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Australian Flaked Stone Tools: A Technological Perspective

J. JEFFREY FLENNIKEN[a] and J. PETER WHITE[b]
[a]Laboratory of Anthropology, Washington State University, Pullman
[b]Department of Anthropology, University of Sydney

ABSTRACT. Australian flaked stone technologies are examined from a flintknapper's perspective. We identify six different flaking techniques in the archaeological collections, but only a single reduction sequence. The five stages of this sequence are described in detail and it is demonstrated that Australian technologies are highly opportunistic. We examine major classes of Australian flaked stone artefacts — adzes, backed artefacts, burins, points, 'scrapers', 'utilized flakes' — from a technological perspective. We conclude that most morphological variation within these broad classes is not the result of deliberate design. We also note that 'backing' is simply the application of already-known bipolar technology to small flakes, and that more precise use-wear studies are needed to determine that 'scrapers' and 'utilized flakes' were actually used as tools.

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Stone tool manufacture has been established for at least 2.5 million years. In this period, flintknappers have transformed stones into tools by literally thousands of different techniques. Technological sophistication, necessity, and time and energy expended to make these different stone tools have varied considerably throughout prehistory, with every technology having in common the basic necessity of producing functional tools.

In this paper we argue that within Australia and Tasmania all the tool type preforms used throughout the last 40,000 years were produced from a single reduction sequence. Lithic raw materials were selected and reduced, solely by percussion techniques, into a variety of flakes and blades which served as preforms for formal as well as informal tool types. Heat treatment was frequently employed at different stages of reduction to improve the flaking qualities of the raw materials (Flenniken & White, 1983). The technologies used in Australia were thus ingeniously simple and flexible. They were also highly opportunistic, and exploited the potential of the reduction sequence in a variety of ways.

In the sections which follow we present Australian flaked stone technologies as a single sequence, for the sake of clarity and continuity. We stress that this sequence was rarely produced prehistorically as a single event from a single piece of stone. Our account is based on JJF's flintknapping experience, replicative experiments, intensive inspection of museum collections and material from a number of archaeological sites, discussions with various colleagues, and the literature.[1] It is important to note that this paper is primarily JJF's technological view of the Australian flaked stone material and we do not attempt any detailed comparison with ethnographic or archaeological assemblages from particular sites. As far as we are aware, no studies based on a detailed understanding of knapping technology have been made of Australian assemblages, although such are now in progress (e.g. by D. Witter, P. Hiscock and R. Fullagar). These are clearly necessary to test and develop the interpretation given here.

We start by defining the concepts of technique, sequence and technology (cf. Crabtree, 1972; Flenniken, 1981). A technology is the total sum of flintknapping knowledge possessed by a group of knappers and demonstrable from the end-products of their knapping behaviour. Each technology is composed of a number of particular techniques, which are specific methods by which flakes are removed from a stone to achieve a particular goal. The techniques, and the sequence in which those techniques are applied to the stone, form an identifiable cultural pattern. This pattern is visible in the prehistoric record in the stone material remains at knapping locations. It should be noted that technologies are defined by both technique and sequence, so that if, for example, the same techniques were used at two sites, but the sequence in which those techniques were applied to the stone differs, then we are observing two different technologies. Within Australia, the situation is that the same sequence has been used throughout prehistory, but six different techniques have been employed in a variety of orders. Thus there are a number of areally and temporally specific prehistoric technologies. We do not attempt to define these here. We note that the technology used at any site is deduced from the material record: what the manufacturers 'had in mind' is neither detectable nor relevant (cf. White, Modjeska & Hipuya, 1977).

The basic Australian reduction sequence is given in Figs 1 and 2. All stages of this sequence can sometimes be found in a single prehistoric record, but this is not always the case. The sequence remained the same, but stages in it were often intentionally by-passed depending on the numbers of specific tool types required (e.g. backed blades, adzes) and the shape and geological type of raw material. In other words, if only macro-flakes were required for specific tool types, then a selected core was totally reduced within stage II, or, if only poor quality flaking raw material was available, then the reduction sequence may have been limited by it to stage II only. The fact remains, however, that all of the stone tool preforms were produced from a single reduction sequence. A series of different reduction sequences has not been seen in Australian or Tasmanian materials, and we suspect the same is true for New Guinea. We note that this situation is unusual in world terms. In north America, for example, many different reduction sequences were used, over time, even within a very small area such as a single stream valley. A similar pattern is widespread throughout the Old World.

Within Australia, artefact manufacture from flake or blade preforms most frequently employed the two reduction techniques of free-hand percussion and bipolar. Four other techniques—percussion bifacial thinning, percussion 'backing', burination and pressure flaking—were also used at various times, the latter two probably only during the last few thousand years. All of these techniques employ the same basic knapping principles. None of them imply drastic technical changes such as might be introduced from some external source; all are developments of a single reduction sequence.

We suggest that to find only a single reduction sequence, a limited number of techniques and thus a highly opportunistic use of stone in Australia is congruent with our other information about stone tools. It has been known for a long time that formal patterning of stone tools was relatively uncommon in the prehistoric record (e.g. Mulvaney & Joyce, 1965) and that this is also the situation in other parts of the southwest Pacific (White, 1977). Ethnographic observations in both Australia (Hayden, 1979; Wright, 1977) and New Guinea (White, 1968a; White & Thomas, 1972) have shown that most stone tools were completely opportunistic, being pieces of stone selected for their intended task, rather than designed and made to a regular formal pattern.

What can now be demonstrated is that all formally patterned stone tools can easily be produced from a single reduction sequence, i.e. Australian knappers worked within a framework of the minimum possible complexity. We will demonstrate further that in the production of formal tools, Australian knappers were also often opportunistic, that is, they would frequently only employ the minimum amount of flaking required to make a particular shape. Thus, for example, many backed artefacts, which were already small, appropriately shaped flakes, were only backed along part of one side.

The Australian Reduction Sequence

Stage I: Selection of Raw Materials. All lithic materials that were selected for the production of flaked stone tools must fracture conchoidally to some degree. A conchoidal fracture ensured the prehistoric knapper of a predictable end result whether it was a flake in the manufacturing process or the intended end product such as a tula adze. Conchoidally fracturing

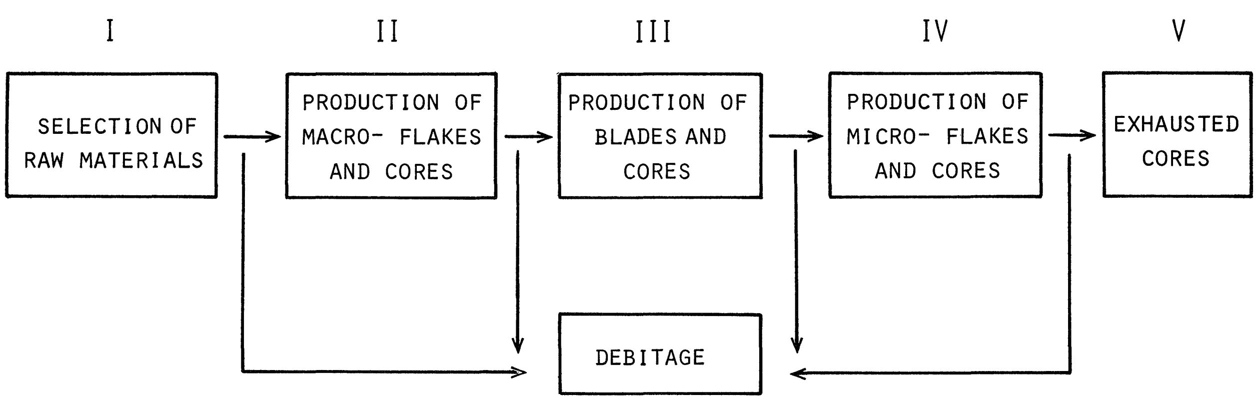

Fig. 1. Australian flaked stone tool reduction sequence.

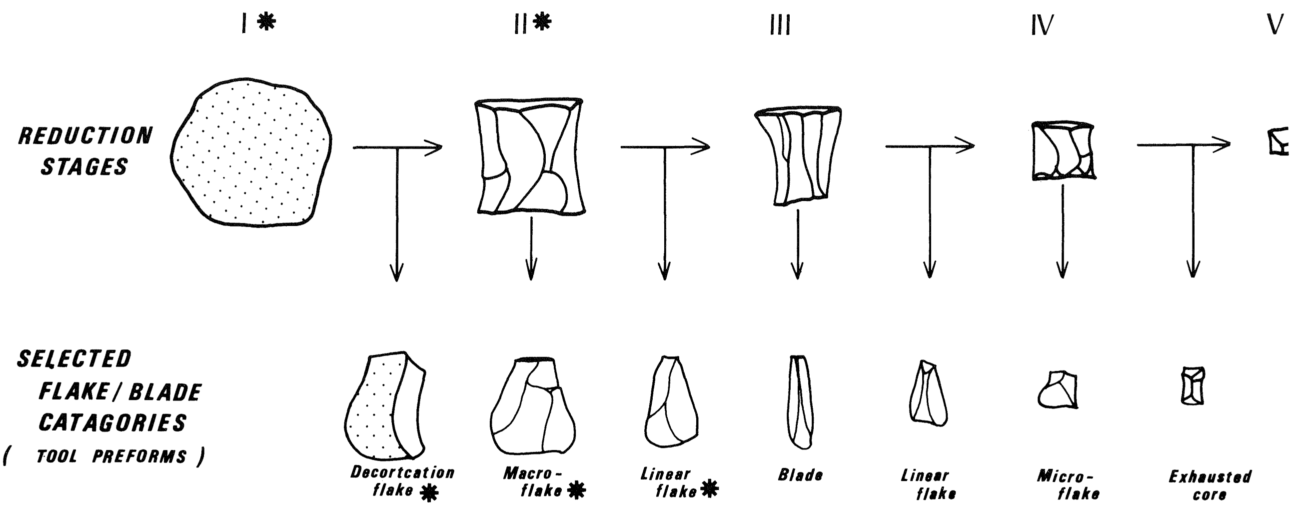

Fig. 2. Australian reduction sequence and selected flaked tool preforms. * indicates heat treatment locations during the sequence.

materials selected by Australian knappers included chert, chalcedony, jasper, silcrete, quartzite, basalt, silicified wood and other igneous and metamorphic rocks.

Flakeable lithic materials occurred naturally in a variety of sizes and shapes. Both size and shape played an important role in both transportation and reduction sequences. Transportable materials occurred in three sedimentological sizes: pebbles < 64 mm, cobbles 64–256 mm and boulders > 256 mm. Within this size range, large cobbles and small boulders were frequently too heavy or awkward to transport and were therefore partially reduced where they were found. Some initial reduction was often also conducted to test the quality of each piece of stone. Thus primary reduction of material from any source may have been an economising measure rather than one designed with particular end-products in mind. This is consistent with the observations of, for example, Love (1936:74) and Byrne (1980).

Raw materials occurred naturally in four basic shapes: rounded, sub-rounded, sub-angular and angular. The specific shape of a rock may be the result of its primary geological deposition or of processes acting on it later. For example, if angular materials are transported long distances by water, they will be secondarily deposited as rounded or sub-rounded rocks depending upon distance travelled; the longer the distance, the more rounded the material.

The natural shape of material was important from a technological perspective. Material shape often dictated the primary stage of the reduction process. For example, if a material occurred in tabular (angular) pieces, the first stage of reduction would be alternate flaking which started at a corner and established each flake platform by the previous flake scar (cf. Basedow, 1925:368). If the selected raw material was a medium sized, rounded pebble, then bipolar was the most frequent method of primary reduction due to the physical limits of the stone. We note that even if material did dictate the primary reduction stage, a culturally patterned reduction sequence may be employed subsequently.

Flakeable lithic materials possess two types of cortex or weathered exterior. The cortex type will identify the geological environment from which the material was quarried or collected prehistorically. Primary geological cortex occurs on materials that were procured from the same geological environment in which they were produced. Incipient cone cortex, on the other hand, is created by hundreds of small intersecting conchoidal fractures that can only result from water transportation. Therefore, materials with this kind of cortex were collected from a secondary deposit such as a river point bar or a beach.

Stage II: Production of Macro-flakes and Cores. Once the selected raw material was ready for reduction into useable flakes, either a natural platform was established at some location on the potential core, or a flaked platform was established by a percussion technique. If the material was angular or sub-angular in shape, then a natural, thin cortical surface, providing an angle of 90° or less to the potential working face of the core, was usually selected as the platform. Platform-to-working-face angles of greater than 90° created technical problems for the knapper on any type of core because more obtuse angles caused the flakes or blades to terminate abruptly in a hinge or reverse hinge (Fig. 3).

If the potential core was more rounded in shape, a flaked or faceted platform was prepared by one of four percussion techniques:

(i) If the selected material was large and rounded to sub-rounded, the potential core was placed on a stone anvil and struck with a hammerstone (on-anvil or block-on-block technique) (Gould, 1980:123). This sheared the core, providing a flat, single faceted platform at one end or through the middle of the cobble (Fig. 4).

(ii) An alternative technique for single facet platform preparation on large rounded to sub-rounded material was simply throwing the potential core onto a stationary rock in the ground, then selecting suitable fragments as cores. This has been observed by JPW, in the eastern highlands of New Guinea in 1964.

(ii) A bipolar technique was frequently employed to fracture a small pebble or cobble in order to obtain a platform, or to get access into the stone for further reduction by a bipolar technique.[2] Small rocks were extremely difficult to fracture by direct free-hand percussion because it was difficult to support the small mass by hand (see Hiscock, 1982:39–41). Some bipolar techniques used in Australia and New Guinea are described by White (1968b). See Fig. 5.

(iv) The platform of a potential core of angular or sub-angular material could be prepared by direct free-hand percussion at a favourable location. A favourable location was one where acute angles occurred naturally between the potential core platform and the working-face of the core. This technique was usually employed in preference to (i) above when the cortex was thick and too much force dissipated within it or when, given the shape of the rock, a suitable platform did not naturally occur. Therefore, the cortex or an irregular surface was removed and a multifaceted platform was established directly in the fresh, cortex-free material (cf. Gould, Koster & Sontz, 1971:161; Gould, 1980:125–6).

Frequently, platform preparation and flake or blade removal occurred alternately throughout the entire reduction sequence due to raw material shape. Once a core platform was flaked or faceted, usually as a result of angular material shape, it had to be flaked after each series of flake or blade removals because the acute platform-to-working-face angle changed adversely as a result of the flake or blade removal (Figs 3 and 6). Platform preparation flakes usually exhibit a wide (margin to margin), faceted and laterally curved (margin to margin) platform with a pronounced bulb of force covering the majority of the ventral flake surface. The flakes usually terminate in a slight hinge or feather.

Another kind of faceted platform core is the bifacial core commonly found in Australia. With this, each bifacial core platform was created as a result of flake or blade removal. This bifacial process of flake or blade removal was usually dependent upon material shape (sub-rounded to rounded) and intended end product, and was an extremely efficient use of the raw material (Fig. 7).

The actual choice of the specific platform production technique was more a function of the size, shape and petrology of the selected raw material and was not necessarily a 'cultural' decision. All four core platform preparation techniques were known and used in prehistoric Australia. This fact illustrates the opportunistic and economising nature of Australian reduction technologies.

The first series of flakes produced from the macro-flake core were decortication flakes or flakes whose dorsal surface were wholly or partially covered by cortex. These flakes were employed as tools or blanks for tools if they met the technical and functional requirements of the user. The selection of decortication flakes as tools or tool blanks was dependent upon availability of material, flake size, shape and the presence of at least one useable edge.

Once the core was established, more regular flakes, in terms of size and shape, could be produced. Specific ones were then selected for the production of tools, or were edge-modified by percussion or pressure flaking into flake tools. The remainder of the flakes were either used as unmodified flake tools or discarded as debitage.

Selection of flakes for the production of tools was based upon a formal set of attributes. However, the limitations put on this attribute set varied directly with the availability of 'good' raw materials. In other words, the 'formality' of a morphological type was conditioned by functional necessity: the poorer the quality of raw material, the wider the range of formal attributes within any class of tools.

It should be noted that very large macro-flakes were also employed prehistorically as cores (Fig. 8). The

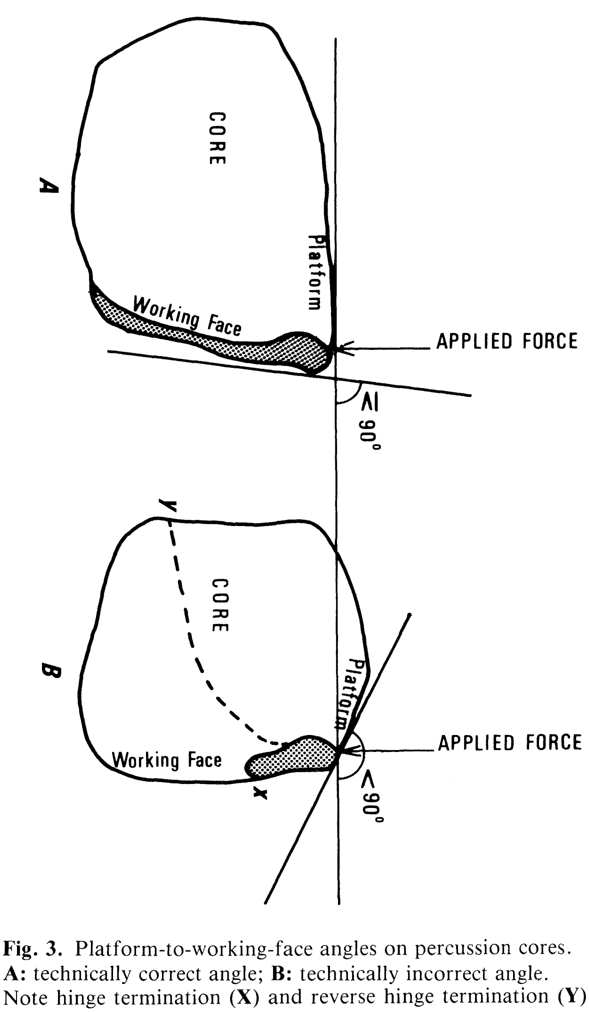

Fig. 3. Platform-to-working-face angles on percussion cores. **A:** technically correct angle; **B:** technically incorrect angle. Note hinge termination (**X**) and reverse hinge termination (**Y**).

ventral surface of large macro-flakes served as a single facet platform and micro-flakes were produced from the dorsal surface of the original macro-flake. In addition, exhausted cores of this type were often used as tools if they met the rather loose morphological requirements of the potential tool user.

Specific or individual platform preparation for the removal of macro-flakes was frequently necessary for successful flake removal. One of the most common Aboriginal methods of preparation was by rubbing the hammerstone over the edge of the core platform, thus removing the 'lip' or 'overhang' while creating small stacked step fractures on the face of the core (Fig. 9). This method of individual flake platform preparation allowed the flakes to be produced with small flake platforms, less curved in long section and often with smaller bulbs of force. In prehistorical Australian collections this platform preparation technique has been very frequently mis-identified as 'use-wear' on many cores such as 'horsehoofs'. We suspect it is mis-identification of platform preparation techniques which has led many workers to identify these cores as tools (Kamminga, 1978:308-320, with refs). More recently, Lampert (1981:Ch. 4) assumes that horsehoofs are tools and compares them with hand-held chopping implements used recently in central Australia (Hayden, 1979). However, none of the tools illustrated by Hayden display the overall morphology or edge-fracturing apparent in Lampert's samples, and we reject his comparison and conclusion.

Although some of the cores may have been used as tools, there is little direct evidence of this. Kamminga (1978:310–314) microscopically examined 41 horse-hoof cores from a number of archaeological sites and detected clear use-wear on only one, and probable use-wear on another. We repeat that the stacked step-fractures resulting from platform preparation are a characteristic marker of non-rejuvenated cores.

Stage III: Production of Blades and Cores. As flaking continued, the knapper was able to produce macro-flakes which were more regular in shape and size. Linear flakes, about twice as long as they are wide and with sub-parallel margins and dorsal ridges, could also begin to be produced. The change from macro-flakes to linear flakes was the result of a deliberate change in technique, in bringing platform contact points (where the hammerstone contacts the core platform) closer together (Fig. 10). The shift between linear flakes and true blades was also an intended technical change determined by the Australian knapper.

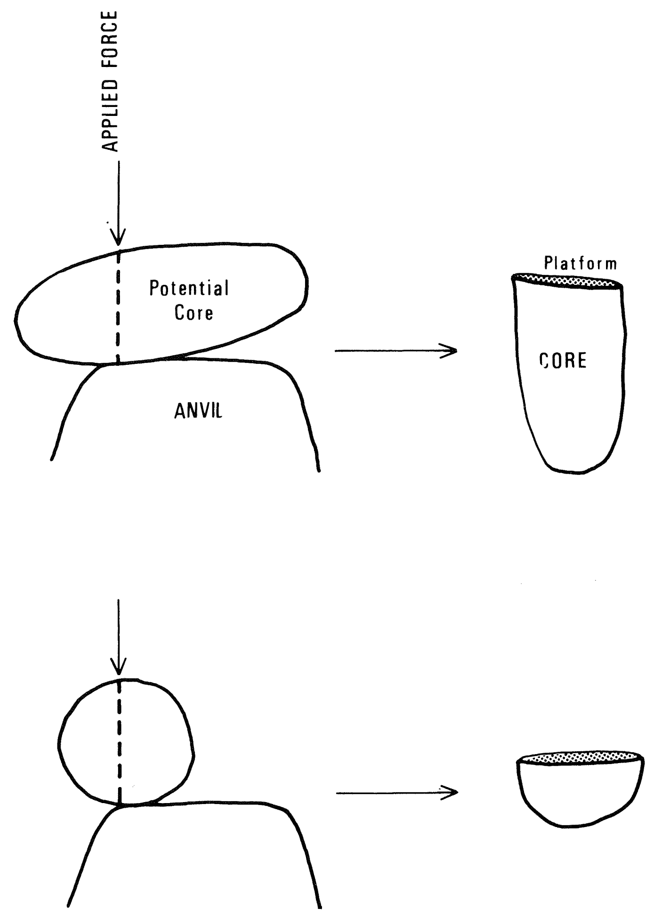

Fig. 4. On-anvil method: a method of single facet platform preparation on large, rounded to sub-rounded lithic materials.

The success of these changes was determined by the knapper's ability to maintain straight, closely spaced ridges or arrises on the working face of the core (Fig. 11). Actual ridge maintenance was required prior to blade production since some ridges, or previous linear

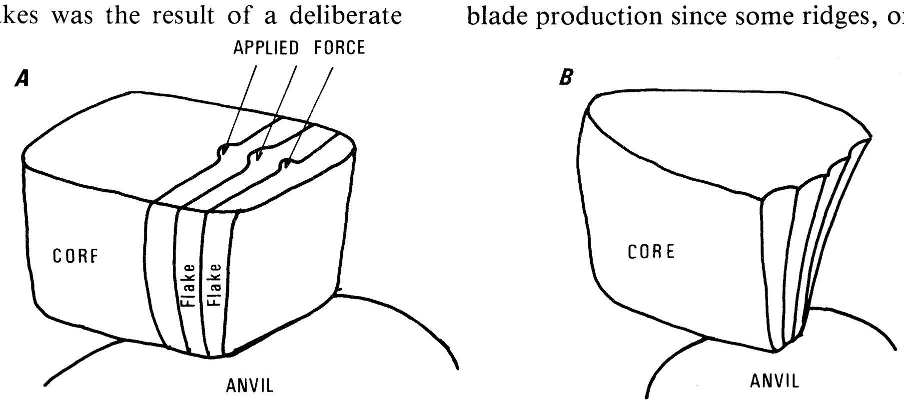

Fig. 5. Diagrammatic illustration of two bipolar techniques. **A:** 'sectioning' a large angular block; **B:** producing flat flakes.

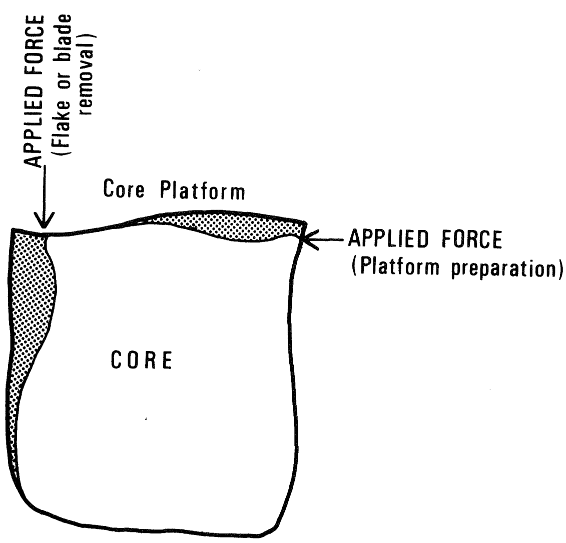

Fig. 6. Continuous platform faceting or preparation as a result of loss of technically correct angle after flake or blade removal. (See also Fig. 4)

flake scar margins on the face of the core, required alteration by flaking in order to 'straighten' the ridge for blade removal (Fig. 12). Small percussion flakes were removed from one side of any sinuous ridge thus making the ridge straight or in line from the proximal to the distal end of the core. This maintenance technique meant that the blade produced from that location on the core would be straight with parallel sides. It is a mechanical fact that flake or blade shape in plan or outline is largely dependent upon surface topography of the core since a fracture will follow the area of higher mass, i.e. a ridge or arris. Therefore, by straightening a sinuous ridge on a core, both before blade removal and during the sequence of blade removal (as a rejuvenation technique), the subsequent blades will have parallel margins.

In order to produce successful blades not only must straight ridges be maintained but also the working face of the core must be kept rounded when viewed from above the platform. The less rounded (flatter) the core working face, the wider the blades or flakes will be (see Fig. 10).

True blades are intentionally prepared. They are specialized flakes at least twice as long as they are wide, with sub-parallel to parallel margins and the dorsal arrises or ridges parallel to the long axis of the blade (Fig. 13). Within the Australian reduction technology, true blades were produced until the core became exhausted or too small and irregular due to mistakes or internal checks (fractures or other unconformities in the stone). The determination that a core was 'too small' depended upon the raw material. Cores of coarse, hard stone that was difficult to work were frequently 'exhausted', even though they were still fist size, because it became too difficult to support the core by hand and drive off flakes by direct free-hand percussion. The horsehoof cores of the 'Kartan' are good examples of exhausted cores of this nature (Lampert, 1981).

At this point in the reduction sequence, if linear flakes were again desired, they were produced from the now irregular 'blade' core. Linear flakes were produced within the reduction sequence both before and after true blade production.

Occasionally, very thick macro-flakes and linear flakes would serve as blade cores when the intended end products were blades that were triangular in cross-section (Figs 14, 15). A platform was prepared at one end of the flake by unifacial flaking or 'backing'. Then, a blade, triangular in cross-section, was struck by direct free-hand percussion from the margin of the flake. Frequently, these cores are referred to in the literature as 'burins' (e.g. McCarthy, Bramell & Noone, 1946:33). We discuss the occurrence of functional burins in Australia below.

Stage IV: Production of Micro-Flakes and Cores. As the reduction sequence continued, the core and flakes became more irregular, like those produced at the beginning of the sequence (Figs 16, 17). The main difference between macro-flakes and micro-flakes is, as their names imply, size. Micro-flakes are wide and irregular in plan, have faceted or natural platforms and frequently terminate in a hinge. Micro-flakes are defined in comparison with macro-flakes within one technological reduction sequence. Size, shape, petrology and specific reduction technique will determine the size ranges of macro-flakes, linear flakes, blades and micro-flakes: they are context-dependent.

During this stage of reduction, the core frequently became too small to reduce it any further as a single

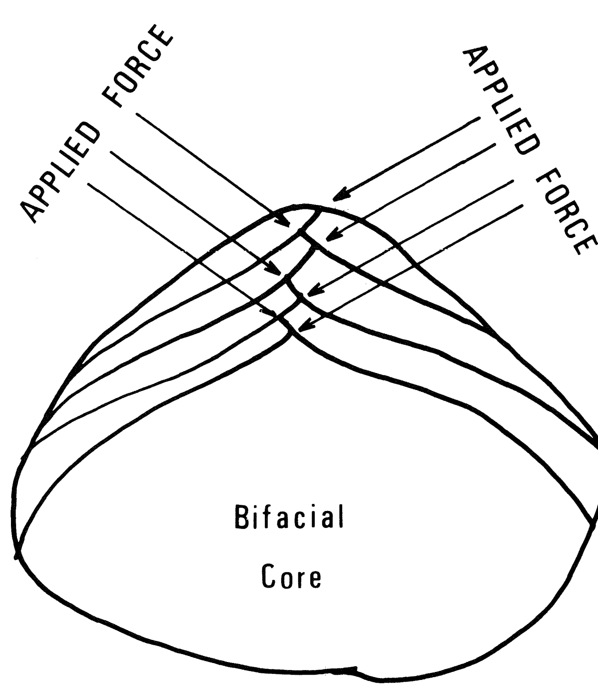

Fig. 7. Diagrammatic cross section of bifacial core where each flake platform was created by previous flake removals. Seven flakes have been removed.

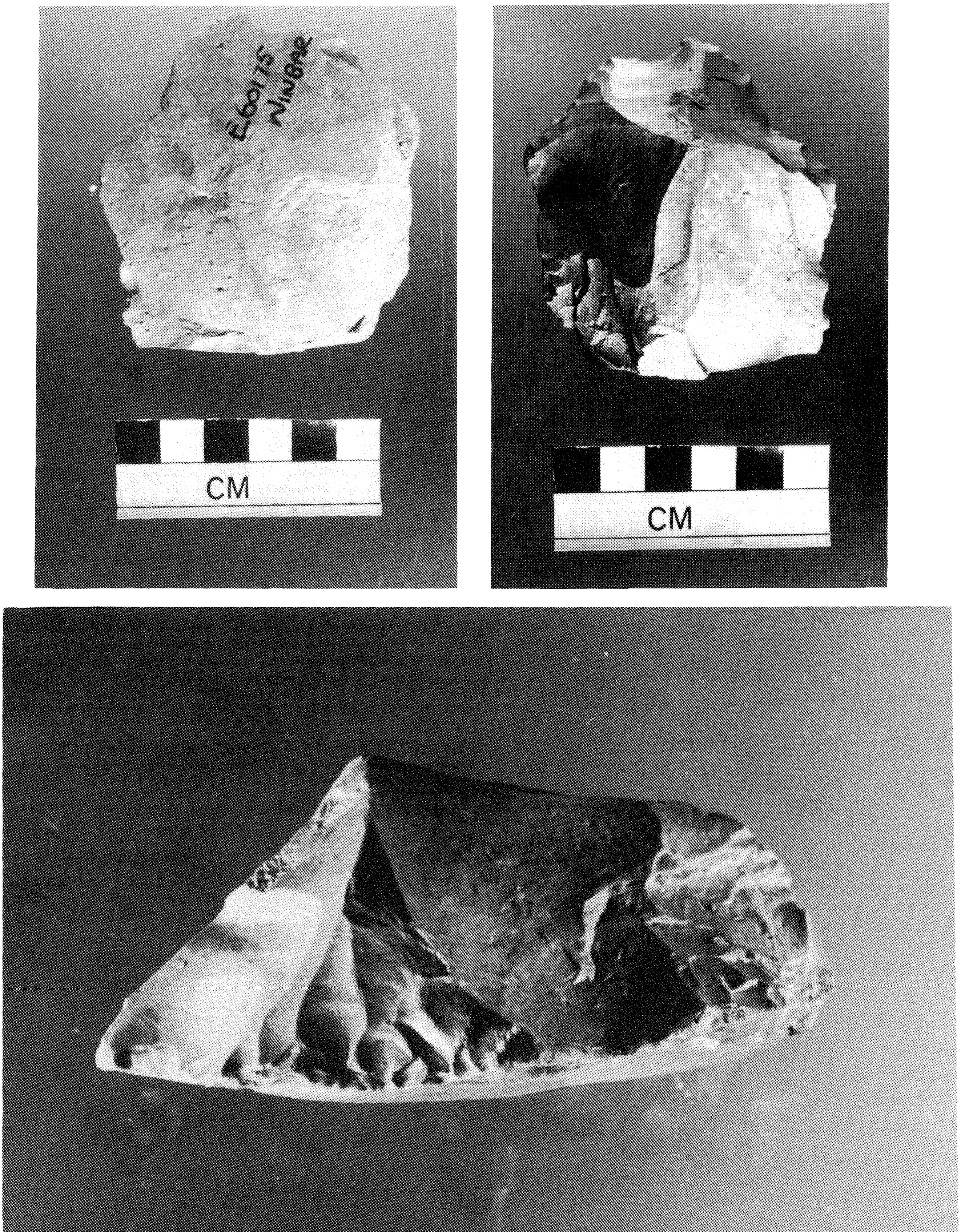

Fig. 8. Flake core. **Top left:** proximal (platform) view. **Top right:** distal view. **Below:** lateral view. Winbar, western N.S.W.

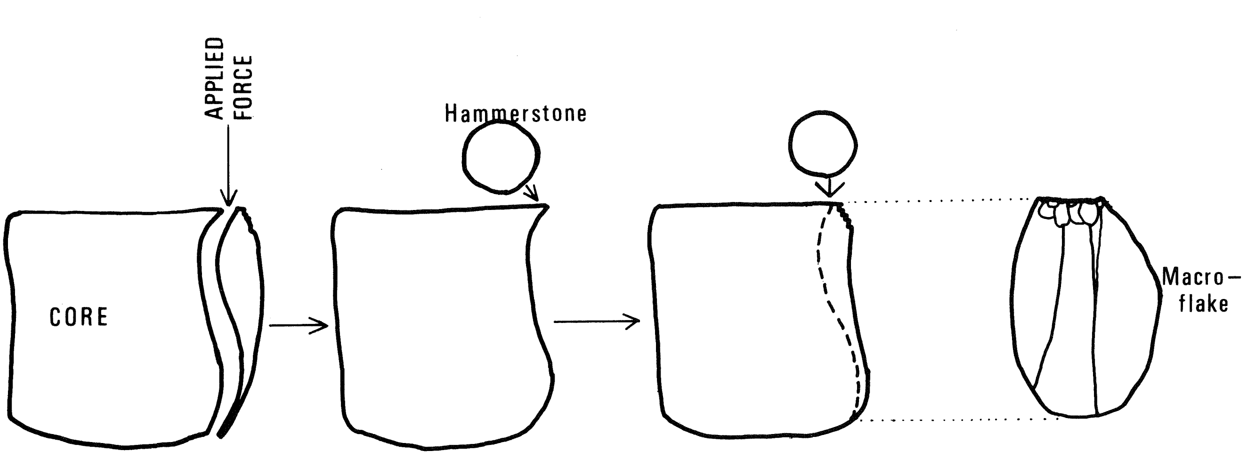

Fig. 9. Technique of individual flake platform preparation. Note that stacked step fractures on the dorsal surface result from platform preparation.

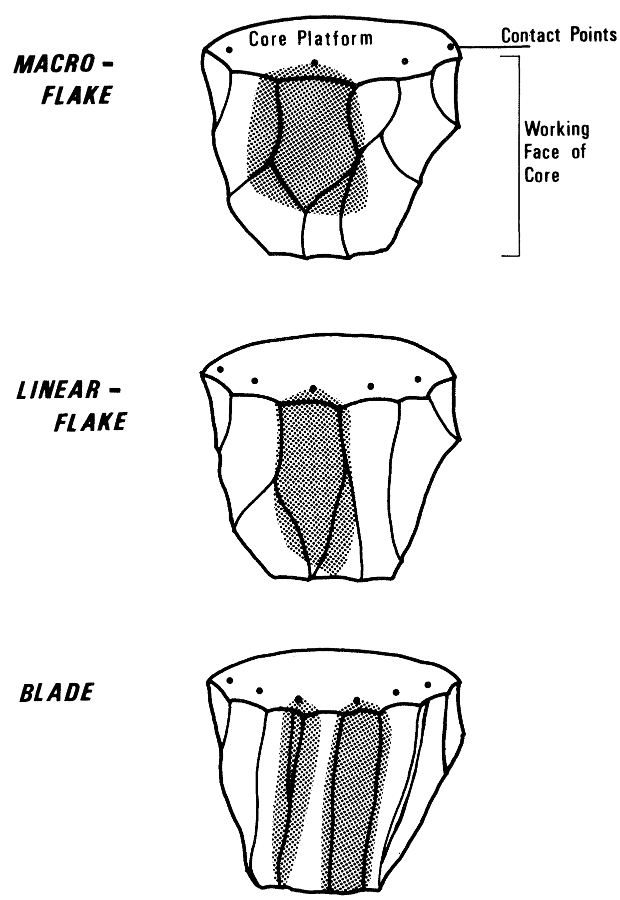

Fig. 10. Flake and blade production. Note distances between contact points on each core, and rounded working face of cores.

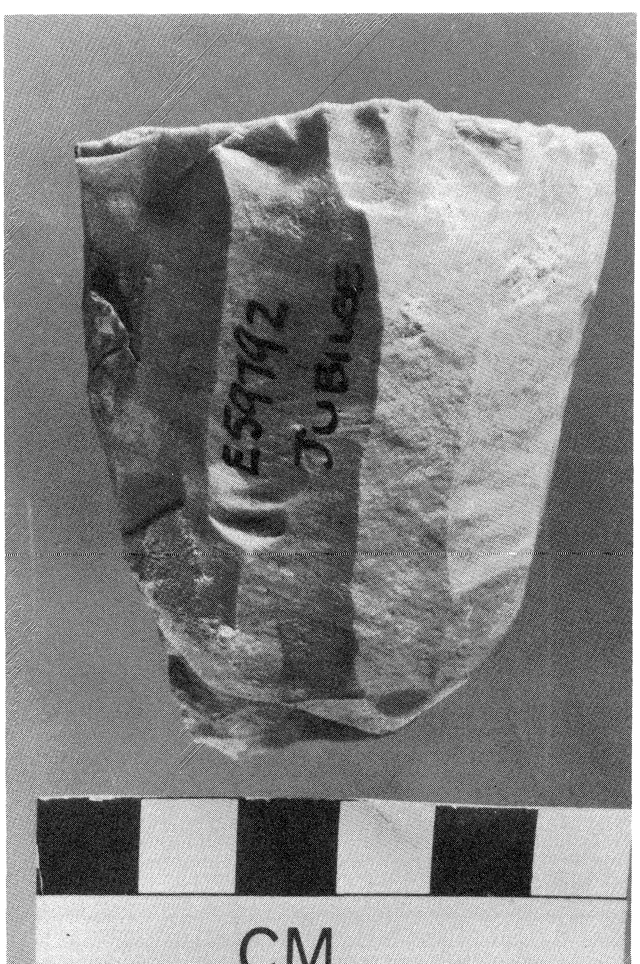

Fig. 11. Blade core. Note parallel arrises on working face of the core. Jubilee, near Andamooka, Lake Torrens.

Fig. 12. Ridge or arris alteration blades ('redirecting flakes') to 'straighten' ridges for blade removal. Singleton, NSW; L–R: E50893, E50893, E50441, E50438.

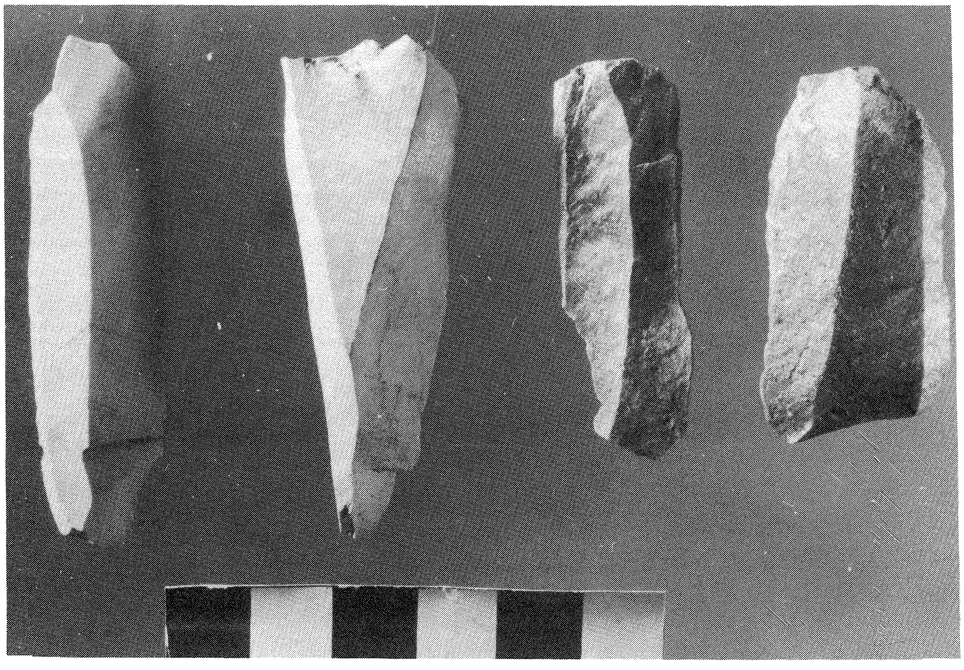

Fig. 13. True blades. Note parallel margins and arrises. Singleton, NSW; E50889, E50464, E50464, E50464.

Fig. 14. Blade cores produced on macro-flakes and linear flakes. Blades were removed from the original flake margins. Singleton, NSW; L-R: E50218, E50891, E50891, E50891.

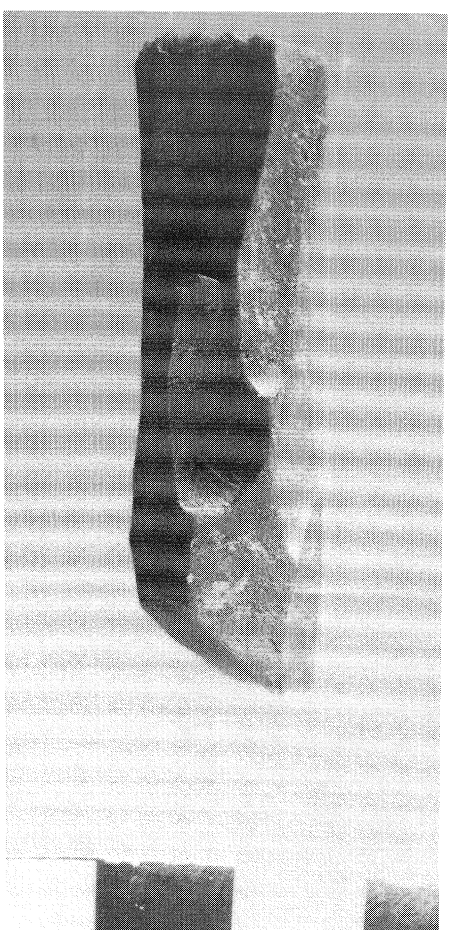

Fig. 15. Macro-flake employed as a blade core. Singleton, NSW; E50218.

platform core. Therefore, other locations on the core served as one or more platforms if the appropriate angles were present (see stage II). These locations were prepared by flaking, or served as platforms without any additional modification.

It should be noted that single platform cores were transformed into multi-platform cores at all stages of the reduction sequence. The change from single to multi-platforms depended upon core size, shape, internal checks, or desired flake production.

Stage V: Exhausted Cores. A core became 'exhausted' when it no longer functioned as a core. Lack of bulk material was not the only reason to discard a percussion core. Core abandonment was frequently a result of small size or difficulty of holding, extremely tough or coarse material in relation to size, material hardness, size of the intended tool, availability of raw material, internal checks, excessive mistakes, and/or platform-to-working-face angle becoming greater than 90°.

Reduction technique may have changed when a direct free-hand percussion core of good quality became too small. Often an exhausted direct free-hand percussion core was further reduced by a bipolar technique (see footnote 2). Some bipolar techniques offer the benefit of producing long, flat, sharp flakes from extremely small cores. Eventually, the bipolar core either totally shattered or became too small to work any further. At this stage, the core (frequently referred to as a 'fabricator', see White, 1968b) was discarded into the archaeological context.

Sometimes small cores of good quality material were reduced into flat, bifacial cores, almost square or rounded in plan. These produced small, flat micro-flakes (Fig. 18).

Fig. 16. Sequence of flakes and blades representing the Australian flaked stone tool reduction system. Bondi, NSW; L–R, Top: E11507, unnumbered, E16378/53, E16378/33, unm, unm; Base: unm, unm, unm, E16377/13, unm, unm.

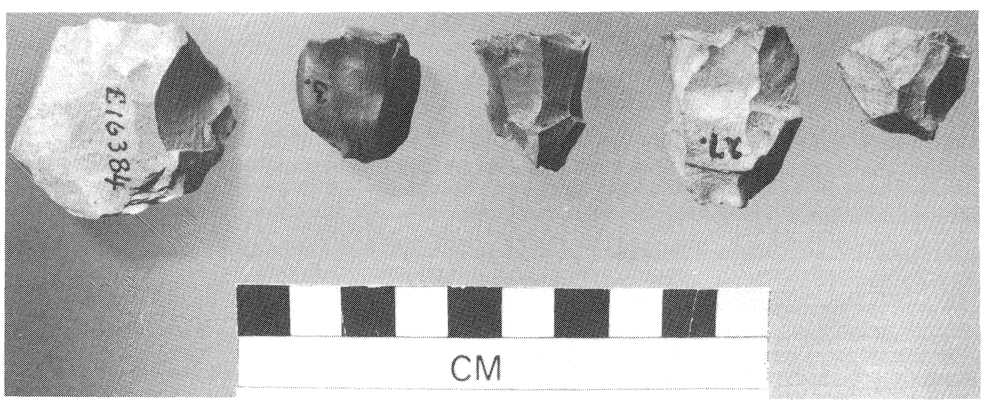

Fig. 17. Sequence of cores representing the Australian reduction system. Bondi, NSW; L–R: E16384/33, E16383/3, E9072, E16383/27, E16383/30.

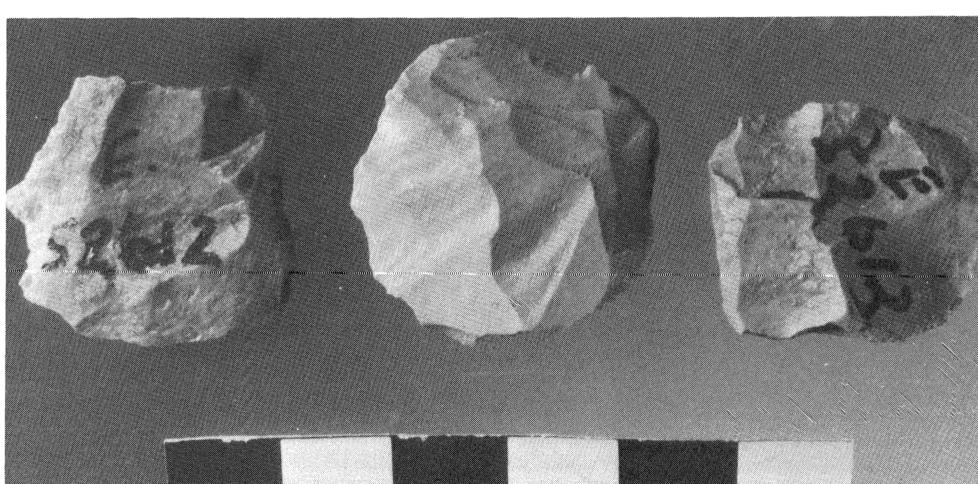

Fig. 18. Exhausted bifacial cores. Inverleigh, Vic.; All: E52612.

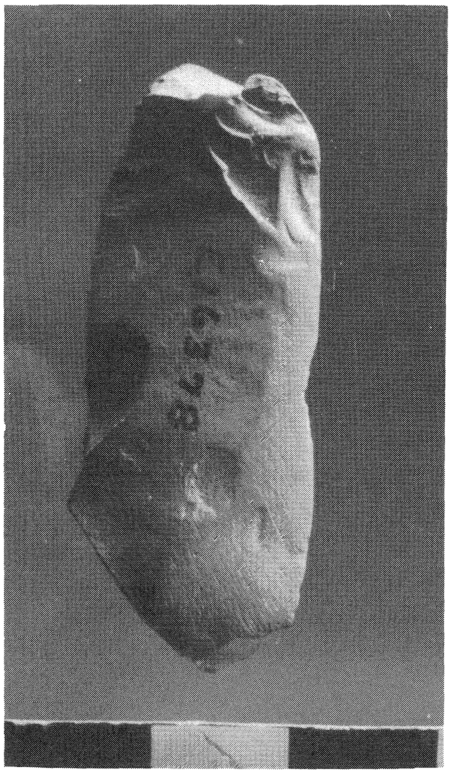

Fig. 19. Exhausted bipolar core which has been subsequently altered, as witnessed by the striations along one edge. Bondi, NSW; E16378/24.

Exhausted cores, of any type, were employed as tools if the core had the necessary attributes required by the user. For example, a bipolar was employed as a tool at the Bondi site (Fig. 19), and Lampert (1971:46) gives other examples. Such recycling further supports the thesis of the opportunistic nature of Australian technologies.

Australian Flaked Stone Artefacts

Tula adze. The flakes employed for the manufacture of tula adzes were perhaps the first formal flake type produced within the Australian reduction system (Fig. 2). They were produced during stage II, the production of macro-flakes. Classic tula adze flakes were produced within a definite size range, were rounded in plan view, possessed a shallow V-shaped, natural, single or multi-faceted platform, a large, pronounced bulb of force, and were slightly concave on the ventral surface below the bulb of force (Fig. 20). For further details on tulas see Sheridan (1979).

In situations where raw materials were small in size, of poor flaking quality, or not readily available, tula adze flake attributes were less restrictive. In other words, a specific set of morphological attributes was preferred by Australian knappers for tula adze flakes but not necessarily adhered to. Therefore, a very wide morphological range of prehistoric tula adzes and adze slugs exists.

Acceptable flake size for a tula adze was dependent upon hafting and intended use. Flakes that were too large or too small would not be easy to haft, or effective in use.

The rounded shape in plan of a tula adze flake was either produced intentionally as a result of core preparation, or was the result of unifacial flaking from the ventral surface. A working edge rounded in plan (from side to side) was preferred because it would not let the adze bit 'bite' into material being worked and break the adze or the haft. When the platform end of

Fig. 20. Tula adze flakes. Inverleigh, Vic.; E39382, E39388.

the adze flake was used, the bulb of force provided the rounded working bit.

The V-shaped natural, single or multi-faceted platform on a 'classic' tula adze flake was intentionally created by the removal of a small flake or flakes from the core at the location of the potential dorsal surface of the adze flake (Fig. 20). These smaller flakes were removed in order to set the contact point of the adze flake back further into the core's platform, so creating a more pronounced bulb of force when the adze flake was produced. This pronounced bulb of force, which caused the concave ventral surface below the bulb of force, was required to create a functional adze, which would push the shavings off the wood (Sheridan, 1979).

In addition, the removal of these small flakes played another important role. When associated with the V-shaped (natural, single faceted or multi-faceted) platform, the removal of these flakes (removed while the potential adze flakes remained on the core) caused the force loaded into the stone (percussion flaking) to spread around this much stronger flaked area, thus creating a much wider than necessary platform (Fig. 20). This wider platform served as the second, or opposite, edge on the adze after the adze flake was removed from the core.

The V-shaped platform of a 'classic' tula adze flake also had a slightly convex surface from side to side (Fig. 20). This convex surface was created naturally or intentionally when the core was prepared. When the core was a large flake with a single facet (ventral surface of flake) platform, potential adze flakes were removed from the slightly convex surface of the bulb of force on the core's platform. If the core's platform was flat, flakes were removed from the platform to provide a slightly convex core platform which created adze flakes with multi-faceted platforms. This slightly convex core platform aided the prehistoric knapper in predicting the desired flake morphology and termination.

Burren adze. The burren adze as an artefact type is far less formalized than the tula adze. Burren adzes were manufactured on linear flakes or true blades due to the fact that, by definition, the platform of the adze flake or blade remained intact at one side of the adze bit. The bit or bits of the burren adze were established at opposite sides of the long axis of the flake or blade preforms (Mulvaney, 1975:82–3). Burren adze preforms usually had convex ventral surfaces in order to increase the effectiveness of the adze.

As with most other Australian flaked stone tools, burren adze morphology was subject to size, quality, availability and quantity of raw materials. The fact that both burren adzes and tula adzes are sometimes found archaeologically in the same context may indicate an economical use of stone rather than that adze preforms were culturally or functionally defined. Further studies of the distribution of both forms is required.

Backed artefacts. The specific process of 'backing' artefacts as a pattern of behaviour required a reduction technique separate from all others found in prehistoric Australia. Backing as a technique, however, had the same technical attributes as all other bipolar techniques, and these have been common in Australia for at least 30,000 years. There are four technical attributes which demonstrate that backing is the same as other bipolar techniques (see footnotes 2, 3). These are:

(i) the use of anvils to support small masses (small artefacts),

(ii) the use of anvils to support small artefacts, increasing predictable fractures,

(iii) the use of anvils to increase flaking efficiency by 'bipolar' and 'shearing' actions; anvil often acts as percussor during reduction process (double backing), and

(iv) all are accurate methods of reducing lithic mass, and are economical in terms of time and energy.

Thus 'backing' as a technique should not be perceived as something 'new' within Australia. Rather, it appears to us to be readily derived from techniques widespread within the country.

The formal properties of 'backing' which identifies 'backed artefacts' have been debated at length (e.g. Croll, 1980; Dickson, 1975; Glover, 1969; McCarthy, Bramell & Noone, 1946:36; Pearce, 1973, 1977; Wieneke & White, 1973). The backing process was conducted by placing the potential artefact (linear flake, blade or micro-flake) on a narrow anvil such as the poll of a hatchet (Fig. 21) and, by percussion, chipping away the unwanted mass of stone to form a blunted edge. A narrow anvil was used to allow the knapper greater freedom of movement while holding the potential tool. Stone was the most likely anvil material since it gave the firmest support and actually served as a percussor during the backing process when the backed edges approached 90°. Therefore we consider that 'double backing' was most frequently caused by a bipolar action where both the anvil and the hammerstone functioned as percussors (Fig. 22). We note that there are many pitted hatchet polls and anvil stones in the Australian Museum collections, especially from the coast south of Sydney where backed blades are extremely common.

The amount of lithic mass removed from a tool preform to produce a functional tool depended upon the preform morphology and desired artefact width, and was not a locally patterned 'cultural' style (Fig. 23). First, the margin that was the sharpest and straightest was selected as the chord while the opposite lateral margin, the more irregular of the two, was backed. This created either a 'right' or 'left' backed artefact. If the dorsal ridge was situated close to the margin to be backed and/or the preform was near to desired shape prior to modification, then minimal mass was removed to form a functional backed artefact (Fig. 23A). Furthermore, backing was often restricted to small areas of the tool's margin. In this situation, the anvil only supported the light weight of

Fig. 21. Hatchet poll probably employed as an anvil. Manly, NSW; E60730.

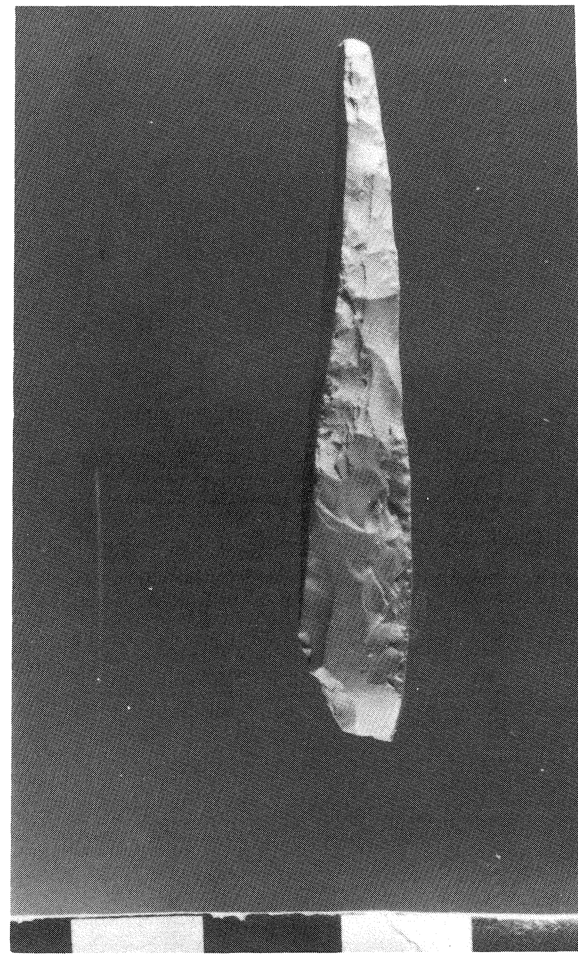

Fig. 22. 'Double' backing on a Bondi point. Singleton, NSW; E49129.

the preform, and anvil 'contact'[3] with the potential tool never occurred, leaving the backed edge unifacially rounded.

A second 'style' of backing required the entire margin to be altered due to preform morphology (too wide or irregular). But with the dorsal ridge more or less in the centre of the preform, anvil contact may not have occurred, leaving the edge backed from one side and rounded on the other (Fig. 23B). A third 'style' of backing resulted when anvil contact did occur, and in this case the backed edge was 'squared-off', being flaked from both sides (Fig. 23C).

We consider that by taking a technological view of these artefacts a number of their 'puzzling' aspects are explained. The percentages of 'right' and 'left' hand backing, of backing from one or both sides and the length of retouching can all be considered to result from specific contextual circumstances, such as the nature of the particular pieces of raw material available, the knapper's skill, etc. We suggest that the occurrence of geographical or temporal patterns in the attributes (Pearce, 1973) is best explained in this way.

Within 'styles' A, B and C of Fig. 23, a dorsal ridge(s) still appears. Prehistorically, however, the backing process may have removed all evidence of a dorsal ridge(s) (Fig. 23, D–F). This can occur because of desired tool width, sinuous ridge(s) and/or manufacturing error.

In situations where a part or all of the margin to be backed was quite thick, the backing process often left the margin bifacially rounded due to the process of shearing (Fig. 23F). Because the preform was thick, flakes were removed from both edges (by hammerstone and anvil edge). However, the potential tool was not hit hard enough to allow the force to travel completely through the mass and, therefore, small flakes were removed from both edges, travelling a very short distance and leaving the backed edge bifacially rounded. The knapper's percussion force was not increased for fear of breaking the artefact in half. Figure 24 illustrates the various technical forms of backing on Bondi points.

Bondi Points and Geometrics. All Bondi point and geometric preforms were relatively flat in long-section, had at least one fairly straight, sharp margin, a relatively thin cross-section and none to more than one dorsal ridge. The actual number of dorsal ridges does not seem to have been an important factor. Most

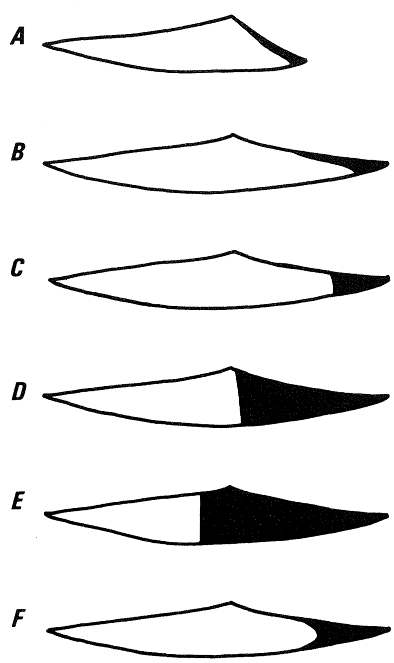

Fig. 23. Technical 'types' or 'styles' of backed artefacts, viewed in cross-section.

preforms were, however, either triangular or trapezoidal in cross-section due to one or more than one dorsal ridge, respectively. This loose definition of Bondi point and geometric preforms illustrates the opportunistic nature of preform selection. It also suggests that 'types' should be examined technically in the first instance.

Both backed artefact classes have three attributes in common: one or more points, one fairly (but not necessarily) straight, sharp edge and one or more backed margins. Technically, based upon the above discussion concerning backing, there is only one 'type' or 'style' of Bondi point and geometric. Quality, quantity, availability and size of raw materials often placed restrictions upon Bondi point and geometric manufacture which created a wide range of morphologically divergent, but technically the same, backed artefacts.

The elouera has also been placed by typologists into the 'backed artefact' category (Mulvaney, 1975; Kamminga, 1978). The above discussion concerning 'backing' applies to artefacts loosely defined as eloueras in southeastern Australia (see Kamminga, 1978 for further data).

Burins. True, technical burins (i.e. not flakes so snapped by chance during flaking) manufactured on blades did exist in prehistoric Australia. They may have been used in some situations to groove bone or wood.

Perhaps the most conclusive archaeological evidence of burins associated with grooved bone comes from the Jack Smith Lake site (East Gippsland) on the south coast of Victoria (inspected by courtesy of K. Hotchin and P. May). Many other prehistoric Australian lithic assemblages such as the Ingaladdi site in the Northern Territory contain some true burins (D.J. Mulvaney, pers. comm.). The lithic analyist must, however, be certain of the differences between true burins and blade cores manufactured on large macro-flakes with similar morphological attributes (see end of section entitled "Production of Blades and Cores"; cf. also Crabtree, 1972; Brezillon, 1968).

True technical burins were manufactured on linear flakes or true blades (Fig. 2). Once the flake or blade preform was selected for alteration, a platform was produced at one end (usually the distal end) of the preform by the backing technique discussed earlier. The backing technique allowed the platform to be flat or perpendicular (at 90°) to the burin preform margin, a requirement for proper burin spall removal. Mass was removed until full contact with the stone anvil was established thus creating the necessary 90° platform-to-margin angle. If full anvil contact was not established, then a rounded platform (from dorsal to

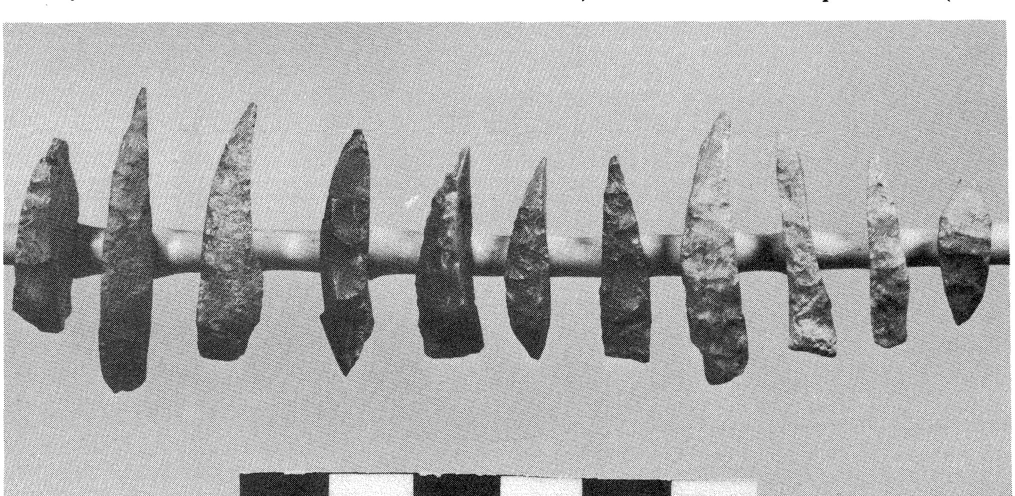

Fig. 24. Backed artefacts (mostly Bondi points) with various amounts of backing due to preform size and desired shape. Bondi, NSW; L-R: unnumbered, unm, E9056, E16375, E16375, E9080, E9080, E16375, unm, unm, unm.

Fig. 25. Burins. Left: displays platform and margin preparation; centre: single burin spall removed from the right margin; right: multiple burin spalls removed from right margin and platform. Jack Smith Lake site, Vic.

Fig. 26. Burin spalls. Jack Smith Lake site, Vic.

ventral surfaces) would be created. This would not allow correct margin or burin spall removal (see Fig. 23A, B, F). After platform preparation, the preform's margin was straightened and strengthened by light percussion retouch unifacially applied from the ventral surface to the margin from which the 'burin spall' was to be removed (Fig. 25 left). At that stage, the burin spall was removed by either direct free-hand percussion or the on-anvil percussion technique (Figs 25 centre, 26). If a successful spall was created, the burin was then ready for use (Figs 25 right, 27).

The working edge (or bit) of the burin was the negative bulb of force and was V-shaped, which provided a strong, sharp edge for grooving bone or wood.

This burin edge could be applied to bone or wood either in the same plane as the V-shaped bit creating a V-shaped groove, or at right angles to the V-shaped bit creating a U-shaped groove the width of the burin bit. In addition to the use of the burin bit, the lateral margins of the burin spall scar were ideal obtuse angle cutting edges and were most certainly employed prehistorically to shave down wood or bone (Crabtree, 1973). Once the bit of the burin became dull through use another spall was removed from the same flake or blade margin, creating a new, sharp burin bit as well

Fig. 27. Burins. Jack Smith Lake site, Vic.

Fig. 28. Grooved bone found in association with burins. Jack Smith Lake site, Vic.

as a new obtuse angle tool (Fig. 25 right).

Burin resharpening also occurred by removing additional burin spalls from what once served as a faceted platform for the removal of the first burin spall (Fig. 27). In addition, this action changed the bit angle of the burin from 90° to considerable less than 90°. More acute bit angles on burins were necessary when the groove in the bone or wood became too deep to work efficiently with a 90° angle without making the groove considerably wider at the outside surface of the groove (Fig. 28). Once a burin was exhausted by numerous resharpenings, it was discarded.

Points. From a technical perspective, the different point 'types' found throughout Australia form a single, uninterrupted continuum (Fig. 29). This technological fact once again demonstrates the opportunistic and economising nature of prehistoric Australian technology.

The simplest type of point found archaeologically as well as ethnographically in Australia was the unmodified 'pointed' true blade or linear flake. If the core was prepared correctly and the knapper's aim was true, a blade, triangular in both cross-section and plan, was produced. It required no modification in order to function successfully as a lethal projectile point. This point type was either a direct result of intentional core preparation for the production of triangular points, or more often, suitable pointed blades were selected from numerous blades produced in one or more reduction sequences (Thomson, 1949: 55). The size of these points depended entirely upon the physical attributes of the raw material, its size range and the knapper's preference.

If a flake or blade did not meet the knapper's concept of a 'point', modification by percussion and/or pressure was required. The extent of modification depended upon the original morphology of the preform as well as on the knapper's concept. Technologically, the simplest form of modification was to unifacially retouch the dorsal surface. This created a unifacial point.

When the point preform was very irregular and thick, then platforms had to be established on the ventral surface along the preform's margin in order to detach flakes from the dorsal surface. Platform preparation was usually in the form of small flake removal in addition to heavy abrasion. This action frequently left small flake scars on the ventral surface of the completed point. Technically, a point of this type can still be considered a unifacial point.

Frequently, a flake or blade was morphologically suitable as a point preform but the potential base (proximal, bulb of force end of the flake or blade) was too thick for proper hafting. In this situation, the bulb of force on the ventral surface was thinned by percussion and/or pressure flaking. Technically, even if the dorsal surface of the point was modified in association with ventral surface basal thinning, the point is still a unifacial point, as Mulvaney notes (1975:219).

All of the unifacial point types defined above are plano-convex in cross-section (Fig. 29). The attempt to change a plano-convex cross-section into a bi-convex cross-section resulted from a deliberate technological change designed to produce a 'bifacial point'. To produce a point with a bi-convex cross-section, the knapper had to establish platforms on the preform by first removing flakes from the ventral surface (Fig. 30A) and then abrading the margins. This action moved the margins of the preform toward the middle of its mass so that flakes could be removed successfully from both faces (Fig. 30B–E). This technique produces a true bifacial point (Figs 29, 30E).

We therefore can demonstrate, on the basis of point cross-sections, the only technical difference among prehistoric and recent points in Australia is between unifacial points ('points', 'unifacial points', and 'pirri points') and bifacial points ('bifacial points' and 'Kimberley points') (Fig. 29).

Flaking techniques employed to produce points can be briefly discussed here. Direct free-hand percussion and bipolar techniques (Fig. 5B) were employed to produce both the flake or blade preform and, in many situations, to modify the preform into the desired shape. Pressure flaking was also often employed to modify preforms into both unifacial and bifacial points. We think, however, that pressure flaking was used primarily to deal with particular preform morphologies (thin, small, etc.) and was not a culturally dictated pattern. It should not, that is, be used archaeologically as a particular cultural indicator. We say this because we have observed pressure flaking on many pirri points, and even on some with lesser amounts of surface modification. We suggest that the technique of pressure flaking was known thoughout all areas of Australia in which points were made. We stress that this knowledge, as far as we can tell, has nothing to do with blade production, but is a technique for surface and margin modification.

Miscellaneous flake tools ('scrapers') and 'utilised flakes'. Miscellaneous flake tools are the most common artefact 'type' recovered from prehistoric Australian sites. These artefacts possess no common set of diagnostic morphological attributes. Their presence, indeed their frequency, illustrates the opportunistic nature of Australian technologies.

Miscellaneous flake tools can be divided into two categories for analytical purposes: unmodified flake tools and modified flake tools.

(i) The unmodified flake tools can be distinguished as tools, if at all, only on the basis of having abrasive

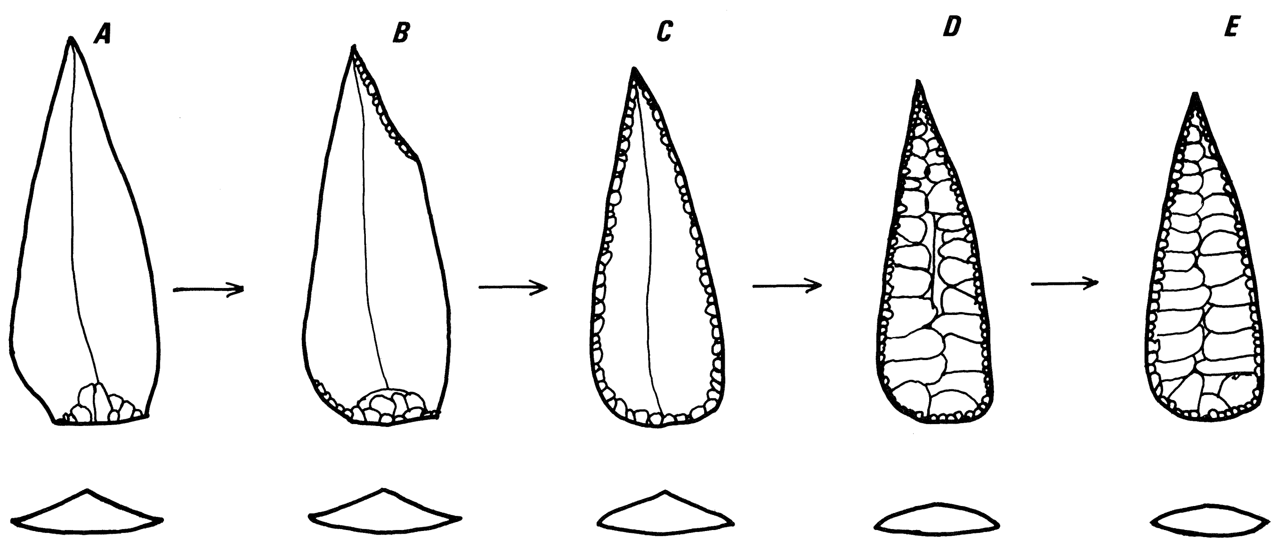

Fig. 29. Technological sequence of Australian points. **A:** no modification; **B:** tip and base modification only; **C:** 'unifacial point'—total margin modification; **D:** 'pirri point'—total dorsal surface modification; **E:** 'bifacial' or 'Kimberly Point' — total dorsal and ventral surface modification. Note that only E has a convex ventral surface.

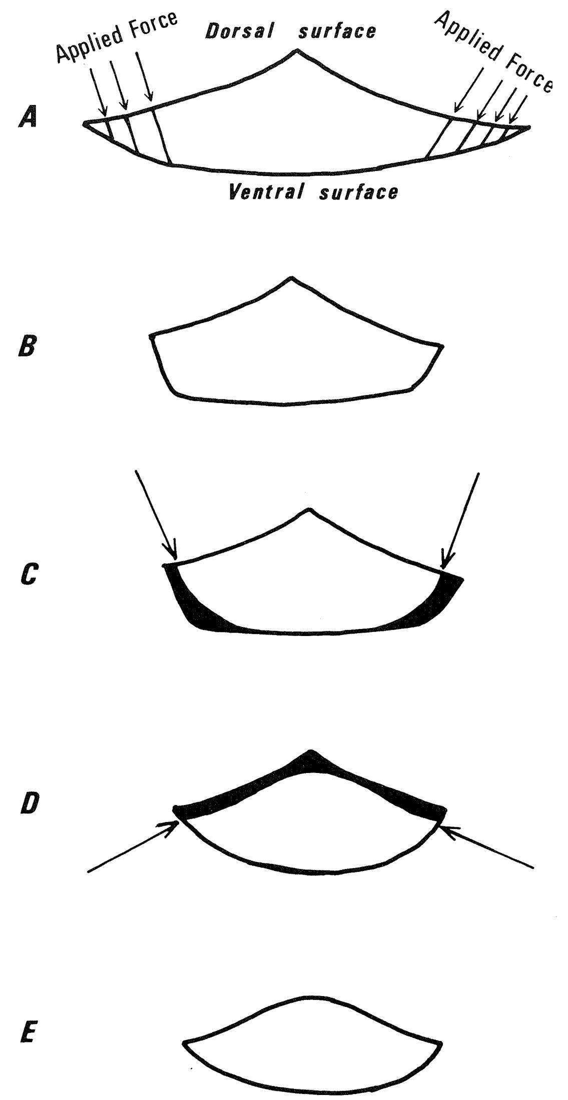

Fig. 30. Sequence for the production of a bifacial point. **A:** margin moved to centre of preform mass; **B:** ventral surface modification; **C:** further ventral surface modification; **D:** dorsal surface modification; **E:** bi-convex cross-section of a bifacial point.

wear as well as edge flaking since the latter can readily be produced by intentional or unintentional edge modification (e.g. Ahler, 1979:305; Keeley, 1980:Ch. 3). Distinguishable kinds of abrasive use-wear will allow different uses of tools to be distinguished, although this process will clearly be a tedious one.

(ii) The determination of flakes as modified flake tools is the most difficult analytical problem facing archaeologists world-wide. The presence of 'modified' edges on a flake does not automatically designate it as a prehistoric tool. 'Modified' edges can and frequently did occur naturally through post-depositional agencies such as trampling and soil movement (e.g. Knudson, 1979; Flenniken & Haggarty, 1979). These naturally modified flakes possess no form of use-wear abrasion. Without abrasion, it is virtually impossible to define flakes as tools because the same mechanical actions that modified the flakes naturally were also used by humans to modify the flake tools prior to the establishment of use-wear abrasion (cf. Hayden, 1979; Keeley, 1980; Semenov, 1964; Flenniken & Haggarty, 1979).

We therefore suggest that 'modified flakes' including 'scrapers' must either possess abrasion and/or striations, or diagnostic humanly-produced flaking (such as pressure flaking) in order to define them as flake tools. Intentionally pressure flaked edges leave diagnostic traits such as evenly spaced flake scars, regularly spaced micro-serrated edges, flake scars terminating in feather or micro-step fractures, as opposed to stacked step fractures and crushing, and flake scars travelling onto one or both faces of the flake. Without such demonstrable evidence, flakes should not be defined as tools. We know of no attempts to systematically apply such criteria to Australian assemblages (cf. Hiscock, 1983).

Conclusions

This paper has made a number of assertions about techniques used in and technologies of prehistoric Australians. These assertions are primarily based on JJF's expertise in flintknapping, and are testable only by people who have themselves some knowledge and ability in this technical area. Many aspects of stone working are readily appreciated only by people who have learned to do it for themselves and who can understand not only what was done in certain contexts, but why. We expect that within the next few years our assertions, which are based primarily on museum collections, will be tested by the detailed analyses of techniques employed at particular places and times by prehistoric Australians. Technological analyses of assemblages are clearly necessary to give a diachronic perspective of our claims (cf. for example, Flenniken, 1981; Bucy, 1974). The major conclusions we derive from our study are:

1. A single reduction sequence has been common to the whole of Australia throughout its prehistory. This means that the technical origins of major changes in formally shaped tools do not need to be sought externally. We have seen no evidence that a technique of producing blades by indirect percussion (punch technique) was ever present here. 'Backing' on artefacts is a simple application of a bipolar technique known in Australia since the Pleistocene.

2. Australian stone technologies have always been opportunistic, taking full advantage of whatever the environment offered. By this we do not mean that there was laziness or carelessness, but that stone tools were very largely the result of the least possible effort necessary. If a cortex-backed flake could be used instead of a backed blade, or a naturally triangular pointed flake was available, then these tools were used. The one situation where this does not seem to be so is in the production of bifacially flaked bi-convex points.

3. Many of the smaller typological categories based on morphological variation within broad classes (backed artefacts, unifacial points, scrapers) are as much the result of variations in size, availability and exact nature of raw material along with knapper's skill as they are of deliberate design. Analyses of assemblages need to start with technological studies, and use 'cultural' variation only as a residual category.

4. This same principle should also apply to the analysis of cores and 'scrapers'. The 'retouched' and 'utilized' edges on many of these are the result either of continuing attempts to remove flakes from refactory raw material or the unintended result of natural and cultural processes acting on unmodified pieces of stone (cf. Flenniken & Haggarty, 1979). It is worth noting here that in the Australian ethnographic record (e.g. Daisy Bates in Wright, 1977; G. Aiston in Horne & Aiston, 1924:91–2; Hayden, 1979) the majority of scraping tools (other than hafted adzes) were not 'retouched' into shape, or were only adventitiously so. Thus there seems to be a discontinuity between present behaviour and the many interpretations of past technologies which have focused entirely on pieces with apparently deliberate retouch (e.g. McCarthy, Bramell & Noone, 1964; Mulvaney & Joyce, 1965; Jones, 1971; White, 1972; Lampert, 1981). We suggest that it might be useful to assume that our ethnographic records are a good guide to the past, and to look at archaeological assemblages more in the light of them.

Footnotes

1. Flenniken has some 20 years experience of knapping, which he has been teaching and researching in full-time for 8 years. During 6 months in Australia he worked through all the sequences described here and participated in a week-long workshop with Australian knappers including K. Akerman, P. Bindon, R. Fullagar, B. Cundy, P. Hiscock and D. Witter. Collections inspected included Australian Museum (2 weeks), Western Australian Museum (2 days) and short visits to several others.

2. Seven technically different bipolar techniques are known. Each leaves definably different debitage in an archaeological context (Flenniken, in press). The seven techniques are:
   (1) Small rock (pebble, flake, chunk, etc.) wrapped in cloth, bark, etc., placed upon a stone anvil, held lightly by the wrapping and smashed with a hammerstone. Useable pieces are selected out, the remainder is debitage.
   (2) Large (no larger than 10 cm in diameter), rounded rock, hand held on a stone anvil, split with a hammerstone to enter the rock and establish a percussion flake or blade core platform. Core platform was created as a result of a sheared cone leaving the core platform with no negative or positive bulb of force.
   (3) Small rock (pebble, flake, chunk, etc.) placed upon a stone anvil, split with a hammerstone and continued reduction via bipolar flaking. Platform preparation is carried out, and the morphology of flakes can be predicted. The bipolar core(s) remain as a result of the reduction process.
   (4) The same process as (3) except there is no flake prediction and the core is smashed for potentially useable pieces of stone.
   (5) The technique of 'backing' artifacts. See section of this paper entitled "Backed Artifacts".
   (6) A large angular block of material can be 'sectioned' by use of an anvil and hammerstone. The force is applied to travel through the core, producing large flakes, rectangular in cross-section (Fig. 5A).
   (7) Same process as (6) except flakes or blades are produced from the core. Use of the anvil allows the flake or blade to be produced flat in long-section (Fig. 5B).

3. Anvil contact is defined as a bipolar percussion technique where force is allowed to travel completely through the preform's mass into the anvil. Flake removal may occur from either the hammerstone surface or the anvil surface (Flenniken, 1981).

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