Technology of Hunter Valley microlith assemblages, New South Wales

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This study was prepared as part of a lithic analysis for an archaeological testing project undertaken by the Australian Museum Business Services in 1996 at three Aboriginal sites encountered on Bettys Creek, near Singleton in the Hunter Valley of New South Wales. The goal of the analysis was to determine the place of the Bettys Creek assemblage within Hunter Valley lithic technology, thereby providing information relevant to evaluating the significance of the Bettys Creek sites.

The analytical approach of the Bettys Creek analysis involved applying a ‘technological typology’ to the lithic assemblages. In this approach, flakes are classified into types based on the knapping techniques which produced them (Andrefsky 1998:118-122; Shott 1994). Formed objects— artefacts from which flakes have been removed—are examined scar-by-scar to determine the sequence and strategy of stone reduction (Andrefsky 1998:136-188; Moore 1992). The results of the flake and formed tool studies are correlated through knapping experiments and artefact conjoining. A stage-based reduction model, often in the form of a flow chart, is used to structure the results. The intent is to develop a detailed model of the way in which stone was manipulated at a site or in a region.

This approach has rarely been applied in Australia, although two published examples are available for the Hunter Valley: Flenniken and White (1985) and Hiscock (1993). The first step of the Bettys Creek analysis involved extrapolating a reduction model from these studies. The intent was to examine the nature and distribution of reduction steps at Bettys Creek in light of the reduction model. It quickly became apparent during the fieldwork that, while the reduction model derived from these studies reflected one method of microlith production, the model was too narrow in scope to account for all aspects of knapping behaviour practiced at Bettys Creek.

A review was then undertaken of unpublished pre-1996 Hunter Valley lithic analyses in order to expand and refine the reduction model and provide a more holistic account of the Bettys Creek artefact assemblages. However, most pre-1996 Hunter Valley studies involved attribute analysis and this method yields results which are of limited use in developing lithic reduction models. Hence, the necessary technological information was not available in any single analysis. Nevertheless, as a group, these studies covered most aspects of Hunter Valley reduction technology. By extrapolating from information in the unpublished literature combined with analysis of the Bettys Creek assemblages and heat-treatment experiments, it was possible to broaden the scope of the initial model to include the range of manipulations stone went through prior to tool exhaustion and discard (Fig. 1). This paper describes the reduction model.

Definitions

The focus of this study is the knapping steps involved in producing the principle tools and products of the Hunter Valley 'Australian Small Tool Phase' (after Mulvaney and Kammenga 1999:230-233), including blades and blade-making debris, microliths, 'early reduction' cores, and retouched flakes. The term 'microlith' is used in this study to refer to small backed artefacts. A 'core' is 'any piece of raw material that has had flakes struck from it, the desired product being the flakes' (Bradley 1975:6).

Blade technology and products are viewed from a technological perspective. In blade technology, platforms for blade-making are aligned and prepared over straight arisces created by earlier flake removals, and flakes are struck down these arisces in a series by applying force near the core's edge (Whittaker 1994:219-234; Patten 1999:56-57; Hiscock 1993:68). A blade technology is defined at the assemblage level, where much of the debitage exhibits parallel dorsal arisces and placement of platforms in alignment with these arisces. Flakes created by blade technology will not always be twice as long as wide and parallel-sided, the traditional definition of a blade based on morphology (Hiscock and Attenbrow 1996). Indeed, flakes with these characteristics might represent only a small proportion of the debris produced in blade core reduction. As demonstrated by conjoining studies in the Hunter Valley, backing was applied both to elongated and parallel-sided 'blades' and to non-elongated flakes produced in the reduction of blade cores (Koettig 1992a, 1994a-c).

The 'early reduction' flake type is produced to regularise the surface of a core and to isolate mass for the production of a large flake, which can itself be an early reduction flake. Blade platforms tend to be deep, reflecting the strategy of removing large amounts of mass by applying the blow well-back from the core edge. The shape, cross-section, and scar patterning on an early reduction flake depend on the morphology of the area of high mass targeted by the percussion blow. The shape of this area of high mass is influenced by previous flake removals, but, in contrast to blade production, successful removal of an early reduction flake may not be dependent on the configuration of dorsal arisces. An early reduction flake’s dorsal surface is often marked by unpatterned flake scars. Early reduction flakes can be removed in the early stages of blade core reduction and during attempts to re-set a blade core face after knapping mistakes or core rotation. "Early reduction cores" are characterised by the removal of relatively large early reduction flakes. The arrangement of flake scars on early reduction cores is frequently unpatterned.

Flakes were themselves reduced as cores in the Hunter Valley. Flakes struck from the ventral surface of one of these cores will sometimes have a portion of this ventral surface as a dorsal scar. This has been referred to as a 'positive flake scar' (Hiscock 1986:7), 'conchoidal scar' (Hiscock 1993:68) or 'detachment scar' (Flenniken and Stanfield 1980:27). The latter term is used in this study. If the detachment scar includes all or part of the original blank's ring crack, it is called a 'contact removal flake'.

The terms 'quarry' and 'quarrying' refer to a wide range of stone procurement behaviours (Hiscock and Mitchell 1993; Wilke and Schroth 1989; Ericson and Purdy 1984). To avoid confusion, these terms are avoided here. An important aspect

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of this study was to determine if reduction was occurring at the stone outcrop. The term 'on-source' is used to refer to reduction at the outcrop, and the term 'off-source' is used to refer to reduction away from the outcrop.

**Stone procurement**

Both on-source and off-source reduction were practiced by knappers in the Hunter Valley. Off-source reduction, the most widespread strategy, involved gathering small- to medium-sized stones and adding them to the tool kit either as-is or after limited assaying. These stones were then reduced off-source as small cores.

The procurement evidence at the stone source tends to be a diffuse background scatter of flakes and flaked cobbles representing the results of assaying and cobble rejection (Dean-Jones and Mitchell 1993; 58; Dean-Jones 1990; Moore 1970; Rich 1992:21, 50; Koettig 1994a:19, 21). In off-source areas, this type of procurement is demonstrated by conjoin sets which reconstruct complete or nearly complete cobbles (Koettig 1992a, 1992b, 1994b). Outcrops lacking evidence for intensive on-source reduction may appear to be relatively unimportant stone source areas; however, given that little assaying debris might be produced in proportion to the number of exported cobbles, it is possible that the majority of the stone used by Hunter Valley microlith knappers derived from these low density procurement localities.

Intensive on-source reduction was also practiced by Hunter Valley knappers (Baker 1992a:16-17, 1992b:37-38, 40; Hiscock 1993:67). This strategy was focussed on the gravels of the Hunter River, which provided large and easy to extract mudstone and silcrete cobbles. The cobbles were reduced into large flake blanks for export, and the resulting on-source cores and reduction debris were abandoned on the gravel bars. Flooding of the Hunter River incorporated the discarded cores anddebitage into the river's bed load and exposed new raw material (Hiscock 1986:16). Large numbers of on-source cores are often present on these gravel bars. For example, a study by Hughes and Lance (in Hiscock 1986: 14-16) discovered 22 Aboriginal mudstone cores within a 1200 square metre section of a gravel bar at the mouth of the Goulburn River near Denman (see also Hiscock and Koettig 1985; Rich 1992:24).

Inspection by the author of riverbed gravels at the road crossing near Jerry's Plains and a gravel quarry south of Maison Dieu Road also revealed a number of silcrete and mudstone cores. The possibility that these artefacts derived from erosion of riverbank sites is unlikely due to the virtual absence of comparable assemblages on the banks of the Hunter River (McCarty and Davidson 1943:228; Moore 1970:30; Rich 1992:16-27).

Flake blanks struck on-source tend to be considerably larger than the core reduction debris produced in off-source core reduction. Hunter River on-source core dimensions and scar sizes suggest that silcrete flake blanks measured up to 300 mm long. Mudstone blanks tended to be somewhat smaller, in keeping with the generally smaller cobbles of that material (Hughes and Lance in Hiscock 1986:14-16; Koettig 1994a:29; Hiscock 1993:66; Baker 1992a:36-37, 1992b:40). The on-source reduction pattern is documented at off-source sites by conjoin sets which reconstruct exceptionally large flake blanks (e.g. Koettig 1992b, 1994b; Hiscock 1986), and large-scale
ventral and platform attributes on off-source contact removal flakes and cores made on flake blanks (e.g. Baker 1992a:16-17, 18, 1992b:37; Koettig 1992a:37, 1992b:6, 37, 43, 1994b:21, 90, 1994c:Fig. 2.86) (Fig. 2a-d).

**‘Early Reduction’ cores and tools**

Blanks exported from stone source areas included (1) large flakes derived from on-source reduction and (2) unmodified or assayed cobbles (Koettig 1992a:56, 1992b:39). These items are referred to as ‘primary’ blanks in recognition of their place in the reduction process (Bradley 1975; Koettig 1994c:Fig. 1.10-1). Some of them were reduced as early reduction cores.

Cobble-based early reduction cores were reduced in an ‘opportunistic’ manner; that is, suitable platforms were struck as they fortuitously developed during the knapping process (e.g. Baker 1992b:36-37; Koettig 1992a:36). It would appear from the nature of platform selection and the orientation of the blows on these cores that the Hunter Valley knappers attempted to create as large a flake as possible rather than a flake of a standard shape. The morphology of discarded freehand off-source cores varies widely as a result of the combined idiosyncratic factors inherent in each knapping event, such as stone quality and cobbles shape. Small quartz pebbles were procured and reduced by bipolar percussion (Koettig 1994b:30; Baker 1992a:17, 1992b:40-41; Gorman and Rich 1992:150), although Baker (1992a:17) characterises the technique as a ‘little used strategy in the Hunter Valley’.

Large flake blanks produced on-source were also reduced as early reduction primary cores (Baker 1992a:15, 16-17, 1992b:23, 37; Koettig 1992a:37, 1992b:14; Gorman 1992:116). In most cases, reduction involved applying a percussion blow to the ventral surface of the blank, well-back from the blank’s edge (Fig. 3). The resulting early reduction flake propagated through the blank at a steep angle, usually removing part of the blank’s dorsal surface (Fig. 2e). Flakes might also be removed from the ventral surface or both surfaces of the blank (e.g. Koettig 1992b:4-5) (Fig. 2e). Multiple series of flakes were removed prior to discard. These ‘flake blank cores’ differ from scrapers by (1) a steeper percussion angle on the reduction face, (2) proportionately larger scars, and (3) an absence of small trimming scars associated with preparing a working edge. Flake blank cores were used as tools and as sources of flake blanks (Gorman 1992:116; e.g. Koettig 1992b:16-18, 1994c:Fig. 2.11; see also McCarthy et al. 1946:20-21).

The flake blanks struck from off-source early reduction cores mostly measure smaller than about 50 mm long, 35 mm wide, and 10 mm thick. Early reduction flakes from off-source cores were destined for one of three purposes: (1) for use as a cutting tool without further modification; (2) for use as a scraper, elouera, or microlith by retouching along the flake margins; or (3) for further reduction as a core to provide early reduction flake blanks or blades.

![Figure 2: Artefacts from Bettys Creek. (a) Contact removal flake, unheated silcrete. (b) Contact removal flake, mudstone. The single-barbed arrow indicates the contact removal flake’s platform and direction of applied force, and the double-barbed arrow indicates the flake blank’s platform and direction of applied force. (c) Early reduction core made on a flake blank, mudstone. (d) Blade core made on a flake blank, mudstone. The single barbed arrow indicates the flake blank’s platform and direction of applied force. (e) Early reduction flake struck from a large flake blank core, mudstone. The platform surface is a detachment scar derived from the ventral surface of the flake blank. (f) Blade core made on a small flake blank, heat-treated silcrete. (g) Blade struck from Y'.](image-url)
The flake blanks created in the primary-secondary-tertiary process diminish in size, providing a basis for their identification. Primary cores made on flake blanks produced in on-source reduction will be larger than flake blanks produced in off-source reduction, as reflected by the sizes of core scars and early reduction flakes at off-source sites. In contrast, secondary and tertiary cores will be similar in size to off-source core scars and early reduction flakes (Fig. 2f). Distinguishing between secondary and tertiary cores is most reliably conducted through conjoining. It appears that most secondary and tertiary cores were blade cores rather than early reduction cores. Many, perhaps most, secondary and tertiary blanks were retouched into scraping tools or used as cutting tools and discarded. Due to their small size, few flakes tended to be removed from tertiary cores prior to discard (Koettig 1994b:11). While primary blanks might be either cobbles or large flakes, secondary and tertiary blanks are flakes. The ‘nesting’ of core blanks is characteristic of Australian Small Tool Phase technology in the Hunter Valley.

By altering reduction techniques, off-source early reduction cores could be ‘redirected’ as blade cores at any point in the reduction process. Also, larger blade cores might also have been redirected as early reduction cores. Clear evidence for these options has not been identified, although early reduction flakes produced in the reduction or blade cores are known to have been further reduced as secondary/tertiary cores (e.g. Koettig 1994b:28-66).

Heat-treatment and heat-fracture in Hunter Valley assemblages

The products of heat-treatment are different from heat-fracture (Rondeau 1995). Heat-treatment is designed to produce changes in siliceous stones to make them more amenable to stone tool manufacture (Crabtree and Butler 1964; Mandeville 1973; Flenniken and White 1983). Successful heat-treatment alters a stone’s matrix, resulting in a colour change and/or an increase in lustre. Heat-fracture causes cracks and sometimes detrimental changes in texture and often creates angular fragments and potlids (Patterson 1995).


Despite evidence for successful heat-treatment, mudstone and silcrete heat-fracture fragments are common elements of Hunter Valley knapping floors (Baker 1992b:28; Hiscock 1993:67; Koettig 1992a:29-32). Two heat-fracture processes were identified by Baker (1992a, 1992b; 1994a), sometimes occurring together in the same assemblage. In one of these, silcrete blanks were shattered by heating which failed to alter the internal nature of the stone. The outer surface of the material was sometimes altered to a red or pink colour, but the inside remained unchanged. Material from this trajectory was rarely selected for further reduction. In the second process, silcrete was shattered into angular fragments while also inducing desirable textural change into the material; heat-treatment and heat-fracture occurred together. These silcrete and mudstone fragments were reduced as cores in various localities in the Hunter Valley (Baker 1992a, 1992b, 1994a; Koettig 1992a, 1994a; see also Dickson 1973:8), including
Bettys Creek (Fig. 4). Flake scars truncated by heat-fracture planes are sometimes present on these artefacts, indicating that the stone had been initially reduced prior to heat-fracture (Koettig 1992a:29, 1994b:25). Silcrete and mudstone cores made on angular heat-fracture fragments are the most common type of core in certain Hunter Valley assemblages (Baker 1992b:21). Use-wear analysis indicates that some heat-fracture fragments were used as tools (Gorman 1992:116, 145-146).

Hunter Valley microlith knappers applied heat-treatment to relatively large early reduction flakes, perhaps up to 300 mm long (Hiscock 1986; Baker 1992b:40; e.g. Koettig 1994b:20, 39). Most of these flake blanks probably derived from source reduction. Evidence also exists for heat-treating small elongated silcrete flakes prior to backing (Koettig 1992a:32).

Experiments at heat-treating silcrete
Silcrete requires very high temperatures for successful heat-treatment. The median fracture toughness of Australian silcrete decreases most dramatically between 300°C and 400°C (Domanski and Webb 1992:Table 1). This contrasts with various types of chert, which reach their optimal heat-treatment characteristics by 250°C; indeed, many are destroyed at 350°C and above (Luedtke 1992:101, Table 7.1; Whittaker 1994:74; Patten 1999:19). Domanski and Webb (1992:612) conclude that macrocrystalline materials such as silcrete were easier to heat-treat using traditional methods because these materials are less sensitive to extreme temperatures.

Variables taken for granted in kiln experiments are often difficult to control using traditional methods. Generally, the more heat required to properly heat-treat a material, the more difficult it is to control the outcome using traditional techniques, particularly if the time available for heat-treatment is limited. The key problem in heat-treating silcrete is to raise the stone to an extremely high temperature without causing its destruction by rapid temperature change or overheating. Hobbyist knappers have discovered that ideal heat-treatment results are obtained by raising the temperature of stone no more than 40°C per hour up to the boiling point of water (Native Way n.d.)

Heat can be controlled in a traditional setting using two methods: (1) altering the size of the fire, and (2) altering the distance between the stone and the heat. Numerous combinations are possible. For instance, a large fire might be employed with a thick sand or soil buffer layer between the stone and the coals, or a small fire might be employed with a thin buffer layer. Some types of wood burn hotter and faster than others, and careful selection of the fuel type might influence the results. The nature of the buffer soil also makes a difference, particularly if the buffer layer is relatively thick. For instance, using dry soil requires less heat than wet soil because heat is not lost in drying the buffer prior to raising the temperature of the stone. Preheating the pit might shorten the required heat-treatment time (e.g. Akerman 1979). Altering pit morphology may affect the results: a fire in a deep pit generates less intensive heat compared to a fire at ground surface due to differences in oxygen circulation. The use of stone cobbles to retain heat may also influence the outcome (see Koettig 1992b:27).

The results of informal heat-treatment experiments carried out in conjunction with the Bettys Creek study provide insights into why heat-fractured silcrete is so common on Hunter Valley Aboriginal sites. The aim of the experiments was to provide successfully heat-treated stone for knapping experiments and demonstrations. Large Hunter River silcrete and mudstone blanks were chosen for heat-treatment; these measured between about 120 mm to 200 mm long, 90 mm to 120 mm wide, and 40 mm to 70 mm thick. The blanks were placed in a pit near the Bettys Creek site each morning and a fire was tended over the top of the buried stone until the afternoon. The heated stone was allowed to cool overnight and was uncovered and assayed the next morning.

In the first heat-treatment run, a medium-sized fire fuelled by seasoned eucalypt branches was built in a shallow heat-treatment pit on top of a damp, well-packed sand/clay buffer layer measuring 50 mm thick between the coals and the upper surface of the stone. The top of the buffer layer was about 100 mm below the ground surface. A relatively thick, uniform bed of coals was established within two hours and was maintained for another 6 hours by stoking every 45 minutes to 1 hour. The layer of hot coals, measuring an estimated 80 to 100 mm thick, was buried for the evening cool-down. The stone was exhumed the following morning after 18 hours of cooling. Although still very hot, the stone failed to change in colour or show any signs of heat-treatment. This suggests that the material failed to reach 350°C, the transitional temperature for silcrete colour change (Corkill 1997). The buffer layer formed a fire-hardened shell between the coals and the stone.

In the second run, a new set of blanks was buried in the same pit with a damp sand/clay buffer, 20 mm thick, and a larger fire. Charcoal from the first run was used as the foundation for the new fire. The bed of coals was established within about 40 minutes and was maintained for another 6.5 hours in the same manner as the previous experiment. Again, 18 hours was allowed for cool-down. This method was felt to be sufficient to destroy most fine-grained cherts. Although the surface of the silcrete blanks located near the centre of the pit changed dramatically from yellow to red, indicating that the surface temperature of the stone exceeded about 350°C, the colour change failed to penetrate the material. The internal quality of the stone appeared to be unaltered. As before, the buffer layer had formed a fire-hardened shell between the coals and the stone.

It was clear by this point that the necessary temperature was not being achieved. Hence, in the third run, the buffer layer was changed to 25 mm of slightly moist silty sand, the surface of the buffer zone was made flush with the ground surface to increase air circulation through the fire, and a large fire was built. A new set of blanks was buried, and the heat-up and cool-down times were maintained as before. The coals were not covered at the end of the day. The stone located near the edge of the pit was, for the most part, successfully heat-treated. The silcrete changed in colour clear-through from yellow to red, and the successfully heated blanks were either intact or cracked in only one or two places. Several blanks in the centre of the pit were partially exposed to the coals because the thin buffer soil was disturbed during stoking. The buffer appeared to have thinned as soil moisture evaporated. These silcrete blanks were crazed and broken into numerous angular fragments and potlids. The amount of crazing and fracturing increased from the perimeter towards the centre of the pit. Many of the larger fragments proved to be internally intact and blades were successfully detached from them. It was estimated that about 50% of the heat-fracture fragments were sufficiently large to produce blades at least 30 mm long.

One blank each of silcrete and mudstone were tossed directly into the fire during the third run. The fragments were recovered from the ashes and surrounding area the next day.
This material rapidly and explosively fractured into angular fragments which were, on average, smaller than those produced in the pit: fewer than 15% were sufficiently large to produce blades over 30 mm long. Unlike the heat-fracture fragments from within the pit, a large proportion of these fragments failed to change in colour or matrix characteristics—many fragments were thrown clear of the fire when the material exploded—although several fragments showed suitable knapping characteristics. Many fragments appeared to be overheated, resulting in unnappable stone with severe internal crenation damage and a sugary texture. The range of variation seen in stone texture was apparently influenced by where the shatter fragments came to rest in relation to the coals. The results

<table>
<thead>
<tr>
<th>Blank No.</th>
<th>Technological History</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>A chert tabular cobble measuring 70 x 45 x 20 mm was imported to the site, apparently in a minimally modified form, and substantially reduced. The core was not recovered at the site. Flakes from this cobble were backed and discarded.</td>
</tr>
<tr>
<td>2a.</td>
<td>A large partially reduced and possibly heat-treated mudstone primary cobble core was imported and reduced, producing a flake blank for secondary core reduction (2b).</td>
</tr>
<tr>
<td>2b.</td>
<td>The secondary core measured approximately 80 mm long and 20 mm thick. The blank may have been used as a tool prior to reduction. The core’s dorsal surface was reduced by delivering percussion blows to the ventral surface (Figure 3). At least one flake was backed and discarded. The core was not recovered.</td>
</tr>
<tr>
<td>3.</td>
<td>A partially reduced mudstone primary cobble core measuring over 60 x 60 mm was imported to the site, partially reduced, carried some distance away from the reduction area, and discarded. One flake from this reduction was utilised and discarded.</td>
</tr>
<tr>
<td>4a.</td>
<td>A mudstone flake blank measuring at least 32 x 44 x 14 mm was produced off-site, imported, and partially reduced. The core was not recovered. One flake from the core was backed, utilised, and discarded.</td>
</tr>
<tr>
<td>4b.</td>
<td>A mudstone flake blank measuring at least 40 x 60 x 10 mm—evidently produced off-site from the same core as 4a—was imported and destroyed in an attempt at heat-treating. The blank fractured into angular fragments.</td>
</tr>
<tr>
<td>5a.</td>
<td>A mudstone primary core measuring over 60 mm long—perhaps a partially reduced tabular cobble—was imported and reduced at the site. One flake from this primary core was reduced as a secondary core (5b). A total of 21 flakes of similar material to this reduction were backed and discarded. Two show signs of use.</td>
</tr>
<tr>
<td>5b.</td>
<td>A secondary core blank from 5a measuring 55 x 25 mm was reduced by striking four flakes down a lateral edge, apparently from the distal end.</td>
</tr>
<tr>
<td>6.</td>
<td>A partially reduced mudstone core measuring over 40 x 25 mm was imported to the site, reduced further, and discarded. Flakes of similar material to this reduction were backed and discarded.</td>
</tr>
<tr>
<td>7.</td>
<td>A mudstone flake blank was imported to the site, modified by the removal of one flake, and discarded.</td>
</tr>
<tr>
<td>8a.</td>
<td>A heat-treated and partially reduced silcrete primary core measuring over 65 x 50 mm was imported to the site. A flake blank was struck from it and reduced as a secondary core (8b). Two flakes were selected for backing but broke during the backing process. Six successfully backed blades were produced and discarded. Two flakes were utilised and discarded.</td>
</tr>
<tr>
<td>8b.</td>
<td>The secondary core flake blank measured over 40 x 25 x 20 mm and was reduced by striking 6 flakes down a lateral edge. The core was then discarded.</td>
</tr>
<tr>
<td>9a.</td>
<td>A heat-treated silcrete primary core of unidentified form was reduced off-site, imported, and further reduced, producing two flake blanks for secondary core reduction (9a and 9b). A total of 33 flakes of similar material to this reduction were backed and discarded. Four flakes were utilised and discarded.</td>
</tr>
<tr>
<td>9b.</td>
<td>This secondary core blank measured less than 50 mm long and 15 mm thick. Reduction involved striking fewer than four flakes down the lateral edge of the flake blank using the proximal end of the flake blank as the platform. The core was not recovered.</td>
</tr>
<tr>
<td>9c.</td>
<td>This secondary core blank measured less than 50 mm long and 25 mm thick. Reduction involved striking fewer than three flakes down the lateral edge of the flake blank using the proximal end of the flake as the platform for two flake removals, and the distal end for one flake removal. The core was not recovered.</td>
</tr>
<tr>
<td>10.</td>
<td>A small silcrete core of unknown form was imported, partially reduced, and exported. Two flakes were backed and discarded, and a third flake was utilised and discarded.</td>
</tr>
<tr>
<td>11.</td>
<td>A partially reduced heat-treated silcrete core of roughly cuboidal form measuring over 46 x 55 mm was imported and substantially reduced. A core of this material measuring about 15 x 20 mm was also discarded, and may represent the exhausted product of core reduction. One flake was selected for backing and discarded.</td>
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<tr>
<td>12.</td>
<td>A primary heat-treated silcrete core of unknown form was imported and reduced. The core measured at least 52 mm in largest dimension upon import, and less than 20 mm at the end of reduction. A large number of flakes may have been exported. The core was not recovered.</td>
</tr>
<tr>
<td>13.</td>
<td>A large unheated silcrete primary core of unidentified form was imported to the site and minimally reduced, resulting in several large flakes which were discarded.</td>
</tr>
<tr>
<td>14.</td>
<td>A large silcrete flake blank core was imported and heat-treated, resulting in heat-fracture. At least one fragment was assayed.</td>
</tr>
<tr>
<td>15.</td>
<td>A silcrete flake blank core measuring over 40 x 50 x 25 mm was imported, reduced, and discarded. Reduction was apparently limited to the dorsal surface, which was covered by cortex.</td>
</tr>
</tbody>
</table>

Table 1: Lithic technology at Bulga Lease Site B8, Area II. Extrapolated by the author from conjoin sets described and illustrated by Koettig (1994b:28-66).
suggest that blocky fragments made into blades by Aboriginal knappers were created by overheating buried material rather than tossing stone directly into the fire.

The third heat-treatment run replicated a pattern seen on Hunter Valley Aboriginal sites. The principal constraint of the experiments which resulted in this pattern was the relatively short amount of time available (ca. 6.5 to 7 hour) to ensure that a sufficiently high temperature was reached. Under this constraint, the most practical way to achieve the necessary temperature was to adjust the nature of the soil buffer layer by decreasing its thickness and changing the soil type. This in turn resulted in heat-fracturing as the buffer lost its moisture and was disrupted during stoking. It is suspected that heat-fracturing was caused by too rapid a temperature change rather than a too-high temperature; the latter results in undesirable textural changes.

Heat-treating mudstone

The Bettys Creek heat-treatment experiments indicate that mudstone fractures in a similar fashion to silcrete when heated to extreme temperatures. However, the quality improvement for mudstone seems to be more variable than for silcrete. Well-silicified mudstone appears to change in a similar fashion to certain coarse-grained cherts, improving marginally in texture while markedly shifting in colour (from yellow to various shades of orange or yellow-orange, to dark red in some cases). In contrast, all of the silcrete samples changed in both texture and colour when the appropriate temperature was reached.

Heat-fracture debris on Hunter Valley Aboriginal sites is dominated by silcrete, and heat-fractured mudstone is rare but present (Baker 1992a, 1992b). The heat-treatment experiments described here resulted in similar shattering patterns for both materials when destructive temperatures were reached. Hence, the lower proportion of heat-fractured mudstone compared to heat-fractured silcrete in the archaeological record suggests that the two materials were segregated for heat-treatment. The rarity of heat-fractured mudstone may indicate that lower—and more controllable—temperatures were adequate to heat-treat mudstone, or that mudstone was not heat-treated as often as silcrete.

Blade cores

The blanks reduced into blade cores in the Hunter Valley derived from a number of sources, including: (1) primary flake blanks created through the reduction of on-source cores; (2) primary cobble blanks carried from the source in unmodified or minimally modified form; (3) secondary flake blanks struck from primary blanks; (4) tertiary flake blanks struck from secondary blanks; (5) angular fragments created in heat-treatment; and (6) recycled early reduction cores probably made on primary or secondary blanks.

Hunter Valley blade cores were reduced using a variety of strategies (Koettig 1992a:33-39, 1994a:68, 1994c:Fig. 1.10-3; Baker 1992b:356; Hiscock 1986:71). The most common of these strategies involved striking flakes down two core faces from one platform edge. Blades were usually removed in series from the first face, then in series from the second face (Fig. 5a). The core was often rotated to a second platform edge and the process repeated (Fig. 5b). An ‘alternating’ blade removal pattern was sometimes applied where sequential removals were alternated from one face to the opposite face (after Crabtree 1972:33). Another common strategy involved rotation of the core and removing blades from several faces using multiple platform edges (Fig. 5c). Conjoining indicates that more than one strategy might be used to reduce a single core (Koettig 1994a:29, 69). Variations in the morphology of discarded blade cores appear to be the result of similar blade-making techniques applied to different blank forms. The requirements of the blade-making process tended to result in recurring patterns for certain blade core blank types, particularly secondary and tertiary flake blanks. Blanks with relatively large amounts of mass, such as primary cobbles and flakes, allowed more knapping options as reduction proceeded.

The reduction of flake blanks as blade cores has been described in detail (Flenniken and White 1985:136; Hiscock 1986, 1993). Flake blanks most often chosen for reduction weighed between 20 and 50 grams and were about 10 mm thick (Hiscock 1993:66). The edge of the flake blank was first unilaterally retouched, providing a straight edge (Hiscock 1986:70, 1993). Any edge of the
flake blank might be chosen for reduction (Hiscock 1993:70; Koettig 1992a:34, 1994c:fig. 10-3). A platform was prepared at one end of this straight edge and the first blade was struck down it by direct percussion. Additional blades were removed from the flake blank by targeting the arrises created by the first removal. Edge straightening and blade removal were sometimes alternated throughout the reduction event (Hiscock 1993). In many cases, scars from previous blade removals were used as platforms for removing blades from other portions of the flake blank (Koettig 1992a:34, 1994c:fig. 1.10-3) (fig. 5a). A new platform might also be established and the blade face reduced from the opposite end of the core (Koettig 1994c:fig. 1.10-3). The reduction of a flake into blades is called the ‘tranchet’ technique (Witter 1988:39) or ‘Redbank A Strategy’ (Hiscock 1993).

Hiscock (1986:39-40; 1993:69) has suggested that reduction of a blade core proceeded from start-to-finish prior to selection of flakes for backing. This is supported by many of Koettig’s conjoins (1994b) which indicate that core reduction was conducted in segregated ‘events’ each of which involved a series of blade removals rather than production of a single blade. Clark (1987:268) has discussed some factors in blade-making which help explain this pattern:

- Blade making requires planning, proper tools and facilities, and sustained concentration. Each blade is produced by the same process as the one preceding it, a monotonous process. As with other skilled knapping it also requires rhythm. One can make more and better blades if he makes a batch at a time. Removing one blade at a time, as needed, would have been a ridiculous waste of time and effort—if not impossible. Blade removal takes only a fraction of a second; but getting set up and reawakening the needed ‘touch’ for making blades, requires the most time.

- Certain flakes and blades were selected and carried away with the rest of the toolkit. For example, a site assemblage recovered from the Camberwell Lease includes 37 relatively large mudstone flakes and blades from three cores. None of the items could be conjoined, suggesting that many items are missing. The artefacts are concluded to be blanks selected for backing that were carried to the area from off-site core reduction events (Koettig 1992a:35). The transporting of these blanks is a further indication that multiple blades were produced in each blade core reduction event and that those blades which were not backed immediately were transported and backed elsewhere.

- Blade cores were sometimes used as tools during or at the end of reduction (Gorman 1992:116).

**Microliths**

**Microlith manufacture**

The first step in backing involved selecting suitable flake blanks from the reduction debitage. The nature of microliths in many Hunter Valley assemblages suggests that blank selection was opportunistic (Flenniken and White 1985:145). The ‘best’ blanks were selected from the flakes at hand, and the morphology of the selected examples was probably contingent on the results of the particular reduction event (Dickson 1973:7). Hiscock (1986:39-41) suggests that preferred flakes were elongated and possessed a straight edge, but cross-section was more important than length. Prominent dorsal arrises were a key variable (Hiscock 1993:70). Baker (1992b:59) discovered that microlith edge-angles ranged between 40 to 50 degrees for asymmetrical microliths and 30 to 40 degrees for symmetrical microliths. The number of dorsal arrises was not an important factor (Flenniken and White 1985:144-145). Flakes selected for backing derived from all steps of blade manufacture (Koettig 1992a:55, 1994a:69, 1994b). Many of these flakes were snapped prior to backing (Koettig 1992a:48; 1992b:76). Patton (1999:57) notes that “[k]eeping blades intact [during detachment] can be a major problem”, and it is possible that the snapped blades identifies by Koettig were broken during detachment.

- Backing was conducted using a bipolar technique (Flenniken and White 1985:143-144). Flake propagation in bipolar flaking is limited to a plane between the percussor and the anvil (Flenniken 1981:29-32). In blade backing, the bipolar technique prevents flakes from propagating onto the face of the blade and results in a vertically backed edge. As the edge approaches 90°, flakes often initiate from both the anvil and percussor. This results in a ‘double-backed’ edge (Flenniken and White 1985:143). Platform edges are often crushed by the percussor and/or anvil. Hiscock (1986:66, 67-68) suggests that backing proceeded from a unifacial ‘roughout’ stage to a later stage involving finer work which created the double-backed edge. Backing failures occur regularly (McBryde 1986:205-206), including bending fractures, overstrikes, and perversive fractures. The resulting products are analogous to fractures created in biface reduction (Crabtree 1972; Purdy 1975). Dickson (1973:12-14) notes that a form of pressure flaking using anvil support, called ‘chimbling’, can produce similar results with fewer backing failures than direct percussion.

**Microliths as composite spear elements**

Microliths are widely interpreted as spear barbs. Analogies are drawn between the microliths and the quartz barbs on ‘death spears’ in Australian ethnoarchaeological collections (McCarthy et al. 1946; Mulvaney 1985:216; Mulvaney and Kamminga 1999:292-293), European Mesolithic weaponry (Baker 1992a:3-4, 48-49, 1992b:75), and African composite arrowpoints (McBryde 1985:239-240).

Experimental studies of microlith breakage patterns when used as spear points have been conducted by Dickson (1973:8-9) and McBryde (1985:244-245, 1986). Dickson’s experiments involved hafting replicated symmetrical microliths on the ends of spears measuring 2.5 to 2.7 m long and throwing them with a spearthrower to a target 20 m away. McBryde’s experiments involved hand-throwing spears armed with multiple microliths mounted on the side of the spear tip. Dickson found that his replicated points tended to break where they emerged from the hafting resin. Tip damage observed by Dickson on Aboriginal points was not replicated by his experiments. McBryde, in contrast, found that the microliths barely broke across the middle, but instead tended to suffer damage on the chord and tip. Chord damage consisted of the removal of several small flakes or a large flake which notched the edge. Tip damage consisted of blunting and snapping. The damage proportions in McBryde’s experiments failed to reflect the damage proportions in the Aboriginal assemblage; however, the Aboriginal assemblages contain a mixture of microlith manufacturing failures and use-damaged artefacts, perhaps accounting for the discrepancy (McBryde 1986:206).

Microliths from the Lemington Lease in the Hunter Valley, a sample of 113 specimens, were examined by the author to identify impact damage. The study assumed that microliths...
protruded from the tip of the spear point, rather than the side, and the assemblage was inspected for macroscopic damage types typically encountered on tip-mounted bifacial dart points (Akerman 1980; Flenniken 1985; Flenniken and Raymond 1986; Frison and Stanford 1982). The most easily identified impact damage types on tip-mounted dart points are large-scale burination and face shearing. Six burinations were noted in the Lemington Lease assemblage, including four bend-initiated burinations that propagated down the chords and two that propagated down backed edges. However, all six of these burin scars are extremely small and narrow and are inconsistent in scale with impact scars seen on tip-mounted projectile points. The scars are similar in appearance to the minute 'spalling' scale with impact scars seen on tip-mounted projectile points. Most of the Lemington Lease burin scars are somewhat longer than most of the Lemington Lease burin scars are somewhat longer than McBryde's illustrated example. Unlike the larger burin scars on tip-mounted points (e.g. Akerman 1980:Fig. 4), these small burin scars can be produced in other activities involving a pointed tool's tip, such as engraving or perforating (e.g. Kamminga 1982:Plate 47). Two blades were observed in the Lemington Lease assemblage with minor face-shearing damage possibly consistent with tip-mounted impact.

The results of the Lemington Lease study indicate that microliths did not protrude from the tips of spears. However, McBryde's (1986) experiments suggest that common types of tip-mounted impact damage such as large burination scars and face shearing rarely occur on side-mounted microliths. While published experimental and archaeological studies of impact fracture characteristics have not conclusively demonstrated that microliths were hunting weapons, the possibility has not been eliminated.

**Microliths as composite processing tools**

Ethnographic analogy has also been cited to suggest that microliths were used as elements in cutting tools. Composite *taap* knives composed of small quartz flakes set with resin on wooden handles are known from southwestern Australia (McCarthy et al. 1946) and backed microliths may represent a form of this type of tool (Hayden 1973:125; Mulvane 1985:216; see also Stockton 1970:228). An 'engraver' consisting of a hafted microlith was collected from Birdsville in western Queensland (Tindale 1945); however, this specimen has been interpreted as an ancient tool recycled for use in more recent times (McBryde 1985:239; see also Mulvane 1969:126).

Hunter Valley use-wear studies have shown that many microliths were used as processing tools. Microlith use-wear has been identified which resulted from a variety of light-duty tasks involving woodworking, plant processing, and hide working, prompting Fullagar (1992:10) and Fullagar et al. (1994:39) to propose that microliths were utilised as multipurpose knives. Although McBryde (1985:246-247) has suggested that some microliths may have functioned as spear barbs, she views them as versatile, multifunctional tools (see also Dickson 1973:7; Kamminga 1980). Similar observations have been made in Europe, where use-wear studies of microliths have suggested that European microliths were not exclusively, and perhaps not even commonly, elements of hunting weaponry (Finlayson and Mithen 1997).

**A single-event view of microlith technology in the Hunter Valley**

The assemblage from site B8-II on the Bulga Lease offers a glimpse into reduction behaviour represented at an early microlith assemblage in the Hunter Valley, dated to 3120 ± 70 BP (Beta 62207) (Koettig 1994b:28-66). Certain artefact clusters at the site are in direct association with the dated hearth, and the surrounding clusters are linked back to the hearth clusters by artefact conjoining. The spatial integrity of the site is excellent, suggesting that little post-depositional disturbance has occurred. The occupation may have been short-term and single-event, although this could not be demonstrated conclusively (Koettig 1994a:62-64). A large lithic assemblage was recovered from the site. Knapping strategies were reconstructed through conjoin analysis, resulting in high-quality technological information (Koettig 1994b:28-66) (Table 1).

Based on the evidence at B8-II, the Australian Small Tool Phase toolkit included the following items in various proportions: (1) primary cobble blanks, (2) large primary flake blanks struck during on-source reduction of large cores, (2) secondary flake blanks for use and/or reduction as blade cores, (3) blade cores, (4) flake blanks for backing, (5) unused microliths, (6) flake tools, and (7) composite tools made from microliths. The precise composition of the toolkit was probably influenced by a number of variables such as the availability of suitable stone cobbles in the foraging radius, the timing of the last visit to the Hunter River gravel bars, and stone usage rates. These elements reflect nearly all the primary components of the technological strategy summarized in previous sections and shown in Fig. 1. If the hearth at B8-II in fact dates the associated reduction events, this indicates that most elements of the Hunter Valley Australian Small Tool Phase technological strategy shown in Fig. 1 were in place by about 3120 BP.

**Discussion and conclusions**

A useful method for examining a technology is to contrast it with the preceding approach. Characterising the lithic technology which existed before the advent of the Australian Small Tool Phase in the Hunter Valley is problematic due to a lack of local assemblages dating to this early period (Hiscock 1986:19). However, studies by Koettig (1990) and Baker (1994b) suggest that the technology practiced by early Hunter Valley knappers was part of the 'core tool and scraper tradition' described for much of Pleistocene Australia. This technology focused on early reduction cores—some of them quite large—to provide flake blanks for use as tools. Cutting tools were often made on robust flake blanks struck from cores carried off-source or were made on flake blanks struck from cores abandoned on-source. The sizes and shapes of the resulting tools were probably influenced by the nature of the raw material from which they were manufactured. Tool edges were refurbished by unifacial retouching (Holdaway 1995). In early Hunter Valley assemblages, volcanic materials were preferred over silcrete and mudstone (Koettig 1990, 1992:5; Baker 1994b). Heat-treatment is rarely reported for these early assemblages and may not have been a part of the knapping repertoire (however, see Flenniken and White 1983:46). It would appear that stone tools in this early period formed a processing technology rather than extractive technology (after Binford and Binford 1966).

Although the situation has not been resolved, present evidence suggests that microliths in the Hunter Valley were primarily a processing technology. If so, the appearance of the Australian Small Tool Phase appears to have been an adjustment of an existing processing technology rather than its replacement with an extractive technology. Relatively large cutting tools manufactured during earlier periods were
replaced by small microlith elements which were hafted in series, thereby building composite cutting tools which were functionally analogous to earlier cutting tools. The tranchet technique of making blades from large flake blanks can be compared to earlier unifacial reworking of large flake-based tools, with the focus of tool production shifting from the blank being reduced (a large flake) to the resulting flakes (microlith blanks).

If microliths were principally knife elements rather than spear barbs, their appearance in the Hunter Valley can be characterised as an adjustment in the nature of the stone technology rather than a shift in stone’s function. Why might this adjustment have occurred? Kuhn (1995:33) has described two strategies for refreshing a worn tool edge: (1) a knapper may resharpen the worn tool, or (2) a knapper may create an entirely new tool. As discussed by Kuhn, the optimal utility of a tool is when it is first created, and this utility declines with each resharpening episode. But resharpening a tool extends its use-life, which in turn results in less demand for stone and lowers stone transport costs. This approach appears similar to the strategy in place prior to the emergence of the Australian Small Tool Phase.

On the other hand, according to Kuhn’s model, creating a new tool each time one becomes worn means the tool kit is maintained at its optimal functional utility, but greater costs are incurred in transporting larger amounts of stone. The latter strategy appears to apply to the Australian Small Tool Phase in the Hunter Valley, but with an important difference. The Hunter Valley strategy neatly side-stepped the trade-offs in Kuhn’s model by drastically changing tool form to meet a need in the face of unpredictable environmental change and territorial expansion.

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