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Ateliers of basalt. Basalt industries of Tafuna (AS-31-150) and Pava'ia'i (AS-31-170), Tutuila Island, American Samoa

TOMO ISHIMURA and DAVID J. ADDISON

Keywords: basalt adze, industry, technological sequence, Tutuila Island, American Samoa

Abstract

We examine two basalt industry sites, one at Tafuna and one at Pava'ia'i, located on a Holocene lava and pyroclastic plain, several kilometers from potential adze-quality-basalt quarries. Statistical analyses of flakes from two discrete 'workshops' are used to reconstruct the adze production process at each site. The results show that while the Pava'ia'i site was a production site for adzes, the Tafuna site was both a production and reproduction site for adzes and scrapers. This suggests that the basalt-tool production system was diverse and multi-dimensional.

Tutuila was an adze production centre in the South Pacific (Best *et al*. 1992; Clark *et al*. 1997). Adzes made from the fine basalt of Tutuila were widely distributed in the region between the Solomon Islands and the Cook Islands (Figure 1) and have thus long been a major focus for understanding long-distance interaction in Oceania.

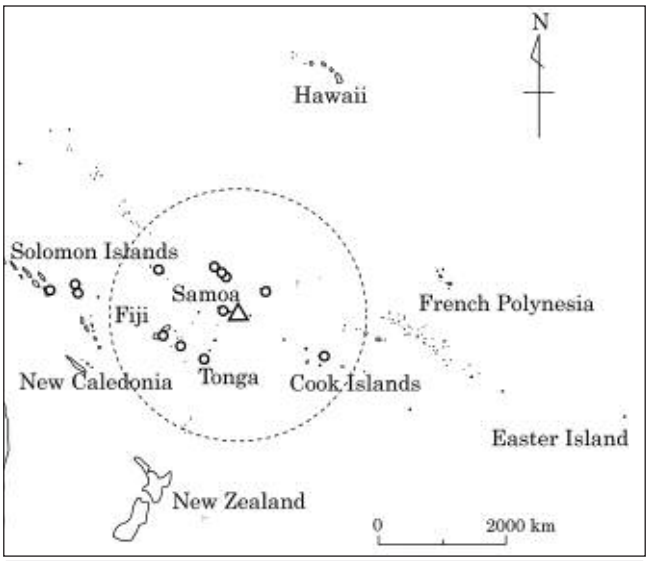

Figure 1. Distribution of Tutuila basalt adzes. Dotted line shows 2000-km-diameter circle centered on Tutuila. Open dots indicate sites with Tutuila basalt. (Modified from Best *et al*. 1992: 69; Fig. 9)

TI: National Research Institute for Cultural Properties, Nara; 2-9-1 Nijocho, Nara 630-8577, Japan. tomoishi@nabunken.go.jp; DA: Samoan Studies Institute, American Samoa Community College, PO Box 2545, Pago Pago, AS 96799, USA. add1ison@gmail.com

The major subaerial portion of Tutuila was formed 1.0-1.5 Ma (McDougall 1985). Three shield volcanoes formed roughly simultaneously along a fracture lineament associated with deformation of the underlying Pacific Plate near the Tonga Trench (Natland 1980, 2003). These volcanics are the source of the fine-grained export-quality Tutuila basalts (Figure 2). Following a long erosional interval, a 6 km rift zone opened in the late Holocene and produced vesicular lava, tuff, and ash deposits forming a large bulge on the southern coast (Figure 2). These Leone Volcanics continued to be produced until at least c.1500 BP (Addison *et al*. 2006) or perhaps as late as c. 1200 BP (Addison and Asaua in press).

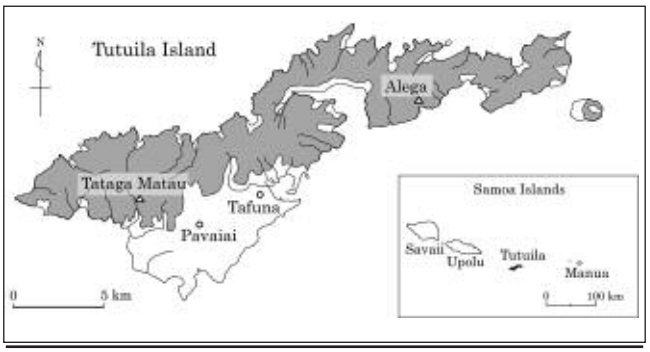

Figure 2. Tutuila. Dark area indicates the ~1-1.5 mya shield-building volcanic phase yielding fine-grained basalts. Light area indicates late-Holocene Leone Volcanics.

In the ethnographic period, Tutuila adzes were distributed to Fiji and Tonga as prestige goods (Kaeppler 1978). Archaeologically, basalts geochemically similar to samples from the Tataga Matau quarry on Tutuila are common in analyzed samples from sites around the region (Best *et al*. 1992; Clark *et al*. 1997; Di Piazza and Pearthree 2001).

The production processes of adzes from the Tataga Matau quarry site have been studied by Leach and Witter (1987, 1990), analyzing finished and unfinished adzes. However, basalt flakes – likely to have been wastes and by-products of the adze production process – were not analyzed. Clark (1993) analyzed the flakes found at the industry site at Alega, but the data quality is insufficient for carrying out a detailed analysis.

In this paper we analyze data obtained from two basalt industry sites on Tutuila – at Tafuna (Site AS-31-150) and Pava'ia'i (Site AS-31-170). These sites are workshop sites situated several kilometers from potential quarries (Figure 2). We use statistical analysis of the flakes from these industries to investigate the differences between the adze production processes. We compare the data obtained with that obtained from the Alega quarry site.

Data and protocol of description

We obtained 1756 samples from the Tafuna site and 1308 samples from the Pava'ia'i site, both located on a Holocene lava and pyroclastic plain. At Tafuna an area in excess of 100 m^2 was excavated by the Archaeological Specialists Division of the American Samoa Power Authority (ASPA) between November 2003 and January 2004. The Pava'ia'i site was found by the Archaeological Specialists Division in May 2004 during monitoring of sewer line construction. Archaeological materials were collected from the surface of a disturbed area around a house foundation. Although no radiocarbon date associated with the industries has been obtained for the two sites, they are assumed to belong to the aceramic period of Samoan prehistory (from 5th to 19th century AD), since no pottery was found.

Ishimura measured and described the artefacts according to the following parameters (Figure 3):

1. Type classification (finished/unfinished adze, scraper, or flake)
2. Quality of basalt (fine, normal, or coarse)
3. Size (length, width and thickness on a 0.1 mm scale, using a caliper)

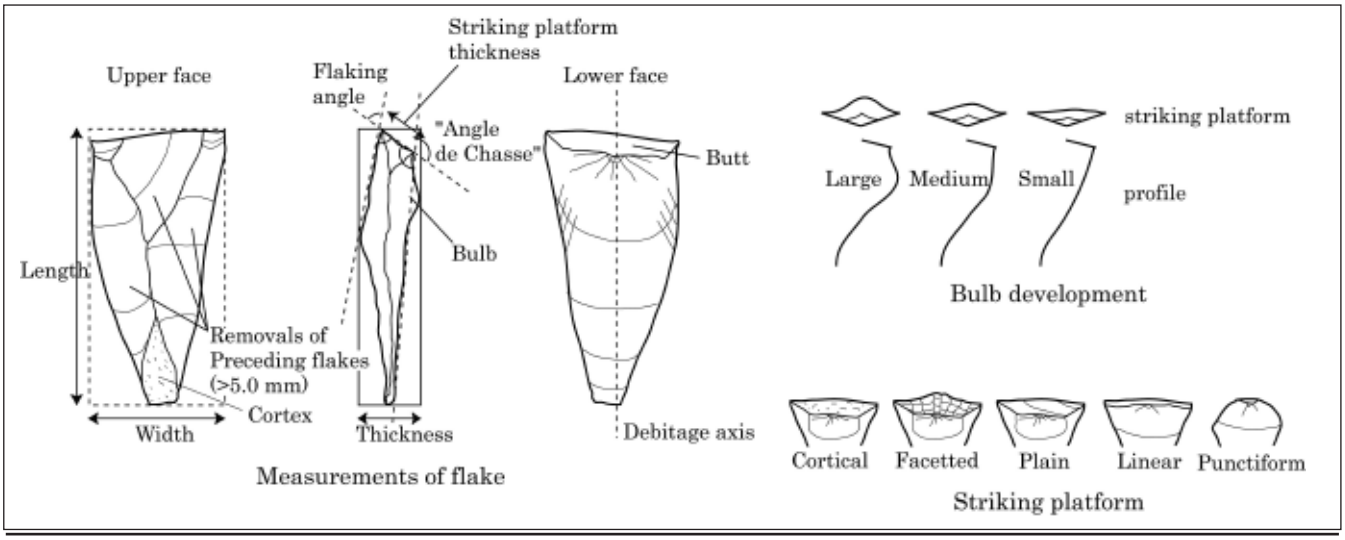

Figure 3. Protocol for description of flakes.

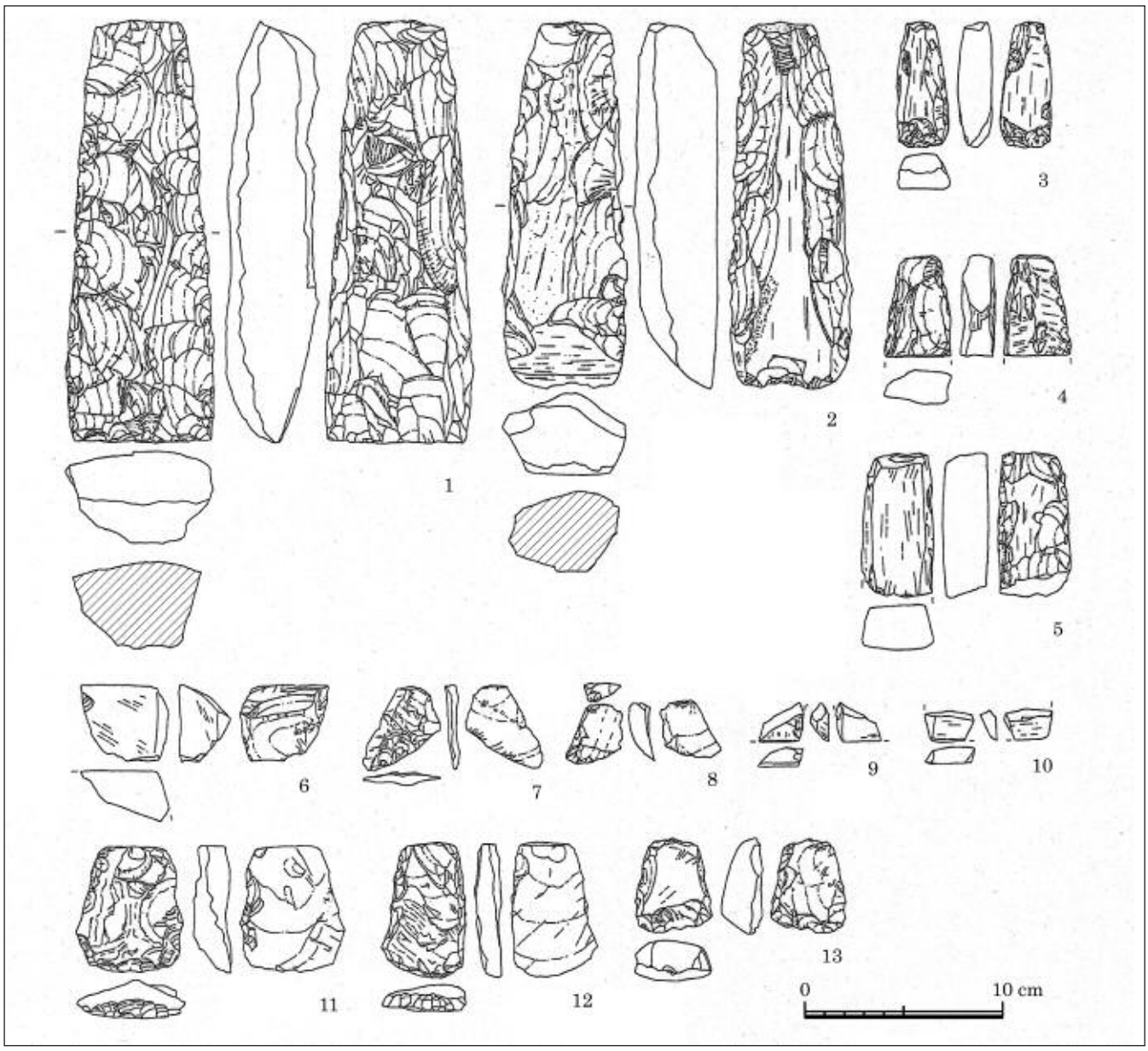

Figure 4. Selected artefacts from Tafuna and Pava'ia'i. 1-5 Adzes (including unfinished adzes and adze fragments); 6-10 Polished flakes; 11-13 Scrapers. Specimen 2 is from Pava'ia'i; others are from Tafuna.

4. Weight (on a 0.1 g scale, using an electric balance)
5. Striking platform (cortical, facetted, plain, linear, punctiform, or polished)
6. Striking platform thickness (on a 0.1 mm scale, using a caliper)
7. Flaking angle and 'angle de chasse' (on a 1° scale, using a protractor)
8. Bulb development (large, medium, or small)
9. Number of removals of preceding flakes from the upper face (>0.5 mm in length)
10. Cortex remains on the upper face (100%, >50%, <50%, or 0%)
11. Wear due to usage (present or absent)
12. Polished face (present or absent)

	Tafuna	**Pava'ia'i**
Adzes	21	5
Scrapers	5	0
Normal flakes	1684	1299
Polished flakes	43	2
Cores	0	1
Hammer stones	3	0
Anomalous	0	1
N =	1756	1308

Table 1. Inventory of basalt artefacts at Tafuna and Pava'ia'i sites.

Basalt tools

Table 1 lists the various tool types from the two sites; Figure 4 shows some of the artefacts from the assemblages. Compared to quarry-based workshops, the quantity of basalt artefacts is small. A major portion of the samples is comprised of flakes. The Tafuna site exhibited a greater variety of tool types (including adzes, scrapers, and hammer stones) than the Pava'ia'i site. Few flaked tools were found at either site; therefore, it is likely that the flakes were not blanks for tools but by-products and waste of the adze production process.

- **Adzes.** Adzes were found both at Tafuna and Pava'ia'i (Figure 4). A single finished adze (2) was found at Pava'ia'i. Unfinished adzes without ground edges (1 and 3) were found at Tafuna. The other specimens were broken or unfinished. Specimens 9 and 10 at Tafuna were parts of broken adze edges. Their presence may be because the adze was used and broken at the site, or reduction and reworking of the adze was conducted at the site, or the adze was broken during production.
- **Scrapers.** Five scrapers were found at the Tafuna site (Figure 4: 11-13). A scraper is a tool that is retouched at the edge and not ground. We consider this kind of tool was used as coconut grater-elements (Leach and Witter 1990: 76-80). Specimen 13 was partly ground, and it was retouched and cut through the polished face. Probably this specimen was originally a ground adze that was reworked and modified in order to be reused as a scraper.
- **Polished flakes.** Flakes with polished faces were found at Tafuna and Pava'ia'i (Figure 4: 6-8). Since these were broken off a ground (polished) adze, either the adze was used and broken at the site, or the adze was reduced there, or the adze was broken during production. We suggest the second scenario is probable since the striking platforms of seven flakes at Tafuna were set on the polished face.

It is clear that a greater variety of tools existed at Tafuna than at Pava'ia'i. They reflect the various activities conducted at the site. It is likely that adze reworking and scraper production were carried out along with adze production at Tafuna. In contrast, it is likely that only adze production was carried out at Pava'ia'i. These interpretations are tentative and could be influenced by the different sampling strategies at the two sites.

Analysis of flakes

It is likely that the majority of the flakes in these assemblages were created during adze production and their characteristics may suggest differences in the production processes at each site. They should provide some information about stone knapping, a process difficult to observe on finished adzes because they are ground. Characteristics of the knapping process at the manufactories are observed by statistically analyzing the flake data.

- **Sampling.** As mentioned above, the sampling methods used at the two sites were not identical, being excavation at Tafuna and surface collection at Pava'ia'i. Small flakes may have been overlooked at the Pava'ia'i site. We measured the lengths of flakes from Tafuna (N = 1727; mean = 17.7 mm, SD = 9.0) and Pava'ia'i (N = 1301; mean = 24.1 mm, SD = 11.0). The mean size of Pava'ia'i is greater than from Tafuna. Because sampling error was possible, we then excluded flakes that had a maximum length or width less than 20 mm, leaving 766 flakes from Tafuna and 1006 flakes from Pava'ia'i. The mean length, width, thickness, and weight of these flakes are given in Table 2.
- **Quality of basalt.** A considerable portion of the basalt obtained from Pava'ia'i was fine and blackish. Some of the basalt obtained from Tafuna was water-rolled and weathered. However, most of the basalt materials obtained from the two sites were of adze production quality and were not available in areas around the sites. We graded the quality of basalt by eye observation (Table 3): Pava'ia'i material was finer than that used at Tafuna ($\chi^2 = 12.2$, $\varphi = 2$).

	Tafuna (N=766)		**Pava'ia'i (N=1006)**	
	Mean (mm)	**s.d**	**Mean (mm)**	**s.d.**
Length	24.1	10.0	26.9	10.8
Width	27.1	10.2	30.1	10.0
Thickness	5.9	3.6	5.8	2.7
Weight	6.1	7.2	6.2	6.7

Table 2. Frequency distributions of basalt quality.

	Tafuna	**Pava'ia'i**
Fine	118	219
Normal	612	751
Coarse	**36**	**36**
N =	766	1006

Table 3. Measurements of flakes (mm).

- **Length/width ratios.** Tables 4 and 5 show the length/width diagrams of flakes from the two sites. Length/width ratios are approximately 1:1 and there is no tendency towards the production of oblong flakes (blades). Most flakes were less than 50 mm long, so we assume that most were not removed for use as tool blanks, but were waste from adze production. T-tests revealed a significant difference in length ($t = 5.6$, $\varphi = 1{,}770$) and width ($t = 4.0$, $\varphi = 1{,}770$) between the two sites, with larger flakes occurring Pava'ia'i. We suggest either the flake size reflected the raw material size, or fine fabricating operations were carried out at the Tafuna site, which resulted in small flakes.

	<19.9	20-24.9	25-29.9	30-34.9	35-39.9	40-44.9	45-49.9	50-54.9	>55	Sum
<19.9	–	81	23	9	1		1			115
20-24.9	185	60	23	10	5	1				284
25-29.9	65	41	27	19	7	1	1	1		162
30-34.9	19	21	21	9	10	2	1	1	1	85
35-39.9	4	4	11	9	5	4		4	2	43
40-44.9	1	3	6	5	8	5	1	1	2	32
45-49.9		2	1	5	3	2	1	1	1	16
50-54.9		2	4	3		3	1	2	1	16
>55		2		1	2	3	1	3	1	13
Sum	274	216	116	70	41	21	7	13	8	766

Table 4. Tafuna: flake length/width diagram (mm). Column=length; row=width.

	<19.9	20-24.9	25-29.9	30-34.9	35-39.9	40-44.9	45-49.9	50-54.9	>55	Sum
<19.9		59	18	3	3	2	1			86
20-24.9	152	64	44	11	5	2	2	1	1	282
25-29.9	63	72	43	20	9	3	4	1	3	218
30-34.9	25	31	33	24	8	7	7	2	5	142
35-39.9	10	26	34	22	12	11	6	1	6	128
40-44.9	1	5	14	9	12	5	3	3	3	55
45-49.9	1	4	6	7	12	6	4	1	2	43
50-54.9		1	6	5	6	3	3	3	2	29
>55		1	3	4	3	6	2	1	3	23
Sum	252	263	201	105	70	45	32	13	25	1006

Table 5. Pava'ia'i: flake length/width diagram (mm). Column=length; row=width.

- **Cortical remains.** Table 6 shows the frequency distribution of cortical remains. There were more cortical remains at Pava'ia'i than at Tafuna ($\chi^2 = 19.1$, $\varphi = 3$). The presence of flakes with cortex implies that some raw material arrived at the site and was flaked there, but the low frequency suggests much decortication before arriving at the site.

	Tafuna	Pava'ia'i
100%	10	20
>50%	11	38
<50%	38	84
Absent	707	864
N =	766	1006

Table 6. Frequency distributions of cortical remains.

- **Striking platform.** Table 7 shows the frequencies of striking platform form. Fewer cortical striking platform were found at Tafuna and no polished striking platforms were found at Pava'ia'i. There was a significant difference in striking platform occurrence at the two sites ($\chi^2 = 43.6$, $\varphi = 5$). The presence of polished striking platforms implies the onsite reworking of a polished tool.

	Tafuna	Pava'ia'i
Cortical	4	5
Facetted	58	153
Linear	92	120
Plain	287	325
Punctiform	53	71
Polished	7	0
N =	501	674

Table 7. Frequencies of striking platform form.

- **Striking platform thickness.** Table 8 shows the means and standard deviations of striking platform thickness at each site. A t-test did not reveal any significant difference between the two values ($t = -1.2$, $\varphi = 1191$). It is likely

	Tafuna (N=499)		Pava'ia'i (N=694)	
	Mean (mm)	s.d	Mean (mm)	s.d
Striking platform thickness	4.7	1.2	4.5	2.3

Table 8. Striking platform thicknesses (mm).

that the striking platform thickness will correspond to both the technique used for controlling the impact point as well as to the flake thickness. Using a punch ensures a constant striking platform thickness, while free-hand flaking produces a non-uniform result. There is no difference between the flaking techniques at the two sites, and no punching technique was used.

- **Removal of preceding flakes from the upper face.** Table 9 shows the frequency distributions of the removals of preceding flakes from the upper face of a flake. A majority of the flakes exhibited one or two preceding flake removals. There was no significant difference between the removals ($\chi^2 = 7.3$, $\varphi = 6$).

No.	Tafuna	Pava'ia'i
0	18	20
1	242	276
2	283	378
3	149	224
4	52	64
5	14	28
>5	8	16
N =	766	1006

Table 9. Frequency distributions of the removals of preceding flakes.

- **Flaking angle and 'angle de chasse'.** Table 10 shows the means and standard deviations of the flaking angle and 'angle de chasse' of the flakes at the two sites. T-tests revealed no significant difference in either the flaking angle ($t = -0.4$, $\varphi = 847$) or the 'angle de chasse' ($t = 0.6$, $\varphi = 1056$) between sites. The angle of hammer knapping was the same at both sites.

	Tafuna (N=440)		Pava'ia'i (N=618)	
	Mean (mm)	s.d	Mean (mm)	s.d
Flaking angle	98.8	9.3	98.5	11.1
'Angle de chasse'	85.1	7.7	85.6	12.3

Table 10. Flaking angle and 'angle de chasse' (degrees).

- **Bulb development.** Table 11 shows the frequency distribution of bulb development at the two sites. The frequency of developed bulb occurrence was greater at Pava'ia'i ($\chi^2 = 17.9$, $\varphi = 2$). Bulb development corresponds to the quality of the hammer (soft or hard), flaking technique (direct or pressure flaking), and strength of the flaking force. In this study, the last factor appears to be most significant, since flaking force directly relates to flake size, and this result is consistent with the high frequency of large flakes at Pava'ia'i.

	Tafuna	Pava'ia'i
Large	32	43
Medium	188	334
Small	288	305
N =	508	682

Table 11. Frequency distributions of bulb development.

Summary

We conclude that the quantity of raw materials bearing cortex arriving at Pava'ia'i was greater than at Tafuna. Thus the former site has more flakes with cortex as well as larger flakes than the latter. Further, the adze reworking was also carried out at Tafuna, and consequently smaller flakes, some bearing polished faces, were removed. Scraper production also produced smaller flakes.

Spatial distribution of basalt artefacts at the Tafuna site

The spatial distribution of artefacts at Tafuna was recorded during excavation. Figure 5 shows the excavated area, density of excavated flakes, and the distribution of stone tools in each grid (1x1 m).

Most artefacts were found in the southern part. One house platform was located to the north of the excavated area. This had glass and ferrous-metal nails under the foundation which makes the antiquity of the platform suspect. Three other possible habitation platforms of

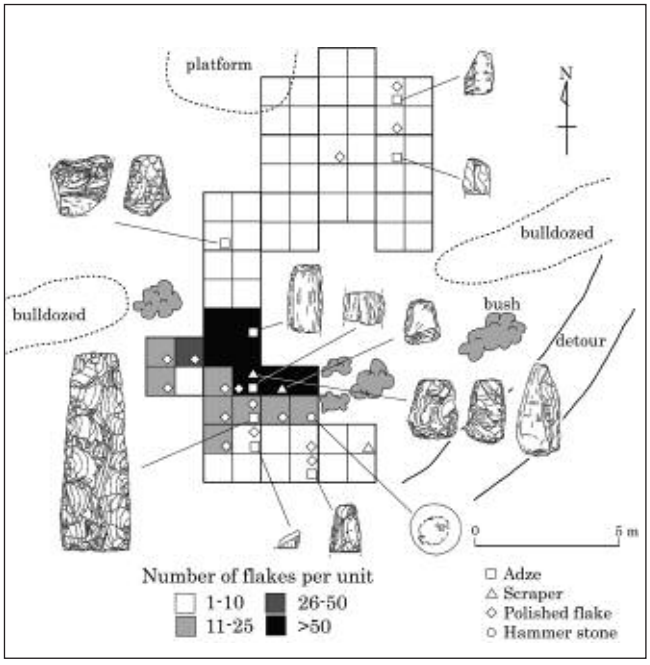

Figure 5. Spatial distribution of basalt artefacts at the Tafuna site. Additional excavation areas to the north and west of the platform are not shown.

unknown age, an immense stone wall, numerous smaller stone walls, as well as small linear and circular mounds are found within 50 m of the industrial area (Cochrane *et al*. 2004:379-97; Taomia 2002). Lithics found at Site AS-31-150 are likely temporally associated with one or more of these other features. The distribution of the artefacts suggests that locations for habitation and tool-making were distinct.

The scrapers were concentrated at the center of the flake distribution which suggests they were produced onsite. Polished flakes were similarly distributed, suggesting adze reworking here. Adze distribution (most were broken) was relatively scattered and did not correspond with the distribution of other artefacts. We assume that finished adzes were removed from the production site, and broken adzes were discarded randomly around the site. It is also possible that two temporally distinct uses of the site are represented – one relating to the adze and scraper production and one relating to the used and broken adze fragments.

Comparison with the Alega quarry site

Alega is a complex site that contains a settlement and probably belongs to the same period as Tataga Matau. A total of 2500 excavated flakes from Alega were classified into four categories: primary decortication flakes (with 100% cortex), secondary decortication (with occasional cortex), polished flakes, and reduction flakes (normal flakes). Table 12 compares the frequency of the categories between Alaga, Tafuna, and Pava'ia'i. Primary decortication appears to be higher at Alega, and the number of polished flakes was low at Alega as well as at Pava'ia'i. There are significant differences between the samples from Alega and Tafuna (χ^2 = 96.6, φ = 3), and from Alega and Pava'ia'i (χ^2 = 27.8, φ = 3). We infer that while decortication was intensively conducted at Alega, some decorticated preforms arrived at the Tafuna and Pava'ia'i sites. In contrast to Tafuna, minimum reworking of polished adzes was conducted at the Alega and Pava'ia'i sites.

Table 13 shows the frequency distribution of the maximum length of the flakes (> 20 mm) obtained from the Alega, Tafuna, and Pava'ia'i sites. Larger flakes were removed at Alega. There was a significant difference between the flakes obtained from Alega and Tafuna (χ^2 = 14.2, φ = 2), but none between Alega and Pava'ia'i (χ^2 = 2.3, φ = 2). This is consistent with the fact that the flakes from Tafuna were small due to adze reworking.

We conclude that intensive decortication was conducted at the Alega quarry site and some decorticated preforms were exported to locations distant from quarries (such as Tafuna and Pava'ia'i) for further flaking and finishing. Although we do not suggest that Alega was the source of basalt used at Tafuna and Pava'ia'i, we are suggesting that the production strategy of doing initial reduction at or near an extraction site, with finishing at a different site, may have been common on Tutuila.

	Alega	**Tafuna**	**Pava'ia'i**
Primary decortication	89	17	22
Secondary decortication	159	65	133
Polished flake	2	43	2
Normal flake	**2250**	**1602**	**1142**
N =	2500	1727	1299

Table 12. Frequencies of flake type occurrence at Alega, Tafuna, and Pava'ia'i.

mm	**Alega**	**Tafuna**	**Pava'ia'i**
20.1-40	993	668	793
40.1-60	205	84	193
>60	32	14	24
Total	1230	766	1010

Table 13. Maximum length of flakes from Alega, Tafuna, and Pava'ia'i (mm).

Conclusion

We now describe the basalt tool production process at the Tafuna and Pava'ia'i sites.

- Tafuna: Adze production, adze reworking and scraper production were conducted. Many decorticated preforms were imported from quarry sites.
- Pava'ia'i: Mainly adze production was carried out. Some decorticated preforms were imported from the quarry sites.

Figure 6 shows a schematic model of the technological sequence of basalt adze production in Tutuila. The figure depicts the different activities carried out at each site and shows that these sites were part of the operational chain. One important discovery is that adze reworking was conducted at the Tafuna site. We assume that the adze production and distribution systems were appropriately organized so that adze maintenance and recycling of adzes were integrated into the system.

Previous studies on the basalt adzes of Tutuila have focused on the issue of inter-island long-distance exchange, although most of the Tutuila adzes have been found on Tutuila Island itself. Our study begins to reveal the technological sequence of the basalt adze production and distribution within Tutuila and contributes toward understanding the economics of basalt adze production. Further work can examine possible differences or similarities between the intra-island and inter-island exchange involve in the production and distribution of Tutuila basalt tools. Many questions remain.

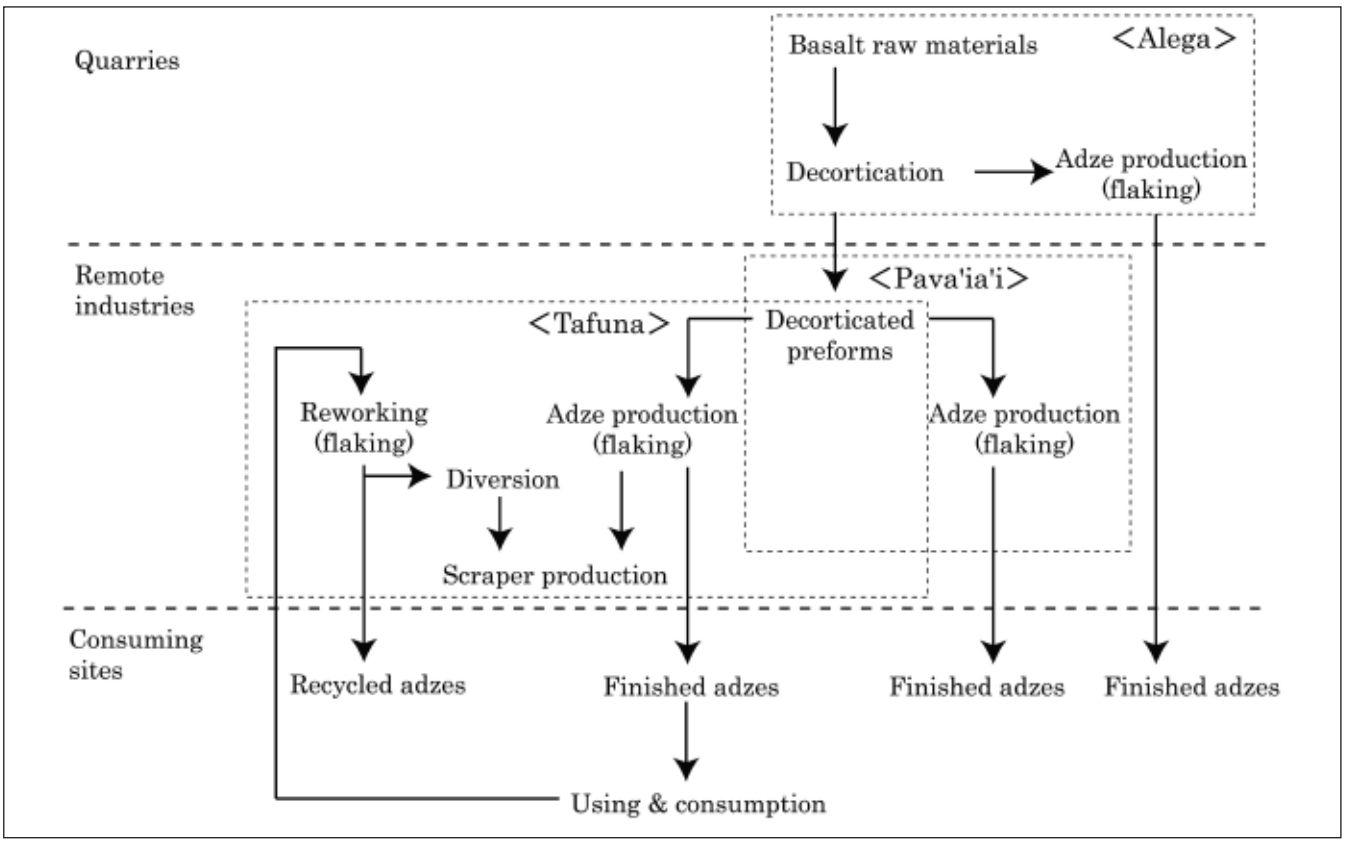

Figure 6. Technological sequence of basalt artefacts in Tutuila.

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