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Following the Flake Trail:
Adze Production on the Coromandel East Coast, New Zealand

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ABSTRACT

Fourteen archaeological flake assemblages of Tahanga basalt from early sites on the east coast of the Coromandel Peninsula and one from Mount Camel in Northland, New Zealand, were examined. Fourteen adze replication flake assemblages were used to define processes of adze manufacture at those sites and at the Tahanga quarry. Work at the quarry involved breaking up parent rock into adze blanks and roughing them out. They were finished at the Coromandel coastal sites where broken preforms and adzes were reworked and waste flakes were modified, forming a range of flake tools. No sites beyond the east coast of the Coromandel were involved in major Tahanga basalt adze production. The people at Mount Camel were repairing broken adzes. A reworking strategy was a central component of Tahanga adze production. It is suggested that the people who roughed adzes out at the quarry finished them at the east coast sites.

Keywords: TAHANGA BASALT, ADZE PRODUCTION, EAST COAST COROMANDEL MIDDEN SITES, FLAKE ASSEMBLAGES, ADZE REPLICATION EXPERIMENTS.

INTRODUCTION

Tahanga basalt was an important source of adze quality rock for early North Island settlements (Moore 1976: 82). The presence of Tahanga basalt flakes in assemblages has been interpreted as evidence of adze manufacture (Leahy 1974; Davidson 1975; Crosby 1977; Harsant 1985; Furey 1990). However, such interpretation is uncertain in the absence of an understanding of the procurement, distribution and working of the material. Flake assemblages offer a means of retrieving this information. They are durable, often found in abundance and unlikely to be removed by fossickers. In some cases they may be the only remaining evidence. Also, as noted by Leach and Leach (1980), flakes provide a less biased sample than the preforms found with them, as the latter provide evidence only of those that were discarded as failures, whereas flakes can provide data on those which were successful and transported elsewhere. In short, they leave a tell-tale trail from the quarry out to sites some distance away.

Tahanga basalt flakes are often associated with adze manufacture but some 'waste' flakes were used for other purposes, including as drillpoints, awls and scrapers (e.g., Shawcross 1964; Bellwood 1969; Leahy 1974; Furey 1990). Therefore it is necessary to establish the

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degree to which these flakes were employed in other activities and how such use altered the original flake distribution.

The first part of this paper outlines methods of analysis used in the present study. This is followed by the presentation and discussion of data from 15 sites. These are then compared with data from adze and other flake tool replication experiments.

METHODOLOGY

The theoretical premises underlying flake formation are clearly stated, if somewhat poorly understood (Cotterell and Kamminga 1987). Conchoidal fracture is predictable and controllable when certain technological conditions are met. Adze manufacture can be viewed as a reductive process in that flakes will normally decrease in size 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 (Stahle and Dunn 1982). 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.

Two basic methodologies are used in the analysis of flakes. These are 'Individual Flake Analysis' (IFA) and 'Flake Aggregate or Mass Analysis' (FAA). Their strengths and weaknesses are debated (e.g., Ahler 1989; Amick and Mauldin 1989; Rozen and Sullivan 1989). IFA involves analysing each flake according to a set of selected attributes (e.g., weight, length, width and thickness, striking platform angle). This can be very time consuming. Therefore, it restricts analysis to small samples and, usually, a small number of attributes, whereas flake assemblages are often large and complex. FAA involves classifying flakes according to a combined set of attributes. For example, flakes can be assigned a size class which removes the need to take individual measurements. This allows analysis of large samples.

Leach and Leach (1980) formulated an FAA technique of waste flake analysis and used it effectively in their analysis of adze manufacturing processes at Riverton, Southland. Using a similar approach Harsant (1985) showed that finishing adze manufacture was the dominant lithic activity at Hahei (T11/326) on the Coromandel Peninsula.

Newcomer (1971) and Stahle and Dunn (1982) have demonstrated that FAA is optimal if attributes are first tested and defined through controlled core reduction experiments. Stahle and Dunn (1982) first established stages of manufacture experimentally. Then debitage from each of these defined stages was put through size-graded sieves (Stahle and Dunn 1982: 86–7). In the present study, IFA was used on experimental data and a sample from site T10/459 at Tahanga (Kronqvist 1991) to define significant flake classes and attributes. Their frequencies were found to be significant (Turner 1992 as per Stahle and Dunn 1982). Dorsal surface features including presence/absence of cortex and degree of scarring were most important for indicating manufacturing stage. Generally the number of flake scars increased as cortex decreased. Four flake categories were defined. They are described more fully below. Flake shape and size were important but quantitative attributes including weight, length, width and thickness were less useful when considered one at a time.

Therefore, flakes were size-graded on the basis of weight and shape. Enough classes were used: "...to record a wide range of flake sizes but few enough to preserve efficiency in data recording" (Ahler 1989: 99).

The flake typology formulated in the present paper is based on extensive adze replication with Tahanga basalt carried out by one of the authors (Dante Bonica) who has, over a 25 year period, achieved a level of skill comparable to that of the Maori artisans.

DEVELOPMENT OF A FLAKE TYPOLOGY

Four categories were used. The first three are basic attributes, namely size (based on weight), dorsal surface characteristics (including cortex and scarring) and shape (including type of termination). Several uncommon but useful attributes are included in the fourth category, 'special flake types'.

CATEGORY ONE: SIZE

Size 1 (> 300 g) and Size 2 (201–300 g). Flakes over 200 grams were produced in experimental trials during breaking up of boulders and roughing out of blanks over 2,500 g. Only 10 percent of total boulder weight was produced as debitage. Most flakes are produced during adze making. At Tahanga, most blank production occurred at concentrations of raw material. Flaking of blanks occurred where there was less clutter. For this reason, working floors at Tahanga represent the second task (Turner 1992: 143). Large flakes resulted mainly from the reduction of large blanks; at Tahanga those were usually cobbles.

Size 3 flakes (101–200 g) were produced during the initial roughing out of flake blanks over 2,000 g. Those in *Size 4 (51– 100 g)* were usually the primary flakes produced during the initial roughing out of flake blanks under 2,000 g. The amount of dorsal cortex and scarring indicated whether they were produced in the roughing out of small preforms or at a later stage in the manufacture of larger ones.

Size 5 (21–50 g) and *Size 6 (3–20 g)* flakes were most commonly produced in the flaking out of preforms of all sizes. They were generally the largest flakes produced from the working of blanks under 1,000 g. *Sizes 6 and 7 (less than 3 g)* flakes were numerically dominant and their frequency increased as manufacture advanced. Size 7 flakes made up 85 percent of the experimental flake total. They were the most frequently produced flakes at all stages of manufacture, especially during fine trimming. During blank production and initial roughing out, Size 7 flakes commonly resulted from shattering and broken distal flake ends. In experiments, Size 7 flakes were counted and the total weighed, but no further analysis was undertaken. This was because their size made identification of diagnostic features difficult and the quantities produced made analysis very time consuming. Size 7 flakes were uncommon on the surface of the Tahanga quarry working floors as they become lost between larger flakes (Turner 1992; Kronqvist 1991). They are equally rare in surface collections and excavated assemblages from other sites because sampling procedures have not ensured that these flakes are retained.

CATEGORY TWO: DORSAL SURFACE CHARACTERISTICS

Cortex and no scarring (CO). The roughing out of large cobble blanks produced the highest frequency of these primary flakes (CO), especially in Sizes 1–3. Preparation of small cortical flake blanks also produced CO flakes, typically of Sizes 4 and 5. However, a greater number of Size 6 CO flakes was produced overall because of small flakes shearing from dorsal surfaces of larger flakes on hammer impact.

Cortex and primary scarring (CP). These flakes have one or two flake scars on the dorsal surface. The majority were produced during the roughing out stage. Cobble blanks required more extensive roughing out and, being more cortical, produced the highest frequency of CP flakes.

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

No cortex and no scarring (OO). These flakes are uncommon, but resulted 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 was produced during trimming of the ventral surface of flake and split cobble blanks after some side trimming.

No cortex and primary scarring (OP). This is the commonest class of flake, and it occurred most frequently between the initial and later stages of roughing out, particularly during reduction of flake blanks. The initial shaping of boulder cores also produced many of these flakes.

No cortex and secondary scarring (OS). 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 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 was rejected. Flaws and inclusions of poor quality material often caused this. In one set of experiments (Experiment F, see below), 30 percent of flakes belonged in Category A because the material being flaked was of poor quality and coarse-grained. This establishes that it is necessary to ascertain stone quality before inferring a low level of skill from the frequency of Category A flakes present in an assemblage.

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 were unlikely to develop. Skill was required to produce these flakes consistently, although stone quality was important.

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

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. 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 were most frequently produced in experiments when a hard hammerstone was used with considerable force. They occurred most commonly in larger flake sizes and during the early stages of roughing out where hard hammers were often needed, particularly with large blanks. These flakes were also produced in the reduction of thin flake blanks where the flake travelled the thickness of the blank. This form of fracture was frequently produced when reworking broken preforms and adzes (this is discussed in greater detail below).

Category F flakes are wider than they are long with feather terminations. They were more frequent in the later fine trimming stage after the preform had been thinned down considerably, but were 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. The presence of 'hogback flakes' in the Riverton assemblage (Leach and Leach 1980) indicated the production of Type 4 adzes (Duff 1977), although no preforms were found. During experiments, their production was one of the last steps undertaken before hammer dressing. Therefore, they provide information on the stages of manufacture represented at a site.

The reworking of broken preforms into smaller adzes produced distinctive 'reworking flakes'. These were identified in archaeological assemblages. Preform pieces, which result from transverse fractures, require different shaping strategies from those applied to primary blanks. The width and thickness 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 the triangular hogback beaks. For this reason, identification of hogback manufacture can be difficult in assemblages containing a high percentage of reworking flakes.

The 'truncated blade' (Witter 1985: 87) is another common form of reworking flake. These are commonly produced from the reduction of quadrilaterally flaked pieces using the side or face as the striking platform, where flake termination carries through the width or thickness of the piece detaching two corners. These flakes are valuable because measurement of length provides evidence of the width or thickness of the preform from which they were struck. This can be used as an index of the size and shape of preforms brought to or made at a site (Witter 1985: 86).

Other less common reworking flakes have a bifacially flaked corner at the lateral margin. Another type of fracture that only occurred in experiments during reworking is one Witter refers to as '*passé*' (1985: 71, 73). The more correct term is '*outrepassé*' or 'overpassed' (Tixier 1980). This term describes flakes struck from the transverse fracture plane of a broken preform piece but instead of a blade-like flake, a plunging termination is produced where the line of fracture curves down deeply, almost coming back on itself but generally terminating at a right angle (see Fig. 1). A consequence of this is that vital length is removed. Such a fracture inevitably leads to abandonment of the piece. In experiments the use of too much hammerstone force was the probable cause of these flakes. This probably also explains their occurrence in most of the archaeological assemblages described below.

Symmetrical pieces broken at a late stage of manufacture were selected for reworking experiments primarily because of their greater potential for successful reworking with the minimum of effort and risk. Many were from large quadrangular preforms which provided the greatest length. Analysis of archaeological specimens suggests that a similar selection process was carried out by Maori adze makers of old.

Flakes were modified to form a range of flake tools including an array of points and flakes which have edge damage indicative of use wear. Experiments are currently being conducted on the functions to which these tools were put. As with the reworking flakes, these are not included in the surface characteristics or shape data as the modification they have received alters their original status in these categories.

Adze flakes have hammer dressed and ground surfaces produced from the repair and reshaping of finished adzes, not from preform production. Their presence and frequency indicate the degree to which these activities have taken place at a site.

Finally, striking platform angles were measured on a representative sample of flakes from all sites, following the method used by Shawcross (1964) and Jones (1972).

ARCHAEOLOGICAL DATA SETS

The flakes from 15 sites were selected for final analysis (see Fig. 2 for site locations)[2]. Moore (1976: 87) reviewed Tahanga basalt use in East Coast Coromandel sites and

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[2]The lithic samples from Tairua and Skipper's Ridge I and II could not be included because many of the smaller flakes had been lost since initial analyses were reported (Bellwood 1969; Davidson 1975; Jones 1972; Smart and Green 1962). Moreover, some excavated assemblages were too small for FAA analysis because of small excavation areas and selective retention in the field.

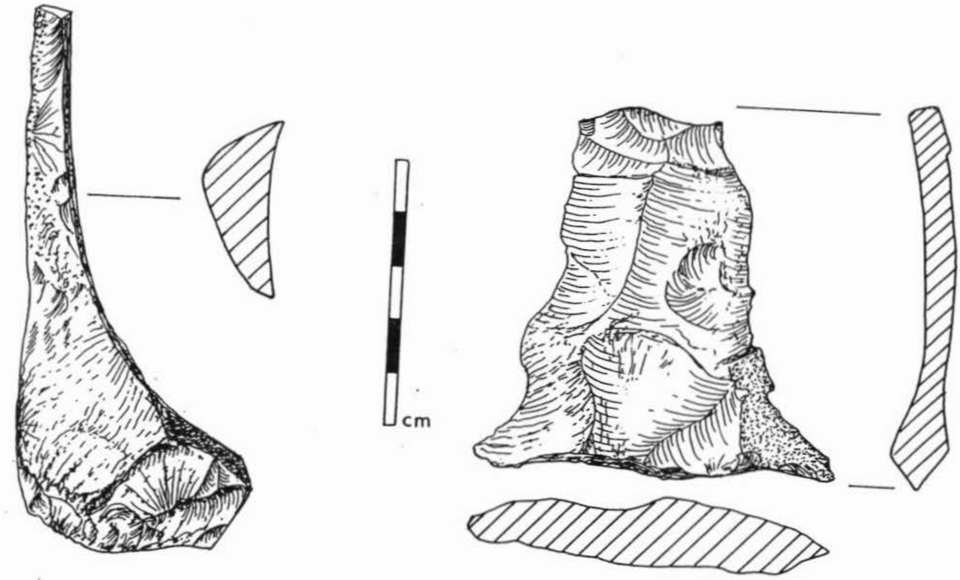

Figure 1: Right: 'Truncated blade' flake from Whitianga. Left: *Outrepassé* flake from replication experiments.

concluded that "adze manufacture was one of the main occupations...[and]...the whole of this coast then can be regarded as a major industrial centre". Research on Tahanga basalt has been extended to include sites in the eastern Bay of Plenty and Tauranga Harbour areas. The K. Fletcher Collection in the Whakatane Museum contains assemblages of Tahanga flakes from Pilot Bay at Mount Maunganui and other sites in the area. These include fine trimming and reworking flakes. Unfortunately only a selection of the waste flakes has been retained so the sample could not be included in the present analysis. The Jolly collection from Bowentown was intact and quite substantial. It is listed below.

Seven of the major working floors around the Tahanga quarry were chosen for surface flake analysis and data were collected on at least 500 flakes from each site. In addition, a representative sample of flakes from the 1990 excavation of a working floor at T10/459 (Kronqvist 1991) is included to facilitate comparison between surface and excavated assemblages.

Table 1 provides details on site location and context of the archaeological flake assemblages. It is likely that all were early settlement sites. Radiocarbon dates have been obtained from the majority of those excavated and the surface collections were clearly derived from very similar sites (see Moore 1976). All sites are likely to have been occupied before A.D. 1500.

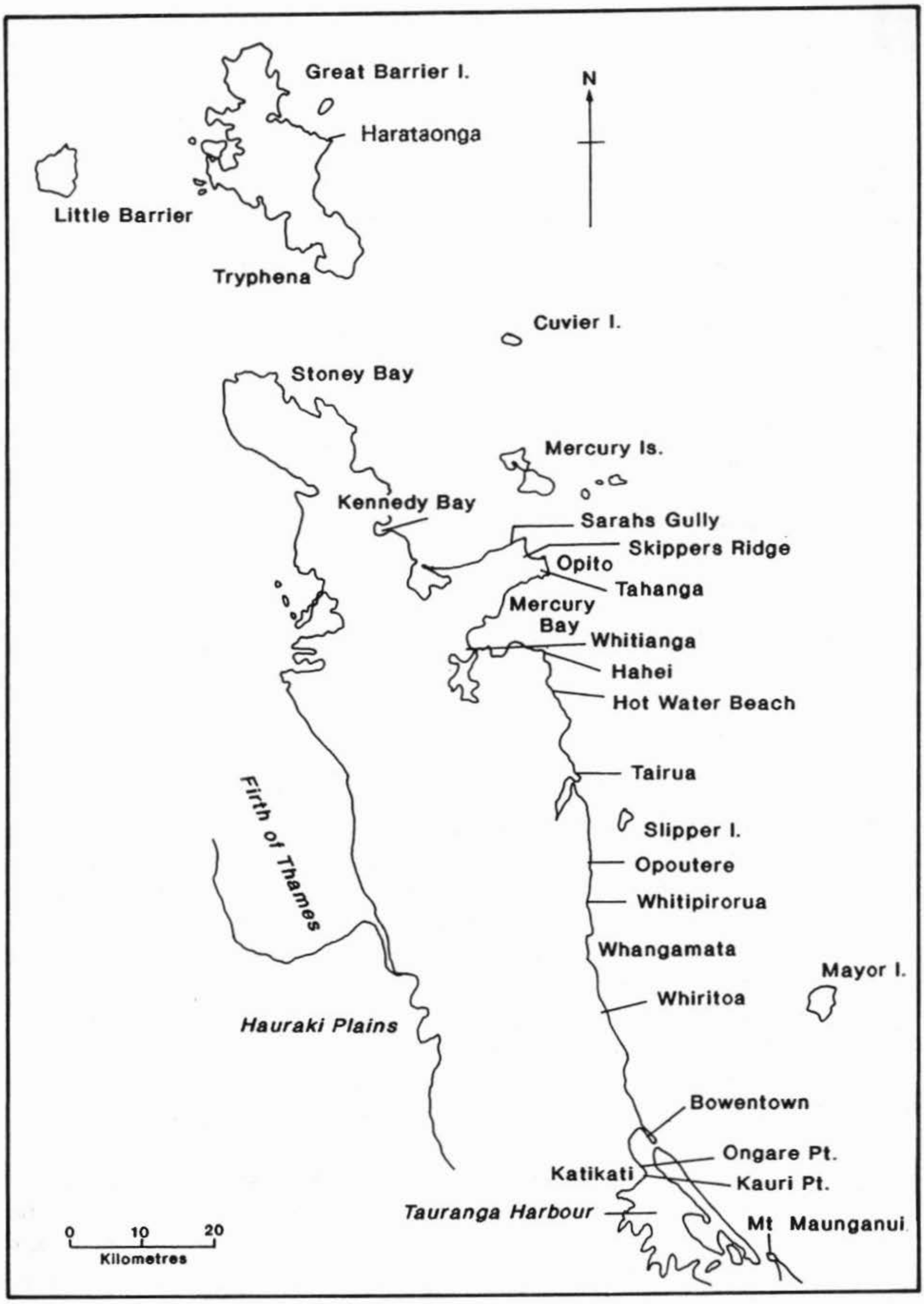

Figure 2: The Coromandel Peninsula and Great Barrier Island, showing places mentioned in the text.

TABLE 1

LOCATIONS MENTIONED IN THE TEXT

Site No.	Place and Code	Source of Data	Site Type	Context	Flake N
T10/166 etc.	Tahanga (TQ)	Turner 1992	Quarry	Surface	4706
T10/459	Tahanga	Kronqvist 1991	Quarry	Excavation	446
T10/940	Opito Bay	Turner 1992	Working floor	Test trench	11359
T10/159	Opito Bay	Green 1963	Beach midden	Excavation	575
T10/399	Cross Creek (CC)	Sewell 1984	Beach midden	Excavation	1960
T10/690	Whitianga (WH)	-	Harbour midden	Surface coll.	24567
T11/326	Hahei (HI)	Harsant 1985	Beach midden	Excavation	5022
T11/115	Hot Water Beach (HWB)	Leahy 1974	Beach midden	Excavation	909
Home Bay	Slipper Island (SI)	Rowland 1975	Beach midden	Excavation	910
T12/20	Opoutere (OP)	-	Harbour midden	Surface coll.	1309
T12/16	Whitipirorua (WP)	Furey 1990	Beach midden	Excavation	3435
T12/3	Whangamata (WM)	Shawcross 1964	Harbour midden	Exc.& Surface coll.	2040
T12/500	Whiritoa (WO)	Crosby 1977	Beach midden	Surface coll.	1923
U13/877	Bowentown (BT)	-	Harbour midden	Surface coll.	4186
N03/59	Mt Camel (MC)	Roe 1969	Harbour midden	Excavation	918

EXPERIMENTAL DATA SETS

Blank production (BP). Thirteen boulders ranging from 1,000 to 20,000 g were broken up to produce blanks. A large number of the flake blanks produced from this process were used in adze manufacturing experiments. N = 1,740 flakes (not flake blanks).

Experiment F. The flake blanks used for adze manufacture in these experiments were derived from a boulder of poor flaking quality. Thirty flake blanks from 500 to 5,000 g were selected. Seven were successful, 10 were rejected while attempting to rough out the shape of the adze, and 13 while refining the shape of the adze by fine trimming. These data are included to enable comparison of flake characteristics produced from good and poor quality stone. N = 1,814.

Experiment G. This series of experiments involved the manufacture of adzes from 53 small to medium flake blanks (250–2,000 g). Seven of these attempts were successful, 27 were rejected during the roughing out stage and a further 19 during the fine trimming stage. N = 2,340.

Experiment H. These experiments concerned the use of cobble blanks (cores). At Tahanga these were the major source of blanks for large adzes, particularly those of quadrangular form (see Turner 1992: 127–129). Thirty-three adzes were attempted of which 7 were successful, 17 rejected during roughing out and 9 during fine trimming. N = 2,949.

Flake blank roughing out (ROFL). These flakes were derived from 20 experiments in the 'G' series where preforms suffered transverse fractures within 10 minutes of roughing out, thereby isolating these flakes to that stage. N = 602.

Cobble blank roughing out (ROCOB). These flakes were derived from 10 preforms in the 'H' series which broke within 15 minutes of roughing out. N = 621.

Flake preform fine trimming (FTFL). These flakes were derived from 20 preforms where fine trimming flakes were collected separately from the roughing out flakes. N = 432.

Cobble preform fine trimming (FTCOB). The flakes from the fine trimming stage of 44 large cobble preforms were kept apart from roughing out flakes in a separate series of experiments. N = 2,677.

Final trimming and edge straightening (ES). Three large preforms received further fine trimming after the conclusion of these experiments. This enabled the collection of flakes from the final flaking process. N = 50.

Experiment total (ET). This is the sum total of flakes from adze manufacturing attempts. This involved 116 experiments: 83 from flake blanks and 33 from cobble blanks. These data do not include edge straightening, blank production, the separate series for cobble preform fine trimming or reworking data. N = 8,758.

Reworking of broken preforms (RWPF). Forty-seven experiments were conducted using preform pieces which had sustained transverse fractures but were symmetrical enough for remodelling into smaller adzes. N = 798.

Reworking of broken adze (RWA). This experiment was undertaken when a large adze of Type 1A (Duff 1977) fractured transversely while the tang was being hammer dressed. The adze was well ground with the blade formed. Both pieces were reflaked into smaller adzes. Reworking of broken pieces from adzes like this occurred in the past, and adze flakes are often present with waste flakes from manufacture at habitation sites. The 1A was reworked to observe the number of flakes produced without evidence of hammer dressing and grinding; that is, how many flakes from reworking and repairing broken adzes resembled the waste flakes from adze manufacture? Adze manufacture is generally identified from the presence of 'waste' flakes. However, it is possible that their frequency compared with the frequency of adze flakes is the significant factor. N = 66.

Point manufacture (PMb = before manufacture, PMa = after manufacture). Although adzes were certainly the major item manufactured from Tahanga, waste flakes at secondary adze production sites were sometimes used for other purposes. Drillpoints, awls and other flake tools have been recorded from many Coromandel east coast sites, including Whangamata (Shawcross 1964), Skipper's Ridge I and II (Davidson 1975; Bellwood 1969), Hot Water Beach (Leahy 1974), Hahei (Harsant 1985) and Whitipirorua (Furey 1990).

The authors made 100 attempts to make drillpoints and larger hand held points (awls) from Tahanga waste flakes in order to establish how the manufacture and use of these items affects the flake distributions. The debitage at these sites cannot be interpreted as deriving purely from adze manufacture. The number of flakes and pieces over 2 g produced during these experiments was 89. Data are given from before and after experiments.

Damage experiments (Db = before damage, Da = after damage). The question this experiment addressed was: can modification which occurs from manufacture and use of flake tools be distinguished from that which occurs as a result of flake dumping, trampling or other forms of accidental damage? Are some flakes more vulnerable to damage than others? Two archaeological assemblages, Opoutere and Whitianga, have many broken flakes with aberrant damage patterns, the causes of which were difficult to identify. They could be deliberate actions or accidents. To test this latter possibility 100 flakes were trampled and tossed on to a hard surface. They were then re-examined. After the experiment, the number of flakes over 2 g was 122. Data are presented from before and after experiments.

The total experimental flake total = 12,409.

DATA PROCESSING

In the initial sorting process, reworking flakes and those with hammer dressing and grinding were separated from waste flakes produced by primary adze manufacture. Calculations were then made based on experimental data to estimate the degree to which activities represented by these flakes were carried out. For example, in preform reworking experiments only 25 percent of flakes were distinctive as deriving from this process. The remainder resembled waste flakes. In another case, 50 percent of adze reworking flakes had no traces of hammer dressing and grinding on them. Therefore an assemblage with 50 percent of flakes showing grinding and hammer dressing will indicate that the site's occupants were repairing and remodelling adzes, not manufacturing them.

Table 2 shows the distribution of special flake types after these calculations have been made (an example of this calculation is included for the Whitianga assemblage). Only when considering size were all flakes examined as one assemblage. After this, reworking, adze and modified flakes were analysed separately.

TABLE 2

ADJUSTED BREAKDOWN OF PROCESSES INDICATED BY FLAKE DATA

Site	**N**	**% Waste**	**% RWPF**	**% RW Adze**	**% All Mod**
TQ	4706	100.0	0.0	0.0	0.0
940	11359	82.8	16.1	1.0	3.0
Opito	575	93.7	6.2	0.0	0.0
CC	1960	77.4	18.5	4.0	24.2
WH	24597	62.7	33.0	4.2	25.6
HI	5022	63.0	25.8	11.0	4.0
HWB	909	67.3	17.0	15.6	2.8
SI	910	79.4	19.2	1.3	3.8
OP	1309	48.2	39.1	12.6	36.2
WP	3435	58.7	30.4	10.8	10.5
WM	2040	47.7	46.0	6.1	28.7
WO	1923	69.7	22.4	3.9	7.0
BT	4186	39.5	41.8	19.7	18.1
MC	918	8.4	5.6	83.6	4.3

TABLE 2 Continued:

Total archaeological flakes = 64,265
N = 24,567.
Distinctive reworking flakes = 2,028 (8.2%).
Hammerdressing and grinding flakes = 517 (2.1%).
Waste flakes = 22,022 (89.6%).

However, from observations of experimental results, 75% of the flakes produced as a consequence of reworking broken preforms, and 50% of those resulting from the reworking of broken adzes, are disguised in the flake data. The following adjustment therefore, is a more realistic representation of the frequency of these events:

N = 24,567.
Reworking flakes: 2,028 x 4 = 8,112 = 33% of 24,567.
Hammerdressing and grinding flakes: 517 x 2 = 1034 = 4.2% of 24,567.
Waste flakes = 22,022 - 6601 = 15,421 = 62.7% of 24,567.

DISCUSSION OF RESULTS

SIZE (Table 3)

The Tahanga quarry flake size distribution is most similar to the experimental distribution of flakes produced during the roughing out of large cobble preforms (ROCOB), particularly in the relatively high frequencies of large flakes. The size data suggest that the primary stage, that of roughing out the basic shape of the blank, was the predominant adze manufacturing activity there. Only rare examples of Size 1 and 2 flakes and only a small number of Size 3 flakes appear at sites away from Opito Bay. This suggests that considerable reduction of adze blanks occurred at the quarry. Experimental flake distributions show that at the fine trimming stage 75 percent of all flakes produced are small (Size 6). The experimental data for fine trimming do not include flakes from preceding stages. The archaeological data show that sites away from the quarry have frequencies of Size 6 flakes approaching and frequently exceeding 75 percent. This indicates that roughing out was confined to the quarry. Reworking also produced high frequencies of small flakes.

DORSAL SURFACE CHARACTERISTICS (Table 4)

The experimental data show that even during the fine trimming stage a considerable number of flakes are cortical. This suggests that the presence of cortex alone is not a reliable indicator of stages of adze manufacture. At the other extreme, OS flakes become numerically dominant only during reworking and in the fine trimming and edge straightening processes, but only when roughing out flakes are absent.

TABLE 3

SIZE AND STRIKING PLATFORM ANGLE

Site/ Experiment	**S1 & S2 (%)**	**S3 (%)**	**S4 (%)**	**S5 (%)**	**S6 (%)**	**SPA Degrees**	**N**
BP	10.2	8.1	14.8	22.3	45.5	68.0	1740
17	1.3	4.0	4.7	24.8	65.1	74.0	8825
Exp. F	1.1	2.0	3.8	28.3	64.6	72.5	1814
Exp. G	0.0	3.1	5.9	27.1	63.7	73.1	2340
Exp. H	5.2	4.9	4.8	26.5	58.4	77.6	2949
ROFL	0.0	4.3	4.1	31.7	59.6	72.4	602
ROCOB	12.6	12.4	13.0	22.2	39.7	75.5	621
FTFL	0.0	1.3	2.6	21.7	74.3	78.1	432
FTCOB	0.1	0.5	1.1	13.4	84.7	81.6	2677
ES	0.0	0	0.0	7.0	93.0	86.0	50
RWPF	0.7	2.3	5.0	12.0	79.6	80.6	798
RWA	0.0	0.0	0.0	0.0	100.0	86.5	66
Mb	0.0	2.0	17.0	67.0	14.0	ND	100
Ma	0.0	1.1	0.0	12.3	86.5	ND	89
Db	0.0	1.0	7.0	33.0	59.0	ND	100
Da	0.0	0.9	2.1	24.5	72.3	ND	122
TQ	9.3	8.9	16.3	25.4	40.0	73.4	4706
T10/459	7.0	3.0	14.0	27.0	49.0	75.9	446
T10/940	2.2	5.4	6.3	24.7	61.2	80.5	11359
Opito	0.5	0.6	1.1	20.9	76.8	85.7	575
CC	0.1	0.8	3.3	12.3	83.4	81.8	1960
WH	0.2	0.2	1.0	17.4	81.1	83.9	24597
HI	0.0	0.0	0.6	8.1	91.2	85.1	5022
HWB	0.0	0.4	4.7	22.4	72.3	88.3	909
SI	0.0	0.5	1.1	11.5	86.7	82.6	910
OP	0.0	1.1	3.0	14.0	81.7	83.4	1309
WP	0.0	0.3	1.1	17.1	81.0	81.0	3435
WM	0.0	0.2	0.6	14.6	84.5	84.7	2040
WO	0.0	0.2	1.1	14.4	84.3	81.1	1923
BT	0.0	0.5	1.1	17.4	80.8	83.2	4186
MC	0.0	0.5	2.1	27.6	69.5	84.5	918

TABLE 4

DORSAL SURFACE CHARACTERISTICS[1]

Site/ Experiment	CO (%)	CP (%)	CS (%)	OO (%)	OP (%)	OS (%)	All Cor (%)
BP	35.5	15.2	0.0	2.1	44.4	2.8	50.7
ET	18.2	27.3	3.4	7.7	32.3	10.9	48.9
Exp.F	10.7	14.3	4.8	9.7	50.5	9.9	29.8
Exp.G	22.2	16.9	5.7	12.4	32.8	9.8	44.8
Exp.H	24.2	33.1	8.0	0.0	24.6	10.0	65.3
ROFL	24.9	33.4	6.3	0.0	31.2	3.9	64.6
ROCOB	33.3	40.0	4.8	0.0	17.6	4.2	78.1
FTFL	6.1	14.7	9.4	5.0	39.2	25.4	30.2
FTCOB	1.6	4.6	7.9	0.8	16.7	68.1	14.1
ES	1.0	6.0	3.0	0.0	21.0	69.0	10.0
RWPF	0.0	2.5	6.2	0.3	15.9	74.9	8.7
RWA	0.0	0.0	0.0	0.0	30.2	69.7	0.0
TQ	23.0	23.3	2.1	10.2	32.3	9.0	48.4
T10/459	20.4	27.2	3.3	0.0	39.6	9.3	50.9
T10/940	2.3	8.1	15.8	0.0	6.7	66.8	26.2
Opito	1.1	5.7	9.2	1.1	15.8	67.0	16.0
CC	1.5	4.7	6.1	2.2	15.4	69.8	12.3
WH	1.4	5.2	5.1	1.0	16.3	70.9	11.7
HI	1.3	6.0	7.4	1.5	13.4	70.0	14.7
HWB	1.2	5.9	6.1	1.0	17.0	69.0	13.2
SI	1.0	7.9	8.8.	2.1	19.5	60.6	17.7
OP	3.4	9.8	8.2.	0.3	14.4	63.7	21.4
WM	1.1	4.4	8.2	1.9	11.4	72.8	13.7
WP	2.4	6.2	7.1	2.2	15.6	66.2	15.7
WO	1.1	5.7	7.8	0.7	10.6	73.9	14.6
BT	1.2	5.1	9.8	0.7	10.3	72.6	16.1
MC	0.5	2.4	9.7	0.7	10.5	76.1	12.6

1. See Table 3 for number of flakes in each site or experiment.

The Tahanga quarry flake distribution is most similar to the experimental total, suggesting that some minor initial fine trimming was undertaken there. The high percentages of OS flakes at sites T10/159 and T10/940 close to Tahanga suggest that adze manufacturing processes there were more akin to what was undertaken at sites further away. This accords with the flake data for size, indicating that while some roughing out was taking place at these two Opito Bay sites the emphasis was on the later stages of adze production. The flake distribution in the Coromandel east coast group of sites as a whole reflects an emphasis on the latter stages of fine trimming with OS frequencies boosted by subsequent reworking after some preforms suffered a transverse fracture.

In summary, both size and dorsal surface characteristics support the probability that the early stages of adze manufacture occurred almost exclusively at the Tahanga quarry. There is little evidence to suggest that unmodified stone or blanks were removed from the quarry and transported to other sites.

STRIKING PLATFORM ANGLE (Table 3)

At Tahanga the average striking platform angle (SPA) for flake blanks was 66° and for flakes it was 73°. These are very similar averages to the replication experiment data for blank production (68°) and the experimental total (74°). The average SPA for T10/940 was 80.5°. Significance tests (T-tests) established that there were real differences between the three archaeological samples. This suggests that angles increased through the stages of manufacture of most forms of adzes (the rare Duff (1977) Type 3 being an exception). In the experimental data sets, however, a significant difference was found only between the roughing out (73°) and the final trimming and edge straightening stages (86°). Significant differences were evident between the quarry and all other sites. This further supports the data above in establishing that at the quarry roughing out was the predominant manufacturing activity (where angles are generally low) while at other sites the later stage of fine trimming was the major process (where angles are generally high). High striking platform angles are also associated with a high degree of skill; the lower the SPA the easier it is to detach flakes while preserving the striking platform. The high angled quadrilaterally flaked preform pieces common at T10/940 represent a high degree of skill (the converse, that low angle percussion implies low levels of skill, is not necessarily true). Particularly toward the final trimming stages, striking platform angles come within the range of 90° in order to create the almost square cross-sections characteristic of the Tahanga 1A type (see Turner 1992: 125, 126 for examples from T10/940). The 'truncated blade' reworking flakes in particular are evidence that these preforms were being brought to, and worked on at, sites away from the quarry. This evidence, coupled with the high striking platform angle averages, makes it abundantly clear that high skill levels were involved.

SHAPE AND TERMINATION (Table 5)

Flake shapes cannot be readily related to specific stages of manufacture. However, they can identify various processes. The experimental flake total provides distributions in an assemblage which has suffered no post depositional damage. It included low frequencies of broken flakes (C and D) compared with most archaeological assemblages. The roughing out of large cobble preforms produced the highest numbers of broken flakes in experiments, apart from blank production, and this may be reflected in their more frequent occurrence at Tahanga, including the excavated sample from T10/459. Otherwise the experimental flake total is comparable to the quarry flake sample, giving expected flake shape frequencies for assemblages derived purely from primary adze manufacture. An example of this is the frequency of A flakes where percentages between 10 and 20 can be seen as falling within the normal expected range. As mentioned above, these flakes with step and hinge terminations generally result from difficulties encountered during flaking. Initially two factors were thought to be involved; poor quality raw material (as in Experiment F with 30 percent A flakes), or low skill levels. The stone quality of the flakes at sites away from the quarry was generally higher than at the quarry itself. This stands to reason. In experiments, poor quality blanks generally broke during the early stage of roughing out and there was evidence for this at Tahanga (see Turner 1992). It is probable, therefore, that only well shaped preforms of high quality would be removed for further work elsewhere.

TABLE 5

SHAPE AND TERMINATION[1]

Site/ Experiment	A (%)	B (%)	C (%)	D (%)	E (%)	F (%)
BP	15.0	22.5	38.3	10.2	9.8	4.0
ET	17.6	45.5	5.1	3.2	8.6	19.9
Exp.F	30.2	32.5	3.0	2.3	9.1	22.7
Exp.G	16.3	32.8	5.1	1.2	18.4	26.1
Exp.H	16.6	42.3	8.7	1.7	10.9	19.6
ROFL	21.3	31.3	2.1	3.5	16.7	25.0
ROCOB	22.6	37.3	10.1	3.4	9.2	17.3
FTFL	14.6	49.1	2.1	1.5	11.0	21.6
FTCOB	22.1	36.1	1.7	16.9	6.6	16.2
ES	13.0	71.0	0.0	0.0	2.0	13.0
RWPF	3O.9	30.0	6.3	5.4	18.1	10.1
RWA	12.0	50.0	0.0	0.0	20.0	18.0
Mb	4.0	40.0	0.0	0.0	28.0	28.0
Ma	27.9	18.3	11.4	14.6	18.8	8.7
Db	6.0	50.0	3.0	0.0	21.0	20.0
Da	33.4	0.8	10.3	40.6	6.5	8.2
TQ	13.2	44.6	14.1	4.4	7.8	15.8
T1O/459	11.5	51.3	12.4	6.1	5.2	13.5
T10/940	12.8	49.6	6.3	2.1	15.8	13.1
Opito	18.0	41.3	9.6	9.1	10.9	10.0
CC	29.1	29.9	4.2	13.5	9.6	13.5
WH	38.4	24.8	6.7	18.7	6.2	5.0
HI	18.5	31.6	8.6	19.4	9.7	11.9
HWB	16.3	46.6	8.2	11.1.	10.7	7.0
SI	18.0	41.5	9.0	14.5	9.5	7.5
OP	38.3	19.4	4.6	18.5	8.4	10.4
WP	22.7	53.4	0.6	1.2	12.2	9.8
WM	35.0	29.8	8.7	11.6	7.5	7.1
WO	20.0	33.5	7.0	12.1	15.2	12.0
BT	39.5	21.7	7.5	11.0	9.5	10.5
MC	21.8	35.2	8.7	10.3	16.6	6.4

1. See Table 3 for numbers of flakes in each site or experiment.

The issue of skill has already been addressed. Sites with high frequencies of A flakes, such as Whitianga, also had high striking platform angle averages indicating that lack of skill was not a factor.

Reworking also resulted in a higher than average frequency of A flakes (31 percent). This may be related to the difficult high angled flaking required to reshape the broken piece combined with the bold strokes and heavier hammer blows more commonly associated with roughing out. These actions often caused flakes to snap transversely and laterally on impact which increased frequencies of A, C and D flakes.

The deliberate modification of waste flakes into flake tools, generally by retouching one or two edges, also resulted in high frequencies of A, C and D flakes. As with adze manufacture, the process of retouching edges involves a high risk of transverse fracture which often leaves at least one half of the flake without signs of modification. It then resembles either an A type waste flake, if it is the proximal end, or a D/C type waste flake, if it is the distal end. The trampling experiments resulted in a sharp increase in A flakes and very high frequencies of D flakes. Ironically, as seen in both sets of experiments, B flakes were both the most desirable flake shape for conversion into a range of flake tools and, because of their fine feathered margins and generally thin elongated shapes, the most vulnerable to accidental breakage.

Deviation from the normal distribution is strikingly apparent in some of the archaeological assemblages. The frequencies of A flakes at Whitianga, Opoutere, Whangamata and Bowentown are higher than any generated in the experimental programme. To understand this phenomenon it is necessary to review the data in Table 2.

In experiments it was found that processes of flake reworking, accidental damage and modification into other tool types were probable causes of high A frequencies. Table 2 shows that all sites away from the quarry contained evidence of processes other than the final flaking stages of adze production. People at all sites apart from Tahanga were reworking broken adzes and/or preforms and at all but T10/159 at Opito some modification of flakes was occurring, although the degree to which these processes were undertaken varied from site to site. There is a correlation between frequencies of A flakes and modified flakes suggesting that flake modification was the major cause.

Reworking of broken preforms is another likely cause of higher frequencies of A flakes, although sites such as Hahei and Whitipirorua have relatively high proportions of reworking flakes along with frequencies of A flakes which fall within the normal distribution. However, sites with high frequencies of both reworking and modified flakes have the highest frequencies of A flakes, suggesting that both processes were involved. There is a weaker correlation between frequencies of A and broken flakes. Whitianga and Opoutere have high frequencies of A, C and D flakes but at Whangamata and Bowentown C and D frequencies are similar to those with normal A flake distributions. Nevertheless all sites, except Whitipirorua, have quite high frequencies of C and D flakes. It is likely that reworking and flake modification, rather than accidental post-depositional damage, caused this.

Tahanga basalt weathers from dark to light shades of grey, making fresh damage easy to identify. Generally flake assemblages were in good condition and freshly broken flakes were not included in the data. Broken edges on C, D and A flakes had the same patina as the rest of the flake surface suggesting that breakage had occurred at the time of detachment or shortly after. Trampling and throwing experiments addressed the latter situation. Tahanga basalt is a tough rock and even the most fragile B type flake endured considerable punishment on hard concrete before breakage occurred. It is difficult to envisage situations in pre-European contexts that would have caused such damage. The working floors at Tahanga are constantly trampled over by livestock and flakes are frequently displaced down steep slopes with little damage resulting. There is some archaeological evidence in the Coromandel beach midden sites that flakes were collected up and dumped elsewhere (as for example Hahei; Harsant 1985: 17) but from experimental evidence, flake damage resulting from this activity would have been minimal. It is, therefore, highly probable that flake breakage was a consequence of deliberate practices such as those mentioned above.

REWORKING FLAKES

Table 2 shows that reworking, particularly of broken preforms, was undertaken at all sites except the quarry itself. Even at T10/940 and T10/159, sites at the base of Tahanga which are within a stone's throw of good quality basalt, reworking was a minor component. The premise that conservation of raw material increases over distance is supported to some degree. Certainly at Opito Bay close to the quarry, conservation, as reflected in the reuse of broken pieces, was minor in contrast to Mount Camel 350 km away where reworking was the major process. In the sites belonging to the Coromandel east coast group, however, the degree of reworking is variable. It accounts for between 25 and 50 percent of all flakes produced. This does represent quite substantial investment in the reuse of broken pieces when, for most of these sites, Tahanga was a local source.

Experimental results provided information on the effort and time required for adze manufacture and on success to failure ratios. Small flake preforms took an average of 30 minutes to reach the final trimming stage, but the roughing out of large cobble preforms could take over an hour, with fine trimming occupying several hours more. In adze manufacture where the flaking technique is employed, production levels are low. Investment of time and energy is not necessarily rewarded, because of the unpredictable problem of transverse fracture. At Tahanga, as in experiments, it was a major cause of preform rejection and failure (see Turner 1992). The experimental result of an 80 percent failure rate is probably higher than that of the early adze makers who had generally better quality stone to work with, but it does indicate that the majority of adze making attempts were doomed to failure. The probability of transverse failure increases as preform mass decreases and where thickness and width become disproportionate to length (Turner 1992). The fine trimming stage carries a high risk factor, particularly during flaking of the blade and bevel on larger adzes. Therefore, it is probable that most, if not all, of the flaking occurred at the quarry. However, as the data suggest, many preforms were removed from the quarry and transported to habitation sites at a stage when the risk of breakage was highest. Other observations made by the authors at Tahanga and by the authors and other researchers at some of the Coromandel east coast sites help to clarify this situation.

Length is the variable that changes least through the manufacturing stages. Thus it is a useful measure when comparing preforms at different stages of production. The average length of 500 preforms examined at Tahanga was 18 cm and very few were under 10 cm. In contrast, most preforms found in the Coromandel east coast middens are described as small (under 10 cm), nondescript, and of unremarkable craftsmanship (Jolly and Green 1962; Leahy 1974; Davidson 1975; Boileau 1980; Harsant 1985).

The 'truncated blade' reworking flakes provide a quantitative indication of the sizes of preforms that were imported to the Coromandel east coast sites at the fine trimming stage. This is illustrated in Table 6.

TABLE 6

'TRUNCATED BLADE' REWORKING FLAKE LENGTHS

Site/Experiment	**Number**	**Average Length (cm)**	**Range (cm)**
Reworking experiment	59	4.37	9.6–2.0
T10/940	65	5.68	12.0–3.0
Cross Creek	24	4.85	11.9–2.8
Whitianga	275	4.37	9.9–1.8
Hahei	52	3.15	5.8–1.2
Opoutere	31	4.60	9.1–2.6
Whitipirorua	84	3.24	6.4–1.1
Whangamata	38	4.51	7.5–2.2
Whiritoa	29	3.67	5.1–2.0
Bowentown	67	3.80	6.3–1.8

Note: The data from some sites have been omitted because of small sample size; also, these reworking flakes are vulnerable to transverse fracture on impact, thereby decreasing the number that could be included in the sample (complete flakes only).

The Opito and Mercury Bay preform caches, with the preforms from T10/940 and a small sample from Opito in the Whakatane Museum, enable us to gauge the size and type of preforms these flakes were detached from, particularly those in the large size range.

The Opito Bay cache was found with a burial (Olsen 1980: 173). It comprises 14 preforms, all large unbroken specimens ranging between 21.5 and 32 cm. Eleven are of the 1A type (Duff 1977) while the other three are hogbacks. The majority were at an early fine trimming stage, indicating that they had just been removed from the quarry. Some are better formed than others but most required considerable further trimming, especially in reduction of thickness and in bevel and blade straightening. It is likely that some would not have survived to undergo the finishing processes of hammer dressing and grinding. Average length was 28.8 cm while average thickness was 5.8 cm (range 9.5–5 cm).

If the Opito cache represents a group of large preforms fresh from the quarry, the Mercury Bay cache represents the other end of the spectrum. These are preforms of similar form and size that have survived the risky stage of fine trimming and are undergoing the more laborious process of hammer dressing. Ten of the 11 preforms are large 1A types with an average length of 28.6 cm and average thickness of 6.1 cm.

Sixty-one broken preforms from T10/940 are of the 1A type and are at an advanced stage of manufacture. The majority have received considerable quadrilateral bi-directional fine trimming. Estimates from remaining portions (usually halves) gave an average length of 26.5 cm and an average thickness of 4.9 cm. A small group of seven large 1A preforms at a similar stage of manufacture from Opito Bay (now in the Whakatane Museum) had suffered transverse fractures, but all pieces were recovered and refitted. Average length is 26.6 cm and average thickness 4.8 cm. In reworking experiments, the average length of complete preforms before breakage was 24.8 cm with an average thickness of 5.2 cm.

It is clear from comparison between these preform data and Table 6 that large preforms, possibly at a similar stage to those in the Opito Bay cache, were transported to the Coromandel east coast sites. When a substantial number suffered transverse fracture, the pieces were still long enough for conversion into medium-sized adzes. Of significance was the much higher success rate achieved in reworking experiments (55.3% success compared with 20% for primary manufacture). This makes reworking a very viable strategy, one that very probably influenced the actions of the adze makers while they were at the quarry.

A likely scenario is that adze makers maximised their access to the raw material by boldly roughing out blanks to a desired shape but saved the more hazardous and time consuming task of fine trimming, particularly of large preforms, until they returned to their settlement, whether in Opito Bay or a day's journey away. Low production rates meant that time spent at the quarry had to be effectively used. Adze makers removed preforms from the quarry at the fine trimming stage knowing that many would break, but safe in the knowledge that from one broken preform two smaller ones could be made. Hence an emphasis at the quarry would be to try to produce a preform as large as possible. The strategy of reworking explains the difference in preform length, size and appearance between the quarry and other sites and gives a possible explanation of how many primary and well formed preforms were transformed into small scrappy reworked rejects after they had left the quarry and broken. Those that were reworked successfully were removed from the working areas leaving only the flakes as a clue to their former presence.

Reworking therefore conserves raw material and saves the time and effort which would otherwise be expended in returning to the quarry to prepare and rough out new blanks. It also negates the need to carry out the more time consuming stage of fine trimming at the quarry.

The reworking strategy adds a new dimension to the significance of the 'mega-adze' (Leach 1993: 39). It has been suggested that these large and well formed 1A adzes were prestige items and that their manufacture was under the control of specialists (Witter 1985; Leach 1990, 1993). It is true that large adzes are 'expensive' to make in terms of time, effort and skill and this is exacerbated by a high breakage rate. But reworking provides the means of capitalising on this expense, thereby freeing up adze makers to concentrate on their production because they can cut their losses later with an investment in smaller adzes. Additionally, with reworked portions providing small and medium-sized adzes, a return to the quarry would be necessitated only by the need to replace large adzes and forms such as the side-hafted adze (which, because of a generally broad blade, would be difficult to fashion from a broken piece; such has been the experience in our replication experiments). Thus the manufacture of large preforms may not have been a specialised activity reserved for adze makers with the highest levels of skill, but rather a central and essential component of adze production strategies both at the quarry and at the Coromandel east coast group of sites. This suggests that all adze makers were involved in their production.

This is not to say that the opportunity to rough out smaller but well formed flake blanks was passed up. In the initial roughing out of large cobble/core blanks many flake blanks are produced which are suitable for reduction into smaller preforms; these are common at Tahanga (Turner 1992: 132). It is clear from the preform data from sites away from the quarry that even the broken pieces from smaller preforms were reworked into chisels and gouges, if not adzes.

ADZE FLAKES

Reworking of broken adzes was also occurring at sites away from the quarry as indicated by frequencies of flakes with hammer dressed and ground surfaces. At the Coromandel east coast sites, however, this was a minor practice. The reverse is true of the Mount Camel flake data. Particularly in terms of its adze manufacturing evidence, Mount Camel is an anomaly. No other site outside the Coromandel area has produced such an abundance of Tahanga adze manufacturing debris. Tahanga flakes have been found at sites such as South Kaipara Head (Wilson 1991) and Ponui Island (Nicholls 1964) but only in minor quantities, and they are numerically overshadowed by local sources of rock such as Motutapu greywacke. Mount Camel is close to at least one local source of adze quality rock (serpentinite). This was quite extensively exploited in the whole of the Far North region except at the Mount Camel site where Tahanga flake, preform and adze assemblages dominated. In this and in the nature of other stone materials and artefacts found at the site, Mount Camel has much affinity with the Coromandel east coast group of sites except for the large distance that separates them and the lack of 'satellite' sites thus far discovered in between. Mount Camel, then, appears as an isolated outpost with probable close kinship affiliations to the Coromandel area (Best 1975; Davidson 1984). Analysis of the Tahanga flake assemblage from Mount Camel has, however, revealed one startling difference. A large proportion of the flakes (83.6 percent) are from the reworking of broken adzes not preforms. Only a mere 8.4 percent of flakes were produced from the fine trimming of primary preforms and the reworking of these is correspondingly low.

This is an important distinction when considering modes of distribution and control of Tahanga adze production. The data presented here cannot directly address the question of who had access to raw material at Tahanga. However, these data, combined with knowledge gained from the replication experiments, do suggest that the adze makers who roughed out blanks at the quarry were the same people who removed them elsewhere for final trimming. Preforms on which the flaking process is incomplete are not viable items of distribution, be it by exchange, trade or gifting. It has probably never been a common or recommended practice to acquire or give unfinished goods that have a high probability of breaking nor would it be any consolation to find oneself with two smaller adzes when a large one was needed. In the chain of adze production, the Coromandel east coast group of sites are on the same level as those at Opito Bay close to Tahanga. T10/159 and T10/940 were primarily involved in the same finishing flaking processes as the sites further south. Previous researchers (Leahy 1974; Moore 1976; Harsant 1985) have noted that the abundance of adze manufacturing debitage evident in the Coromandel east coast middens was such that it must represent large scale adze production for distribution elsewhere; the data described above support this likelihood. The sheer number of flakes recovered from the Whitianga site, for example, represents the fine trimming and reworking of literally thousands of preforms. No sites outside the Coromandel east coast area had the same production status; they were involved in the repair, reworking and maintenance of finished adzes but not in their manufacture, and this includes Mount Camel. Thus it is unlikely that the people at Mount Camel had direct access to the stone at Tahanga; instead their relationship to the people who did may have ensured a reliable supply of Tahanga adzes, much as the people at geologically impoverished Palliser Bay had confidence that the stone materials they needed could be imported from elsewhere (Leach 1978).

Finally, as expected, hogback 'beaks' proved difficult to identify in assemblages where reworking was a common practice. Probable specimens were few in number in almost all sites. This should not be interpreted as indicating an absence of hogback preforms and adzes as, in contrast to Riverton, such preforms were generally well represented in the preform data, albeit often in reworked form. From examination of the modified flakes a probable reason for this low occurrence can be given (see below). At the Tahanga quarry only nine hogback beaks were identified although preforms of this type were common. This supports the probability that preforms were removed from the quarry before beaks were detached.

MODIFIED FLAKES

Except at the quarry itself and at T10/159, Tahanga waste and reworking flakes proved a handy resource for a range of other tools. The authors disagree both with Bellwood (1969) regarding the modified Tahanga flakes at Skipper's Ridge II, and with Challis (1976) regarding the metasomatised argillite flakes at Riwaka Point, when they assert that the flake tools found at these sites were produced from blanks deliberately struck from prepared cores. At Riwaka Point, adze manufacture was taking place which would have provided waste flakes suitable for the range of tools evident at the site. The reworking process in particular would have produced adequate numbers of blades ideal for a variety of points. The requirement for larger flakes would have been anticipated and these, along with the preforms, may have been removed from the quarry, although in the Coromandel east coast sites, modified flakes fall within the same size range as waste flakes. Challis (1976: 484) also notes the presence of several 'argillite cores' which seems to support the probability that flakes were being deliberately produced for specific purposes. Similar 'cores' were produced from preform pieces during reworking experiments when 'outrepassé' fractures occurred. This is a more likely explanation for the specimens at Riwaka Point. At Skipper's Ridge II, adze manufacture appears to have been a minor activity, but an abundance of suitably sized and shaped flakes could have been scavenged from old sites nearby or at the quarry—there was no need to go to the extra effort of preparing them (which would have included going to the quarry for the raw material).

Familiarity with flakes resulting purely from primary adze manufacture made the identification of 'aberrant' specimens in archaeological assemblages quite straight forward. The largest and most distinct category of modified flakes were points ranging from large hand held reamers to drillpoints and tiny incising points. Another more problematic group were broken flakes with minor edge modification which may have resulted from accident rather than design. The trampling experiments addressed this and found that only 3 flakes of 119 could have been mistaken for broken pieces from modified tools. Conversely, 58.5 percent of flakes (over 2 g) produced during modification experiments resembled, and would have been classified as, waste flakes had the process from which they derived been unknown. Seventy-six percent of these were blanks which had suffered a transverse fracture during manufacture; in an archaeological assemblage these would have been classified as, and increased the frequencies of, A, C and D flakes.

Another problem was the suitability of some flake shapes for use as points and edges without requiring any modification at all. The 'truncated blade' reworking flakes, for example, often have ready made points at the corners where lateral and distal margins intersect (see Fig. 1). Undoubtedly they would frequently have been selected for point tools but because they lack visible proof of such utilisation their original status has to be retained. A contrasting problem is the likely selection of 'hogback' beaks for conversion into triangular drillpoints, which may explain their low representation in the archaeological data.

During this analysis we have erred toward the conservative and classified as modified only those flakes where deliberate modification was clear. Thus the data presented in Table 2 may be a serious under-estimation of the actual frequency of waste flake use that took place at these sites. Half the A flakes at sites such as Whitianga and Opoutere, for example, may have resulted from failed attempts to make points. The same could be said of the C and D flakes although the correlation of these with modified flakes is not as strong. If this was the case then close to half the flakes at Whitianga, Opoutere, Whangamata and Bowentown may indicate the manufacture of flake tools or attempts to make them.

From the variability evident in the types of modification and edge wear, a wide range of tools are represented in most sites. There is generally a bewildering variety of points—from those designed for gouging, drilling and reaming to others with short fine sharp points which appear designed for scratching or incising. Edge wear ranges from unifacial low angled chipping to bifacial high angled damage utilising all flake sizes and shapes. A small number of flakes also have ground edges. The variety of flake tools suggests their use in a range of activities or, alternatively, specialisation in one activity that requires such a range. Many of these tools have previously been associated with woodworking—canoe construction in particular (Knapp 1924). Research involving experimental manufacture and use of such tools is currently in progress to test this possibility.

An obvious link between four of five sites in which flake modification is most intensive is their location in inner harbours near harbour mouths. The other sites in the Coromandel east coast group are situated on open beaches. Inner harbour locations with their many resources were probably more secure and sheltered environments, particularly in winter during bad weather. Projects such as canoe construction would also have been more viable in this type of environment. The degree to which these Coromandel coastal sites were permanent habitations or temporary camps has not been resolved (Davidson 1984: 169). It is possible there was seasonal movement between open beach and inner harbour sites. It is interesting to note that for another inner harbour site, Tairua, faunal analysis supported winter occupation (Rowland 1975). Winter conditions may have confined people to their workshops and hearths for longer periods, during which they engaged either in the manufacture of a wider range of products than at the open beach sites, or more intensively in certain activities. This tenuous scenario needs to be corroborated by the analysis of other artefact types along with examination and comparison of the use of other raw materials and resources.

CONCLUSION

The humble flake has proved that it can hold its own with a story to tell when the signs can be read. Replication experimentation combined with constant cross-consultation of archaeological data has been a valuable aid to this end. At the Tahanga quarry the story is relatively straight forward. Two manufacturing stages predominated: the selection, testing and breaking up of parent material into blanks, and the roughing out of a proportion of these blanks to achieve the basic rough outline of the adze. Some preforms were shaped further; these were usually small flake preforms which did not require extensive fine trimming and thus took far less time to make. The differences in flake size distributions, in frequencies of cortical and OS flakes and in striking platform angles between the quarry and other sites provide firm evidence that sites away from the quarry were, in contrast, concentrating on more advanced stages of manufacture — refinement of adze shape and preparation for hammer dressing and grinding. These latter two processes were undoubtedly taking place at these sites also but, as they leave no debitage and only an occasional grinding or hammer dressing stone, little can be said about the degree to which they occurred.

In none of the flake or preform assemblages from the Coromandel east coast group of sites have we observed any evidence that unmodified raw material was being worked. There is good reason for this. The stone at any one source can exhibit remarkable variability and Tahanga basalt is no exception. During replication experiments it was discovered that the only sure test of soundness and quality was to break up the parent material. Flaws, flow layering and stubborn inclusions were often invisible until attempts were made to flake the rock. However, they were common problems in replication experiments. Similar problems are apparent from the Tahanga debitage (see Turner 1992). Secondly, upwards of 70 percent of the experimental blank weight was removed during roughing out. By carrying out these processes at the quarry the adze makers could leave this weighty rubbish behind and ensure that what they carried away was worth while. By the time the fine trimming stage was reached, problems with material quality and shape were usually solved, or else the preform was rejected because of asymmetry. The risk of a transverse fracture increased during fine trimming but the waste of time, energy and raw material which occurred was then minimised by the strategy of reworking.

Preforms were made as large as possible at the quarry as part of the reworking strategy, as transverse fracture of large preforms allowed smaller adzes to be produced from the broken pieces. In addition, saving most fine trimming for later meant that those working at the quarry had more time to search for optimal material. Increasing the quantity of large preforms produced at the quarry would increase the number that survived in primary condition once they were removed and finished at leisure. If small to medium-sized adzes could be procured from reworked pieces then the impetus to return to the quarry would come about when the need arose to replace large adzes and special types of adzes such as the 5A or side-hafted adze.

The manufacture of large adzes was a central element in adze production strategies which involved all adze makers, not an exclusive set. The large 'truncated blade' flakes prove that large and well shaped preforms were taken to Coromandel east coast sites, although those preforms are rarely found. Typically, the remnants are scrappy rejects where reshaping failed or resulted in a second transverse fracture. Only the flakes bear witness to their original size, form and state of manufacture.

The strategies used at the quarry and in the coastal sites were different but tightly linked. This indicates that the people finishing off and recycling preforms at sites such as Whitianga, Hahei and Bowentown also roughed them out at the quarry. During the replication experiments it was concluded that adze makers would probably not have exchanged, traded or gifted their preforms before the flaking stage was completed because of the ever present risk of transverse fracture.

Few sites beyond the Coromandel east coast have comparable Tahanga flake assemblages. Those that do, such as Mount Camel and South Kaipara Head, demonstrate major involvement in the repair and reworking of finished adzes but not in primary adze production. This suggests that only local and probably related groups of people had direct access to the stone. The abundance and nature of the adze manufacturing debitage found at their sites suggests production beyond local requirements.

An assumption is made here that these occupants were sedentary residents of the area. If they were just passing through the coastal areas on their way back from the quarry then all return journeys (and preforms/adzes) appear to be going down the east coast in a southerly direction when, as indicated by the distribution of finished Tahanga adzes (Best 1975; Moore 1976; current research by authors), the majority were shifted in a northerly direction.

The geographical range of sites with evidence of considerable primary adze production extends from Pilot Bay at Mount Maunganui in the south, to Ahuahu (Great Mercury Island) and Opito Bay in the north. It is probable that the northern extent included the tip of the Coromandel Peninsula and Great Barrier Island where similar assemblages and sites have been reported (Harataonga, Law 1972; Port Jackson, Foster 1983) but to date this has not been confirmed.

There is a lack of evidence of intensive adze production in sites along the northern part of the Coromandel east coast. This favours the likelihood that groups involved in adze production lived close to Tahanga, with access to obsidian and chert as well as resource rich harbours and offshore islands. The adze production gap to the north is in a more rugged environment which contains limited resources.

In summary, analysis of flake assemblages resulting from adze production has proved effective in identifying adze manufacturing techniques and strategies at the quarry and beyond. It would be useful to know whether similar strategies occurred elsewhere, within New Zealand and in tropical Polynesia. In the case of the Motutapu greywacke, for example, adze quality stone could be found on several islands in the Hauraki Gulf. This provides an interesting contrast to Tahanga. A plausible scenario has now been established for the Tahanga adze production complex. Similar studies elsewhere will provide valuable comparisons.

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