatisfactory. The working edge profile was very irregular.

![Diagram](image)

Volcanic Tuff

V: 120 mm, 3743 g

see diagram A for edge profile, s/s, see diagram B for edge plan, no abrasive

At two minutes a large, well-defined feather/hinge fracture (9 mm) appeared on one margin, somewhat centrally placed, and a shallow step fracture (3 mm) appeared on the opposite face (see diagram C). Some 10 minutes later further large fractures appeared on one end of the first-mentioned margin. The tool was used for 40 minutes by which time it was still very effective in wood removal. When work ceased the edge was dulled. This tool was very heavy, a fact which should be taken into account when assessing the wear-pattern. The five large fractures on one end of the working edge probably occurred because the direction of the edge changed in plan and profile (see diagram A and B) so that it struck the wood at quite a different angle than the rest of the working edge.
CHOPPING GREEN AND DENSE WOOD ACROSS GRAIN

#250 Volcanic Tuff

V: 75 mm, 4195 g
s, s/s, uplifted on the righthand end; the upper face is composed of two fracture surfaces, 28 grams of sand

At 10 minutes a step flake broke from the edge, lodged in the wood and was shattered by the following blow to the wood. Also at about this time major step fracturing began to occur on the righthand end of the working edge, on the part that was angled away from the rest of the edge. This fracturing occurred because the edge at this part of the tool was not striking the wood at 90°. During the use of the tool, feather fractures progressively appeared along the rest of the edge. The job was discontinued at 15 minutes although the chopping tool was still quite serviceable. When work ceased the working edge was rounded and there was smoothing along the lateral margins for up to 2.5 mm from the edge.
Flint

V(86°, 85°, 86°): 57 mm, 907 g
irregular, s/variable, irregular, no abrasive

After 18 minutes of use this tool still had a sharp working edge with no use-fractures larger than 0.2 mm. The experiment was discontinued at 25 minutes when the tool was still working well. There was no significant use-wear on the tool when the job was finished.

Obsidian

IV: 65 mm, 454 g
s, straight to convex/s, slightly curved, no abrasive

This was a lightweight chopping tool. After about 30 seconds the edge began to fracture severely, a process that continued for three minutes until the whole edge was fractured and irregular. The tool was ineffective at three and a half minutes because of the severe fracture damage. The artifact material was too brittle for this specific task.

Silcrete

IV: 85 mm, 3743 g
irregular, irregular/irregular, irregular, no abrasive

A 13 mm step fracture appeared on the working edge within a minute. Twenty seconds later a 15 mm step flake was detached from the opposite face. This fracturing continued until the experiment was discontinued at five minutes. The tool was
still functional when work ceased and edge-fracturing probably had not stabilised. Large scars gave the edge a very irregular profile and there were some large spurs. The irregularity of the edge before use could well have contributed to its propensity to suffer fracture damage.

As soon as chopping commenced, step, hinge and feather fractures appeared on the convex margin. In the first 5 minutes the tool worked well even though the working edge fractured and could not cut into the wood properly. It then the edge was broadened to relatively flat surface by fracturing and crumbling.

Step, feather and hinge fractures appeared immediately along one margin of the working edge. At 10 minutes, edge blunting was barely apparent. A centrally placed retroflexed hinge fracture 17 mm wide appeared at 16 minutes. This fracture was the result of a poorly directed swing onto the wood. The experiment was discontinued at 40 minutes although the tool was still quite efficient. This artifact material proved to be suitable for the task, and edge fractures were the only identifiable form of wear.
#255  Silcrete

V(90°, 89°, 85°): 130 mm, 2495 g
convex (10 mm), s/s, slightly curved, 24 grams of sand

This tool was the same as the one used in #254. After the first few minutes of chopping only one small fracture appeared. The tool was used for 12 minutes by which time its efficiency was slightly reduced. When work ceased the working edge was rounded, especially on prominences. Smoothing extended for 2 mm from the edge on one face and 1 mm on the other.

#256  Rhyodacitic Volcanic

IV: 65 mm, 1361 g
convex, s/straight to convex, s, no abrasive

As soon as chopping commenced, step, hinge and feather fractures appeared on the convex margin. In the first 5 minutes the tool worked well even though the working edge was fractured. After 10 minutes the working edge was severely fractured and could not cut into the wood properly. In places the edge was broadened to relatively flat surface by fracturing and crumbling.

#257  Altered Basalt

IV: 97 mm, 1020 g
roughly straight with an irregular dip in the centre, variable/variable, wavy, no abrasive

Fractures appeared sporadically along the edge during the first five minutes of use. At five minutes the edge began to
severely fracture. The job was terminated at six minutes because of the severity of the edge fracturing.

#258 Altered Basalt

IV: 100 mm, 680 g
irregular, s/convex, irregular, no abrasive

The tool was light but quite efficient even when the edge dulled, a feature noticeable by 25 minutes. Work ceased at 35 minutes although the tool was still functional. Fractures and edge blunting were the only forms of use-wear.

#259 Andesitic Basalt

V(93°, 94°, 95°+)
irregular, straight to slightly convex/straight to slightly convex, roughly straight, no abrasive

By five minutes feather/hinge fractures up to 5 mm wide had appeared on the working edge. At 30 minutes the tool's efficiency was reduced a little. Work ceased at 30 minutes although the tool was still functional. Under the microscope
the working edge appeared blunt. The fractures which had occurred during use could not be identified properly because of the granularity of the basalt. This wear pattern was not distinctive. It was considered that more acute angles on a chopping tool made from this material would have worked better and that andesitic basalt did not chop as well as silcrete. Compacted wood fibres adhered to the crystals and especially in depressions, on the areas of lateral faces that had been in contact with the wood during chopping. It extended along most of the working edge and 10 mm up one face and as much as 40 mm up the opposite face (see diagram). If sand had been sprinkled on the wood these contact surfaces would have sustained a degree of abrasive smoothing.
edge rounding up to 0.5 mm wide was noted on some parts of the working edge. Smoothing was not detected on the lateral faces.

**#261 Orthoquartzite**

IV: 76 mm, 1133 g
wavy, irregular/irregular, s, no abrasive

In the first 15 minutes the working edge fractured bifacially and dulling was noticeable. The job was terminated at 30 minutes when the tool's efficiency was significantly reduced. At this point there was some edge blunting but it was not very pronounced. The fractures depicted in the diagram are the minimum number as not all fractures on the granular edge were identifiable, especially the smaller ones.

![Diagram of fractures](image)

**SAWING GREEN LIGHT WOOD**

**#262 Volcanic Tuff**

I: 20 mm (23 mm)
s, s/s, very slight curve, no abrasive

Immediately on commencing work the working edge snap fractured and within a minute the entire length was fractured (see diagram A). After three minutes two larger flakes were detached and the spurs between the snap fractures were progressively degrading. Smoothing wear began and further large snap fractures appeared on the progressively rounding edge. Smoothing was macroscopically visible at 23 minutes of sawing (see diagram B for fracture pattern). At 123 minutes the tool was still functional but it was working at a reduced efficiency. As the wear pattern was not likely to change after this point the
experiment was discontinued. The length of sawn grooves totalled 380 cm. Microscopically, edge rounding was well-developed with smoothing evident on high areas on the lateral faces, invading as much as 2 mm equally on both faces giving the smoothing on these surface a lattice-like appearance. Degraded spurs were heavily smoothed.

![Diagram of sawing process](image)

**Volcanic Tuff**

IV:26 mm

convex, convex/s, pronounced curve, no abrasive

The curvature of the edge in plan made it quite difficult to initially cut into the wood, as the tool could not be forced to repeatedly follow the same path. The convex face seemed to take most of the pressure. After five minutes, blunting and rounding were detected on the working edge. The blunting continued until it was quite advanced at 25 minutes of sawing, but the wood was so unresisting that effective sawing could continue. The job was terminated at 35 minutes when 80 cm of grooves 5 mm deep had been sawn and when the tool no longer worked properly. Microscopically the edge blunting was pro-
nounced and moderate smoothing could be detected on high spots as far as 2 mm from the edge on both lateral faces. There were a few scattered feather/hinge fractures.

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**#264 Volcanic Tuff**

$$IV\left(70^\circ, 72^\circ, 74^\circ\right):45\ mm$$

convex with denticulate retouch, s/variable because of retouch, s, no abrasive

The denticulation on the working edge bit into the wood like a metal saw edge and this made it easier to begin the groove. Rather than cutting, the edge ripped the wood. At 25 minutes of sawing the tool was working efficiently but only 10 minutes later its sawing ability had noticeable decreased. The extreme ends of the convex edge - each about 10% of the total length - still had good cutting ability relative to the middle section of the edge. The job was terminated at this time when 450 cm of groove 3mm - 8mm wide and 2mm - 4mm deep had been sawn. When work ceased, edge rounding could not be detected and even blunting was not positively identified. If any use-fractures occurred they were not distinguishable from retouch damage.

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**#265 Flint**

$$1:15\ mm$$

convex, slightly convex/slightly concave, slightly curved, 1 gram of sand

The edge immediately snap fractured (see diagram A), and smoothing and rounding on prominences developed shortly after the first series of snap scars appeared. The tool was quite blunt at 50 cm of sawing and the job was terminated. Microscopically the edge rounding was well developed, especially on the spurs and at the centre of the convex edge where the greatest pressure
had been applied. 'Polish' invaded 2.5 mm on the convex lateral face and 1 mm on the concave lateral face.

Snap fractures appeared almost immediately (see diagram A) but after 10 minutes when 330 cm of groove had been sawn the edge was beginning to stabilise. Subsequently the working edge ceased to snap fracture and polish/smoothing appeared. The tool was operating at a reduced efficiency when the job was terminated when 1660 cm of grooves had been sawn. I estimate that the tool would have continued to operate at this level of efficiency for a considerable time. At termination there was a light polish or smoothing on the high areas of the lateral faces which were within 1 mm of the working edge.
straight but fissures intersect the edge, s/s, slight curve, 0.2 grams of sand

Within 40 cm of sawing the working edge was completely dulled and therefore the experiment was terminated. Edge rounding was uniform and edge thickness increased to 0.3 mm. Polish appeared on the lateral faces of the edge, and in particular on ridges, while depressions in the surface were not polished at all. This polish invaded 0.5 mm on one face and 2.5 mm on the opposite face.

The working edge snap and feather fractured within 5 minutes (90 cm of sawing, see diagram A). No further fracturing was noticed. Sawing continued for another 40 minutes until 620 cm of groove 3 mm deep had been cut into the wood. The edge remained snap fractured but the feather/hinge fractures were added to the suite (see diagram B). Spurs between snap fractures were rounded to varying degrees and some very fine striations could be detected running longitudinally at the very edge between the feather and hinge fractures. These striations seemed to be interrupted by pits (to illustrate: ···········). Certainly the striations were caused by fragments breaking from the edge during use. The tool's efficiency was much reduced when the job was terminated.
#269 Obsidian

II: 18 mm

s, s/convex, s, 1.5 grams of sand

Grooves totalling 30 cm in length were sawn before the tool was no longer functional. All prominences on the edge were rounded and fracturing was concentrated on the straight lateral margin of the working edge. The opposite convex face and both ends of the fractured face were heavily abraded with definite indications of the abrasive agent moving parallel to the edge. Most striations were indistinct although some could be identified. The width of the abraded zone was 1 mm on each face (see plates 141-144).

The curvature of the edge made it difficult to keep straight grooves to the wood. After 2 minutes of sawing there were no saw-fractures along the working edge which measured more than 1 mm. 10 minutes later 110 cm of grooves 3 mm - 3 cm wide had been sawn. The job was terminated after 70 cm of grooves up to 2 cm wide had been sawn. Although the tool was still functioning reasonably well the edge was becoming unstable. The groove was clearly visible in one zone of the wood which was polished up to 2 mm wide. Abrasion was quite definite on the side of the working edge, especially on the face. It was sporadic but quite reflective or brilliant on areas that would have been subjected to the greatest pressure.
#270 Olary Chalcedony

II: 22 mm

fairly straight, s/fairly straight, slight curve, no abrasive

The curvature of the edge made it difficult to saw straight grooves into the wood. After 40 minutes of sawing there were no use-fractures along the working edge which measured more than 1 mm. 10 minutes later 510 cm of grooves 2 mm - 3 mm wide and 2 mm deep had been sawn. The job was terminated after 730 cm of grooves up to 5 mm deep had been sawn. Although the tool was still functioning reasonably well the edge had stabilized and it was expected that further significant use-modification would not occur. Snap fracturing of the working edge was not severe. A zone of light polish up to 2 mm wide was situated on both sides of the working edge, especially on the spurs. It was sporadic but quite reflective or brilliant on areas that would have been subjected to the greatest pressure during use.

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#271 Olivine Basalt

II (30° variable): 19 mm (effective 10 mm)

irregular, irregular/irregular, irregular, no abrasive

After 10 seconds of use a 7 mm wide snap fracture appeared at one end of the working edge. Subsequently, the edge progressively blunted, and at 320 cm the whole edge broke off due to mishandling of the tool. No wear was identified and the edge had an irregular and jagged profile when viewed under the microscope.
#272 Orthoquartzite

II (30°, 32°, 34°):20 mm
irregular, convex/very slightly concave, slight curve,
no abrasive

After 4 minutes there was minor crushing on the working edge, much of it occurring in the first 2 minutes of use. This was accompanied by blunting which was easily detectable by touch. There was also a build-up of wood pulp on the working edge. By 15 minutes of work when 340 cm of grooves had been sawn, only 9 mm of the original cutting edge was functioning at all effectively. This was due to the reduction of much of the working edge by fracturing. At 45 minutes of use, moderate edge rounding and smoothing was noted, although it could have developed much earlier. At 50 minutes of use the tool no longer worked well and the job was discontinued. As the edge was irregular before use it was not possible to precisely identify use-fractures, although it does appear that such fractures reversed along the concave margin of the working edge. These seemed to be snap and feather/hinge up to 2 mm wide. A 2 mm length of the working edge was rounded but this would be very difficult to identify on a prehistoric tool.

#273 Orthoquartzite

II (29° - 34°):20 mm
slightly convex, s/s, s, 1 gram of sand

The edge began to snap fracture very soon after work commenced. Snap fracturing ceased before a groove 10 cm long and 4 mm deep had been sawn. The edge was then beginning to blunt and as the work continued the blunting progressed into edge rounding and smoothing. By the time the tool was no longer working well and the job terminated, the snap fractures were almost obliterated by the abrasive wear. At termination, edge rounding was pronounced on edge prominences, the edge being as much as 0.5 mm wide. Abrasive smoothing was also well developed on prominences and it extended up both lateral faces for up to 2 mm from the working edge.
Quartz

III(54°, 55°, 55°):18 mm
s, s/s, s, no abrasive

This tool was used for 65 minutes to saw 900 cm of grooves before its efficiency was much reduced, although the work could have been carried on for much longer. At termination the tool was carefully examined under the microscope. Identifiable use-fractures comprised a 3 mm snap fracture and two other fractures which were both less than 1 mm wide. Definite edge blunting merged into moderate edge rounding which increased the width of the working edge to only 0.1 mm. This would probably not be noticeable on a prehistoric tool. One of the lateral surfaces was altered in some way for a width of 3 mm from the working edge. It appeared to reflect less light than before, giving the appearance of a matt surface (plate 146). Very close examination showed that it was pitted, microfractured, or both. Some internal fracturing on this 'frosted' surface could be identified by the 'prism-like' reflection of light from the internal crack faces. There were no striations.

Quartz

III(54°):35 mm
s, s/s, s, 1 gram of sand

The tool was used to saw 30 cm of grooves by which point the tool would no longer function properly. The sand which collected in the groove caused rapid abrasion of the working edge. Edge rounding was pronounced along the whole length of the working edge. The width of this rounded edge was between 0.3 mm and 0.4 mm. Abrasion, with clear striations absent, extended 1 mm evenly from the working edge on both lateral margins. No use-fractures were identified.
#276 Carbonate

II (34°): 20 mm
convex, s/convex, irregular, no abrasive

Grooves totalling 160 cm in length, 2 mm to 3 mm wide and 3 mm deep, were sawn in 13 minutes. The tool was not functional beyond this point. No fracturing occurred along the edge but rounding to a width of 0.6 mm and smoothing on the convex face extended for a distance of 1 mm from the working edge.

SAWING DRIED LIGHT WOOD

#277 Volcanic Tuff

II: 26 mm
slightly concave, s/slightly concave, s, no abrasive

The tool was used to saw a total of 250 cm of grooves 3.0 - 3.5 mm deep. The job was discontinued although the tool was still quite serviceable. At termination small snap fractures (0.5 mm - 3 mm) were scattered along the working edge. The edge was blunted and some of the spurs were rounded. This tool could have been used effectively for a very long time.

#278 Flint

II: 27 mm
very slightly convex, s/s, very slightly curved at one end (1 mm - 1.5 mm), no abrasive

Immediately on commencing the operation small snap fractures (2 mm and less) appeared. The job was terminated after 250 cm
of grooves, 3.5 mm deep, was sawn, although the tool was still quite serviceable. Edge blunting was the only form of use-wear besides snap fracturing.

A series of grooves totaling 250 cm in length and 3 mm - 3.5 mm deep were sawn. The tool suffered no loss of efficiency at the end of this series. Snap fractures developed between these were not clearly identifiable because of its inexactness in the quartzite. The scars were therefore not recorded. Edge rounding up to 0.4 mm wide, was quite distinct and individual grains were worn down and smoothed over on projecting parts of the edge, such as the spurs between snap fractures. The lateral margins were smoothed to a distance of 1 mm from the working edge. This smoothing and edge blunting is probably autogenic, attributable to fragments of quartz grains which were detached from the edge.

#279 Obsidian
II:17 mm
very slightly concave (0.7 mm), straight to concave/s, slight curve, no abrasive

The job was discontinued at 43 minutes and 250 cm of sawing, although the tool was still reasonably efficient and could have continued in use much longer. At termination the use-wear comprised feather/hinge, feather and snap fracturing of the working edge and the rounding of a spur 1.2 mm wide. This spur was reduced by abrasion and a few striations ran across it, most certainly caused by detached fragments or flakes being dragged over the edge within the sawn groove.
Orthoquartzite

II(30°, 33°, 35°): 50 mm
very irregular, irregular/irregular, fairly straight,
no abrasive

A series of grooves totaling 250 cm in length and 3 mm - 3.5 mm deep were sawn. The tool suffered no loss of efficiency at the end of this task. Snap fractures did occur, but these were not clearly identifiable because of the granularity of the quartzite. The scars were therefore not recorded. Edge rounding up to 0.4 mm wide, was quite distinct and individual grains were worn down and smoothed over on projecting parts of the edge, such as the spurs between snap fractures. The lateral margins were smoothed to a distance of 1 mm from the working edge. This smoothing and edge rounding is probably autogenetic, attributable to fragments of quartz grains which were detached from the edge.

Sawing Green Dense Wood

Volcanic Tuff

II: 50 mm
wavy, s/s, s, no abrasive

Snap fracturing began immediately and continued until 70 cm of grooves had been sawn. At this point the tool failed to saw cleanly and effectively. The edge was thickened by snap fracturing to as much as 1 mm. Under the microscope, blunting and very moderate rounding of spurs between the fractures could be observed. The snap fractures were initiated from both margins of the edge, somewhat reminiscent of the use-fracturing on a bone saw.
Volcanic Tuff

II (29°): 20 mm

very slightly convex (1 mm), s/very slightly convex, s.

1 gram of sand

Initially, while sawing the first 10 cm groove, snap fractures appeared along the working edge. The edge then stabilized and rounding and smoothing became the major form of use-modification. The snap fractures were smoothed over and mostly obliterated. The tool could not saw beyond 20 cm and the job was terminated. The edge was symmetrically rounded and was widened to approximately 0.5 mm. This form of use-wear was very pronounced. The lateral surfaces were smoothed uniformly as much as 0.7 mm from the working edge (plate 145) and very fine striations ran longitudinally with the edge within this smoothed zone. One of these striations was 5 mm long.

Flint

II: 30 mm

s, s/slightly concave, very slightly curved, no abrasive

Feather/hinge fracturing occurred immediately and continued at least until a 60 cm groove 3 mm deep had been cut. The job was terminated at this time although the tool was still effective. Spurs at either end of the working edge seemed to take all the pressure but they did not sustain blunting or rounding.
**Obsidian**

II: 18 mm (26 mm)
convex, s/slightly convex, very slightly curved, no abrasive

Within 30 cm of sawing, fractures up to 2 mm wide appeared on both sides of the working edge. The edge was dulled and its profile appeared irregular. Within 100 cm fracturing continued - the largest scar measured 4 mm. However, the tool was still effective. At 140 cm of sawing the rate of use-fracturing along the working edge was noticeably lessening and the edge appeared more even, but the tool was becoming less efficient. The job was terminated at 220 cm of sawing as the tool was no longer working effectively. At this stage the working edge in plan was very irregular because of the binormal use-fracturing. The edge was thickened in some sections as much as 1 mm while still being quite acute in other places. Two of the spurs between fractures were rounded and abraded. This abrasion was presumably caused by fragments being detached from the edge.

Total time of job: 47 minutes.

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**Silcrete**

II: 35 mm
wavy, irregular/irregular, s, no abrasive

The tool worked very efficiently at the beginning of the job; only two fractures constituted the macroscopic use-wear. Progressively the working edge snap fractured along most of its length. By 540 cm of sawing the tool could be used to cut a reasonably straight groove only with great difficulty, and
the job was therefore terminated. Microscopic examination at this point revealed edge blunting and moderate rounding on some of the prominences or spurs between the snap fractures. Total time of job: 45 minutes.

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#286 Olary Chalcedony

II: 40 mm convex, s/slightly convex, s, no abrasive

The working edge snap fractured as soon as work commenced and this fracturing continued at least during the first 95 cm of sawing. No other form of wear occurred. Most of the observation notes for this experiment are missing so it is not known how much work was done or how well the tool performed.

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#287 Chert

III: 26 mm s, convex to straight/s, s, no abrasive

Shortly after sawing commenced, the righthand end of the working edge snap fractured. After 100 cm of grooves had been sawn some fine feather and feather/hinge fractures appeared on the straight margin. At termination the total length of the grooves was 200 cm and depth varied from...
2.5 mm to 3 mm. The tool's efficiency at this point was greatly reduced.

After 60 seconds of sawing with the sand in the sawcut the working edge rounded and was no longer effective. Macroscopically the edge rounding was pronounced and within this altered area there were traces of abrasion. One very pronounced and well defined striation which ran parallel to the edge was 6 mm long. This striation was positioned 0.5 mm from the edge. Other finer striations also running roughly parallel to the edge were not clearly visible at X40. The striations could be seen on both margins of the edge for a distance of 0.5 mm but they were concentrated on the convex face. One end of the working edge was thickened by rounding to 0.3 mm.

#289 Radiolarian Chert

II: 35 mm
convex, straight to convex/straight to convex, straight on the 1/h and slightly convex on the r/h, no abrasive

The edge immediately began to snap and feather/hinge fracture but it stabilized to an efficient sawing edge after about 4 minutes work. There was very little subsequent fracturing until 18 minutes of sawing had elapsed, at which time a 2 mm snap fracture occurred. After 37 minutes the edge was
significantly blunted but still somewhat efficient. The job was terminated at this time, when 350 cm of grooves had been sawn, because the edge was stable and the serrations caused by snap fracturing made the tool capable of continuing to saw for a very long time. Microscopically there was definite edge rounding on some projections between the snap fractures.

Initially severe snap fracturing 'shattered' the edge and after this event the snap fracturing continued at a more regular rate. It was noticed that the edge was rejuvenated by this fresh fracturing. After 170 cm of grooves had been sawn the job was discontinued as the tool no longer worked effectively. Snap fracturing was the only form of use-wear observed microscopically or under the microscope.
Orthoquartzite II (30°): 16 mm
very irregular, s/s, s, no abrasive
The tool was used to saw 100 cm of grooves 2 mm - 3 mm deep. It was then no longer efficient and the job was terminated. Snap fractures included three that were 4 mm wide but all were poorly defined because of the granularity of the stone. A 2 mm length of the edge was clearly rounded but not much smoothed. The mechanisms causing this rounding were probably grain detachment and auto-abrasion.

Quartz II: 32 mm
very irregular, irregular/irregular, s, no abrasive
The working edge snap fractured, with individual scars being up to 2 mm in width, by the time 70 cm of groove had been sawn. The tool's efficiency was less than when work commenced. The tool was still functioning at a greatly reduced efficiency after 150 cm of grooves had been sawn. It was at this point that the job was terminated. Fractures were the only traces of use but on this artifact material they were difficult to identify.

The tool was used to saw only one 10 cm groove. Areas of abrasion as much as 2 mm² was seen on the prominent parts of the
working edge. Abrasion also extended up the lateral faces; in some places for as much as 1.5 mm (see plate 147). The abrasion had a frosted appearance. Abraded spurs and other prominences on the edge were also rounded and occasionally isolated fine striations ran parallel to the working edge within abraded areas.

SAWING DRIED DENSE WOOD

#294 Volcanic Tuff

II: 27 mm

irregular, straight to slightly concave/s, no abrasive

Within the first 20 cm of sawing the working edge snap fractured along most of its length giving it a serrated appearance. At 30 cm of sawing the working edge was dulling and it became increasingly difficult to saw the wood. The tool, however, was still working at a reduced efficiency when the job was terminated after 50 cm of grooves had been sawn. The only wear was snap fracturing.

#295 Volcanic Tuff

II (34°): 27 mm

serrated by snap fracturing, straight to slightly concave/s, 1 gram of sand

The tool used in experiment #294 was subsequently used in this experiment in which the altered variable was the addition of sand. After two minutes of use the spurs on the working edge were almost entirely worn down. Within 12 minutes the entire length of the working edge was smoothed and 'polish' began to appear in some areas of this smoothing. The tool could no
longer penetrate the surface of the wood at 20 minutes of sawing and the working edge was 'polished' along its entire length. The experiment was terminated at this point but there is no record of the length of the sawn grooves. At termination a microscopic examination revealed that the edge was worn to a width of 0.5 mm - 0.75 mm, with perfectly symmetrical rounding of the smoothed/polished area. Long striations within this rounded zone ran parallel and were restricted to 0.5 mm of the surfaces on both sides of the working edge. A series of small abrupt feather fractures (transitional snap-feather) occurred along a 5 mm length of one side of the rounded edge.

**DRILLING GREEN LIGHT WOOD (HAND-HELD)**

#296 Volcanic Tuff

(41°, 53°, 107°): no abrasive

Within a minute of commencing work the tip snapped off about 1 mm from the apex and fracturing was sustained on the 41° and 53° edges. There was little addition to this damage until major use-fracturing was reinitiated on the 41° edge at 25 minutes. At 27 minutes a further section of the tip, 3 mm long, snapped off and the job was terminated. The platform left on the apex of the drill measured 7 X 4 X 4 mm.

#297 Volcanic Tuff

(68°, 79°, 93°): 20 - 30 grams of sand placed at the location to be drilled prior to the operation

The drill was too thick to be efficient in drilling deep holes. It was able to drill four 3 mm holes in 10 minutes before it began to perform poorly. Besides a few small fractures the only wear was moderate blunting on all the contact edges.
Volcanic Tuff

(55°, 60°, 92°): 4 grams of sand

Within one minute the tip snapped 1 mm from its apex, an event that was followed by a great deal of minute fracturing along the edges near the snapped apex. In 3 minutes seven holes, each 4 mm deep, had been drilled and moderate rounding was visible on the edges leading to the apex of the drill. At 20 minutes the test was concluded although the blunt tool could have been used for much longer. The lateral edges near the apex were well rounded and high areas of the faces between these edges were smoothed. The abrasive action of the large quantity of sand in the holes removed all traces of the use-fracturing that had occurred earlier in the experiment.

Flint

no abrasive

With the first twist of the drill the tip snapped off about 1 mm from its apex. The experiment was discontinued at 95 minutes when 27 holes up to 10 mm deep had been drilled with no appreciable reduction in the tool's efficiency. Edge blunting was not detected and the only form of wear was fracturing.
#300 Flint

(50°, 61°, 94°): 3 - 5 grams of sand

This was the same tool as the one used in #299. One gram of sand was sprinkled into the first hole drilled, and the contact edges immediately blunted. A total of 1.5 grams of sand was sprinkled into the following 3 holes but the increase in abrasive wear was not great. The job was discontinued after the fifth hole was drilled although the tool was still quite effective. When work ceased the tip was moderately rounded and a moderate rounding (0.1 mm - 0.2 mm) and 'polish' could be detected on the lateral edges for a distance of 6 mm from the apex. This latter 'polish' and rounding was restricted to the prominences between fractures. The lack of pronounced polish may have been because the light density wood was so yielding.

#301 Olary Chalcedony

(62°, 66°, 85°): no abrasive

The tool was used for 12 minutes and five holes 10 mm deep were drilled. The tool was still serviceable when the job was discontinued. The only use-wear was a feather (1 mm) and a step (1.5 mm) fracture initiated from the tip.
After three minutes of use no macroscopic wear was evident on the edges of the tool and by 25 minutes only very small fractures had appeared. Although the tool was essentially still as efficient as when the job was begun the experiment was discontinued at this stage. A total of 24 holes 5 mm deep had been drilled. When work ceased the use-wear on the drill consisted of four feather/hinge fractures, each no more than 1 mm wide, and a very restricted polish on one of the lateral faces.

By seven minutes the tip was rounded and ineffective. In this time four holes 5 mm deep were drilled in the wood. During the operation it was noted that fragments of stone broke off the apex and lateral edges and lodged in the hole. At termination the apex of the drill was well rounded.

Within the first two minutes of use a spall fracture 4 mm wide appeared along the 55° lateral edge. It effectively took 40 minutes to drill four holes 13 mm deep and I considered that the tool did not work well because sufficient load could not be applied on the wooden shaft of the drill. At termination there were only a few minute fractures along the lateral edges.
DRILLING GREEN MEDIUM-LIGHT WOOD

#305 Volcanic Tuff

no abrasive

The tip of the drill snapped completely off before a second hole could be drilled. This damage plus a couple of other fractures was the only use-wear.

#306 Flint

(54°, 66°, 91°): no abrasive

The artifact material was flawed and because of this the tip snapped off leaving a triangular platform 4 X 3 X 2 mm. The experiment only lasted 90 seconds as the tool did not work after this major damage. Besides tip fracture there was shallow step fracturing down two faces and some minute fractures along on the lateral edges.
#307 Volcanic Tuff

(62°, 63°, 85°): no abrasive

Only one hole could be drilled before the tip of the drill snapped and the tool became ineffective. The broken apex was blunted with moderate rounding on prominences. The 85° lateral edge sustained two 1.2 mm step fractures.

#308 Flint

no abrasive

While drilling the first hole the tip of the drill fractured leaving an irregular apex. After 5 holes had been drilled the tool was less efficient but it was still acceptable and by the time the eighth hole had been drilled the point was not properly penetrating the wood although it did manage to excavate to a depth of 7 mm, which was comparable to the depths of the other holes. At termination fracturing was the only form of wear.

#309 Obsidian

(50°, 57°, 101°): no abrasive

The tip immediately fractured and the tool could only be used to drill one hole 3.5 mm deep.
Silcrete

no abrasive

This tool could only be used to drill one hole. At termination the initially fractured apex was rounded and smoothed to a width of slightly over 1 mm. Grain detachment had undoubtedly contributed to this rounding. On two of the lateral edges for a distance of 8 mm from the apex there was a concentration of overlapping step fractures (plate 149).

Rhyodacitic Volcanic

(57°, 70°, 94°): no abrasive

This tool performed very poorly and was only able to penetrate 5 mm into the wood. Only one hole was drilled before the tool became ineffective. The tool was not examined for wear.

Chert

(54°, 58°, 105°): no abrasive

The tool was used to drill four 7 mm holes. By this time the tool could widen a hole but not begin a new one. A triangular spall 1 mm wide at its termination and 3 mm long, ran from the broken apex down one of the faces.
**#313** Altered Basalt

no abrasive

The tip fractured immediately but 3 holes 6 mm deep were drilled before the tool was ineffective. At termination, projections on the edge were well rounded and smoothed.

**#314** Andesitic Basalt

(55°, 65°, 90°): no abrasive

The tip fractured immediately and then proceeded to blunt. Only one 5 mm hole could be drilled before the tool was inefficient. At termination the tip was feather/hinge fractured but they were not clearly delineated because of the granularity of the artifact material. There was blunting and moderate rounding along the parts of the lateral edges.
that had been in contact with the wood, and ridges between the fractures at the tip were also moderately rounded.

**#315 Orthoquartzite**

(68°, 85°, 94°): no abrasive

This tool was not very efficient and it was only used to drill one hole. The tip was cleanly snapped off leaving a platform 0.5 mm wide. No fractures were identified on the 94° edge but the 85° edge sustained shallow step fractures (1, 1, 1, 5, 2 mm) on one of its margins, while the 68° edge sustained only a 3 mm wide transitional snap-feather fracture.

**#316 Quartz**

(67°, 77°, 90°): no abrasive

The tool did not work well and it could only be used to drill two shallow holes. At termination the tip was completely fractured away leaving an irregular, fractured platform 2.5 mm wide.

**DRILLING DRIED DENSE WOOD**

**#317 Volcanic Tuff**

no abrasive

The tip fractured when the first hole was being initiated. After four holes had been drilled the tool's efficiency was greatly reduced and the experiment was terminated. The tip had been removed by step fracturing and fractures extended down two of the edges. There was blunting or moderate smoothing of projections on the fractured apex and along the lateral edges.
no abrasive

The tip and the 35° edge were heavily fractured shortly after work began. Efficiency was much reduced at 14 minutes and the job was terminated at that time, the number of holes drilled not being recorded. At termination the tip and edges were heavily fractured but blunting was not pronounced.
DRILLING CHARRED DENSE WOOD

#319 Volcanic Tuff
no abrasive

After four holes had been drilled the tip was reduced by fractures up to 1.5 mm in size. At 14 holes one of the edges was bifacially fractured for a distance of 10 mm from the apex. After 44 holes had been drilled into the charred wood the tool was still perfectly useful. The charred wood offered no effective resistance and damage occurred when the point or edges of the drill made contact with the underlying wood. At termination the edges and apex were definitely blunted as well as being fractured.

HAND-HELD SCRAPING GREEN LIGHT WOOD (75° - 90°)

#320 Volcanic Tuff
II:27 mm
s, very slightly convex/s, slightly curved forward, no abrasive

The edge immediately began to snap fracture. By 10 minutes the edge had almost stabilised, the occasional flake 1 mm - 1.5 mm in width being detached. After 75 minutes of shaving when the edge was again examined, fracturing had ceased completely and
the quality of the work was much reduced. The tool gouged out the wood rather than shaving it because the edge profile was irregular. The job was therefore terminated. The only form of use-wear was edge fracturing - snap and transitional snap-feather/hinge.

### Volcanic Tuff

**IV (31°):** 31 mm  
s, s/s, slightly curved, no abrasive

The wide edge angle inhibited fracturing as can be seen from the diagram. By 65 minutes the edge was slightly blunted and the job was terminated. On some areas of the edge a moderate edge rounding could be detected.

### Flint

**V (85°):** 55 mm (only 27 mm of the edge was continually in contact with the wood because of the convexity of the edge). convex, s/s, slightly curved, no abrasive

This tool was used for 60 minutes by which time it was deemed to be working inefficiently. Microscopic examination revealed that edge blunting was advanced but edge rounding was absent.
The fractures that appeared were few, scattered, and all less than 0.1 mm in width.

**Obsidian**

II: 23 mm

moderately curved, s/s, s, no abrasive

The edge immediately began to snap fracture when work commenced. By 30 minutes no further fracturing occurred and the edge was stable. Scraping continued for another 90 minutes with only minor change in the edge. Blunting was noticeable by one hour and when the job was terminated at two hours the edge was no longer capable of shaving the wood. The edge had an irregular profile and this caused it to gouge the wood rather than shave it.

V: 27 mm

s, s/s, very slightly curved, no abrasive

The tool was used for 25 minutes before it ceased to be effective. When work ceased the lee or trailing margin of the working edge was abraded for most of its length. This abraded zone was approximately 0.5 mm wide and partly obliterated numerous very fine (most 0.2 mm, some 0.5 mm and less) indeter-
minate fractures. The abrasion no doubt resulted from detached flakes and particles. The few fractures on the forward margin could not be identified at X50.

Within the first 60 seconds snap, feather/hinge and shallow step fractures appeared along most of the working edge (mostly 1 mm - 2 mm each). The snap fractures were almost wholly superseded by other types of fractures as the work progressed. At 16 minutes the edge began to scratch or scour the wood rather than remove it as regular shavings because fracturing had given the edge an irregular profile. As the rate of wood removal was also much reduced the job was terminated. No form of wear other than use-facturing was detected.

HAND-HELD SCRAPING GREEN DENSE WOOD (75° - 90°)

#325 Volcanic Tuff

II:27 mm

slightly convex, s/s, slightly concave, no abrasive

Within the first 60 seconds snap, feather/hinge and shallow step fractures appeared along most of the working edge (mostly 1 mm - 2 mm each). The snap fractures were almost wholly superseded by other types of fractures as the work progressed. At 16 minutes the edge began to scratch or scour the wood rather than remove it as regular shavings because fracturing had given the edge an irregular profile. As the rate of wood removal was also much reduced the job was terminated. No form of wear other than use-facturing was detected.
Within a minute a continuous series of feather/hinge fractures, up to 2 mm each in width, appeared on the trailing margin of the working edge. A feather fracture (3 mm) and a shallow step fracture (3 mm) at one end of the trailing margin of the edge formed a small dentation. At 14 minutes of work the tool was too blunt to shave effectively. Fracturing was the only form of use-wear.

After seven minutes of shaving the edge blunted and the job was terminated. The tool worked quite well during this time. Edge blunting and three fractures were the only form of use-wear.
**#328 Radiolarian Chert**

III: 28 mm

slightly convex in centre, s/convex, curved, no abrasive

This tool worked extremely well and produced a quality finish on the wood. Progressively, shallow step and feather/hinge fractures appeared on the lee margin of the working edge. At 25 minutes the tool's efficiency was much reduced and the job was terminated. The apparent dulling of the edge was caused by fine, complex step fracturing which broadened the cutting edge at the origin of the larger fractures.

**#329 Volcanic Tuff**

III: 42 mm

s, slightly convex/s, s, no abrasive

Initially the tool worked well but after only five minutes the edge dulled and the experiment was terminated. Within this period the edge suffered considerable fracturing on its upper margin. When the work ceased the working edge of the tool was blunted and in certain parts rounded. This rounding was accompanied by smoothing which spread inwards for 0.3 mm on the underside of the edge.
Volcanic Tuff

III: 30 mm
wavy, s/very slightly convex, slightly concave (1 mm), 0.3 gram of sand

The edge immediately snap fractured and within two minutes smoothing or polish was visible on the underside. The tool could only be used for three minutes before the edge dulled. When work ceased there was a rounded bevel 0.2 mm - 0.3 mm wide on the underside of the working edge and rounding and smoothing of prominences on the edge. Also on the underside were furrow striations and reflective linear trends angled at around 80° - 90° to the edge and up to 7 mm long.

Volcanic Tuff

IV: 26 mm
convex (1.5 mm), s/s, concave, no abrasive

Thin step and feather flakes were pressed off the upper face on the backstroke when the edge of the tool trailed across the wood. This use-fracturing had a rejuvenating effect on the edge. The tool ceased to work efficiently
by 15 minutes and the job was finished at that time. The working edge was blunted on its least heavily fractured sections and this merged into rounding on spurs.

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Volcanic Tuff

V: 47 mm
s, s/s, s, no abrasive

Almost immediately retroflexed hinge and shallow step fractures appeared on the upper margin of the edge, and in time the numbers increased so the result was a continuous line of fractures. At least some of the fractures were detached during the backstroke. The tool worked quite well and the working life of the edge was prolonged by the rejuvenating effect of use-fracturing. Use of the tool ceased at 20 minutes when its efficiency was significantly reduced. At this time there appeared to be a zone of smoothing a millimetre wide along the underside of the edge and it was especially obvious on the spurs and prominent parts of the surface. However, this may have been a film of resin. Edge blunting merged in some areas of the working edge into rounding. Fracturing occurred only on the upper face.
Flint

III: 30 mm
wavy, s/s, s, no abrasive

Within five minutes snap and feather fractures appeared on the upper face of the tool. The only fracture to appear on the underside of the edge occurred at seven minutes. The tool was used for no longer than this period as its efficiency was reduced. The tool worked well before the working edge was dulled. When work ceased the edge was moderately rounded with slightly more pronounced rounding on the spurs. There were very fine fractures within the larger ones depicted below. What appeared to be a 0.2 mm wide zone of polish on the underside of the edge was identified in the SEM as a coating of resin derived from the dense wood (plate 154).

Flint

IV: 24 mm
s, s/s, s, no abrasive

This tool worked moderately well for four minutes and work ceased when the edge dulled. Besides use-fracturing there was only blunting on the edge.
Flint

IV: 25 mm
convex (1 mm) and wavy, s/slightly convex, wavy, 0.3 gram of sand

The effect of a small amount of sand was so destructive to the working edge that the tool could not be used beyond two minutes. At completion, the working edge was mostly blunted with areas of moderate to developed edge rounding (0.2 mm). There was quite a reflective polish on the underside margin for an extent of 2 mm from the edge. No furrow striations were seen within this polished area but there were some reflective 'lines' of polish-linear trends.

Flint

V (90°): 25 mm
s, s/s, s, no abrasive

The tool could only be used effectively for four minutes but during this time it worked very well. When work ceased there was no detectable use-wear.

Obsidian

IV: 26 mm
convex (1 mm), convex/s, s, no abrasive

At first the tool could only be used with difficulty as the working edge was too 'fine' and tended to cut deeply into the wood. This resulted in severe fracturing within the first
minute of use. Rather than rejuvenating the edge the use-fracturing lessened its efficiency and the job was finished within a minute and a half. At completion the edge appeared 'crushed' on its upper margin. This 'crushing' was in fact a 0.2 mm wide zone of closely packed overlapping step fractures. All the feather fractures drawn in the diagram were undercut by these smaller fractures. On the underside, continuous furrows up to 4 mm long emanated from the damaged working edge. These striations numbered around 20 - 30 and were both scattered and aligned in sets at angles between $80^\circ$ - $90^\circ$ to the edge (plate 155).

![Diagram showing major concentration of striations](image)

The tool was used for 10 minutes before it became ineffective but it did not work well as the fine-textured silicate tools. Fractures were the only form of use-wear detected.

**#338 Obsidian**

V: 20 mm
s, s/s, s, no abrasive

The working edge of this tool was also very 'fine' and light strokes had to be used to avoid the edge cutting too deeply into the wood. It was a very good scraping tool but progressively lost efficiency because of fine fracturing of the upper margin. By eight minutes the tool was not cutting effectively. When work ceased about 50% of the length of the working edge's upper margin was covered with complex overlapping step fractures and 50% with fine (0.2 mm) feather fractures. On the underside, besides small fractures, there were about 10 - 20 scattered continuous furrow striations angled at around $80^\circ$ to the working edge (plate 156). Mostly the striations were about 2 mm long although two prominent ones were 3 mm long. Sleeks may also have been present but the
surface was not viewed with the SEM. The most prominent furrow striation originated in a small use-fracture (plate 157) and the two events were undoubtedly associated - the striation was autogenetic.

The tool was used for 10 minutes before it became ineffective but it did not work well as the fine-textured silicate tools. Fractures were the only form of use-wear detected.

The upper margin immediately began to fracture and this process continued until the edge appeared it had been lightly

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**Silcrete**

**III: 38 mm**

s, s/s, generally s, no abrasive

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**Silcrete**

**III: 25 mm**

minutely irregular, s/s, concave (2 mm), no abrasive
retouched. Work ceased at 10 minutes because the tool failed
to continue working properly. Very small fractures were not
identifiable on this artifact material. Some of the spurs
between fractures were moderately rounded and there was a
small 2 mm area of abrasive smoothing on the underside at one
end of the working edge.

Shortlly after commencing work a feather fracture appeared on
the underside of the working edge. It would be difficult to
identify this fracture on an equivalent prehistoric tool
because of the graininess of the artifact material. Fractures
also appeared at intervals on the upper face. As the edge
dulled, the effectiveness of the tool was maintained by lifting
it to a 10° angle to the wood. At 15 minutes the work was
discontinued although the tool was still effective in scraping
wood. The tool's performance was not as good as that of flint
tools. When work ceased, spurs along the working edge of the
tool were blunted. A small area of abrasive smoothing, a milli-
metre wide, was situated on a prominent part of the underside
margin.

#341 Silcrete

IV: 25 mm
irregular, irregular/slightly convex, concave (1 mm),
no abrasive
#342 Silcrete

V: 28 mm
slightly convex (1 mm), s/s, slightly concave (1 mm)
no abrasive

The tool worked well for the first two minutes and then progressively became less efficient. Resin and fine wood particles lodged in the small depressions between grains. At eight minutes work ceased because the edge of the tool was no longer cutting properly. Use-fractures were difficult to identify on this artifact material but there was one 2 mm hinge fracture on the underside of the edge. The edge was blunted and there was a small area of abrasive smoothing 1.2 mm long at one end of the working edge, on the underside.

#343 Radiolarian Chert

V: 24 mm
s, s/s, s, no abrasive

The tool worked reasonably well for about four minutes but work ceased at around five minutes when the tool was working inefficiently. At this time the working edge was blunted and there was a minute zone of reflection 0.1 mm wide on the underside of the edge. This reflection was almost certainly caused by strongly adhering resin deposition.
Rhyodacitic Volcanic

III: 33 mm
s, s/s, s, no abrasive

The working edge was entirely snap fractured very soon after the job was commenced. As the edge dulled, the angle of the tool was increased from zero to about 15° to keep it working properly. By 12 minutes the efficiency of the tool was reduced and the job was discontinued. When work ceased some parts of the working edge of the tool were blunted and on two spurs there was moderate edge rounding accompanied by smoothing 0.2 mm wide on the underside.

Rhyodacitic Volcanic

III: 28 mm
s, slightly concave/slightly convex, concave (3 mm), no abrasive

Instantly small (1 mm) snap fractures appeared on the working edge and soon the whole length of the edge was fractured. Subsequently larger fractures developed, some through the merging of smaller ones. The job was discontinued at 10 minutes when the tool was no longer working efficiently. When work ceased there were small (c.1 mm) lengths of rounding on the working edge. This edge rounding was accompanied on the underside margin by smoothing for up to 0.4 mm from the edge.
The abrasive action of the sand that had been sprinkled over the wood caused the edge to immediately become dull. Work ceased after only two minutes. Abrasion appeared on most prominent parts of the underside near the edge, the main area stretching for 20 mm long the working edge and up to 5 mm inward. Within this area were poorly defined overlapping striations angled at 80° - 90° to the edge. A few transition snap-feather and snap fractures were scattered along the working edge, the largest being 4 mm wide.

The tool performed very well but its efficiency was greatly reduced by five minutes. The work stopped at this point. No fracturing had occurred but the edge was blunted and there was moderate smoothing just at the very edge - almost imperceptible at X50 under a light microscope.

The tool was only used for two minutes as it performed very poorly. There was no recognisable use-wear and use-fractures could not be identified on this granular material.

Instantly, small flakes were detached from the underside of the edge. The tool did not work very well and rather than
scraping, it was scouring the wood. The job was discontinued at 5 minutes. Use-wear was not recognisable.

#350 Orthoquartzite

V(90° approx): 29 mm
roughly straight, irregular/irregular, wavy, no abrasive

This was not a good tool and only removed small shaving for the three minutes in which it was used. There was no identifiable use-wear.

#351 Quartz

IV: 38 mm
s, s/s, s, no abrasive

The tool worked reasonably well for eight minutes, at which point its efficiency was reduced and work ceased. When the job had begun the working edge immediately began to snap fracture. At completion of the work the snap fractures contained very small overlapping step fractures. These were not drawn. Fine detail was difficult to observe on this material but on the underside of two spurs was seen minute areas of abrasion and associated with them very fine furrow striations. The abrasion and striation was autogenetic.

#352 Quartz

V(85° - 87°): 20 mm
s, irregular/roughly straight, s, no abrasive

The tool was only moderately efficient for the five minutes in which it was used. The working edge was finely (0.3 mm)
step fractured on the upper margin and there were larger feather fractures on the underside margin. Fractures however were difficult to identify.

#353 Quartz

V(91° - 95°):25 mm
s, s/s, s, 0.3 grams of sand

The tool started off very well but ceased to be effective by two minutes because of the abrasive action of the sand. The working edge was abraded and bevelled (up to 1 mm wide) on its underside, while on its upper margin the edge was heavily scarred by minute (0.3 mm), overlapping step fractures. Emanating from the abraded bevel were broad subparallel furrow striations up to 3 mm long and angled between 80° - 90° (mostly 80°), to the working edge. Deep micro-cracks and micro-pits were aligned along some of these striations (plate 158).

HAFTED SCRAPING OF GREEN LIGHT WOOD

#354 Volcanic Tuff

II:28 mm
slight wave causing 1 mm difference between ends, s/s, s, no abrasive

Within the first minute of use the whole working edge snap fractured (see diagram A) and the 's' curve in the edge became more pronounced. Snap fracturing continued, resulting in a concave edge profile. The job was discontinued at 15 minutes although the tool was still functional.
Volcanic Tuff

III: 27 mm

slightly convex (1 mm), s/convex, slightly concave, no abrasive

This tool worked extremely well. Long shavings were removed evenly, comparable to what would be expected in scraping with a metal tool. Immediately on commencing scraping, about 11 small (1 mm) shallow snap fractures appeared (plate 160). At 65 minutes the job was discontinued although the tool was still as effective as when the job was begun. About 2.7 kg of shavings had been scraped from the wooden beam. All use-fractures had their point of origin on the underside of the edge. This edge was variably rounded with a smoothing/polish (of unidentified nature) restricted to the rounded area. The width of this smoothed zone on the underside of the edge was 0.7 mm (plate 160).

Volcanic Tuff

IV: 38 mm

slightly convex, s/convex, concave, no abrasive

The tool worked well but the shavings were not as large as those scraped off the wood with the tuff III tool. The job was discontinued at 60 minutes although the tool was still
quite functional. The entire working edge was moderately rounded. Polish to a width of approximately 0.8 mm on both the margins of the working edge was identified. It appeared to be less distinct on the upper face.

Most of the sand was quickly removed from the surface of wood block with the shavings, but at 15 minutes the edge of the tool was appreciably worn and the shavings being removed were extremely fine. The job was terminated at 15 minutes as the tool could no longer scrape properly. When work ceased the edge was well rounded with smoothing along its length, invading 2 mm on the underside and 0.5 mm on the upper margin. Faint striations angled at 75° - 80° to the edge were discernable only on the upper face (plate 161).

At 12 minutes the edge of the tool struck the support to the wood and a burin spall was produced on the underside. The job was terminated at 60 minutes although the tool was still functional. During the operation only short and progressively narrow shavings were removed. After an hour's use the working
edge of the tool was moderately rounded, its width being 0.1 mm. Smoothing/polish along the edge was 2 mm wide on the underside and 0.5 mm wide on the upper margin.

Volcanic Tuff

V: 38 mm
s, s/s, s, 8 grams of sand

The tool was the same as the one used in #358. After only 15 minutes work the tool's efficiency was greatly reduced and the job had to be terminated. The working edge was uniformly rounded and smoothing/polish extended for 2.5 mm on the underside and 1 mm on the upper margin (plate 162).

Flint

III: 27 mm
s, s/convex, s, no abrasive

A 7 mm snap fracture appeared immediately at one end of the working edge. It had undoubtedly been caused by a flaw in the material. A few other snap fractures also appeared; all no
more than 1 mm in width. These fractures became progressively larger as work continued. The job was discontinued at 45 minutes although the tool was still quite serviceable.

At 35 minutes some fractures were noted, the largest being a 3 cm snap fracture. When the job was temporarily stopped at 43 minutes there was an additional 5 cm wide and 4 cm long on one end of the underside of the working edge. No striations were observed at this point. After 60 minutes there was no change in the scars on the other surface that was not expanded. No blunting was detected on the surface. The job was discontinued at this point.

This tool was the same as the one used in the previous experiment #361. During use there was no change in the scar pattern. Use-polish/smoothing only began to appear at about 55 minutes. The tool was used for 90 minutes at which time it was still perfectly serviceable. The polish was restricted to the underside of the working edge and on this surface extended inwards for 1.8 mm with very faint striations angled at 75° - 80° to the edge. These were viewed at X50. The spurs on the edge between fractures were well rounded.
At 25 minutes some fractures were noted, the largest being a 3 mm snap fracture. When the job was temporarily stopped at 45 minutes there was an area of smoothing 5 mm wide and 4 mm long on one end of the underside of the working edge. No striations were observed within this smoothed area. At 60 minutes there was no change in the fracture pattern from that observed at 45 minutes. The area of smoothing also had not expanded. No blunting was detected on the working edge. The job was discontinued at this point.
width of smoothing being 5 mm on the lefthand end (see plates 163-168). There was no smoothing on the upper face but some prior snap fractures on the upper side of the edge were not now identifiable.

Orthoquartzite

II:30 mm
irregular, irregular/irregular, irregular, no abrasive

From the very beginning of the experiment the granular, uneven edge removed only fine shred-like shavings. After about a minute small fragments were detached from the edge and concavities identical with snap fractures developed. It was more or less progressive fragmenting of the edge rather than single fracturing events. The tool did not work particularly well and the job was terminated at 40 minutes when the wood shavings being removed were very fine. At termination there was no microscopic evidence of smoothing. The attrition to the edge increased its width to about 1 mm and the specific edge angle to as much as 75° - 90°.
HAFTED SCRAPING OF GREEN MEDIUM-LIGHT WOOD

#365 Volcanic Tuff

III: 45 mm
slightly irregular, slightly concave/slightly convex, concave, no abrasive

By 5 minutes small flakes (1 mm - 2 mm) had detached from the working edge and by 15 minutes a 4 mm shallow step fracture somewhat centrally placed appeared on the underside (plate 169). At 20 minutes more large shallow step fractures appeared. By 55 minutes the edge fracturing had apparently ceased as no new fractures could be identified. Although the working edge had a rather uneven appearance the tool still worked quite well. The job was discontinued at 90 minutes when the scraper was still effective. Use-fractures were the only form of wear identified.
Flint

III:19 mm
s, s/s, s, no abrasive

The tool was very efficient and it was still quite serviceable when the job was discontinued after 76 minutes of scraping. The edge was only moderately blunted and there was definitely no edge rounding. Very small use-fractures were recorded.

Obsidian

III:29 mm
convex and slightly irregular, straight and slightly irregular/s, s, no abrasive

The working edge immediately began to snap and hinge fracture; initially these fractures were no more than 3 mm wide. The tool was inefficient by 12 minutes and the experiment was therefore terminated at this time. The results of this experiment should be treated cautiously as the hafting position of the obsidian scraper was not entirely satisfactory. However, it was established that obsidian probably could not work efficiently in this mode of use.
Orthoquartzite

III (55°): 35 mm
irregular, slightly convex, s, s, no abrasive

It was not a satisfactory tool. The whole length of the edge snap fractured during the first 5 minutes of use. It then stabilised with only the occasional fracture occurring after this time. The working edge did not cut well and the 30 minutes of use was more effort than result. Snap fractures up to 5 mm wide were the only form of use-wear.

Volcanic Tuff

II: 26 mm
irregular, s/s, s, no abrasive

The edge immediately snap fractured with initiations of these fractures clearly being on the underside. Subsequent to this initial fracturing, the spurs were removed, leaving an edge which had the appearances of being steeply retouched with abrupt feather and snap fractures. Two thirds of the edge was snap fractured and the remaining third sustained bending fractures with feather terminations. The tool was still effective although it would not scrape in a straight line but dragged a little to one side. At 14 minutes the use-fracture pattern was relatively unchanged except that two fractures had appeared on the underside margin. By 25 minutes the tool still worked quite well, there being only a slight decrease in efficiency. The job was discontinued at this stage. At termination the only use-wear besides fracturing observed under the microscope was blunting and moderate to well developed rounding along the working edge, especially on prominences.
Within 60 seconds small feather fractures, all 1 mm or less, appeared on the underside of the working edge. After six minutes some fractures also appeared on the upper margin. Edge blunting and rounding was observed under the microscope after the tool had been used for 18 minutes. Efficiency was noticeably decreasing at 35 minutes and at 56 minutes the job was terminated because the tool was not performing satisfactorily. During its use and in particular in the early stage, the tool had performed quite well. At termination the working edge was rounded, especially on the spurs between fractures.
Volcanic Tuff

III: 42 mm

very slightly convex, s/s, s, no abrasive

The edge lightly transitional snap/feather fractured in the first two minutes. It then stabilised quickly, to form an efficient working edge. The only subsequent fracture damage consisted of two small fractures that appeared before 13 minutes of scraping. The experiment was discontinued at 83 minutes without any noticeable reduction in efficiency. At termination the fractures on the upper face were identical to those that constitute abrupt retouch. Some very small (0.5 mm and less) step fractures could be seen within the larger snap-feather fractures. The working edge was blunted to moderately rounded. Small areas of pronounced rounding (0.2 mm) were seen on the most prominent projections.

Volcanic Tuff

IV: 36 mm

straight with 2 mm depression on 1/2 half, s/s, straight with a 1 mm rise at the 1/2 end, no abrasive

Within the first few strokes 13 shallow step fractures appeared on the upper margin of the working edge. These fractures were all less than 2 mm wide and could easily be mistaken as light retouch. By three minutes larger fractures had developed (up to 3.5 mm). It appeared as if many of these fractures were caused by the comparatively slight pressure that was applied on the backstroke. The experiment was terminated at 50 minutes when the tool's efficiency was reduced. The tool was still
functional. At termination projections between use-fractures were blunted or rounded and this also occurred along the margins of flake scars. A 5 mm length of the working edge was smoothed and 'striated' at 90° on the underside, just on the edge. Some of these 'striations' were not obvious tears but rather were trends in the surface undulations.

By three minutes two small (1 mm) shallow step fractures appeared on the upper margin of the working edge. Only a minute later another shallow step flake 3 mm in width was detached from the same margin (see diagram). At four and a half minutes a 2.5 mm and a 2 mm shallow step fracture was detached. By nine minutes the tool's efficiency was much reduced and the edge was noticeably blunt. The job was therefore terminated. Microscopically the working edge was blunted and rounded. A 6 mm length of the working edge was almost bevelled, the rounding was so pronounced (width 0.2 mm - 0.3 mm).

\#373 Volcanic Tuff

V:30 mm

slightly concave (1.2 mm), s/very slightly convex, very slightly concave, no abrasive

By three minutes two small (1 mm) shallow step fractures appeared on the upper margin of the working edge. Only a minute later another shallow step flake 3 mm in width was detached from the same margin (see diagram). At four and a half minutes a 2.5 mm and a 2 mm shallow step fracture was detached. By nine minutes the tool's efficiency was much reduced and the edge was noticeably blunt. The job was therefore terminated. Microscopically the working edge was blunted and rounded. A 6 mm length of the working edge was almost bevelled, the rounding was so pronounced (width 0.2 mm - 0.3 mm).
Flint
II: 29 mm

slightly convex, s/s, s, no abrasive

The edge began to snap fracture immediately and as use continued the spurs between snap fractures also broke away. This damage somewhat reduced the tool's efficiency. After 30 minutes of use the edge once again began to snap fracture (average width 2 mm). Efficiency was further reduced but the tool's performance was still acceptable. At 55 minutes a 5 mm snap fracture appeared and smaller snap fractures remodelled the edge so that efficiency was increased. Another snap fracture appeared at 95 minutes and the job was discontinued at 150 minutes although the tool was still effective. Fracturing was the only form of use-wear observed.

Flint
II: 27 mm (30 mm)

straight with two small irregularities, s/s, slightly convex, no abrasive

The edge began immediately to snap fracture and for the most part it stabilised after 90 seconds. A second major series of snap fractures began to appear at eight minutes. With thickening of the edge other types of fractures occurred on both margins. At 20 minutes the working edge began to scour the wood as irregularities had developed from the large snap fracturing. The experiment was terminated at 28 minutes because of the tool's inefficiency. Many of the snap fractures were observed to have occurred on the backstroke when the
tool was pushed away from the craftsman. As well as use-
fracturing some of the prominences along the edge were moderately
rounded.

Fractures on the upper margin within the first minute - all abrupt, feather / hinge nibbling. The tool was cutting very poorly.

Flint

III:32 mm
s, very slightly concave, straight to convex, very slightly
concave, no abrasive

After 3 minutes of scraping there was a fine feather/hinge nibbling on the upper margin of the edge. There were no fractures on the underside. At 55 minutes two hinge flakes 5 mm each were struck off the upper margin of the edge during a heavily applied backstroke. The operation was terminated at 70 minutes although the tool still worked reasonably well. It was certainly not as efficient as when the job was begun. Microscopically blunting and pronounced edge rounding could be seen on the prominences along a 12 mm stretch of edge at one end of the tool. Within the large fractures, depicted below, there were very small feather, hinge and step fractures.
Flint

III: 30 mm
straight with very shallow concavity in centre, s/s, s, 0.5 grams of sand

Fractures appeared on the upper margin within the first minute - all abrupt feather types. By five minutes the tool was cutting very poorly and the job was terminated. The abrupt feather fracturing had widened the working edge to as much as 1 mm. The scars were well defined in plan but the intervening spurs and walls of the scars just along the edge were well rounded and polished. Polish also extended on the underside for as much as 2 mm from the edge.

Flint

IV: 31 mm
s, s/s, s, no abrasive

By four minutes only two fractures both under 1 mm in width appeared on the underface while there were 15 feather fractures scattered along the upper margin of the working edge. Most of these were 1 mm or less in width. A total of five fractures could be identified on the underside at nine minutes. No further fracturing was observed but a small amount could have occurred. The job was discontinued at 66 minutes at which point the tool was less efficient than when the job was begun but still quite effective. An Aborigine might not have retouched it at this stage. In fact, this tool was a superb dense wood scraper which did a job of high quality. At termination there was blunting and rounding of projections between the fractures along the edge.
quality. At termination there was blunting and rounding of projections between the fractures along the edge.

By elimination the edge had become fairly blunt and the job was terminated because of the tool's inefficiency. Microscopic examination of the work pieces showed the fractures to have been formed by the upper face damage seemed to have occurred when the tool trailed back across the stone before beginning the next forward stroke. Fractures up to 3 mm. Two 3 mm long protrusions on the edge were heavily bevelled, almost sawed, and stored at 90°. This may have occurred after the tool ceased to work and certainly subsequent to some of the fractures were made by the abrasive agent responsible for this wear reduced as the tool itself. The tool was not suitable for this task. 

Flint

V:46 mm
s, s/s, s, no abrasive

At eight minutes the underside of the edge suffered severe step fracturing. Fracturing continued for another two minutes after which time the edge stabilised. Further step fracturing occurred on the underside at 38 minutes and this damage was sufficient to make the tool ineffective. When work ceased a 2 mm section of the unfractured working edge was well rounded.

Obsidian

II(32°):40 mm
slightly convex, s/s, slight irregularity, no abrasive

The edge immediately began to snap fracture and snap and step fracture appeared on the under face. Very quickly
the edge took on an irregular profile. Much of the upper face damage seemed to have occurred when the tool trailed back across the wood before beginning the next forward stroke. By six minutes the edge had become fairly blunt and the job was terminated because of the tool’s inefficiency. Microscopically the underside of the working edge was severely step fractured with an accompaniment of some undetached flakes (up to 3 mm). The upper surface was severely feather/hinge fractured (up to 5 mm). Two 3 mm long prominences on the edge were heavily bevelled, abraded, and striated at 75°. This may have occurred after the tool ceased to work well and certainly subsequent to most of the fracturing. The abrasive agent responsible for this wear derived from the tool itself. The tool was not suitable for this task.

#381 Obsidian

III(52°, 50°, 48°)
slightly concave, slightly convex/straight to slightly concave, slightly concave, no abrasive

Instantly, the upper face sustained feather/hinge fractures along most of its length. After these fractures began to appear fractures also appeared on the underside. After only three minutes the edge was irregular, and unsuitable for further scraping. Edge fractures were not drawn. Fracturing on the upper face was step and feather/hinge varieties and on the underside, shallow step and feather/hinge. The maximum size of scars was 5 mm. Projections on the edge were minutely step fractured. Obsidian is obviously not a suitable material for this work.

#382 Obsidian

V(90°): 25 mm
s, s/s, s, no abrasive

Because of improper hafting the tool was not at all efficient. However, it was able to shave wood and the operation was
continued for 14 minutes in an effort to determine the form of damage the tool would sustain, even though the pattern would not be useful for comparison. When work ceased the working edge of the tool was abraded and bevelled along its entire length (plate 7). A total of five feather/hinge fractures (0.2 mm) on the underside margin and 21 step, feather/hinge fractures (up to 1 mm each), and one complex step (3 mm) on the upper margin.

#383 Silcrete

III:30 mm

slightly irregular with small depression in middle, irregular/irregular, concave (2 mm), no abrasive

Immediately on commencing work a continuous series of transitional snap-feather fractures (bending fractures with feather terminations) appeared on the upper face of the edge. At 12 minutes an 8 mm step flake was detached from the underside of one end of the tool through impact with a tuff of wood fibre. The tool's lessened efficiency was noticed at 14 minutes but scraping continued for another 26 minutes when the quality of work was poor. The granularity of the silcrete made it difficult to identify small fractures on the underside but I doubt that there were any. Definitely there was edge blunting but rounding did not develop.
Silcrete

III: 28 mm
irregular, irregular/irregular, s, 1 gram of sand

By four minutes the tools efficiency was greatly reduced and the job was terminated. The working edge was rounded along most of its length, the rounded sections being interrupted by poorly defined fractures. The rounded areas had a bright frosted appearance.

Olar Chalcedony

III: 20 mm
s, s/s, s, no abrasive

Instantly, small abrupt feather fractures (0.5 mm - 1.5 mm) appeared on the upper margin of the tool. Occasional fractures appeared during the following 16 minutes. By 17 minutes about 70% of the upper margin was feather/hinge fractured. It was noticed that at least some of these fractures occurred during the backstroke when the edge of the tool trailed over the wood. The tool was used for 45 minutes by which time its efficiency was much reduced. At termination there was rounding on a 6 mm stretch of the edge at one end and blunting on projections along the rest of the edge.
Radiolarian Chert

III: 38 mm

very slightly wavy, straight to slightly convex/s, slightly concave (1 mm), no abrasive

Within the first few strokes a shallow step fracture 4 mm wide appeared on the underside of the edge, at one end. After five minutes of satisfactory scraping the edge of the tool would not bite into the wood and the job had to be terminated. Fracturing was the only form of use-wear. No reason could be found for the tool's lack of success.

Rhyodacitic Volcanic

III: 35 mm

straight but with serration resulting from intersection between hackles and edge, slightly convex/s, slightly concave, no abrasive

The upper face fractured within the first two minutes creating a steeper edge angle. After five minutes of scraping the tool's efficiency progressively decreased. No subsequent fracturing had occurred. The tool was inefficient by eight minutes and the job was therefore terminated. By this time rounding was well developed along 18 mm of the working edge. Edge angle was increased to as much as 90° by fracturing on the upper face.
#388 Altered Basalt

### III(50°, 54°, 55°):35 mm

Slightly convex, fairly straight/irregular and convex, fairly straight, no abrasive

The edge immediately snap fractured creating an abrupt specific edge angle. The job was finished at 10 minutes when the quality of the work greatly deteriorated. This basalt was quite unsuitable for scraping dense wood. At termination the bifacially positioned fractures were difficult to identify because of the basalt's granularity. Projections on the working edge were rounded and were up to 0.5 mm wide. Moderate smoothing on the underside extended as much as 1 mm from the working edge.

#389 Quartz

### III:31 mm

Irregular, irregular/s, irregular, no abrasive

The tool worked well for six minutes by which time the working edge had snap fractured and a fresh edge with some spurs was formed. One 2 mm hinge fracture was detected on the underside margin. By 11 minutes the spurs had been worn away and more severe snap fracturing reoccurred. At 18 minutes the working edge was significantly dulled and the job was terminated. Microscopically the edge projections were of interest as they were covered with very fine (0.2 mm) step fractures. This micro-fracturing rounded these projections. These finely fractured surfaces were also minutely pitted and appeared 'frosted'.
Quartz

V: 30 mm
irregular, s/irregular, s, no abrasive

By six minutes very small fractures were detected on the underside of the edge. None were noted on the upper face but in any event it was an irregular surface and small fresh fractures would have been difficult to distinguish from pre-existing micro-depressions. By eight minutes the edge was dull and the job was therefore terminated. The working edge was blunted and there was a 'frosted' abrasion which merged into moderate edge rounding.

Volcanic Tuff

II: 34 mm
s, s/s, very slightly wavy, no abrasive

Within four minutes the whole length of the edge on the upper face was feather/hinge and to a lesser degree step fractured. This pattern was very regular, like abrupt scalar retouch. By 14 minutes the tool did not cut effectively and the job was discontinued. Fracturing of the upper face steepened the specific edge angle to about 75° - 90°. Edge blunting and moderate rounding of projections was discernable when the job was finished. The tool had worked reasonably well.
This tool worked quite well although the angle of its underside to the wood was around 15° – 20°. By 70 minutes the tool's efficiency was greatly reduced and the job was terminated. Besides step, feather, hinge and retroflexed hinge fracturing the only other form of wear was moderate edge rounding along sections of the working edge that were not fractured.

ADZING GREEN LIGHT WOOD

Within a minute the edge snap fractured leaving it with a dentated profile (see diagram A). Immediately after these
Fractures were recorded and work resumed, a major snap fracture occurred. This completely new edge on the adze flake could still cut through the soft, unresisting wood fibre. The job was terminated after only two minutes as the fracture pattern was quite pronounced.

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**Volcanic Tuff**

III:45 mm convex, s/convex, concave, no abrasive

This tool was extremely efficient - seemingly almost as good as a modern metal adze with comparable dimensions and design. It was used for 40 minutes and its performance was as good at the finish as it was at the beginning. Besides very fine snap fracturing along the sharp edge there was also moderate blunting.
#395 Volcanic Tuff

III: 45 mm
convex, convex/s, concave, no abrasive

This tool was used in the previous experiment, #394, but in this experiment it was reversed so that the straight face was the underside. The tool was used for 60 minutes and proved to be a very effective adze. The only change in wear pattern was that the number and size of edge fractures increased. The diagram includes fractures which occurred during #394.

#396 Flint

III: 28 mm
slightly concave (1 mm), s/s, s, no abrasive

This tool was quite efficient. By 30 minutes small fractures had appeared on the edge giving it a slightly serrated profile. At 60 minutes the job was discontinued although the tool was still working very well. There was no other use-wear detected along the working edge.
Flint

III(51°, 50°, 50°): 28 mm
slightly concave (1 mm), s/s, s, 6 grams of sand

This tool was used in the preceding experiment, #396. The tool was used for 60 minutes and was still very efficient when the job was discontinued. Fractures were not recorded but it was my impression that none or very few occurred. Smoothing/polishing was extensive on the underside (plate 174). High areas up to a distance of 5 mm from the working edge were smoothed, giving the smoothed underside a lattice-like appearance. In some smoothed areas there were ill-defined striations angled at 80° - 90° to the edge. A lighter polish, extending as much as 4 mm from the edge, was observed on the whole length of the working edge on the upper face of the tool. In some places the working edge was blunted.

Orthoquartzite

III (55°): 30 mm
straight with irregularities caused by granularity, straight to concave/convex, concave (1.5 mm), no abrasive

By 40 minutes some small fractures had appeared along the upper margin but because the stone was granular they were very difficult to identify. The job was continued for another 20 minutes at which point the tool was still effective, although its efficiency was reduced and it did not cut sharply. While the edge was blunt there was no use-wear that could really be recognisable on the prehistoric equivalent.

Orthoquartzite

III (55°): 30 mm
straight with irregularities caused by granularity, straight to concave/convex, concave (1.5 mm), 3 grams of sand

This tool was used in the previous experiment, #398. For an unknown reason the edge snap fractured within 15 minutes. The job was discontinued at 15 minutes although the tool was still quite serviceable. No smoothing had developed on the tool.
Orthoquartzite

IV (65°): 26 mm
irregular, irregular/convex and irregular, concave, no abrasive

This tool did not work particularly well, leaving rather ragged cut marks on the beam of wood. It was only used for 15 minutes. During this time the only use-damage which occurred was feather/hinge fractures as wide as 4 mm on the underside of the edge. Because the quartzite was granular, these fractures were very difficult to identify and certainly would not be identified on an equivalent prehistoric specimen.

Volcanic Tuff

III: 31 mm
s, s/s, s, no abrasive

Within the first minute of use a shallow step fracture 5 mm wide and three smaller (shallow step and feather) fractures about 1 mm wide, appeared on the underface of the tool. By 60 minutes of use more fractures had appeared along the working edge and it was somewhat dulled, though this was not pronounced. The job was discontinued at 60 minutes although the tool was still working well.
Flint

III:24 mm
straight with hackles on the edge, s/s, s, no abrasive

This tool worked very well for an hour. Within this time the edge snap fractured, a wear feature that can be attributed to hackles intersecting the edge and setting up very small irregularities in the edge profile. Edge blunting was very moderate. The job was discontinued at 60 minutes although the tool was still quite effective.

#403 Altered Basalt

III:36 mm
curved (4 mm), roughly straight, straight to convex, concave, no abrasive

This tool did not work efficiently and only produced chips about 1.5 cm long and 0.5 cm wide. Blunting was apparent within 4 minutes and this feature continued to develop. The job was terminated at 15 minutes when a 10 mm hinge flake broke off the underside. At termination edge blunting was pronounced and merged into rounding along the unfractured part of the edge. The blunting/rounding was accompanied by smoothing up to 0.75 mm wide on the underside.
Orthoquartzite

III (55°, 54°, 53°): 30 mm

slightly irregular, irregular/irregular, very slightly concave, no abrasive

This tool was not efficient as the granular working edge, characteristic of tools made from this artifact material, was not keen. The tool seemed to bruise out wood fibre rather than to cut through it. At 15 minutes the job was discontinued although there was no reduction of the already low efficiency. It is definitely not a suitable adze material. Microscopically there were spots of smoothing on high areas along the working edge. Use-fractures were not identifiable because of the granularity of the material.

ADZING GREEN MEDIUM-LIGHT WOOD

Volcanic Tuff

III: 29 mm

s, s/very slightly convex, very slightly concave, no abrasive

This tool was an ideal adze for this type of wood. Its effectiveness was constant throughout the 60 minutes in which it was used, and adzing could have continued for a considerable longer time. Blunting was not observed but the working edge did sustain some very small snap, feather and shallow step fractures.
Volcanic Tuff

III (53°): 29 mm
straight with some fine fractures, s/very slightly convex, very slightly concave, 5 grams of sand

The tool used in this experiment had previously been used in #405. Edge blunting and smoothing did not become apparent until about 40 minutes after the job commenced. Edge blunting, and smoothing abrasion on the underside of the edge, appeared before a full gram of sand had been sprinkled over the wood. The job was terminated at 62 minutes although the tool was still quite efficient. At termination edge rounding was pronounced. Smoothing extended 6 mm from the edge on the underside and there was extremely light smoothing of high spots and 'ridges' on the upper margin, giving it a lattice-like appearance. The smoothed underside was striated at 80° - 90° to the working edge which evidences rehafting of the tool during the experiment (plate 173).

Volcanic Tuff

IV: 30 mm
s, s/s, s, no abrasive

This proved to be a very good tool and when the job was discontinued after 52 minutes it was still quite serviceable. The working edge sustained moderate edge blunting and a few small hinge and feather fractures on the upper margin.
Flint

III: 60 mm

slightly convex with a 3 mm dip on the 1/h end, slightly concave to straight/slightly concave to straight, concave (2 mm), no abrasive

This was an efficient adze which was still serviceable when the job was discontinued after 60 minutes of adzing. When work ceased the only damage was some edge fracturing. Edge blunting was not distinct.

Flint

IV: 54 mm

two fracture faces meet in the centre and this joint forms a projection on the edge, s/s, s, no abrasive

After 10 minutes of use it was noted that some 0.5 mm hinge fractures had appeared on the underside margin. Before 32 minutes the fracturing had stabilised and there was no further scarring. When the job was discontinued at 60 minutes the tool was still efficient. Other than use-fractures there was only moderate edge blunting.
Silcrete

III: 20 mm
s, s/s, s, no abrasive

The tool was used for 25 minutes before the working edge dulled and the job terminated. Edge fractures resulted from impact with tufts of wood fibre.

Orthoquartzite

III: 28 mm
slightly concave (1 mm), irregular/irregular, generally straight, no abrasive

This was not an effective tool. It did succeed in battering out wood fibre, but this was all. The working edge rapidly snap fractured and crumbled. Total time of use was only 10 minutes.
Orthoquartzite

III(46°, 48°, 46°):36 mm
convex (5 mm), irregular/convex and irregular, concave (3 mm),
3 grams of sand

This tool was ineffective and clearly the artifact material
was at fault. Within the first minute of use the working
dege snap fractured and subsequently the edge of the tool
gouged out the wood rather than cut through it. The job was
terminated at five minutes. At termination the convex profile
was reduced from 5 mm to 2 mm curvature. Abrasive smoothing
extended 3 mm from the edge on the underside face and on the
upper face it extended 0.5 mm in some places. There were no
distinct striations in the smoothed area on the underside,
but the trend was 80° - 85°. The working edge was blunted
and in some places rounded.

ADZING GREEN DENSE WOOD

Volcanic Tuff

III:54 mm
s, s/s, s, no abrasive

The edge instantly fractured bifacially. Within 5 minutes
the damage was quite severe and as a consequence the tool
cut poorly. The job was terminated at this point. Besides
use-fracturing the working edge was blunted and there was
moderate edge rounding on prominences.

complex step and
hinge fracturing
Volcanic Tuff

III: 25 mm

s, s/s, slightly concave, no abrasive

After about 20 seconds the upper face step fractured along its entire length. Fractures also appeared on the underside. The job was terminated at about 35 seconds, as the severe fracturing had made the tool useless.

Volcanic Tuff

III: 46 mm

s, very slightly concave/s, s, 4 grams of sand

As soon as the work commenced the upper face fractured, a process that continued for about one minute. The tool was used for a further ten minutes with only a couple of fractures being added to this damage. At 14 minutes no further fracturing was apparent, but the lower margin of the working edge was smoothed. The tool's adzing performance was only very moderate. At 18 minutes it was not working effectively although it could still be used to detach wood. The job was terminated at this stage. Besides the severe fracturing of the upper face, smoothing on the underside extended for 1 mm to 5 mm from the working edge. Poorly defined striations angled at 90° to the edge were detected lying within this smoothed area. Edge rounding was well developed, the width of the rounded edge being up to 0.5 mm.
**Volcanic Tuff**

*IV:34 mm*

*s, s/s, s, no abrasive*

Within five seconds the underside of the edge suffered severe fracturing. This fracturing continued for the next few seconds until the entire edge was destroyed. Within two minutes the tool became useless and the job was terminated. No wear other than fracturing was identified.

![Diagram of complex step fracturing](image)

**Volcanic Tuff**

*IV:55 mm*

*convex, s/convex, concave, 1.5 grams of sand*

For the first 10 minutes the tool worked reasonably well in detaching small shavings. A misdirected blow was responsible for the 14 mm step fracture on the underside. The edge was
progressively rounding. By 20 minutes the tool was still functional despite the rounding, but it was noticeably less efficient than it was during the first 10 minutes of use. The tool's efficiency was probably enhanced by the combined weight of the stock and the large amount of hafting resin. The job was terminated at this stage. The resin haft broke three times during this operation, as the correct hafting position for the adze flake was difficult to obtain. When adzing ceased the working edge was 0.4 mm wide and the area of feather/hinge fractures was well rounded, with the smallest fractures partially smoothed over.

The tool worked moderately well for the first 18 minutes. Then a large expanding step flake was broken off the working edge because the tool struck the wood at too high an angle. Directly following this event the edge disintegrated through rapid step fracturing. With this straight-surfaced flake it was impossible to angle the bottom face with the wood, and this fact almost certainly can be held partly responsible for the fracture damage.

Volcanic Tuff

V: 32 mm

slightly concave (1 mm), s/s, s, no abrasive

The tool worked moderately well for the first 18 minutes. Then a large expanding step flake was broken off the working edge because the tool struck the wood at too high an angle. Directly following this event the edge disintegrated through rapid step fracturing. With this straight-surfaced flake it was impossible to angle the bottom face with the wood, and this fact almost certainly can be held partly responsible for the fracture damage.
Volcanic Tuff

V: 35 mm
convex (1.5 mm), roughly straight/straight to convex, concave (1.5 mm), no abrasive

Within five minutes 4 mm step flake detached from the underside of the working edge along its central portion. By 10 minutes a further 2 mm step fracture appeared on this face and two fractures on the upper face. Another step fracture appeared at 20 minutes. All these fractures were short and wide. No further fracturing occurred after 30 minutes but edge rounding was apparent. The tool worked quite efficiently at first but by 30 minutes its efficiency was reduced and the job was discontinued. Edge rounding was macroscopically detectable, especially when the underside was viewed.

Flint

II (26°): 20 mm
slightly irregular, s/s, s, no abrasive

Severe snap fracturing began immediately and continued until the whole length of the edge was fractured. This process altered the edge angle to about 50° and therefore, for a brief time the tool was able to adze the wood. At five minutes a single snap fracture removed the whole edge and adzing was no longer possible. Clearly the edge angle was unsuitable for adzing.
Flint

III: 25 mm
s, s/slightly convex, slight curve upward on the l/h end of the edge, no abrasive

Within three minutes the edge was quite severely use-fractured. The job was terminated at this point as it was obvious that the edge angle was not high enough.

Flint

IV: 40 mm
very slightly convex, s/very slightly convex, very slightly concave, no abrasive

Most fracturing occurred within the first five minutes. Fracturing did not completely ceased until 40 minutes of adzing had been completed. The edge was very durable and consequently the job was not discontinued until 65 minutes had elapsed. The tool was still working effectively at this time and had performed quite well during its use. At completion of the job there was moderate rounding on some of the projections on the working edge.

Flint

V(95°, 90°, 85°): 42 mm
s, s/s, s, no abrasive

The resin haft broke twice before 60 seconds of adzing had been done. The cause of this problem was the unsuitability of the
adze flake for hafting. The working edge was aligned with the underface, rather than being in line with the central axis of the tool. Consequently, impact during adzing induced a bending stress on the tool which was enough to break it from the haft. In the first few minutes a step flake (2.2 mm) was detached from the underside. After seven minutes of rather unsatisfactory adzing, the working edge was blunted and, as the haft broke once again, the job was terminated. The tool's design was quite unsuited for adzing dense wood. When adzing ceased one section of the working edge was intermittently blunted and rounded and there were three 0.5 mm feather/hinge fractures on the underface.

#424 Obsidian

II(30°): 20 mm

slightly concave, s/very slightly convex, s, no abrasive

The edge immediately snap fractured quite severely. By 90 seconds the part of the flake projecting from the resin had been completely flaked away. The tool did not work at all.

#425 Obsidian

III(48°): 27 mm

irregular, s/s, slightly convex, no abrasive

The edge began to break down immediately. Snap fractures were as wide as 4 mm. The original working edge was completely removed within one minute. In spite of this damage the tool worked effectively for 10 minutes, at which point the fracturing had reduced the edge to the level of the resin haft. At termination the working edge was 2 mm wide, and there was severe bimarginal step, retroflexed hinge and feather/hinge fracturing (up to 5 mm each in width).


#426 Obsidian

V(89°): 33 mm

s, s/s, s, no abrasive

Severe fracturing appeared instantly on the underside of the edge. The job was terminated after 15 seconds. The step and feather/hinge damage (largest, 22 mm wide) on the underside was the only wear observed on the tool.

#427 Silcrete

III: 37 mm

slightly convex, s/convex, concave, no abrasive

Even though the adze flake had suitable edge and under-surface convexity the working edge was not robust and fracturing began immediately after work commenced. Fracturing ceased at two minutes while effective adzing continued. At 25 minutes an 8 mm step flake was detached from the upper face. The tool was still effective in adzing. By 42 minutes the tool was not cutting cleanly into the wood and shavings were small. The job was therefore terminated. Fracturing was the only form of damage detected.
poor quality hafting is probable. The job was finished prematurely at 10 minutes because of the hafting difficulty.

Fractures had appeared on the upper face and areas of smoothing up to 1.5 mm wide were detected on spurs between these fractures. This smoothing appeared even though the sand was quickly cleared off the wood with the shavings.

Fractures had appeared on the upper face and areas of smoothing up to 1.5 mm wide were detected on spurs between these fractures. This smoothing appeared even though the sand was quickly cleared off the wood with the shavings.

Altered Basalt

III (54°): 39 mm

s, s/s, roughly straight but with irregularities, no abrasive

This basalt was too granular for the adze flake to have a keen edge and consequently the tool did not work well. Within five minutes an 8 mm shallow step flake appeared at one end of the working edge, and some poorly defined hinge flakes were detached. After 15 minutes the edge was noticeably blunting and the tool's efficiency was greatly reduced. The job was therefore terminated. Surprisingly, not a great deal of fracturing had occurred. Edge blunting and very modest rounding was identified.

Orthoquartzzite

III (45°, 47°, 50°): 25 mm

irregular, slightly convex/s, s, no abrasive

In the first few seconds of use the edge fractured. This process continued creating a completely new edge that did not cut the wood properly. The job was stopped after only one minute of adzing. At no time did the tool work well. The only damage discernable under the microscope was use-fracturing.
Quartz

II (26° approx.): 40 mm
irregular, irregular/irregular, roughly straight, no abrasive

The edge immediately began to snap fracture and shatter. It then stabilised to a very moderately useful working edge after three to four minutes. Major breakdown of the working edge occurred at 15 minutes with severe snap fracturing. By 17 minutes the edge was fractured back to the resin haft. The job was terminated at this point. At termination fractures were quite large - one step fracture was 20 mm and a feather/hinge was 17 mm.

Quartz

II (25°): 28 mm
irregular, irregular/irregular, irregular, no abrasive

Within a few seconds the exposed part of the adze flake shattered into about 36 fragments between 1 mm - 6 mm each in size. This dramatic result could be attributed to the presence of small internal flaws in the quartz.

Quartz

II (25°): 25 mm
s, s/s, s, no abrasive

The working edge instantly snap fractured and this developed within two minutes into a very large concavity. This concavity was snap fractured for its entire length, and the tool was no longer useful.

Quartz

III (54°): 37 mm
s, s/irregular, irregular, no abrasive

The working edge snap fractured immediately. A 17 mm snap fracture appeared on one end of the edge. Other types of fractures also occurred. The tool was not effective.
#435 Quartz

IV(68°, 65°, 65°):
straight but slightly serrated, s/irregular, s, no abrasive

The edge immediately step and feather/hinge fractured on the underside. The job was discontinued after three minutes due to the unsuitability of the tool for this task. The major damage was a 10 mm and 12 mm shallow step fracture on the underside and complex feather/hinge fractures on one end of the working edge for a length of 10 mm.

SCRAPING *Eucalyptus tetradonta* BARK

#436 Volcanic Tuff

II:43 mm
straight with slight concavity at l/h end, s/s, s, no abrasive

Snap, deep feather/hinge and transitional snap-feather fractures appeared along the working edge immediately after commencement. Three feather fractures (1 mm, 2 mm and 2mm) quickly disappeared in the creation of later snap fractures. When the edge was closely inspected after 20 minutes of scraping it displayed a continuous series of snap fractures (see diagram A). The 3.5 mm fracture on the r/h end of the edge resulted from mishandling the tool during use. All snap fractures had their points of origin on the underface and in reality there was a transition among the fractures from snap to feather/hinge. With continued use the fracture pattern altered to that depicted in diagram B, which shows the stabilised edge at termination of the job. Total work time was 70 minutes and in that period 7,800 cm² of outer bark was scraped away to reveal the dense inner layer of bark. Although a tenacious coating of resin, 2 mm wide on the upper face and 5 mm wide on the underface, formed along the working edge, blunting was detected, and prominent spurs between fractures were rounded. It may be that the adhering resin protected the edge to some degree. The tool was still quite functional when the job was terminated.
Within five minutes the delicate working edge had snap fractured along most of its length (plates 183, 184). This process continued until all the loose outer bark from an 8,000 cm² sheet had been scraped away (see diagram A), a task that took only 18 minutes. The inner bark was then cleaned and levelled using the same scraping action. Larger snap fractures all with their origins on the underface, occurred when tufts of fibre could not be dislodged and greater force was applied to the tool. The scraper was still quite efficient when the job was finished at 28 minutes. At termination the margin on the underside of the edge was bevelled to a width of about 1 mm (plate 184). A very light 'polish' was observed on the walls of snap fractures and as far from the edge as 0.5 mm on the upper margin.

Volcanic Tuff

II:42 mm
irregular, s/straight to slightly convex, concave, 50 grams of Extra Fine Extracted Glass Sand (= dust fraction)
After five minutes the only detectable use-wear was four snap fractures each no more than 1 mm wide. The experiment was terminated after 60 minutes of scraping (area scraped 3.38 m²) although the tool was still quite serviceable. Besides bin- marginal use-fracturing the only other form of wear was edge blunting, which developed into rounding on the 1/h end of the edge (see diagram). There were no positive traces of use-polish or smoothing after the coating of resin, which had been deposited on the edge, was removed.
Orthoquartzite
II: 30 mm
irregular, irregular/irregular, irregular, 20 grams of Extra Fine Extracted Glass Sand

The working edge immediately began to snap fracture, until the edge thickened enough to withstand the pressures that were applied to the tool. Resin from the bark adhered to the tool, in particular the upper face. The job was terminated after 25 minutes when the outer layer had been cleaned from a 8,750 cm² sheet of bark. At termination the snap fractures were difficult to identify because of the granularity of the quartzite. I doubt that any other types of fractures developed. Subsequent to the formation of the fractures the edge was further degraded by grain removal which thickened the edge to 1 mm - 2 mm. Some of the working edge was moderately rounded. An area of moderate abrasive smoothing 16 mm long was observed on the underside of the edge (see diagram). The surface in this area was still undulating.

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SCRAPING CHARRED Eucalyptus tetratoma BARK

Volcanic Tuff
II: 35 mm
s, s/s, s, no abrasive

The bark was charred and then scraped until fresh bark was exposed over the whole surface of the sheet. The process was then repeated. The overall area of bark that was scraped was 6.6 m². The working edge of the tool snap fractured within
the first minute of use and subsequently these snap fractures became progressively larger (compare diagrams A, B and C). A residue deposition of some sort along the edge gave the impression of a polish but a minimal amount of washing removed this material. Spurs between snap fractures were rounded by fine snap fractures which, however, were not in themselves clearly defined.

![Diagram A](image)

**After 1 minute**

![Diagram B](image)

**After 2 minutes**

![Diagram C](image)

**At Completion**

#441 Orthoquartzite

II: 35 mm
irregular, irregular/irregular, irregular, no abrasive

A total area of \(5.76\ \text{m}^2\) of charred bark was scraped in this operation. Use-wear developed very slowly. Large snap fractures, and fine fractures which could not be identified
appeared first. Detachment of individual grains from the edge probably also occurred. At termination there was an area of smoothing 7 mm long and 1 mm wide on the underside of the edge. The undersides of some spurs were also smoothed for an extent of approximately 0.6 mm from the edge. The projecting spurs also sustained edge rounding. All smoothing had the typically 'frosted' appearance characteristic of abrasive smoothing.

Abrasive Smoothing

This form of wear occurs when the microtopography of a surface of a stone tool is levelled by fine microfracturing. In contrast to the adjoining surrounding unmodified surface it may appear to be a polished surface, even though it is not highly reflective. Abrasive smoothing is roughly equivalent to optical grinding.

Brittle Material

Material which fails through well defined crack growth.

Classification

The ordering for some purpose or other, of classes into a scheme.

Class

My application of the term is synonymous with 'type'. A class is an abstract entity which is constituted by specifying the necessary and sufficient conditions for membership.
ABRASION:

This form of wear can ensue when the surface of a tool is contacted by another surface and/or hard particles. An abraded surface is characterised by fine overlapping or closely packed fine microcracks and micropits. It is most often seen on 'glassy' artifact materials such as quartz and obsidian.

ABRASIVE SMOOTHING:

This form of wear occurs when the microtopography of a surface of a stone tool is levelled by fine microfracturing. In contrast to the adjoining or surrounding unmodified surface it may appear to be a 'polished' surface, even though it is not highly reflective. Abrasive smoothing is roughly equivalent to optical grinding.

ATTRIBUTE:

A defining factor of a class. Only one attribute is necessary to set up a class.

BENDING:

When a beam is bent the bending 'moment' (see definition) is resisted by a stress distribution in the beam, such that on one side of the 'neutral axis' the stresses are tensile and on the other side they are compressive.

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CLEAVAGE:

When a crystal or crystalline rock is strained beyond its plastic and elastic limits it will break. If the new fracture surface is related to the crystal structure the rock or crystal shows cleavage. The term is used with qualifiers such as perfect, distinct and poorly defined.
CONTACT MATERIAL:
The material which a tool contacts and which may be responsible for the formation of wear on that tool. It need not be equivalent to the worked material.

CRACK GROWTH-DYNAMIC:
Unstable crack-growth, typified by a rapid acceleration of the crack toward a 'terminal velocity' (about one third speed of sound waves).

CRACK GROWTH-STATIC (QUASISTATIC):
Stable crack-growth, under equilibrium conditions, where extension increases steadily with driving force of applied loading.

DYNAMIC LOADING:
Impulsive loading due to applied forces which displace the material boundary at a rate comparable with sound waves, thus producing stress waves.

EDGE ANGLE RANGE - ACCEPTABLE:
Edge angles on tools that are effective although not necessarily efficient, as determined by the experimenter.

EDGE ANGLE RANGE - PREFERRED:
Edge angles on tools that work efficiently, as determined by the experimenter.

EDGE BEVELLING:
This is the flattening or asymmetrical rounding of a working edge. The edge may simply be more heavily worn on one margin or it may be entirely truncated leaving a flat facet angled at 75° - 90° to the lateral faces. Bevels may be use-wear resulting from rubbing, burnishing, smoothing, fleshing or scraping or they may be intentionally ground.

EDGE BLUNTING:
When an edge no longer terminates in an angular cross-section but is to a very small degree flattened, irregular or rounded. On prehistoric tools, edge blunting will often not be recognisable as use-wear, or indeed, not recognisable at all.

EDGE DULLING:
In experimental tool-use this term is used when a working edge has lost its keeness but shows no visible sign of blunting or rounding.

EDGE ROUNding:
In relation to use-wear, edge rounding occurs when the working edge is reduced by abrasive attrition, by chemical action as in phytolith polishing, or by both. A use-rounded working edge is symmetrically semicircular in cross-section.
ELASTICITY:  
Reversible change of size and shape of a body at small applied loads.

ENERGY:  
Capacity of a body to do work, either by virtue of its motion ('kinetic' energy, as in a hammer blow) or its position ('potential' energy, as with a mass under gravity). Unit - Joule, J, definition kgm s \(^{-2}\).

FINE-TEXTURED SILICATES:  
The group of crypto and microcrystalline rocks comprises flint, chert, chalcedony and the experimental volcanic tuff. These artifact materials are brittle, as compared to the basalts, and macroscopically have relatively smooth surface textures. The mechanical and petrological properties of the first three materials are very similar.

FLAKE-SCAR:  
Synonymous with edge fracture and use-fracture.

FORCE (LOAD):  
Push or pull exerted on a body (defined fundamentally as equivalent to the acceleration that it produces on the body mass - Newton's second law of motion - with need to specify direction as well as magnitude). Unit - Newton, N, definition kgm s \(^{-2}\).

FRACTURE DEBRIS:  
Dislodged material from steps, ledges, etc. on fracture surface - these prevent re-contacting surfaces from 'healing'.

FUNCTION:  
The intended use of a tool or, in other terms, the purpose for which it was designed or shaped. The function of a screwdriver is to drive screws even though it may be used to lever the lid from a paint tin.

GROUP:  
A collection of objects. These objects do not themselves exist as a class, which is an abstraction based on attributes shared by members of the group.

HARDNESS:  
Resistance of material to permanent (inelastic) deformation.

INDENTATION:  
Localised contact of an indenting body on a specimen surface.

ISOTROPIC MATERIAL:  
Material in which physical properties do not vary with direction (e.g. glass).

LOAD:  
An external force applied to a solid material so that deformation ensues.
LATERAL FACE:
One of two major surfaces which meet at the edge of a flake or core. Usually, the edge is a working edge and the face is the dorsal or ventral face of a flake.

LATERAL MARGIN:
The part of a lateral face that lies within approximately three millimetres of a working edge. The term although more specific can be used as an alternative to lateral face.

MATRIX:
Describes cement material that is composed of particles with diameters of less than 0.02 mm.

MOMENT:
Moment of a force is the tendency for the force to rotate the body (for a pure moment equal and opposite forces act at a distance, over the 'moment arm'). Unit - Nm.

RAYLEIGH WAVES:
Waves of surface disturbance propagated along a free surface. The theoretical maximum propagation velocity for a fracture.

SKIN FLESHING:
The process of detaching membrane, flesh and fat from the inner surface of a fresh or dried skin.

SKIN SCRAPING:
This term is used to describe the process of cleaning and softening the inner surface of a skin. The term can also be used when the purpose of the scraping action is unspecified or not known.

STATIC (QUASISTATIC) LOADING:
Forces applied effectively and relatively slowly, causing rate of boundary displacement that is very much less than velocity of sound waves.

STRAIN:
Relative change of size or shape of body under action of applied loads.

STRENGTH:
In a mechanical sense this is the ability of a material to resist stress without largescale failure.

STRESS:
The ratio of force to the cross-sectional area over which it acts (the magnitude, orientation of the area, and direction the force must all be specified). Unit - Pascal, P defined as Nm⁻². This unit is too small for normal use and the MPa defined at MNm⁻² is usual.

STRESS FIELD:
Distribution of stresses within a body.
STRESS INTENSITY FACTOR:

Measure of the intensity of the local stress field that exists about the tip of a crack. Unit MNm^{-3/2}.

STRESS - PRINCIPAL:

At any point in a body it is possible to specify three directions mutually at right angles wherein planes perpendicular to these directions experience only tensile or compressive stresses (no shear) - such stresses are the principal stresses and the directions are principal directions.

STRESS-TENSILE, COMPRESSIVE, SHEAR:

A tensile stress tends to pull two parts of a body apart, a compressive stress tends to push the parts together, and a shear stress tends to make one part slide over the other.

STRESS TRAJECTORIES:

Set of three 'families' of curvilinear lines in a body, each set mutually perpendicular to the other two, so that a tangent to any curve at a point represents a principal direction at that point.

STRIATION - FURROW:

A 'ploughed' groove which has a fractured morphology.

STRIATION - SLEEK:

A smooth-sided striation resulting from a plastic reaction of a surface to an indenting particle.

SURFACE ENERGY:

Energy required to create new surface area (in a brittle solid, this is the work to separate cohesive bonds across a separation plane).

TOUGHNESS:

Resistance of a material to fracture.

UPPER FACE:

This refers to the upper face of a tool that is angled at less than 75° to the worked material. Upper margin is the margin of this face along the working edge.

UNDER FACE:

This refers to the lower face of a tool that is angled at less than 75° to the worked material. The term is synonymous with 'underside' and 'lower face'. Underside margin is the margin of this face along the working edge.

USE:

The actual use of a tool, irrespective of its intended function.
USE-FRACTURE:
A fracture resulting from tool-use and which leaves a scar emanating from a working edge. Synonymous with edge fracture and flake scar.

USE-WEAR PATTERN:
An abstraction of selected use-wear attributes observed on more than one stone tool used to perform a specific task. The term is used on two levels: a general wear pattern involving only one attribute, such as snap fractures within a particular size range; and a specific wear pattern which involves a repeated combination of attributes, such as edge rounding, snap fracturing and longitudinal striations.

WAVE PROPAGATION:
If a body is suddenly loaded the stress propagates in the form of a wave similar to sound in air. There are two basic waves propagating at different velocities
(a) Dilatational waves of volume strain
(b) Shear waves of change in shape.

WORK:
Work is done by a force when the point of application is displaced along the line of action of the force. Unit - Joule, J, definition kg m's 1.

WORKING EDGE:
The edge of a tool that is intentionally brought into contact with and penetrates the material being worked. Most often the whole edge is at some stage in contact with the worked material.

WORKED MATERIAL:
The actual material that is being shaped or processed with a tool. In the tool-use experiments the worked material is the same as the contact material. Prehistorically, this need not be the case and the worked material may not be responsible for use-wear that develops on the tool.
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