Records of the Australian Museum, Supplement 27 (2001): 53–66. ISBN 0 7347 2305 9

Stone Artefacts from the Emily Bay Settlement Site, Norfolk Island

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ABSTRACT. The lithic material from the Emily Bay site consists principally of basalt flakes, blades, preforms and adzes. There are also a small number of obsidian artefacts. The basalt assemblage has been analysed primarily to describe the technology of adze manufacture, which occurred along with reworking of broken preforms and finished adzes. The pattern of adze production is very similar to that found in New Zealand sites. No complete finished adzes were recovered, but the flake material indicates that Duff (1977) Types 1, 2, 3 and 4 were being made. Sourcing studies show that the basalt is local. Sourcing of obsidian shows that nearly all came from Raoul Island (Kermadecs) while one piece may be from New Zealand. Use wear and residues, notably starch grains, were found on many of the sample of 10 basalt and five obsidian artefacts analysed and the range of activities represented is congruent with a permanent or semi-permanent village rather than a temporary camp.

TURNER, MARIANNE, ATHOLL ANDERSON AND RICHARD FULLAGAR, 2001. Stone artefacts from the Emily Bay settlement site, Norfolk Island. In *The Prehistoric Archaeology of Norfolk Island, Southwest Pacific*, ed. Atholl Anderson and Peter White, pp. 53–66. *Records of the Australian Museum, Supplement* 27. Sydney: Australian Museum.

The major component of the stone artefact assemblage consists of basalt adzes and the flakes produced in making them. Some of these flakes were also used as tools and residues and usewear on a sample of these was analysed, along with some of the exotic obsidian. Our joint authorship of this paper is the result of an amalgamation of Turner's work on basalt artefacts, Anderson's on source characterization of stone and Fullagar's on usewear and residue analysis.

Basalt artefacts

The basalt assemblage from the Emily Bay site comprised primarily flakes, with a small number of adzes and preforms. These have been analysed as if all were produced during the manufacture of adzes, giving an overall impression of the lithic technology and manufacturing sequences. We recognize that some flakes were probably made for other uses, but the overwhelming evidence of the technology is that adze production was primary.

Because nearly all adzes and flakes from Norfolk Island were similar to those found in New Zealand, the flakes recovered from the Emily Bay site were analysed according to a flake typology developed from an extensive programme of adze replication experiments by skilled stone-adze maker Dante Bonica (New Zealand), in conjunction with analysis of several New Zealand basalt archaeological flake assemblages. The adze replication flakes were made from Tahanga basalt, the major adze stone used in the North Island of New Zealand. It is a tough fine-grained basalt very similar to the Norfolk Island material.

The development of this typology is discussed fully by Turner (1992) and Turner and Bonica (1994). It divides flakes into four categories according to size (measured by weight), dorsal surface characteristics (cortex and scarring), shape (including the type of flake termination) and a fourth descriptive category "special flake types", based on other attributes of morphology.

Adze manufacture can be viewed as a reduction process during which smaller flakes will normally be produced as manufacture advances. Cortical flakes will be removed during the initial stages of manufacture whereas flakes with multiple scarring on their dorsal surfaces will be removed later. The manufacturing process can be reconstructed from these basic assumptions. Flake shape and termination can provide information on success in shaping, which is an indirect measure of skill. To describe the Emily Bay assemblage it is necessary to outline the typology in some detail.

Adze flake typology

Category One: size. Size 1 (over 300 g) and Size 2 (201–300 g) flakes are produced in experimental breaking of boulders and roughing-out of blanks over 2,500 g. Only 10% of total boulder weight is produced as debitage; most flakes are produced during adze making. At Tahanga, most blank production occurred at areas where raw material was concentrated, whereas flaking of blanks occurred in areas where there was less clutter. Large flakes result mainly from the reduction of large blanks.

Size 3 (101–200 g) flakes are produced during the initial roughing out of flake blanks over 2,000 g, while Size 4 (51–100 g) flakes are usually produced during the initial rouging out of flake blanks under 2,000 g. They also might result from the later stages of production of larger adzes. The amount of dorsal cortex and scarring (Category 2) indicates whether they were produced in the primary roughing out of small preforms or the secondary working of larger preforms.

Size 5 (21–50 g) and 6 (3–20 g) flakes are most commonly produced in the shaping of preforms of all sizes. They are generally the largest flakes produced from the working of blanks under 1000g. Size 7 (less than 3 g) flakes are numerically dominant and their frequency increases as manufacture advances. Size 7 flakes made up 85% of the experimental flake total. They are the most frequently produced flakes at all stages of manufacture, but especially during fine trimming. During blank production and initial roughing out, Size 7 flakes commonly resulted from shattering and breakage of distal flake ends. Size 7 flakes were uncommon on the surface of the Tahanga working floors, as they became lost between larger flakes (Turner, 1992; Kronqvist, 1991). They are equally rare in surface collections and excavated assemblages because sampling procedures generally have not ensured that these flakes are retained; the Emily Bay case is an exception and it reflects sieving to a small mesh size (4 mm), especially at Trenches EB97:23 and EB97:24.

Category Two: dorsal surface characteristics. Flakes retaining cortex and no scarring (CO) represent primary roughing out of blanks. The roughing-out of large cobble blanks produces the highest frequency of these primary flakes especially in Sizes 1–3. Preparation of small cortical flake blanks also produces CO flakes, typically of Sizes 4 and 5. There was, however, a greater number of Size 6 CO flakes produced overall due to small flakes shearing from the dorsal surfaces of large blanks upon hammer impact.

Flakes retaining cortex and with primary scarring (CP) represent secondary roughing out of preforms. These flakes have one or two flake scars on the dorsal surface. The majority is produced during the roughing out stage. Cobble blanks require more extensive roughing-out and, being more cortical, produce the highest frequency of CP flakes.

Flakes retaining cortex and with secondary scarring (CS) represent later stages of roughing-out and fine trimming. These flakes have more than two flake scars on the dorsal surface. They are the rarest category because little cortex generally remained after roughing-out, while secondary scarring mainly occurs during fine trimming and edge straightening. These flakes are produced more frequently in the later stages of roughing-out and in the fine trimming of large cobble preforms.

Flakes with no cortex and no scarring (OO) are uncommon, but result from two distinct processes. First, during blank production and heavy roughing-out of large cobble blanks a thin sliver, shaped like a potato chip, occasionally sheared off the bulb of percussion on hammer impact. Second, a similar flake is produced during trimming of the ventral surface of flake and split cobble blanks after some side trimming.

Flakes with no cortex and primary scarring (OP) represent adze shaping. This is the commonest class of flake, and it occurs most frequently at the later stages of roughing-out (shaping the preform), particularly during reduction of flake blanks. The initial shaping of boulder cores also produces many of these flakes.

Flakes with no cortex and secondary scarring (OS) represent adze shaping. These are predominantly fine trimming and edge straightening flakes produced at an advanced stage of manufacture where the intention is to refine the adze shape in preparation for hammer-dressing and grinding.

Category Three: shape and termination. Category A flakes have step and hinge terminations. They are flakes that failed to follow through the desired distance across the side of the preform and broke off short. Shaping problems resulting from adjacent step and hinge fractures often produced unsightly protuberances and smashed striking platforms. When this could not be fixed the preform is rejected. Flaws and inclusions of poor quality material often cause this to occur. Another practice which also caused high levels of Category A flakes was the reworking of preforms and adzes. The modification of flakes into other types of tools, or the process of using the flake as a tool again resulted in high numbers of flakes with broken or damaged distal margins.

Category B flakes are generally thin, longer than they are wide and have feather terminations. They usually followed through across the surface being flaked. Therefore, lumps are unlikely to develop. Skill is required to produce these flakes consistently, although stone quality was also important.

Category C flakes are chunky, blocky pieces. They are generally the thick central pieces from broken flakes where distal and lateral margins and other diagnostic features had been snapped off. In experiments they are most commonly produced during blank production and the roughing out of large blanks where the degree of force caused frequent shattering of the flakes. They are also produced when end-shock occurred or when pieces broke off as a consequence of hitting a flaw. Flake modification also produces high percentages of C flakes.

Category D flakes are thin small slivers or splinters without a striking platform or bulb of percussion. Therefore, like Category C specimens, they cannot be classified as true flakes. These slivers and chips resulted from flakes shattering on impact during manufacture and flake modification into other tools. Where C flakes are the central pieces, D flakes are often the snapped off lateral and distal margins. Generally they prevailed in the smaller flake classes (Sizes 6 and 7).

Category E flakes have thick, abrupt ends, sometimes known as "plunging" terminations (Cotterell and Kamminga, 1987). They often have prominent bulbs of percussion and are most frequently produced in experiments when a hard hammerstone is used with considerable force. They occur most commonly in larger flake sizes and during the early stages of production where hard hammers are often needed, particularly with large blanks. These flakes are also produced in the reduction of thin flake blanks where the flake travelled the thickness of the blank. This form of fracture is frequently produced when reworking broken preforms and adzes (discussed in greater detail below).

Category F flakes are wider than they are long, with feather terminations. They are more frequent in the later, fine-trimming stage after the preform has been thinned down considerably, but are also prevalent at all stages with thin flake blanks, and common in small size classes.

Category Four: special flake types. Category Four comprises a number of special types. At Norfolk Island this fourth category consisted of reworked preform flakes, reworked adze flakes and modified flakes.

Preform reworking flakes. Reworking broken preforms into smaller adzes produced distinctive "reworking flakes". These can be identified in archaeological assemblages. Preform pieces, which result from unintended transverse fractures, require different shaping strategies than those applied to primary blanks. The width and depth of the broken preform are usually too great for its length. Therefore, reworking involves substantial narrowing of sides and faces. The flat surface created by the transverse fracture serves as an effective striking platform that is rarely available on primary blanks. Striking from this surface frequently produced long blade-like flakes, which are uncommon in primary adze manufacture. When struck down a corner they often resemble triangular "hogback" (Duff, 1977, Type 4) beaks. For this reason, identification of hogback manufacture can be difficult in assemblages containing a high percentage of reworking flakes. The presence of "hogback" flakes in the Riverton assemblage (Leach and Leach, 1980) indicated the production of Type 4 adzes although no preforms were found. During experiments their production was one of the last steps undertaken before hammer dressing. Therefore, their presence in the site provides information on the stages of manufacture represented at a site. However, as explained above, the high number of reworked adze flakes in the assemblage makes their identification problematical. Consequently all flakes that might be hogback flakes are classified as adze reworking flakes.

Adze Reworking flakes. Adze flakes have hammer dressed and ground surfaces produced from the repair and reshaping of finished adzes. Their presence and frequency indicate the degree to which these activities have taken place at a site. However, not all flakes from reworking adzes will have a ground and/or hammer dressed surface. In adze reworking experiments 50% of flakes resembled those of adze manufacture.

Modified flakes. In New Zealand collections, discarded adze flakes were modified to form a range of flake tools including various points and flake tools which have edge damage indicative of use wear. Experiments are currently being conducted to ascertain the functions of these tools (Turner and Bonica, in prep).

Flake analysis results. A total of 3,178 basalt flakes was recovered from the Emily Bay site. Of these, 2,606 flakes were of the smallest size category, Size 7—these are so small that the identification of diagnostic features is difficult and time-consuming. They were excluded from the analysis below. However, they indicate that there was comprehensive recovery of lithic remains which suggests that all remains have been recovered in other categories and, therefore, this is an excellent assemblage upon which to deduce the stages of adze manufacture and its products.

The 572 flakes of Sizes 3–6 indicate that the following manufacturing stages were present in the Emily Bay assemblage: adze manufacture accounted for 63.2% of the flakes, adze preform working was 18.8%, and adze reworking accounts for the final 17.9%. Table 1 shows the manufacturing stages that were occurring at Emily Bay. The results for Emily Bay are shown together with Bonica's experimental data sets and some of the New Zealand archaeological assemblages. These provide a comparison and aid in identifying the processes represented in the Emily Bay assemblage.

Adze manufacture. There are three major stages in the production of adzes. These are the primary manufacture of adzes, followed by the distinctive preform reworking flakes and adze reworking flakes (Table 1). Distinguishing between the different stages of adze manufacture is achieved by a combination of the three basic categories mentioned earlier: size (based on weight), dorsal surface characteristics and termination type. Characteristics used to identify stages of adze manufacture that took place at each site are given in Tables 2 and 3.

In the Tahanga basalt adze production complex in New Zealand, all blank production and most of the initial blank shaping (or roughing-out) took place at the quarry while most of the fine trimming took place at villages elsewhere (Turner, 1992). The fact that there are very low proportions of the larger size classes (Table 2) or of cortex on the dorsal surfaces (Table 3) in the Norfolk Island assemblage compared to our experimental data suggest that this practice

Table 1. Adjusted breakdown of processes indicated by flake data from Emily Bay and selected New Zealand archaeological sites.

site	number	adze manufacture (%)	RWPF (%)	RWadze (%)	modified (%)
Emily Bay NI	572	63.2	18.8	17.9	19.4
Tahanga Quarry NZ	4706	100.0	0	0	0
Whitianga NZ[a]	24597	62.7	33.0	4.2	25.6
Hot Water Beach NZ[a]	909	67.3	17.0	15.6	2.8
Hahei NZ[a]	5022	63.0	25.8	11.0	4.0
Whitipirorua NZ[a]	3435	58.7	30.4	10.8	10.5
Opoutere NZ[a]	1309	48.2	39.1	12.6	36.2
Bowentown NZ[b]	4186	39.5	41.8	19.7	18.1
Mt Camel NZ[c]	918	8.4	5.6	83.6	4.3
Toke/toke NZ[d]	933	0	0	100	14.6

[a] Coromandel Peninsula [b] Bay of Plenty [c] Northland [d] East Bay of Plenty

was followed on Norfolk Island also. Both flake size and dorsal surface characteristics for Emily Bay are more similar to the fine trimming experimental data and the Coromandel settlement sites data than they are to the roughing out experimental data and the Tahanga quarry data. This indicates, in turn, the existence of a quarry or quarries on Norfolk Island which have yet to be located.

These results are consistent with the basic strategy that underpins an adze technology based on the flaking of fine-grained materials. As outlined in detail by Turner and Bonica (1994), the strategy is based on reworking. Low adze production rates characterize a technology based on the flaking technique largely because of the high risk of breakage, which increases with adze size and the extent of flaking. Therefore time at the quarry has to be used carefully. Roughing out is fast and reduces the weight of the blank by up to 70%, but fine trimming requires greater care and time. By maximising the size of preforms at the quarry, adze makers could remove them before the high-risk fine trimming stage knowing many would break during this stage of manufacture but safe in the knowledge that from one large broken preform, several smaller ones could be made. In experiments, preform reworking had a higher success rate than primary adze manufacture. At all the New Zealand sites where adze production took place, reworking of broken preforms was a feature regardless of stone availability. Reworking was, instead, aimed at managing costs of time and effort. The presence of the distinctive preform reworking flakes and adze reworking flakes at Emily Bay provide additional evidence that this strategy was also in operation on Norfolk Island.

The frequencies of A, C and D flakes in the Emily Bay assemblage show the influence of reworking and flake modification, and are unlikely to indicate any deficiency in stone quality or flaking ability (Table 4). As can be seen in the experimental data for flake modification and reworking, these activities increase the frequency of these flake types probably due to a high incidence of flake breakage.

Table 2. Size categories of flakes (%) produced by experiments and from sites in Emily Bay and New Zealand.

		size categories				
	number	1+2	3	4	5	6
experiments						
roughing out	621	12.6	12.4	13.0	22.2	39.7
flake preform fine trimming	432	0	1.3	2.6	21.7	74.3
cobble preform fine trim	2677	0.1	0.5	1.1	13.4	84.7
edge straightening	50	0	0	0	7.0	93.0
reworking preforms	798	0.7	2.3	5.0	12.0	79.6
reworking adzes	66	0	0	0	0	100.0
sites						
Emily Bay NI	572	0	1.2	2.4	13.3	83.0
Tahanga Quarry NZ	4706	9.3	8.9	16.3	25.4	40.0
Whitianga NZ	24597	0.2	0.2	1.0	17.4	81.1
Hot Water Beach NZ	909	0	0.4	4.7	22.4	72.3
Hahei NZ	5022	0	0	0.6	8.1	91.2
Whitipirorua NZ	3435	0	0.3	1.1	17.1	81.0
Opoutere NZ	1309	0	1.1	3.0	14.0	81.7
Bowentown NZ	4186	0	0.5	1.1	17.4	80.8

Table 3. Dorsal surface characteristics (%) produced by experiments and from sites in Emily Bay and New Zealand. For number, see Table 2.

	CO	CP	CS	all cortex	OO	OP	OS
experiments							
flake roughing out	24.9	33.4	6.3	64.6	0	31.2	3.9
cobble roughing out	33.3	40.0	4.8	78.1	0	17.6	4.2
flake fine trimming	6.1	14.7	9.4	30.2	5.0	39.2	25.4
cobble fine trimming	1.6	4.6	7.9	14.1	0.8	16.7	68.1
edge straightening	1.0	6.0	3.0	10.0	0	21.0	69.0
reworking preforms	0	2.5	6.2	8.7	0.3	15.9	74.9
reworking adzes	0	0	0	0	0	30.2	69.7
sites							
Emily Bay NI	0.4	4.2	5.8	10.5	1.6	22.2	65.6
Tahanga Quarry NZ	23.0	23.3	2.1	48.4	10.2	32.3	9.0
Whitianga NZ	1.4	5.2	5.1	11.7	1.0	17.0	69.0
Hot Water Beach NZ	1.2	5.9	6.1	13.2	1.0	17.0	69.0
Hahei NZ	1.3	6.0	7.4	14.7	1.5	13.4	70.0
Whitipirorua NZ	2.4	6.2	7.1	15.7	2.2	15.6	66.2
Opoutere NZ	3.4	9.8	8.2	21.4	0.3	14.4	63.7
Bowentown NZ	1.2	5.1	9.8	16.1	0.7	10.3	72.6

Reworked preform flakes. There were eight reworked preform flakes in the Emily Bay assemblage of the "truncated blade" type indicating detachment from quadrangular Duff (1977) Type 1 adzes. In addition there were three "beaks" that may have been detached to form the bevel and blade of Duff (1977) Type 4A adzes. This evidence suggests a wider range of adze forms were made at Emily Bay than the preform/adze assemblage itself indicates. The range varies also by size. Other Duff (1977) types that are suggested by the preform pieces are Type 2 and possibly Type 3. All of these adze types, except Type 4 occur amongst the Norfolk Island surface finds of Polynesian type, which Specht (1984) labelled Group III (Anderson, Smith and White, this vol.).

Table 4. Distribution of flakes by category of shape and termination (%) produced by experiments and from sites in Emily Bay and New Zealand. For N, see Table 2. For category definitions, see text.

	A	B	C	D	E	F
experiments						
flake roughing out	21.3	31.3	2.1	3.5	16.7	25.0
cobble roughing out	22.6	37.3	10.1	3.4	9.2	17.3
flake fine trimming	14.6	49.1	2.1	1.5	11.0	21.6
cobble fine trimming	22.1	36.1	1.7	16.9	6.6	16.2
edge straightening	13.0	71.0	0	0	2.0	13.0
reworking preforms	30.9	30.0	6.3	5.4	18.1	10.1
reworking adzes	12.0	50.0	0	0	20.0	18.0
flake modification	27.9	18.3	11.4	14.6	18.8	8.7
sites						
Emily Bay NI	27.0	19.4	8.3	15.5	10.8	18.8
Tahanga Quarry NZ	13.2	44.6	14.1	4.4	7.8	15.8
Whitianga NZ	38.4	24.8	6.7	18.7	6.2	5.0
Hot Water Beach NZ	16.3	46.6	8.2	11.1	10.7	7.0
Hahei NZ	18.5	31.6	8.6	19.4	9.7	11.9
Whitipirorua NZ	22.7	53.4	0.6	1.2	12.2	9.8
Opoutere NZ	38.3	19.4	4.6	18.5	8.4	10.4
Bowentown NZ	39.5	21.7	7.5	11.0	9.5	10.5

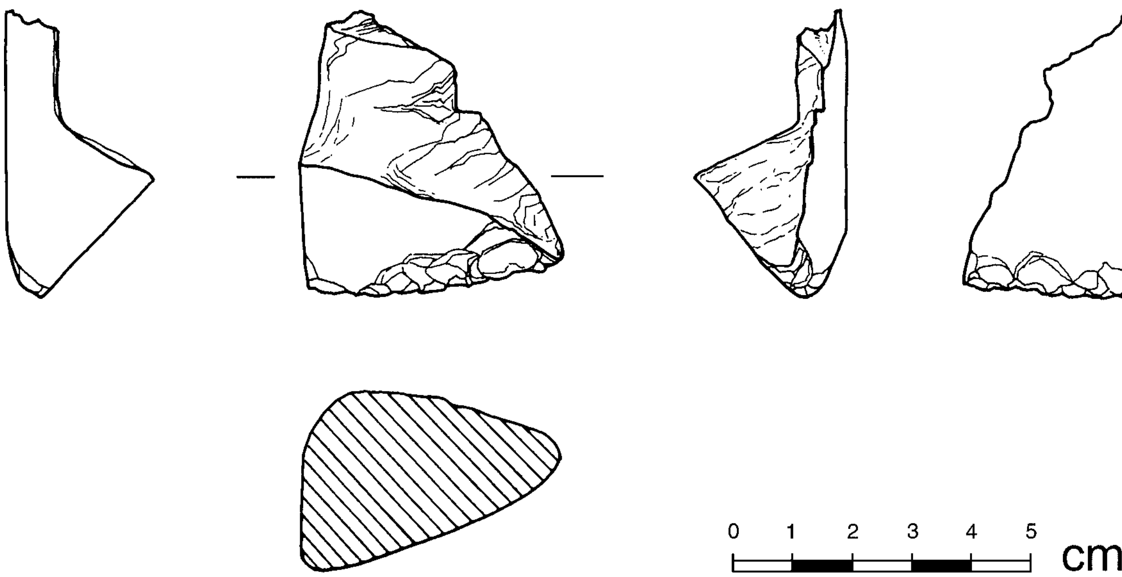

Figure 1. Blade and bevel section of broken adze; left, top, right view. a = base. NIPP 736.

Reworked adze flakes. Among the reworked adze flakes there were five flake pieces from finished adze blades that could be assigned to adze typology. These are more likely to be the product of reworking or blade rejuvenation than the result of damage during use. Two (NIPP 684 and 514) blade corners were from back-wider-than-front forms; one (NIPP 514) possibly from a hogback or Duff (1977) Type 4A adze, the other (NIPP 684) possibly from a Duff (1977) Type 2C adze. Another blade corner (NIPP 613) came from a front-wider-than-back form, possibly Type 1 or Type 2A. A large blade and bevel piece (NIPP 736, Fig. 1) from a Type 2A adze, displays a type of fracture that can occur during blade repair.

Modified flakes. Of the 572 flakes, 19.4% showed definite signs of modification for a range of different functions which included a variety of point tools, high-and low-angled edge use (e.g., NIPP 708, Fig. 2.5), saws and possible bruising and hammering implements (Table 5). One drillpoint was also identified. As in assemblages from New Zealand and elsewhere, flakes proved valuable for opportunistic use at Emily Bay. The toughness and sharpness of the basalt was useful when fine sharp edges were required for boring or pecking points. Most of the modified flakes are, however, broken or badly damaged, making precise identification of function difficult.

Table 5. Numbers of modified flakes from Emily Bay.

drillpoint	1
other points	36
high angled edge damage	19
low angled edge damage	17
saw	1
bruising/chopping damage	21
broken tool pieces	16
total	111

Adzes and preform analysis. There were five adze and nine preform pieces (Table 6). All but one were in a broken state. Among the adze pieces were two small "scrappy flake adzes" (SFA; e.g., NIPP 508, Fig. 2.4). These represent the only expedient adze form thus far known in Polynesian adze technology. That is, they were opportunistically made from a waste flake, and probably discarded after a short period of use. Unlike other adze forms, therefore, they can directly indicate that adze use took place on the site. The curated or unfinished nature of other forms can rarely indicate this.

There are three other pieces from finished adzes. All have seen reworking attempts that failed. One is a butt portion, which may have been rejected after failure to form a new bevel (NIPP 639, Fig. 3.1). Another piece from the bevel section of a quadrangular adze (Fig. 3.3) may have initially broken during blade repair—a very risky operation that can cause transverse fracture. Following this, the piece may have been reflaked for use as a hand-held tool. Reflaking down from the broken transverse fracture plane is evident on the broken gouge section; probably to thin it out for hafting, but this process had not been completed for some reason. NIPP 137 (Fig. 3.2) has been reflaked into a gouge.

Of the nine adze preforms, four (Fig. 4: NIPP 556, 757B, 641, 527) had been rejected, evidently after a reworking attempt that failed, although one was modified into a sturdy point and was probably used before final rejection. Another piece was used as a hammer. Four other pieces were probably too small and ill-shaped to rework (NIPP 757A, 507, 154: Fig. 2.1, 2.2, 2.3). Unusually for an assemblage of reject material, there is also one complete and quite well formed hogback gouge preform (NIPP 1001, Fig. 5). There is no obvious reason why it has not been finished. One possibility—a problem experienced in experimental adze making sessions—is that it may have been accidentally lost among the debitage.

Most of the preforms were derived from flake blanks and tended to be small to medium in size. A range of cross-section shapes is evident with bilateral and trilateral flaking observed. With reject preform pieces it is generally difficult to identify the type of adzes intended, especially when they have been further reshaped in a reworking attempt. It is

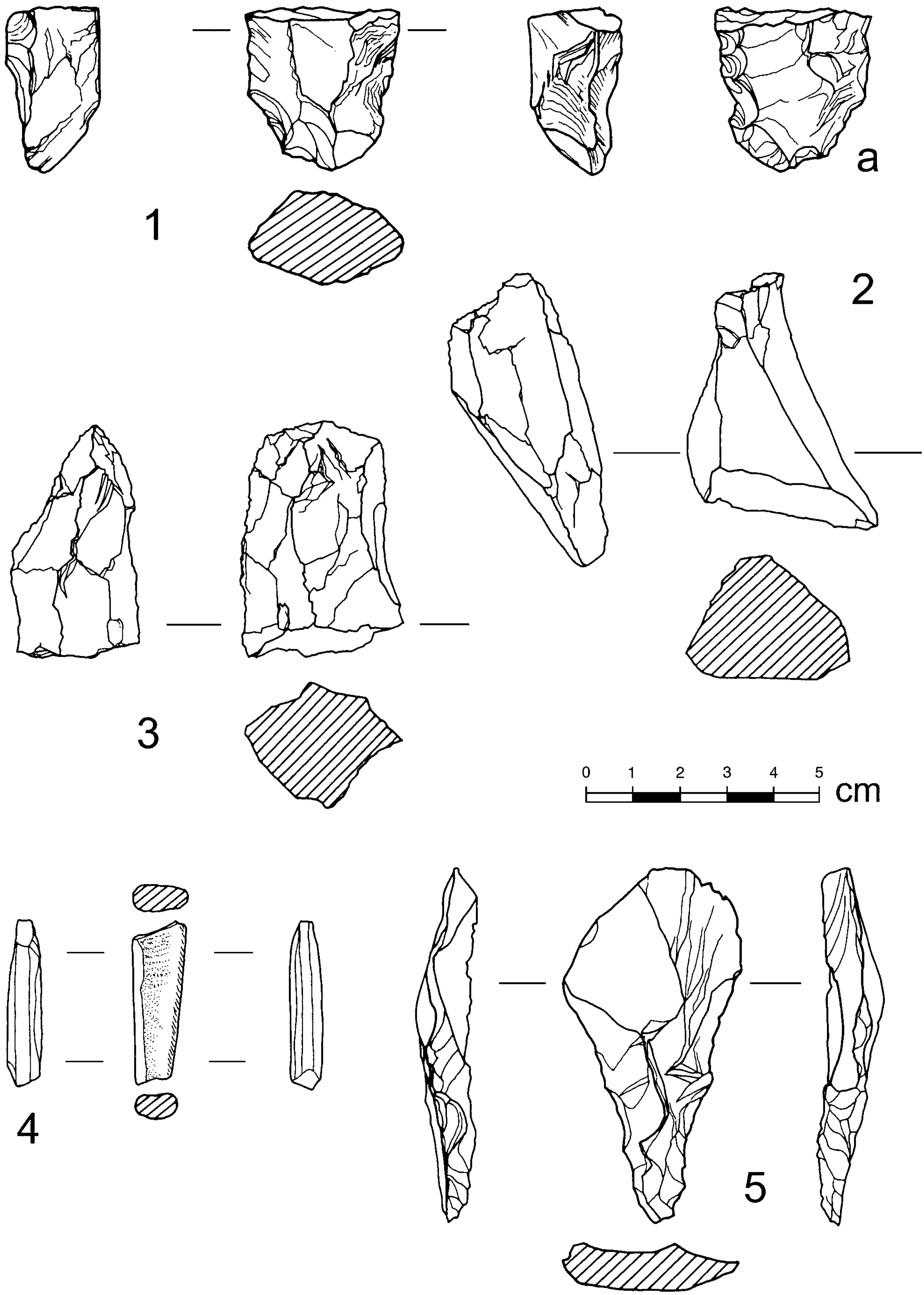

Figure 2. 1. Broken adze preform, butt end. Left, top, right views; a = base. NIPP 757A. 2. Broken adze preform, bevel end. NIPP 507. 3. Broken adze preform, bevel end. NIPP 154. 4. Ground basalt artefact, possibly trolling lure or pendant. NIPP 508. 5. Modified flake. NIPP 708.

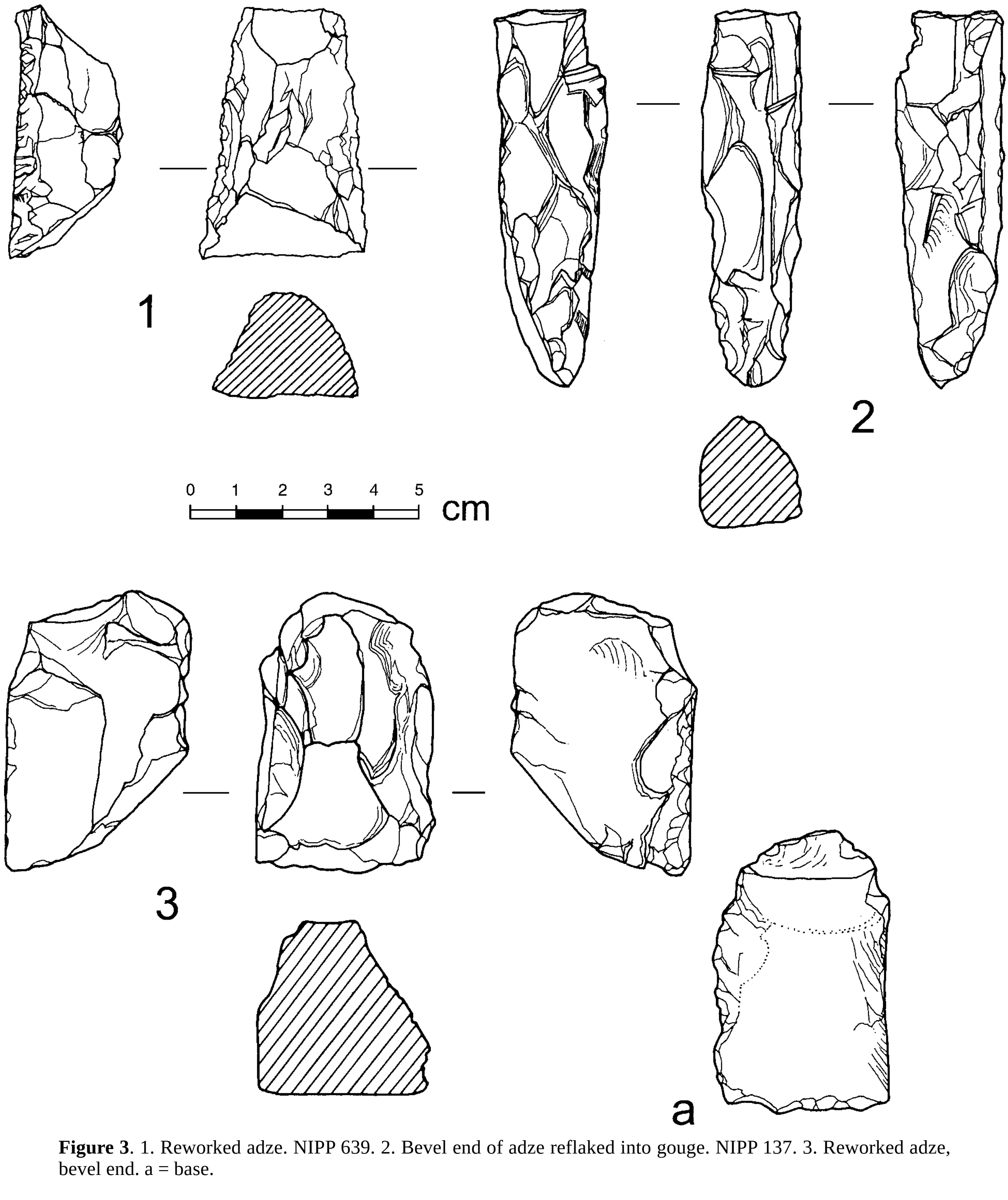

Figure 3. 1. Reworked adze. NIPP 639. 2. Bevel end of adze reflaked into gouge. NIPP 137. 3. Reworked adze, bevel end. a = base.

therefore to the adze flakes (above) that we must look for indications of the type of adzes that may have been successfully made and removed.

Spatial distribution. The majority of the material in this assemblage came from Trench EB97:23—61.3% of diagnostic flakes (Size 3–6) and 71% of the adzes and preforms (see Tables 6 and 7). A further 13.9% of diagnostic flakes and 14.2% of adzes and preforms came from Trench EB97:24. 12.4% of flakes came from Trench EB96:10 and 9.0% from Trench EB96:11. The remaining 1.3% of flakes came from Trenches EB95:01, EB95:02 and EB97:22 (N=18 diagnostic flakes—too small to be considered as separate samples in Table 7). Two other preforms came from Trench EB96:11 and EB97:21 respectively (see Table 6).

It is clear from Table 7 that all adze related processes were occurring in each of the four trenches. While there are no major differences, preform and adze reworking, as well as flake modification were more common activities in Trench EB96:11, as indicated by higher frequencies of “OS” and Size 7 and 6 flakes. Trench EB97:24 also has a slightly higher frequency of preform reworking again accompanied by higher frequencies of “OS” and Size 7 flakes.

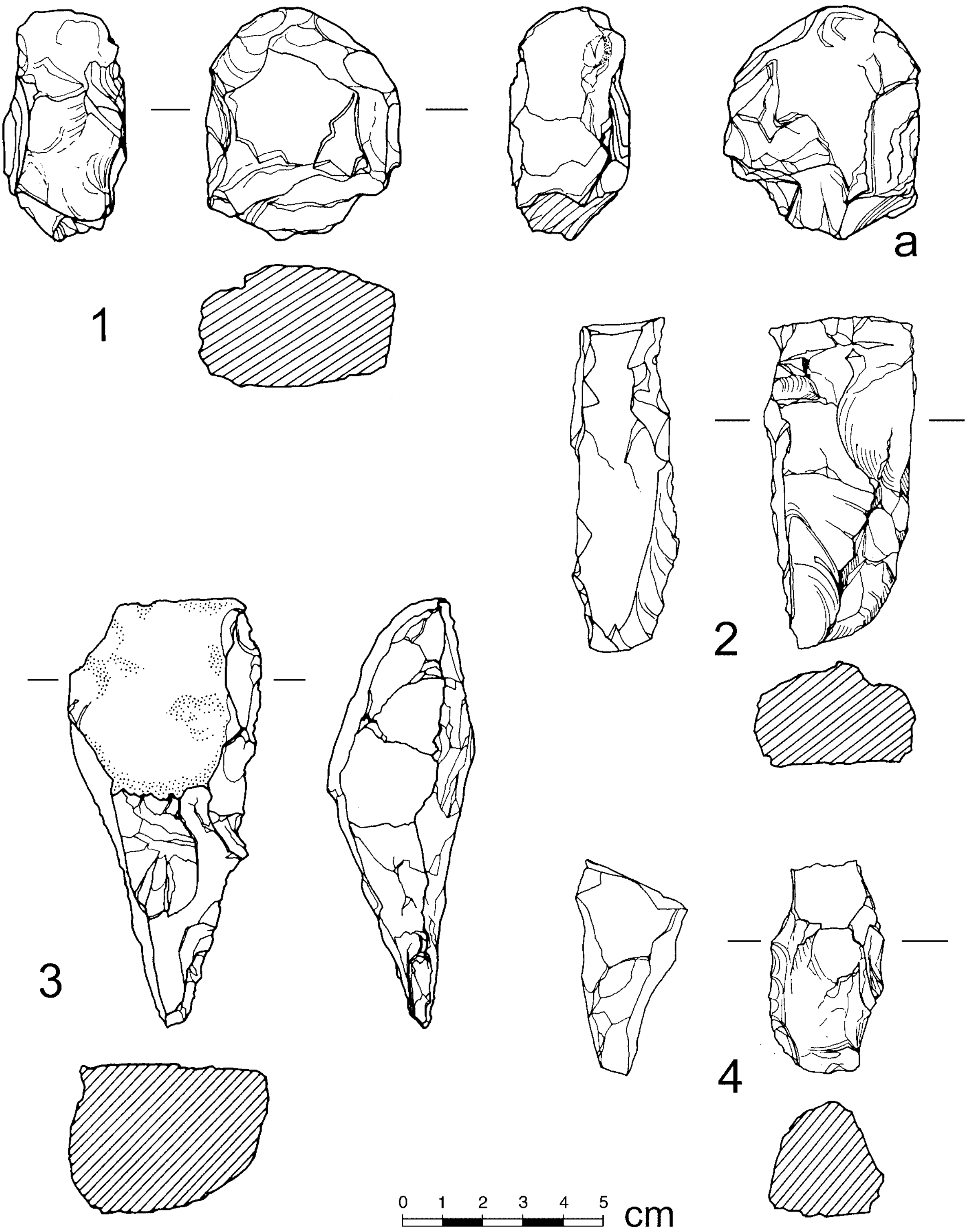

Figure 4. 1. Reworked preform. Left, top, right views; a = base. NIPP757B. 2. Reworked preform. NIPP 641. 3. Reworked preform. NIPP 556 (also used subsequently, see Usewear section). 4. Reworked preform. NIPP 527.

Other material. A single ground basalt artefact (NIPP 508) was recovered from Trench EB97:23, Square B7, spit 3. It was possibly part of a pendant, or perhaps a shank from a trolling lure. It measures 5.4 mm. long, 11.6 mm. wide and 5.5 mm broad. The piece tapers from one end and has been shaped by grinding (Fig. 2.4).

There were numerous pieces from water-rolled andesitic pebbles found among the flake material, but on close inspection, there was no evidence that any of these had been used as hammerstones. Rather the fire damage identified on many pieces suggests their use as oven stones. Two small pieces of sandstone (NIPP 553 and 568) may have come from larger stones used to grind adzes and other items. One piece (NIPP 568) had a ground concave surface.

Table 6. Preforms and adzes from Emily Bay. diag: diagonal; Gr rem: grinding remnant; ND: not identifiable; PF: preform; quad: quadrangular (close to square in section); rec: rectangular (sides < half width); RWA: reworked adze; RWPF: reworked preform; SFA: scrappy flake adzes; TF: transverse fracture; tri: triangular. All lengths in millimetres, all weights in grams.

NIPP	trench	sq.	layer/ spit	artefact	state	cross-section	wgt	lgth	blade max.	width min.	thick	blank type	other data	Fig.
672	EB97:23	H2	Sp 2	SFA	damaged	rec	20	57	18	12	12	flake	chipped blade	
154	EB96:11	A2	L2/Sp3	PF	bevel end	tri	50	47	30	25	26	ND	"gouge, trilat flaking"	2.3
1001	EB97:21	Z1	Sp 1	4A PF	complete	tri	240	165	30	13	37	flake	"cortex, trilat flaking"	5
507	EB97:23	B7	Sp 2	PF	part bevel	rec	40	49	38	6	24	flake	"cortex, diag TF"	2.2
556	EB97:23	D11	Sp 2	RWPF	bevel end	quad	180	105	45	7	35	flake?	"cortex, mod point"	4.3
527	EB97:23	C13	Sp 1	RWPF	bevel end	irregular	40	50	24	21	26	ND	"gouge, trilat flaking"	4.4
508	EB97:23	B7	Sp 3	SFA	mid-sec	round rec	5	35	10	8	6	flake?	chisel? v.small	2.4
641	EB97:23	F10	Sp 7	RWPF	butt end	rec	100	81	35	22	24	flake?	rough reflaking	4.2
555	EB97:23	D11	Sp 1	PF	butt end	lenticular	55	39	41	31	35	ND	Type 3?	
639	EB97:23	F10	Sp 5	RWA?	butt end	sub-tri	50	54	35	24	22	flake	"rough, new bevel?"	3.1
137	EB97:23	B7	Sp 3	RWA	bevel end	tri	56	80	20	11	23	ND	reflaked gouge	3.2
0	EB97:23	D12	Sp 1	RWA	bevel end	quad	131	60	37	32	39	ND	reflaked	3.3
757A	EB97:24	Z4	Sp 1	PF	butt end	lenticular	25	34	32	23	19	ND	poss RW?—Gr rem	2.1
757B	EB97:24	Z4	Sp 1	RWPF	butt end	rec	113	55	47	31	29	ND	reuse as hammer	4.1

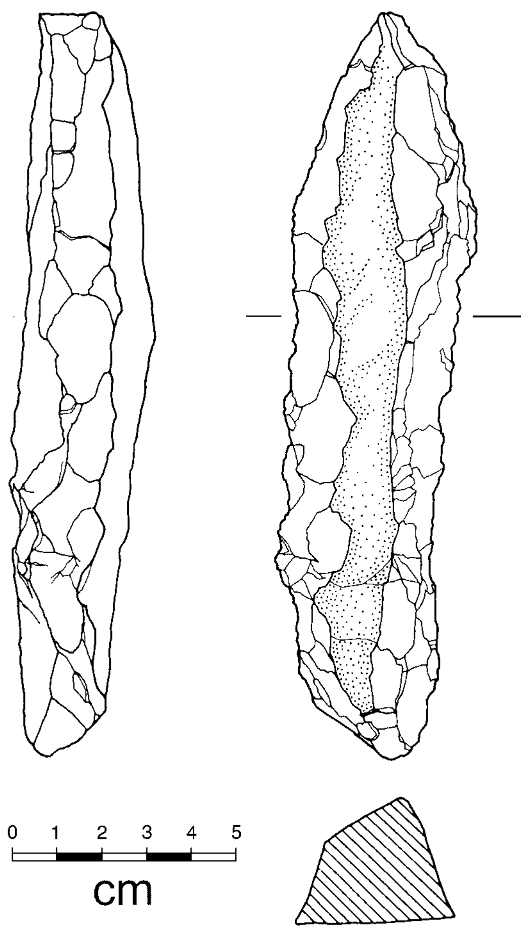

Figure 5. Gouge preform. NIPP 1001.

Table 7. Spatial distribution of basalt flake characteristics in Emily Bay trenches studied. Number (N) as indicated, otherwise data given as percentage.

	all	EB96:10	EB96:11	EB97:23	EB97:24
N	3178	282	527	1408	925
N (size 3–6 only)	572	71	52	351	80
stages					
adze manufacture	63.2	63.5	54	64.5	60.0
preform reworking	18.8	22.5	23	18.3	25.0
adze reworking	17.9	14.0	23	17.2	15.0
modifications					
modified flakes	19.4	12.6	25.0	19.2	20.2
OS fine trimming	65.6	58.4	76.6	65.5	78.0
cortical flakes	10.5	9.1	8.5	10.9	3.7
size category					
7	78.2	74.8	90.1	75.2	86.4
size 3–6 only					
6	83.0	85.9	88.4	82.2	82.5
5	13.3	14.0	9.6	13.5	15.0
3+4	3.6	0	1.9	4.3	2.5
flake category					
A	27.0	32.3	20.7	26.8	19.0
B	19.4	15.4	16.9	20.4	25.3
C	8.3	8.4	7.5	8.6	8.8
D	15.5	11.2	11.3	17.0	15.1
E	10.8	14.1	13.2	9.5	17.7
F	18.8	18.3	30.1	17.5	13.9

Conclusions. Analysis of the basalt assemblage from the Emily Bay archaeological site shows that it was primarily being used for adze manufacture. Flake analysis shows that adze stone was quarried elsewhere and roughing out did not occur on site. Preforms were brought to the site and finishing off occurred there. The flakes, preforms and broken adzes show that Duff (1977) Types 1, 2, 3 and 4 were all made on site. Unique to Polynesia are two small adzes, expediently made on waste flakes. Some broken pieces and preforms have been re-worked into other artefacts, demonstrating further expedient use of the material.

Source characterization of stone

As described in Anderson *et al*. (1997) a sample of the basalt flakes was subjected to non-destructive, energy-dispersive XRF analysis which indicates that there was local adze production, not merely refurbishment, on Norfolk Island. This suggests the quarry and reduction sites might yet be discovered. A collection of obsidian flakes, including one blade section from Trench EB96:11, was made during excavations at Emily Bay. Twenty-four were recovered from the paving feature in Trench EB97:24 (Anderson, Smith and White, this vol.). Distinctive characteristics were visible in hand specimen, confirmed by analysis of major element oxides plus PIXE/PIGME analysis of trace elements (Anderson *et al*., 1997), all but one of the specimens (N = 26) are from Raoul Island. The non-Raoul Island piece, from Spit 4 of Square E12 in Trench EB97:23 was in a high-quality, translucent green obsidian which has a specific gravity and major elements profile consistent with the Mayor Island source (New Zealand), according to Ambrose (pers. comm.). However, the trace element analysis by PIXE/PIGME and NAA contains some anomalous data, and the origin of this piece remains in question (F. Leach, pers. comm.).

Usewear and residue analyses

The excavators selected 15 artefacts (10 basalt and 5 obsidian) from the Emily Bay settlement site for the study of functional traces. They were selected because they appeared to have macroscopic indications of use. The methods and results of a microscopic analysis are described here. Macroscopic and microscopic forms of usewear and residues were recorded. General aspects of lithic technology are also discussed.

Methods and laboratory procedures. Artefacts were handled during excavation, and gloves were not worn in the laboratory. However, adhering sediment protected surfaces and residues and the artefact edges appear to be in good condition, with few contaminant fibres and rare traces of metal.

All artefacts came from sandy dune deposits and some fine-grained sediment remains attached to the artefacts. Artefacts were not cleaned because residues could have survived in the adhering sediment which may provide an opportunity for future quantitative study of certain plant structures (eg phytoliths and starch grains). Evidence presented elsewhere (Anderson, Smith and White, this vol.) indicates that the cultural layer from which these artefacts came is not greatly disturbed.

Two kinds of microscope were used: a stereomicroscope with external oblique lighting (Zeiss model, with a magnification range of ×10 to ×100); and a metallographic microscope with vertical incident lighting, bright-field, dark-field, cross polarising attachments (Olympus model, with a magnification range of ×100, ×200, ×500, ×1,000).

Analysis of the artefacts is based on recognition of the following main forms of usewear: scars, striations, rounding, polishes, and bevels. The length and termination (step, feather, hinge, bending) of scars were noted. The direction and location of striations were recorded. Rounding was recorded in terms of qualitative assessment (low, medium and high) based on my replicative experiments for similar raw materials. Polish was categorized within five stages of development and surface features, which can be distinctive of particular materials given other traces of use (Fullagar, 1991). Bevels or asymmetrical, level bands of smoothing along edges were not observed in this collection.

Other variables recorded were (see Table 8): NIPP No.: unique identification number, assigned by excavators; trench, square and spit number within cultural layer, assigned by excavators; stone: class of stone material, assigned by excavators; weight (g): measured on electronic balance, by RF; type: a technological category, assigned by RF to include core, flake, fragment or morphological type (eg adze); grinding: manufacturing traces of grinding caused by stone rubbing on stone; use status: derived from study of main forms of usewear (see above); cortex: percentage of weathered surfaces (% dorsal flake surface or % whole surface of a flaked piece (a fragment which could not be oriented) or an implement type such as an adze); BL mm: (block length) maximum length of smallest rectangle into which piece could fit; BW mm: (block width) maximum width of smallest rectangle into which piece could fit; BTH mm: (block thickness) maximum thickness; block length×block width×block thickness provides a rough estimate of the volume of the flaked piece. Block length×block width provides an estimate of surface area for ventral or dorsal surfaces; platform: indicates the presence of a measurable striking platform; AL mm: (axial length) maximum length from point of impact to distal end of flake on ventral surface; AW mm: (axial width) maximum width of flake at right angles to axial length; ATH mm: (axial thickness) maximum thickness of flake at right angle to axial length and width; PL mm: platform length; PW mm: platform width from point of impact to dorsal surface at right angles to ventral surface.

The above descriptive technological features were recorded in order to provide a basis for comparing the nature of flake production with other archaeological collections, although no such comparison is attempted here.

Results. Results are given in Table 8 and four representative artefacts are illustrated in Fig. 6. All but one (NIPP 166ii) of the 10 basalt artefacts had clear traces of use. One artefact (NIPP 672) had been ground on various surfaces to produce a small implement with clearly developed polish at the wider end, and impacted fibres from woodworking. Rounding on high ridges which were not ground, and the distribution of less developed polish suggest the implement was hafted in a wooden handle. Eight other basalt pieces had traces of use. Polish on the edge of NIPP 556 can be seen in Fig. 7. Artefact NIPP 588 is almost entirely pecked and ground on the dorsal surface, and the concave cortex surface indicates that it was probably struck from an adze with a raised back. The distal end shows traces of subsequent use in the form of scarring, although the material worked in this instance could not be determined.

Grinding as an edge sharpening technique occurs on three utilized flakes (NIPP 70, 153, 642). Usewear is also present in the form of scars and polish, not well developed but distinct from stone grinding. Artefact NIPP 70 has a small patch of grinding in the centre of the ventral surface, and

Table 8. Basalt and obsidian artefacts from the Emily Bay archaeological site analysed for usewear and residues. For definitions of column headings, see text.

NIPP no.	trench	square	spit	weight (g)	type	grinding	use status	cortex (%)	BL (mm)	BW (mm)	BTH	AL	AW	plat-form	PL	PW
basalt																
68	EB95:06	square A2	spit 2	42.2	flake	absent	used	0	64	44	21	64	44	P	21	12
69	EB95:06	square A4	spit 2	67.3	broken flake	absent	used	10	71	44	18	25	59	P	51	11
70	EB95:06	square A4	spit 3	75.9	split flake	present	used	10	65	61	20	61	65	—	—	—
153	EB96:11	square B1	slumped	56.6	flake	present	used	0	113	46	15	113	46	P	8	crush
166i	EB96:11	square B1	spit 3	51.6	flake	absent	used	40	69	57	13	49	56	P	22	10
166ii	EB96:11	square B1	spit 3	33.1	flake	absent	not used	50	60	38	12	38	60	P	32	7
556	EB97:23	square D11	spit 2	37.9	?biface frag/ split flake	absent	used	0	60	36	18	—	—	A	—	—
588	EB97:23	square E10	spit 4	67.9	flake	present/ recycled adze	prob	0	106	41	13	38	106	P	18	5
642	EB97:23	square F11	spit 1	164.7	split flake	present	used	0	118	58	22	—	—	P	35	19
672	EB97:23	square H2	spit 2	24.1	adze	present	used	0	58	22	12	—	—	A	—	—
obsidian																
595	EB96:11	square A1	spit 3	7.1	flake	absent	poss	0	38	23	11	31	23	P	22	11
701	EB97:24	square A5	spit 2	10.1	flake	absent	poss	0	37	27	13	37	27	P	8	9
723	EB97:24	square B3	spit 2	4.2	fragment	absent	prob	0	25	22	10	—	—	A	—	—
761i		T24:Z6:3		1.9	flake	absent	not used	0	24	13	6	13	24	P	6	5
761ii		T24:Z6:3		0.2	fragment	absent	not used	0	13	8	4	—	—	A	—	—

pitting which may be a result of earlier use as a hammerstone, before this flake was struck off. The other two artefacts (NIPP 642, 153) with ground edges are large blade-like flakes.

Although the precise materials worked could not be identified, plant tissues in association with usewear is common. Starch grains are present on basalt artefacts NIPP 68, 69 (see Fig. 8), 556 and on obsidian artefact NIPP 723. All starch grains observed are small, about one micron and less in diameter. The adhering sediment probably obscures starch grains on these and other artefacts. Further analyses of starch grains by quantitative methods (e.g., Loy, 1994; Loy *et al*., 1992; Therin, 1998) is justified. The origin of the starch grains and the identification of the species of plants that were processed may be further assessed by removal and more detailed study of residues in conjunction with usewear on cleaned artefact surfaces (e.g., Kealhofer *et al*., 1999).

Three obsidian flakes and a fragment (flaked piece that could not be oriented: no distinct ventral surface or direction of blow) were bagged separately. One of the flakes (NIPP 761) had broken in the bag, making an extra, fifth, fragment which was also examined. So, altogether five pieces were examined, and none had clear retouch or other evidence of deliberate edge modification, or formal design.

Artefact NIPP 761 and the broken fragment in the same bag had no traces of use. Artefact NIPP 595 had traces of use (scarring, slight rounding and plant fibres) indicating possible use on soft non-siliceous, plant tissue and artefact NIPP 701 had scarring on a relatively unstable edge indicative of possible use on some soft material. Artefact NIPP 723 had traces (scarring, rounding and starch grain residues) indicating probable use on soft, non-siliceous, starchy plant tissue.

Discussion and conclusions

I presume that the relatively high frequency of use in this small collection of basalt and obsidian artefacts is a consequence of prior selection with a view to picking artefacts with likely macroscopic indications of use.

The study of 10 basalt artefacts from the Norfolk Island excavations indicates that their main function was to process wood and other plant materials. Utilized edges of the basalt artefacts also indicate light-duty wood or other plant processing. There is no evidence of processing animal tissue.

Some edges were sharpened by hard hammer retouch, and others by partial edge grinding. The partial grinding of some flake margins to create a suitably sharp edge may have been a deliberate strategy, employed in preference to hard hammer flaking (which could have been wasteful of scarce stone and unsuitable for the tasks at hand). On the other hand, flaking invariably produces a sharper edge than grinding, suggesting that the Norfolk Island ground flake edges were produced for some kind of plant processing which did not necessarily need such a sharp edge. One possibility is an implement, perhaps hafted, for the processing of plant material for basketry or clothing, a possible function of at least some polished flakes from northern Australia (heavily rounded but not ground) which also explains their usewear and residues (see Akerman, 1998). The possibly introduced flax on Norfolk Island may have been involved (Macphail, Hope and Anderson, this vol.) but further research would be required to test this.

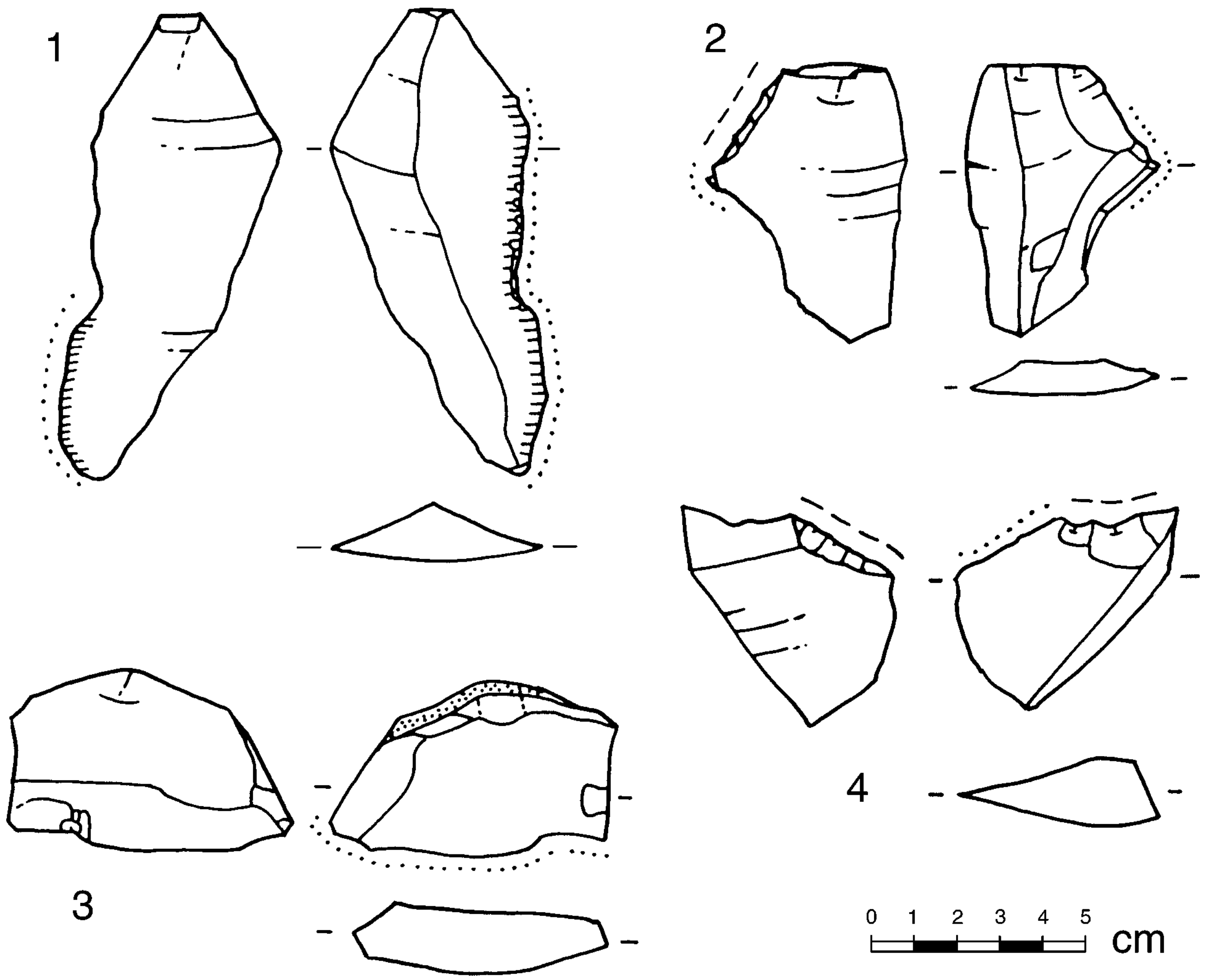

Figure 6. Artefacts with usewear. 1: NIPP 68; 2: NIPP 153; 3: NIPP 69; 4: NIPP 556. Dashed line indicates retouch (68, 556), dotted line indicates polish (all), close short lines at right angle to edge show striations (153). Dotted area of artefact indicates cortex. Scale bar 10 mm.

The excavated assemblage contained one small complete adze (NIPP 672) while the large flake NIPP 588 came from an adze. Design features and wear traces suggest basalt adzes were hafted while other flake implements were probably hand-held.

Indications of conservation of raw material include recycling of a hammerstone (NIPP 70) and adze (NIPP 588) into new tools. Further study of the whole assemblage may shed more light on technological strategies.

Basalt flakes include several decortication flakes (NIPP 69, 166i, 166ii, 642), some from cores more than 10 cm diameter. It is possible that these and others (NIPP 68, 556) are by-products of large adze production, and were selected for use from the adze production locality (if it were not at Emily Bay itself).

The study of five obsidian artefacts from Norfolk Island has provided little detail of function other than to identify that a few were probably used. There are no obsidian cores in the analysed collection and no flakes or fragments that show any signs of intensive use, in contrast with the more developed wear patterns on basalt artefacts. This probably relates in part to functional differences in the utilization of basalt and obsidian implements, as a consequence of the vastly different properties (hardness and fracture toughness) of these raw materials. However, there are too few pieces of obsidian to reliably reconstruct flaking strategies. In fact, all pieces may have come from a single small amorphous core or other implement.

The absence of distinctive animal tissue on any of the artefacts may simply be a consequence of the particular taphonomic conditions in open, exposed, sandy deposits. On the other hand, the absence may be real. Other studies have demonstrated differences in obsidian technology for various regions of the western Pacific. For example, ethnography in the West New Britain area (Specht, 1981) suggests the recent use of flaked obsidian was for surgery and other activities related to the human body. Barton and White (1993) in New Ireland as well as Specht and Fullagar (1988) suggested yams and other tubers were also often processed with obsidian, but that manufactured glass may have replaced it for this task since initial European contact (Fullagar *et al.*, 1998). Other research also indicates that flaked stone was used differently in prehistoric and more recent times (Brass, 1998).

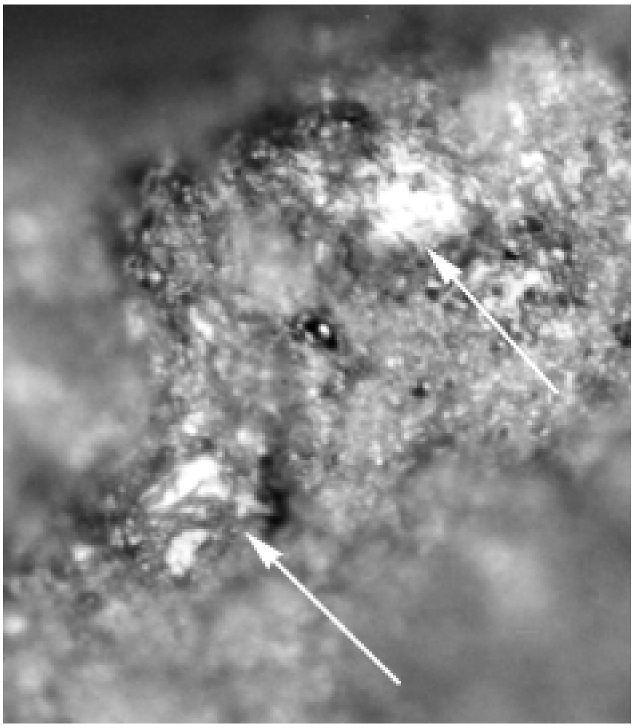

Figure 7. NIPP 556. Patches of smooth polished surface (arrowed white areas). Objective magnification ×50. Photo width 0.1 mm.

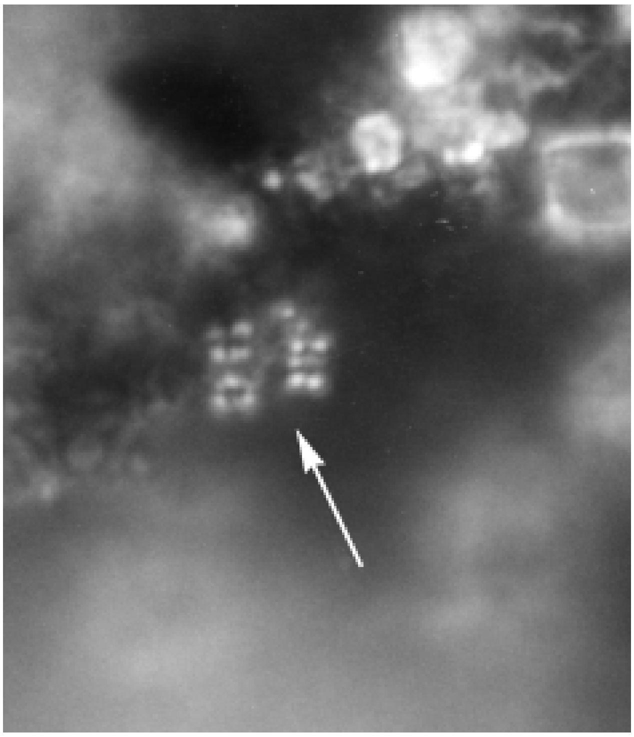

Figure 8. NIPP 69. Cluster of starch granules with dark extinction crosses under polarised light on a pointed end of the artefact. Objective magnification ×80. Starch granule diameter c. 2.5 µm.

ACKNOWLEDGMENTS. Judith Field took the digital photographs. Peter White authorized use of the Archaeological Materials Laboratory, University of Sydney. Dan Witter discussed aspects of ground edges on flaked implements, and their occurrence in Australia and New Zealand.

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