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Bondaian Technology in the Hunter Valley, New South Wales

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Abstract

Manufacture of bondi points in the Hunter Valley, New South Wales, took place in a standardized way, within a production-line structure. Each stage of the manufacturing activities was undertaken at a different locality, but within any single stage the activities were carried out in a uniform manner. One consequence of this complex system of procurement and reduction is that specific forms of stone artefact are found repeatedly, and have previously been identified as implement types. From a technological perspective these forms (ridge-straightening flakes, scrapers, and burinates) are not end products, but by-products from the manufacture of bondi points. This conclusion has implications for evaluations of the nature and diversity of activities represented by archaeological assemblages. An understanding of the complexity of artefact manufacture also highlights inadequacies with previous inferences about technological efficiency and artefact function in prehistoric Australia. Flake elongation is demonstrated to be a poor reflection of technological practices, and regional variation in flake elongation is far more dramatic than chronological variation. Consequently, the Pre-Bondaian/Bondaian transition cannot be described in terms of the appearance of a blade technology; instead it represents an increase in the regularity and precision of knapping related to raw material conservation.

In a previous paper (Hiscock 1986) I described chronological changes in artefact assemblages and stoneworking in the Hunter Valley. One chronological change in the reduction system[1] employed in the Hunter Valley was that only during a brief period after the archaeological appearance of backed blades was platform preparation common, and it is only in that period that flakes with faceted platforms were produced. I designated this period in the Hunter Valley as the Phase I Bondaian (Hiscock 1986) and I implied that knappers used a distinctive technology at that time. In this paper I explicate the stoneworking which prehistoric knappers employed during the Phase I Bondaian by describing the activities that took place in a way that portrays the dynamics of the manufacturing process.

Detailed technological analyses of this kind have not been published before in Australia, and these data from the Hunter Valley have implications for more general issues in archaeology. I deal with three such issues here.

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First is the implication of these data about Phase I Bondaian Hunter Valley technology for typological classifications of stone implements. During the process of reduction, artefacts may be created which bear a close resemblance to recognized 'implement types', though they are not end products but merely artefacts created as a by-product of manufacturing end products. This 'Frison factor' is well recognized overseas (cf. Dibble 1984, 1987), but has been largely ignored in Australia. An understanding of stoneworking in the Hunter Valley reveals several examples of the mistaken identification of knapping debris as various 'implements' and 'tools' because the classification systems that have been employed were not based upon a technological perspective.

The second issue discussed here is the suggestion by Jones (1977) that technologies associated with backed blade production are more complex and efficient than those that existed previously. Description of one reduction strategy that produced backed blades reveals how difficult it will be to test this proposition. It is not the complexity of the 'implements' alone which is in question but the complexity of the entire technological system in which they are made.

The third and final issue discussed here is the traditional assumption that the appearance of backed blades is coincident with the introduction of a 'blade technology' and that the elongation of flakes is an accurate indicator of the presence of the technology. Reconstructions of the flakes on which backed blades were made in the Hunter Valley demonstrate that although elongate flakes were the usual form selected for backing, few of the flakes produced were elongate. Thus although these flakes may derive from a highly standardized reduction strategy it cannot be described as a 'blade' technology in the sense that elongate flakes were frequently produced. An examination of assemblages in eastern Australia reveals that while at any one location there may be an increase in

1 In this paper stoneworking processes are described using three categories:
* A *reduction system* describes manufacturing patterns but does not order the actions in their time sequence. For comparison, attribute analyses describe the frequency of manufacturing actions without identifying their order.
* A *reduction sequence* is a description of the order in which reduction occurs within one block of stone.
* *Reduction strategy* refers to the guidelines used by knappers to enable them to apply their skills.

the proportion of elongate flakes accompanying the introduction of backed blades, this increase may only be small and may not represent a change in the maximum elongation that is found in the assemblage. Furthermore the frequency of elongate flakes, both before and after the introduction of backed blades, varies regionally. In some regions the frequency of elongate flakes in backed blade assemblages is similar to, or less than, Pre-bondaian assemblages in other regions.

Redbank A Strategy

The particular form of reduction described here is called the Redbank A Strategy (RAS for short). I first identified this pattern after extensive conjoining and analysis of three knapping locations along Redbank Creek near Singleton, New South Wales. These three sites are known as RBC5, RBC12 and RBC13. Description of RAS reduction was refined during the salvage and analysis of 21 open sites from Saltwater Creek and Mount Arthur North and South, west of Singleton. Re-analysis of material excavated from the Sandy Hollow I rockshelter confirmed the interpretations gained from open sites. Thus, the description of the RAS presented here is derived from sites throughout the floor of the Hunter Valley between Singleton and Muswellbrook. The description below applies to RAS reduction in all of these areas. Redbank A Strategy reduction can be summarized in terms of several phases, (Table 1). This RAS reduction, and its archaeological manifestations, can be understood by discussing each phase in detail.

Initial reduction (Phase 1)

The first phase of Redbank A Strategy reduction involved the production of large thick flakes. A variety of stone materials was used, including fossilized wood, chert and porcellanite; but the two rock types that were commonly used were silcrete and indurated mudstone. Cortex on the thick flakes indicates that these stone materials were angular cobbles procured from the river gravels which abound along the Hunter River and its tributaries.

Phase	Description
1.	A large, thick flake is struck from a core.
2.	This flake is thermally altered, either before or during the retouching process.
3	This flake is first retouched by blows applied to the ventral surface which remove small flakes from the dorsal surface. Location of each blow is related to the purpose of the retouch, and two types of locations can be defined: a) Retouch on the lateral margins acts to set up potential platforms. b) Retouch on the proximal and distal ends sets up ridges and removes unwanted mass.
4.	Blows are then applied to the platforms set up on the lateral margins in phase 3. These blows remove longer flakes from the ventral surface of the retouched flake.
5.	Phases 3 and 4 are repeated to enable reduction to continue.
6.	Some of the flakes produced in phase 4 may be backed to form bondi points.

Table 1. The Redbank A Strategy.

Large flakes were struck from these cobbles by forceful blows set approximately one centimetre from the core edge and applied by direct percussion. The blows were located to take advantage of prominent ridges on the core. The flakes that were produced are large, weighing 20-50 g and often more than 1.0 cm thick (ventral-dorsal). These flakes almost always contain cortical platform surfaces and have cortex on the dorsal face. At one site several of these large flakes were conjoined together; clearly they were removed blow after blow with no preparation of the core. Knapping of these cobbles presumably took place at or near the gravel beds since no cobble cores have been found at the knapping floors from which the flakes were recovered. I suggest that suitable flakes were transported to a second location before the second phase of RAS reduction was carried out.

Heat treatment (Phase 2)

Many thick flakes produced during phase 1 were thermally altered. Such controlled heat treatment produced very characteristic changes to silcrete but the other types of stone materials found in Hunter Valley sites do not show any macroscopic indications of thermal alteration. Consequently, although the other material may have been similarly treated, this section describes only the heat treatment of silcrete.

The thermal alteration of Hunter Valley silcrete drastically improves flaking qualities and increases the lustre and smoothness of the fracture surface. Most of the silcrete in these assemblages is made up of visible quartz grains, up to 3mm across, set in a matrix. Although this material flakes well, the fracture plane normally passes through only the larger grains and deviates around the small grains, leaving the surface rough and dull. At many knapping floors containing silcrete, chipped artefacts have fracture surfaces that are extremely smooth and lustrous superimposed upon the normal rough and dull surfaces. On these specimens the more recent fractures have passed through rather than around quartz grains. This pattern is consistent with, and indicative of, thermal alteration of the stone material to improve its flakeability (Crabtree 1964; Flenniken and White 1983). Using this distinctive characteristic it was possible to infer the timing and nature of heat treating in the RAS.

Since heat treatment did not occur in the early stages of reduction it can be inferred that the natural fracture quality of the silcrete was adequate for the removal of large flakes. The thick flakes produced in phase 1 were thermally altered either before they were retouched in phases 3-5 or during those phases. Heat treating before these final stages of reduction was probably a necessity rather than merely an advantage. When removing a large flake (2-3cm wide) the effect upon the fracture propagation of a single quartz grain 3mm wide was probably minimal, but when removing a long flake only 5mm wide the effect of such a quartz grain could be major. Heat treating effectively homogenized the silcrete and reduced the effect of individual grains on fracture, allowing smaller, thinner flakes to be removed.

Even though heat treatment of the silcrete was required before the final phases of reduction, the timing of the treatment varied between sites. This variation can be illustrated by reference to sites at Redbank Creek. At RBC5 the thermal alteration took place before the thick flake was retouched, that is before phase 3, whereas at RBC13 the alteration took place after retouching had begun, at the end of phase 3. Further work is required to determine the factors that condition this variation.

Within any one site most, if not all, retouched flakes had been thermally altered at the same stage of reduction. I suggest the stoneworking was organised as a 'production line', with the knapper undertaking the initial reduction on several cores, then heat treating a number of large flakes in the one pit before proceeding to later reduction. It also appears that each of these activities was carried out at different locations, and materials were transported between locations. Activities might, therefore, be carried out in appropriate situations. For example, initial reduction probably took place at gravel beds in major creeks or rivers, heat treating at sandy creek beds or banks, and later reduction along tributary creek lines. Heat treatment pits have not been reported by archaeologists working in the Hunter River Valley, but since there are vast numbers of treated silcrete artefacts it is likely that they were altered locally. This proposition is supported by the occurrence of clusters of heat shattered fragments of silcrete and mudstone near some knapping floors (Hiscock 1985). While these fragments might have resulted from the excessive heat generated by hearth fires they may also indicate unsuccessful attempts at thermal alteration.

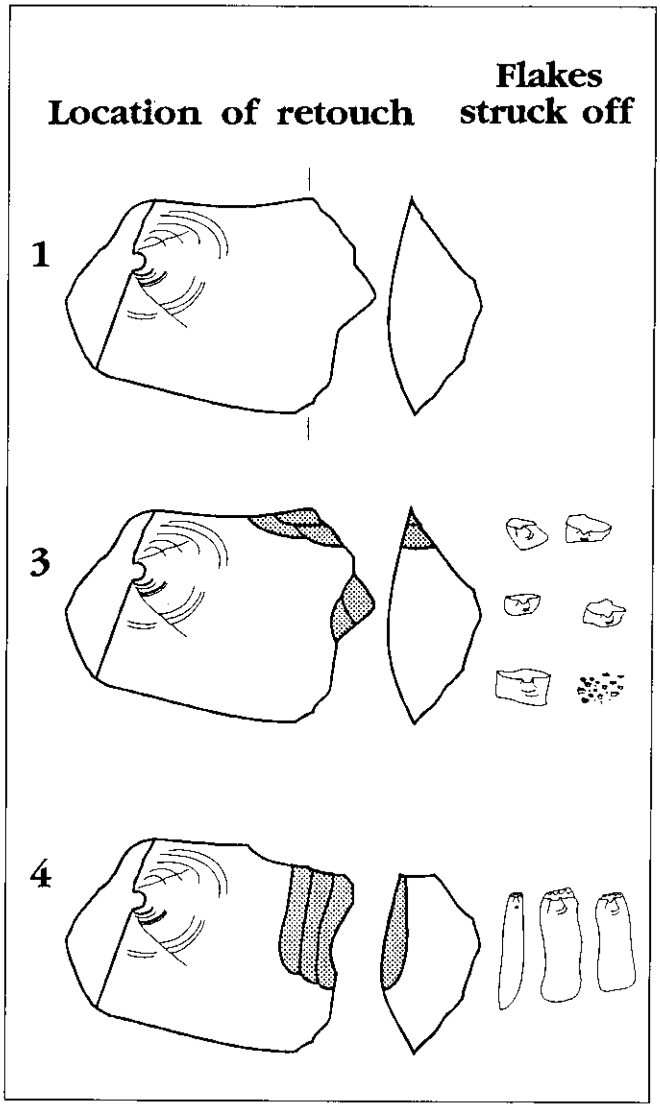

Figure 1. Idealized specimen showing the reduction in phases 1, 3 and 4 (stippled area shows flakes removed during each phase).

Later Reduction (Phases 3-5)

The thick flake produced in phase 1 was then retouched. This retouching process can be divided into three phases: phase 3 that prepared platforms and ridges, phase 4 that involves striking relatively long flakes from the ventral surface, and phase 5 which repeats the activities carried out in phases 3 and 4. Each of these phases is distinguished by the location and nature of retouch and by the distinctive flakes that were removed. Figure 1 illustrates, using an idealized specimen, these phases of reduction in the Redbank A Strategy.

In phase 3 a platform is prepared by striking the ventral surface along one lateral margin and removing small flakes from the dorsal surface. This retouching was usually done at the distal end of the flake and resulted in a much greater angle between the ventral and dorsal surfaces and a flat surface that could be used as a platform in phase 4. This platform preparation along a lateral margin always occurred, but occasionally the distal margin was retouched in similar ways. This distal retouch created a straight edge, and removed any convex portions so that the angle between the retouched lateral and distal margins was 90° or less. Distal retouch occurred only when the junction between the ventral and dorsal surfaces had originally undulated, or when protruding mass meant that the angles between the retouched margins were inappropriate for the next phase of knapping.

Retouching both lateral and distal margins required little effort and, because the flakes removed were extremely small, was accomplished by light taps with a hammer or by brushing the edge with a hammer. Some archaeological specimens have retouch on a lateral margin but the surface created was unsuitable for use as a striking platform. When this occurred the retouched flake was either discarded or a second lateral margin retouched.

At the end of phase 3 the thick retouched flake had retouch on at least one lateral margin and often on the distal margin (Figure 2A). This retouch was always on the dorsal surface of the flake and was characteristically small, usually less than 0.5-0.7cm long. Flakes removed

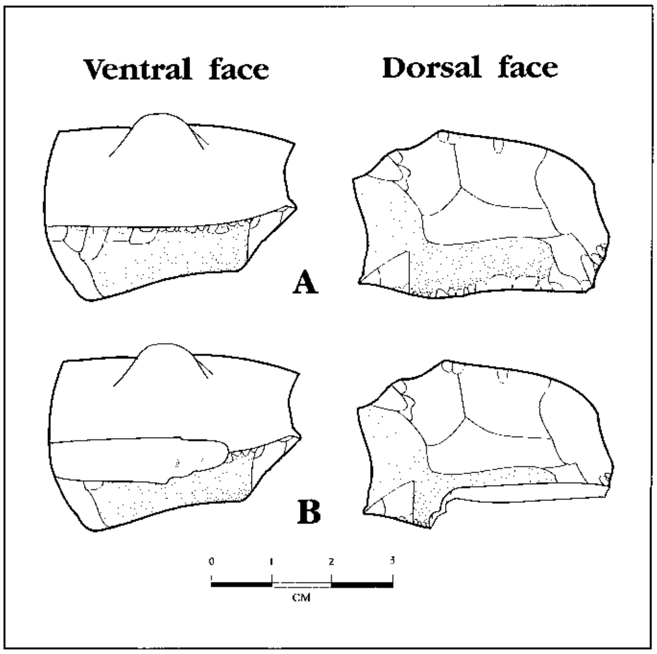

Figure 2. The appearance of the thick retouched flake at A: the end of phase 3 and B: early in phase 4

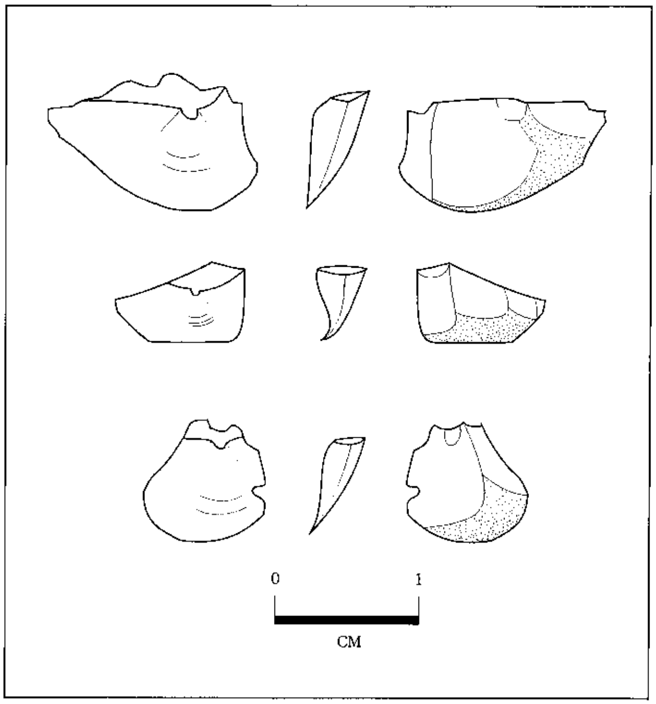

Figure 3. Type 1 flakes.

during phase 3, termed here type 1 flakes (Figure 3), displayed the following features:

* short and squat shape,
* large platform relative to the ventral surface (platform >30% of the ventral surface area),
* cortex on the dorsal face, either all over the face or only at the distal end,
* platform surface is a single conchoidal scar,
* low angle between the platform and dorsal surfaces (usually <60°),
* overhang removal (optional).

Phase 4 was initiated by applying sharp forceful blows to the surface created by retouching on the lateral margin. These blows removed flakes from the ventral surface of the retouched flake. The first blow was invariably placed at the distal end of the retouched flake and used the distal margin as a ridge to direct force. The resulting flake is called here a type 2 flake (Figure 4), and displays the following features:

* long and elongate shape,
* small platform compared with the ventral face (platform <30% of the ventral surface area),
* cortex often present on the dorsal face, and this cortex is usually found along one margin,
* no overhang removal,
* platform surface invariably consists of at least two or three flake scars, and is often faceted,
* high angle between the dorsal and platform surfaces (usually >75°),
* an old platform is often found on the dorsal ridge. This old platform usually had only small flakes removed from it, clearly indicating its ridge straightening function.

Only one of these type 2 flakes was struck off in each RAS reduction sequence. The termination of this type 2 flake largely determined the viability of further reduction. If the flake terminated abruptly, with a hinge or step at the distal end then it was often impossible to continue and the retouched flake was discarded (Figure 2B). If the type 2 flake ran to the other lateral margin and/or had a feather termination then a pronounced ridge was set up across the ventral face, and further blows were located to remove flakes parallel to that ridge (Figure 1). These flakes, termed type 3 flakes (Figure 5), are removed entirely from the ventral surface and consequently never have dorsal surfaces containing cortex or old platforms. In other characteristics, type 3 flakes are similar to type 2 flakes, being long and elongate, with relatively small platforms, high platform angles, no overhang removal, and faceted platforms.

The blows that remove type 2 and 3 flakes must be precisely placed to take advantage of the available ridges. Blows must also be located close to the edge of the platform to remove small platforms on the flake. Failure to place the blow correctly will result in hinge or step terminations and wide flakes that leave curved rather than straight ridges, characteristics that may prevent further reduction. The faceting of platforms aids in the production of flakes with small platforms by removing overhang, altering the platform angle, and creating greater friction with the hammer.

Phase 4 reduction was often brief. At Redbank Creek an examination of eleven reduction sequences that could be entirely reconstructed showed that on average one type 2 flake and four type 3 flakes were removed from each RAS retouched flake. The number of flakes removed

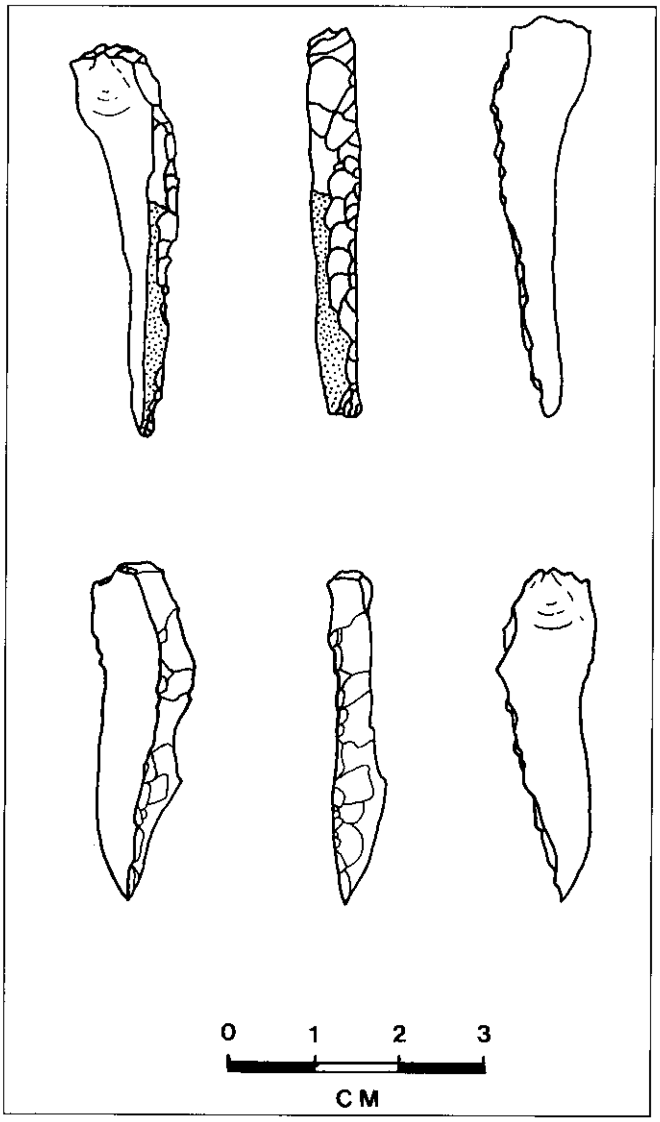

Figure 4. Type 2 flakes (ridge straightening flakes).

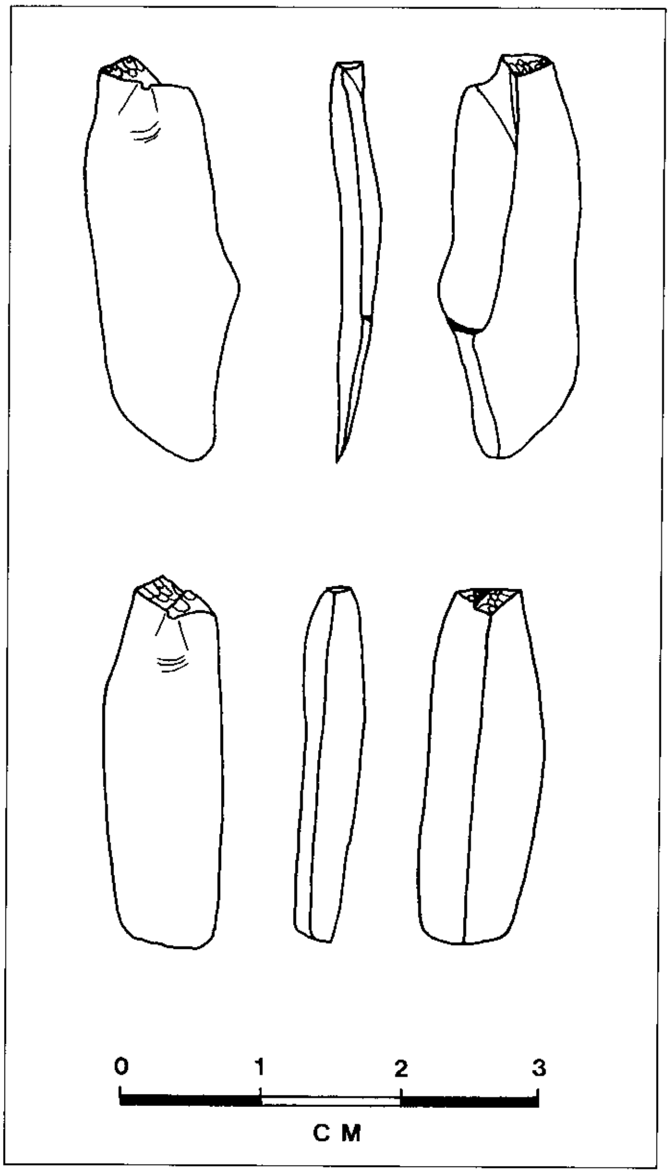

Figure 5. Type 3 flakes.

varied between two and nine. On most occasions knapping ceased after these flakes were removed, and the retouched flake was discarded. However, in approximately 20% of sequences reduction continued, and this further knapping can be termed Phase 5. Stone working in this phase was essentially the same as that of phases 3 and 4 in that it consisted of retouching the lateral margin again to rejuvenate the platform and then striking off flakes from the ventral face by blows applied to the new platform on the margin. The flakes produced by these blows are subtly different to those produced in earlier phases. Type 2 flakes were not generated since ridges had already been established on the ventral surface. Type 1 flakes are the same as described for phase 3, except that many have scars on the platform surface because of the previous flaking of the ventral face.

Backing (Phase 6)

The final phase of reduction involved backing some flakes that were created during phases 4 and 5. This selection and backing of flakes is designated here as phase 6. I suggest that this phase of stoneworking did not occur concurrently with other phases but was initiated only when all flakes had been removed. Evidence in support of this hypothesis comes from the observation that knappers usually continued to retouch the thick flake until it was utterly exhausted, striking off a number of inappropriate flakes after the last one that was suitable for backing. Consequently knappers may have finished reducing available retouched flakes before searching the debris in detail for flakes that might be backed.

Since flakes were often broken during backing, and can be refitted during conjoin analysis, it is possible to infer the characteristics of flakes chosen for manufacture into backed blades. Knappers consistently selected similar flakes for backing. Only type 3 flakes were backed and elongate flakes were preferred. Flakes selected for backing were typically 2.5-3.5 cm long and with a length:width ratio of between 2.0:1 and 3.5:1. Even elongate flakes of the right size were only selected if they had one straight or gently curving lateral margin, and if they had pronounced dorsal ridges but low angles (30-40°) between the ventral and dorsal surfaces.

Several unfinished backed blades suggest that retouching occurred in at least two steps. The first stage removed large flakes to roughly shape specimens and was followed by a second stage in which many small flakes were removed to trim and finally shape the retouched margin. In both stages of backing the knapper began at the distal end and worked back towards the platform.

Most, perhaps all, backed blades in this region were backed using bipolar and/or anvil rested techniques. Consequently, the steep retouched edge has bi-directional scars and crunching indicating contact with an anvil. Backing retouch always occurred along one lateral margin, and on some occasions the platform was removed by backing. Finished backed blades were invariably asymmetrical, and were often typical 'bondi points.'

It is possible to roughly estimate the number of backed blades produced in each RAS reduction sequence. Examination of conjoin sets recovered from knapping floors reveals that no more than three flakes suitable for the manufacture of backed blades were ever missing. Most reduction sequences have only one or two flakes converted into backed blades. Some reduction sequences were refitted in their entirety, and revealed that no flakes were backed. In other reduction sequences the one or two flakes being backed broke during manufacture and no finished specimens were produced. I suggest that on the open sites that were analysed an average of only one or two backed blades were produced in each reduction sequence. A similar production rate was identified in the assemblage recovered from the Sandy Hollow 1 shelter. Here there are 62 backed blades made on indurated mudstone and 37 ridge-straightening flakes of the same material. Since it has already been inferred that there is usually only one ridge-straightening flake per reduction sequence this suggests that there were approximately 37 RAS reduction sequences, each yielding an average of at least 1.7 backed blades per sequence.

Not all of these backed flakes were used. Many backed blades found in knapping floors were broken transversely near the tip, a breakage pattern that commonly occurs during backing (McBryde 1986). At isolated knapping floors 80% (N=40) of the backed blades were transversely snapped during manufacture and discarded. At Sandy Hollow 1 30% (N=61) show similar signs of breakage during manufacture. These figures may be inflated by the tendency for prehistoric knappers to remove complete backed blades and leave broken ones. Nevertheless I interpret data to reflect that a sizable proportion of flakes, at least 25% on average, were broken during backing and immediately discarded. This suggests those sites at which phase 6 knapping was carried out may contain few backed blades that had been used, and consequently these sites may be inappropriate for investigations into the function of backed blades.

Variations of the Redbank A Strategy

Thus far the Redbank A Strategy has been described as though it was invariable. There were indeed few variations to the procedures just described, but some did exist. At Sandy Hollow 1 for instance, the overall strategy remained the same as that described above (Figure 6A), but occasionally the location of phase 3 and phase 4 reduction on the thick retouched flake was different. Phase 3 platform preparation was sometimes positioned at the distal rather than lateral margins on two specimens, and as a consequence phase 4 consisted of removing flakes parallel with the length rather than at right angles to it (Figure 6B). On another specimen the phase 3 platform preparation was located on the lateral margins, but at the proximal end, and consequently the retouching that took place in phase 4 removed the platform rather than the termination of the thick retouched flake (Figure 6C). These variations produced large retouched flakes somewhat different in detail to the usual ones described above. Nevertheless, all of the other salient components of the strategy were employed. The different location of phase 3 and 4 retouch reflects prehistoric knappers not repeatedly applying the strategy in an inflexible way, but making slight modifications where appropriate. If this is the case then the modifications described here should be seen as occasional variations within the Redbank A Strategy rather than manifestations of a different strategy.

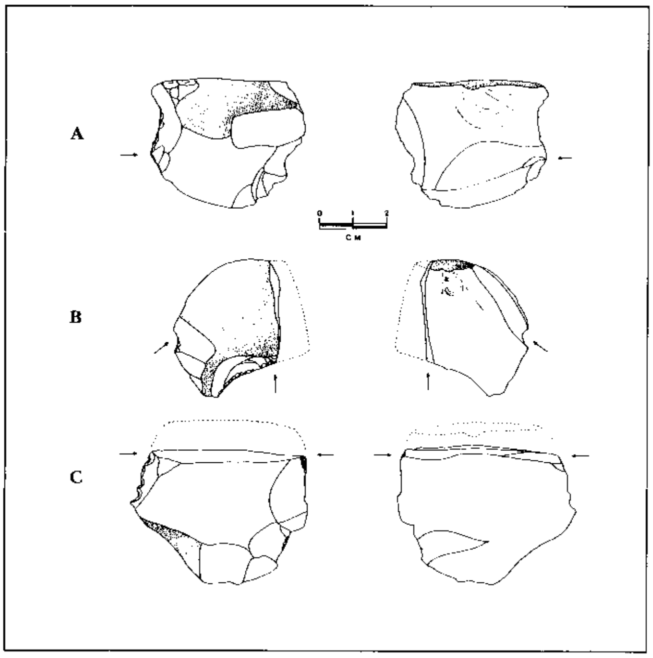

Figure 6. Three of the thick retouched flakes from Sandy Hollow 1 (square AA, level 3) which show variations in the Redbank A Strategy. All specimens are made on indurated mudstone and are oriented with the platform toward the top of the picture, dorsal face of the left and ventral on the right. Arrows show the direction of blows during phase 4; the mass removed by those blows is shown by broken lines. A shows usual RAS reduction; B, the removal of the lateral margin in phase 4; C, the removal of platform during phase 4.

Antiquity of the Redbank A Strategy

The antiquity of the Redbank A Strategy can be estimated by looking at stratified sites in which the distinctive debris occurs. This debris consists of bondi points, flakes with facetted platforms, and the thick Redbank A Strategy retouched flakes. Assemblages of this kind are commonly found in open sites recovered from the thin grey upper sediments of the texture contrast soils that exist widely throughout the Central Lowlands of the Hunter Valley. Hughes (1984) suggests that these sediments and, by association, the artefacts within them are Holocene in age.

Analysis of the Sandy Hollow 1 rockshelter provides more detailed indications of the antiquity of the Redbank A Strategy (Hiscock 1986). Here the artefacts indicative of this strategy first appear in level 4, associated with a date of 1,300 ± 100 years BP (ANU 125). Construction of a depth/age curve allowed Hiscock (1986:41) to estimate a time range of 1320-820 years BP for the levels in which Redbank A Strategy debris was found. Stratigraphic uncertainties, and in particular suspicions of a hiatus at the base of level 4, make the estimate of 1300 years BP a minimum for the appearance of this manufacturing strategy (cf. Hiscock 1986:42). Further excavations at Sandy Hollow 1 and similar sites are required to establish the chronological range of the RAS reduction. Nevertheless, the technological information now available about that form of stoneworking has implications for several methods used by Australian prehistorians.

Typological confussions

Artefacts with a wide range of sizes and shapes are produced during the Redbank A Strategy of stoneworking. A number of these forms of artefacts bear a close resemblance to recognized 'implement types' but are merely discarded by-products of the knapping. The existence of such objects has led to some confusion, by people undertaking typological analyses, between manufacturing debris and finished 'implements' and 'tools.' The (mis)identification of backed blades, a type that is seemingly very distinctive, is one example of this problem.

In a series of articles Moore (1967, 1969, 1970, 1981) identified as backed blades, several objects he had recovered from excavations at the Sandy Hollow 1 rockshelter. Although he did not state his methods in detail Moore apparently emphasized size and shape as his main criteria in identifying bondi points. All of the specimens he assigned to that category are long, thin, asymmetric and have a steep margin opposite a low angled margin. Re-analysis of these specimens from a technological perspective demonstrated that while the original typological approach had identified most of the backed blades it had placed other specimens in that category. Table 2 lists revised identifications of the 93 pieces of indurated mudstone and chert that were originally categorized as backed blades. Over 30% of specimens had been misidentified. Some mistakes arose from unique situations, such as the existence of a semicircular heat shattered fragment that had a steep edge opposite a low angled edge. Most of the misidentifications arose from systematic confusions between backed blades and other debris that derive from the Redbank A Strategy. Ridge-straightening (Type 2) flakes were regularly identified as backed blades because the long asymmetric shape and the steep side covered in small flake scars often combine to resemble bondi points. Figure 4 shows two examples of the ridge-straightening flakes that were misidentified and highlights the ease with which such confusion could take place when backed blades were classified from a non-technological perspective. Another source of confusion arose from the superficial resemblance of squat flakes with extensive overhang removal to backed flakes. Although a technological re-analysis of this kind did redefine the range and numbers of implement types at Sandy Hollow 1 it made little difference to the identification of chronological change in the frequency of backed blades (Hiscock 1986:42). Nevertheless the confusion of unretouched flakes with backed blades may have had a marked effect upon the perception of regional variation if sites elsewhere did not reduce stone using the Redbank A Strategy (see Moore 1970:50-60, 1981:417-420).

The confusion of ridge straightening flakes and backed blades is not peculiar to the Hunter Valley. Museum collections indicate that this mis-classification has occurred in a number of archaeological analyses since backed blades were first examined in this country. Indeed in the article that first identified backed blades in Australia, Etheridge and Whitelegge (1907:238) clearly state that they were unable to differentiate retouching on flakes from flaking done on the core, and they relied instead on the regularity of shape to infer that the specimens were retouched flakes. Even in textbooks illustrated specimens that appear to be ridge straightening flakes are labelled as backed blades (eg. White and O'Connell 1982: Figure 5.3.a-b, Figure 5.4.a).

Johnson (1979:102-103) has argued that such ridge-straightening flakes, which he called redirecting spalls, are easily distinguished from backed blades. He notes that at

Artefact type	Specimens used by Moore (1981) in metrical analysis	All specimens
Backed blades*	55	62
Other retouched flakes	2	3
Ridge straightening flakes	9	15
Other unretouched flakes	4	12
Heat shattered non-artefactual fragments	1	1
Total	71	93

Table 2. Re-analysis of specimens from Sandy Hollow 1 previously indentified as backed blades by Moore (1970, 1981). * includes unfinished and broken specimens.

Capertee 3 these flakes are equilateral triangles in cross-section rather than the flattened triangles of backed blades, have a characteristic 'twist' in the ventral surface that backed blades never have, and may have alternate retouch along the dorsal ridge which backed blades never have. No doubt this is the case at Capertee 3 but, contrary to Johnson's (1978:103) assertion, in the Hunter Valley these characteristics were consistently absent from ridge-straightening flakes, giving them a greater chance of being confused with backed blades. Size and shape criteria will not adequately distinguish between the two forms of artefacts, and the only reliable way of identifying backed blades is to confirm that they have been retouched.

The co-existence and resemblance of ridge-straightening flakes and backed blades has been noticed before (Johnson 1979:102; Luebbers 1978:223). Luebbers (1978:223) suggested that ridge-straightening flakes were either a form of backed blade that was made on the core rather than by being retouched, or was a 'preform' of a backed blade. Neither of these hypotheses is viable in the RAS reduction sequences of the Hunter Valley for the following reasons:

1.Most of the ridge-straightening flakes have cross-sections not suitable for backing and are too thick to remove flakes across the entire backed surface without breaking the retouched flakes. The only way to 'back' such a flake would be to remove no more flakes from the dorsal ridge and to take only short flakes off the backed surface by striking on the ventral face. This would appear as a two-phase backing, with scars originating from the ventral surface consistently overlying old scars coming from the dorsal ridge. Such backed blades are not found.

2. None of the backed blades have been made on flakes that have old platforms on their dorsal face.

3. Ridge-straightening flakes are struck off early in phase 4 of the reduction sequence whereas backed blades were usually made on flakes that are struck off at the end of phase 4 or in phase 5.

4. Since ridge-straightening flakes are a by-product of the core preparation that occurs in Bondaian technology they can be expected to be found in assemblages with backed blades. In eastern Australia, however, the two forms of debris are separate components of the technology (see also Johnson 1979:102).

The thick retouched flakes have also been confused with implement types. As the thick flake is reduced in phases 3-5 of the Redbank A Strategy its morphology changes, and at some points it can closely resemble traditionally recognized implement types. By the end of phase 3 the thick flake is retouched on the dorsal face at the distal end and/or lateral margin. It has already been explained that this retouch functions as platform preparation and ridge straightening during the next phase of knapping. There are, however, occasions on which further reduction will not occur, such as when the platform preparation and ridge straightening yielded inappropriate morphologies. Such flakes which were discarded during or immediately after phase 3 strongly resemble the class of implement designated as 'scraper' (Figure 2A) (see also Johnson 1979:105).

Thick flakes that are knapped in phase 4 were often discarded after only one or two flakes had been struck from the ventral surface. The most common reason for discard is that the first flakes removed in phase 4 reduction terminated abruptly in large steps or hinges, thereby making it difficult to continue knapping. When reduction ceases in these circumstances the thick retouched flakes strongly resemble the class of implement designated as 'burin' or 'burinate' (Figure 2B).

These two components of RAS reduction have sometimes been mistaken for scrapers and burins by researchers working in the Hunter Valley. This confusion may be widespread. After a usewear examination of purported burins from nine regions in Australia Kamminga (1982:92) found that only 5.6% were edge-damaged, and that none of this damage could definitely be attributed to prehistoric use. Consequently Kamminga (1982:93) suggested that many burins were not tools but other classes of artefacts, in particular cores. This proposition has been investigated further by Cundy (1977) while working on assemblages from New England. He demonstrated that in several salient characteristics burins were on the extreme end of a continuum of objects from which flakes had been removed, and included cores as well as retouched flakes. On this basis he hypothesized that burin-like objects were simply a by-product of a specific strategy for detaching elongate flakes from small retouched flakes, which Cundy (1977:137) called the 'twin ridge blade core.' A positive correlation between the numbers of burins and backed blades in the New England and Blue Mountain areas reinforced the hypothesis that 'burins' were acting as the source of long flakes that were manufactured into backed blades. Although this correlation was strong in some regions Cundy (1977:34-35) was convinced that it did not hold throughout eastern Australia because he failed to find it in the nearby Hunter Valley. The Redbank A Strategy reported here demonstrates not only the spatial and temporal correlation between backed blades and burin-like retouched flakes but also the technological relationship. If this relationship was not previously reported, it is because in most cases reduction progressed through phase 4, thereby altering the burin-like appearance of the thick retouched flake. This does not imply that backed blades in all parts of Australia were manufactured in this manner, nor that burins can only have functioned as a producer of flakes for backing (cf. Flenniken and White 1985:145). Nevertheless the widespread and systematic connection between burin-like artefacts and backed blades reveals that it is no longer feasible to assert that the former class of artefacts is a rare or fortuitous result of other manufacturing practices as some authors have suggested (eg. Campbell and Noone 1943:296; McCarthy 1943:143; Kamminga 1982:92).

All of these objects that imitate implement types result from the attempt to produce flakes suitable for backing, and there is no need to interpret them as an attempt to manufacture a wide range of artefacts for a variety of

	RBC12	RBC13	RBC5	Average
Silcrete	3	5	11	6
Indurated Mudstone	6	3	6	5
Total	9	8	17	11

Table 3. Estimated number of reduction sequences represented by debris at Knapping floors along Redbank Creek.

uses. Reassessment of the diversity of artefact morphology from this kind of technological perspective permits other issues concerning Bondaian assemblages to be examined. One issue that is discussed here is the nature of the prehistoric activities that are represented by archaeological material and the structure of those activities.

Structure of technological activities

The major activity represented by the debris in the open sites reported here was stoneworking, and in particular the manufacture of backed blades. Covering only a few square metres in extent, these sites were chosen for study because they clearly represented knapping locations. Table 3 gives the estimated number of reduction sequences at three knapping floors along Redbank Creek. At each site 8-17 thick flakes were reduced. This figure is indicative of RAS knapping floors throughout the region, and demonstrates that each site could easily have been produced in a short time by only one or two individuals. Most of the backed blades that remain at these knapping locations are either unfinished or were broken during manufacture. It is therefore hypothesised that backed blades at these sites were not used, and that those selected for use were transported away from these sites.

Johnson (1979:103-4) hypothesized that ridge-straightening flakes derived from exhausted scrapers that were being converted into a producer of blades. It has been shown that in the Redbank A Strategy these type 2 flakes are removed from a larger retouched flake. In the Hunter Valley knapping floors, however, there is no evidence that between phases 3 and 4 the retouched flake was used as a scraper. Small isolated knapping floors, containing the debris from only two or three reduction sequences, invariably have all of type 1, type 2 and type 3 flakes. This indicates that both phases 3 and 4 were carried out on the same spot, probably within a short time. It has already been argued that phase 3 retouching is explicable in terms of the technological requirements of phase 4, and that there is no need to infer use as a motive for the production of the 'scraper'-like morphology of the thick retouched flake. Use-wear investigations of the dorsal side of ridge-straightening flakes should confirm the hypothesised absence of damage sustained during use.

These conclusions imply that prehistoric activities during the Phase I Bondaian were organised in a very discrete manner, with some points in the landscape, such as these knapping floors, being employed for only a limited range of activities. It has already been argued that the Redbank A Strategy of reduction was carried out in a very standardized way, with only minor variation in the placement and form of blows. This regularity of knapping is parallelled by the complex and consistent structuring of other components of technological activities. Procurement and reduction were carried out at several different sites, with the knapper completing one phase of reduction on every reduction sequence at hand, and then transporting selected objects to a new location before initiating the next phase of reduction. Inferences drawn here suggest the following scenario. A number of thick flakes were struck off and were then carried to a different location for heat treatment and later phases of reduction. These thick flakes were all heat treated and were then all retouched. Phase 3-5 reduction was carried out until the thick retouched flakes were exhausted (ie. no longer able to produce type 3 flakes). Knappers then rummaged through the debris, and selected and backed some flakes. Finished backed blades were taken away for use elsewhere.

This perception of a production-line structure to technological activities does suggest that behaviour was highly patterned. Jones (1977) has interpreted the greater regularity of formal implement types in the 'Small Tool Tradition' as an indication of the greater efficiency of that tradition compared to earlier industries. In this context it is interesting that the presence of Bondi Points, one of these regular implements of the 'Small Tool Tradition,' is accompanied by a highly patterned technology and activity structure. This correlation highlights one problem with Jones (1977) assessment of complexity and efficiency, namely that the issue is not one of 'implements' alone but is ultimately a question of the complexity and efficiency of the entire technological system. It may be that some assemblages containing seemingly simple and unpatterned 'implements' are the product of an extremely standardized and complex system of procurement and reduction.

Furthermore, while the Redbank A Strategy may appear more complex and to involve greater expenditures of energy than earlier technologies, it is not appropriate to conclude that it is therefore more efficient. Efficiency is measured by the net benefit that accrues from an action, and little or no data was obtained about the benefits that might have resulted from the application of the RAS. Two areas in particular need to be clarified before even preliminary calculations about efficiency can be made. First the amount of heat treating in each chronological period must be determined. Hanckel (1982) showed that heat treatment occurred on the NSW south coast since the Pleistocene, but was not able to quantify changes through time in the amount of heat treating. It must be established whether heat treating occurred in the Hunter Valley in chronological units other than Phase I Bondaian, and if so how much energy was expended in this activity at those times. Secondly, it has not been determined how many artefacts were used, the purpose of their use, or the length of use, and consequently it is not known what knappers gained from their investment of energy.

Pursuing the question of artefact function will require a greater understanding of prehistoric stoneworking and activity organization than has until now been employed in Australian use-wear studies. For example, I have pointed out that many backed blades recovered from open sites and rockshelters in the Hunter Valley were manufacturing rejects that were never actually used. Since many backed blades housed in museums originate from sites of this kind they may be an inappropriate sample with which to investigate questions of artefact use. Undertaking systematic and intensive surveys to specifically retrieve artefacts in different contexts, such as broken backed blades from sites and whole specimens found by themselves away from sites, should provide better collections with which to investigate artefact functions.

In the Hunter Valley temporal variation in prehistoric stoneworking technology was far greater than the spatial variation between and within sites. Although this conclusion accords with available data it is based on inferences from only a small number of sites. Future research in the region should seek to determine the extent to which these sites reflect variations in prehistoric stoneworking. The importance of this inference for interpretations is paramount. For example, the ability to date open artefact scatters relative to one another by changes in technology rests upon this principle (cf. Hiscock 1986, 1988).

Even if spatial variation in technology is minimal in comparison to chronological changes, the assemblages at nearby sites may still be noticeably different. It was found that taphonomic factors had worked to alter the original assemblage, and that the combination of various mechanisms and intensity has led to dissimilar modification of material at different sites (Hiscock 1985). Apparently only part of the manufacturing system reflected in artefacts was represented in the open sites that were examined. Consequently, other sites that contain different sorts of assemblages deriving from the same technology should be found.

Blade technology and chronological change in flake elongation

It is sometimes asserted by Australian archaeologists that the mid-Holocene typological changes, in particular the appearance of backed blades, is a reflection of the appearance of a blade technology. Although the concept and definition of a blade technology are not detailed by those researchers they imply that the most obvious manifestation of such a technology is a frequent occurrence of elongate flakes (ie. those with a length at least twice as long as their width).

In the Hunter Valley elongate flakes are infrequent at the open knapping floors where backed blades were manufactured. Even excluding type 1 flakes, which are invariably squat, the highest proportion of elongate flakes on mudstone were 22% at Redbank Creek sites 12 and 13, and elsewhere the proportion was commonly about 15%. In terms of individual reduction sequences this represents the ridge-straightening (type 2) flake, which was almost always elongate, and one or two of the type 3 flakes. Thus although these relatively long flakes were preferentially selected for backing the reduction process was not geared to produce 'blades' consistently and repeatedly.

If blade technologies always accompanied backed blade manufacture then Bondaian assemblages in a number of regions ought to contain similar frequencies of elongate flakes. Furthermore the proportions of elongate flakes should always be higher in Bondaian assemblages than in earlier assemblages. Neither of these propositions is supported by available data.

Table 4 shows that the percentage of elongate flakes varies greatly between regions in eastern Australia. Moreover, while some Bondaian assemblages do indeed have a significant proportion of elongate flakes, others have very few elongate flakes. Similarly, while some Pre-Bondaian assemblages have few elongate flakes, others have relatively large proportions. This variation no doubt springs from the existence of different technological systems producing backed blades (cf. Hiscock 1986) as well as the effect of different stone materials and stone procurement strategies. The operation of local factors, such as raw material form, may be the major determinant of the frequency of elongation in an assemblage, irrespective of the technology employed. Figure 7 plots the percentage of elongate flakes in Pre-Bondaian assemblages against the percentage of elongate flakes in

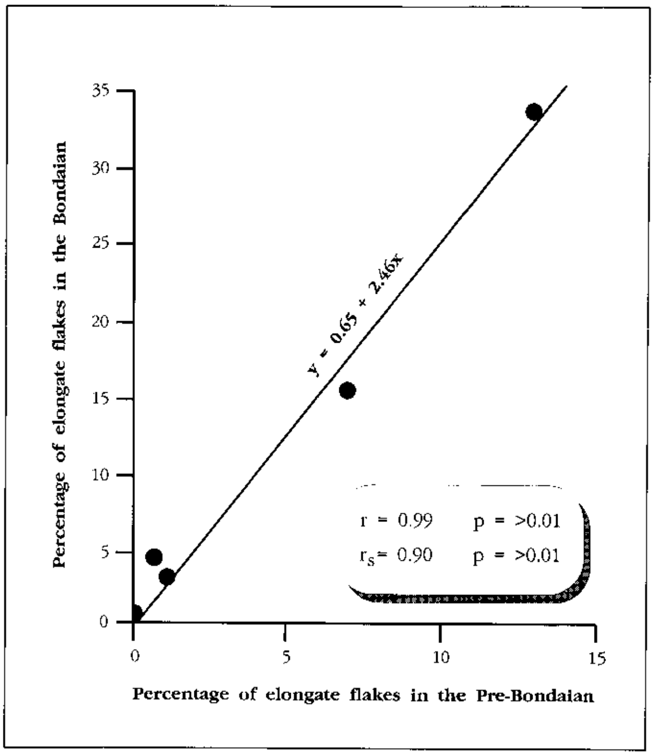

Figure 7. The relationship between the percentage of elongate flakes in Bondaian and the Pre-Bondaian assemblages. The r value represents the standard product-moment correlation coefficient, while the r_s value represents Spearmans rank correlation coefficient.

Period	Site	Levels	% of flakes with L > 2W	Reference
Bondaian	Capertee 3		34	Johnson (1979)*
	Sandy Hollow 1	(Level 4)	15	Hiscock (1986)*
	Maidenwell	(1-3k BP)	7	Morwood (1986:95)
	Gatton	(1-3k BP)	4	Morwood (1986:109)
	Native Well 2		4	Morwood (1981:39)*
	Native Well 1		3	Morwood (1981:29)*
	Shaws Creek KII	(levels 1-3)	0.5	Kohen, Stockton and Williams (1984:62-4)*
Pre-Bondaian	Capertee 3		13	Johnson (1979)*
	Waragara	(1-3.3k BP)	14	Sutton (1985:72)
		(3.3-11k BP)	12	Sutton (1985:72)
	Sandy Hollow 1	(level 5)	7	Hiscock (1986)*
	Native Well 1	(spits 8-14)	1	Morwood (1981:29)*
	Native Well 2	(spits 12-18)	0.7	Morwood (1981:39)*
	Shaws Creek KII		0	Kohen, Stockton and Williams (1984:62-4)*

Table 4. Percentage of elongate flakes in assemblages in Eastern Australia. * = data used in Figure 7.

Site	Assemblage (levels)	Mode mm	% > 2.0	% < 1.0	Maximum elongation	N
Capertee 3	Bondaian (II-V)	1.60	34	19	5.3	99
Capertian	(VII-X)	0.70	13	36	3.8	217
Sandy Hollow 1	Phase II Bondaian (1)	0.95	10	46	4.1	63
	Phase I Bondaian (4)	0.95	15	38	4.4	171
	Pre-Bondaian (5-7)	0.80	7	54	6.0	168

Table 5. Comparison of elongation index (length width) of complete flakes.

Bondaian assemblages for all five sites in eastern Australia for which these data are available. The extremely strong positive correlation indicates that, irrespective of the technology or implement types present, sites in some regions always have much higher proportions of elongate flakes than others.

To illustrate this trend in more detail two sites in eastern NSW can be compared. Table 5 compares chronological change in flake elongation at Sandy Hollow 1 in the Hunter Valley, with that at Capertee 3, a site in the nearby Blue Mountains. It is true that through time in both areas there is an increase in the percentage of elongate flakes in the assemblage and in the modal value of the elongation index. Yet this trend is not undirectional, since there is a decrease in the percentage of elongate flakes in the upper levels at Sandy Hollow 1, even though backed blades are still present. Moreover, even in the Phase I Bondaian at Sandy Hollow 1, when elongate flakes are most frequent, they only occur in the same proportions as in the Pre-Bondaian levels of Capertee 3. Thus flake elongation does not, by itself, reflect the technological differences that exist between assemblages in which backed blades were made and those in which they were not. Consequently the designation of all Bondaian assemblages as the product of a technology that predominantly involves the repeated removal of blades would be incorrect in eastern Australia.

In discussing the Puntutjarpa assemblage Gould (1977:100) pointed out that there was no tradition of blade making but that backed blades were made on irregular elongate flakes that were occasionally produced (Gould 1977:85). This appears to be the situation in the Hunter Valley, and consequently there is little value in depicting the Pre-Bondaian/Bondaian transition as reflecting the sudden development of a blade technology. A more appropriate depiction of these chronological changes has been provided by Johnson (1979:103-104) who characterized the Pre-Bondaian/Bondaian transition as the development of increased regularity of reduction in response to the need for a careful conservation of raw material. From this view the associated increase in flake elongation is only a secondary phenomenon. A direct reflection of the greater regularity and precision of knapping is the elaboration of platform preparation and core maintenance that is typical of early Bondaian technologies such as the Redbank A Strategy. The reduction of flakes instead of cores, the extensive use of thermal alteration, and the complex system of transportation during manufacture, are indications of the attempt to conserve raw material. If this conclusion can be sustained the issue that remains to be investigated is the cause for this imperative to conserve material that apparently intensified during the mid-late Holocene.

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References

Campbell, T.D. and Noone, H.V.V. 1943. South Australian microlithic stone implements. *Records of the South Australian Museum* 7, 281-307.

Crabtree, D.E. 1964. Notes on experiments in flintknapping: Heat treatment of silica materials. *Tebiwa* 7, 1-6.

Cundy, B.J. 1977. An analysis of Burins from New England and Capertee. BA(Hons) thesis, Australian National University.

Dibble, H.L. 1984 Interpreting typological variation of Middle Palaeolithic Scrapers: Function, Style or sequence of reduction? *Journal of Field Archaeology* 11, 431-436.

Dibble, H.L. 1987. The interpretation of middle Palaeolithic scraper morphology. American Antiquity 52, 109-117.

Etheridge, R. and Whitelegge, T. 1907. Aboriginal workshops on the coast of New South wales, and their contents. *Records of the Australian Museum* 6, 233-250.

Flenniken, J.J. and White, J.P. 1983. Heat treatment of silicieous rocks and its implications for Australian prehistory. *Australian Aboriginal Studies* 1983/1, 43-48.

Flenniken, J.J. and White, J.P. 1985. Australian flaked stone tools: a technological perspective. *Records of the Australian Museum* 36, 131-151.

Gould, R.A. 1977. Puntutjarpa rockshelter and the Australian Desert Culture. *Anthropological papers of the American Museum of Natural History* 54.

Hanckel, M. 1983. Hot rocks from the south coast: a study in thermal pretreatment at Burrill Lake and Currarong, New South Wales. BA(Hons) thesis, University of Sydney.

Hiscock, P. 1985. The need for a taphonomic perspective in stone artefact analysis. *Queensland Archaeological Research* 2, 82-97.

Hiscock, P. 1986. Technological change in the Hunter River Valley and the interpretation of Late Holocene change in Australia. *Archaeology in Oceania 21*, 29-39.

Hiscock, P. 1988. Developing a relative dating system for the Moreton region: assessing the prospects for a technological approach. *Queensland Archaeological Research* 5, 113-132.

Hughes, P.J. 1984. NSW National Parks and Wildlife Service Hunter Valley Region Archaeology Project Stage 1. Unpublished report to NSW NPWS through ANUTECH Pty Ltd.

Johnson, I. 1979. The getting of data. PhD thesis, Australian National University.

Jones, R. 1977. The Tasmanian paradox. In R.V.S.Wright (ed), *Stone tools as cultural markers*, pp.189-204. AIAS, Canberra.

Kamminga, J. 1982. Over the edge. Functional analysis of Australian stone tools. *Occasional Papers in Anthropology No. 12*. Anthropology Museum, University of Queensland.

Kohen, J.L., Stockton, E. and Williams, M.A.J. 1984. Shaws Creek KII rockshelter: a prehistoric occupation site in the Blue Mountains piedmont, eastern New South Wales. *Archaeology in Oceania* 19, 57-73.

Luebbers, R.A. 1978. Meals and menus: a study of change in prehistoric coastal settlements in South Australia. PhD thesis, Australian National University.

McBryde, I. 1986. The broken artefact and functional studies. In G.K. Ward (ed.) *Archaeology at ANZAAS Canberra*, pp.203-210. Canberra Archaeological Society, Canberra.

McCarthy, F.D. 1948. The Lapstone Creek excavation: two culture periods revealed in eastern New South Wales. *Records of the Australian Museum* 22, 1-34.

McCarthy, F.D. 1967. *Australian Aboriginal Stone Implements*. Australian Museum, Sydney.

Moore, D.R. 1967. Archaeological field survey of the Hunter River Valley, NSW by the Australian Museum: a preliminary report. *Australian Institute of Aboriginal Studies Newsletter* 2, 34-41.

Moore, D.R. 1969. The prehistory of the Hunter Valley. *Australian Natural History* 16, 166-171.

Moore, D.R. 1970. Results of an archaeological survey of the Hunter River Valley, New South Wales, Australia. Part 1: The Bondaian industry of the upper Hunter and Goulburn River Valleys. *Records of the Australian Museum* 28, 25-64.

Moore, D.R. 1981. Results of an archaeological survey of the Hunter River Valley, New South Wales, Australia. Part II: Problems of the lower Hunter and contacts with the Hawkesbury Valley. *Records of the Australian Museum* 33, 388-442.

Morwood, M.J. 1986. The archaeology of art: excavations at Maidenwell and Gatton Shelters, S.E. Queensland. *Queensland Archaeological Research* 3, 88-132.

Sutton, S. 1985. Waragarra stone. BA (Hons) thesis, University of New England.

White, J.P. and O'Connell, J.F. 1982. *A prehistory of Australia, New Guinea and Sahul*. Academic Press, Sydney.