



The stone adze and obsidian assemblage from the Talasiu site, Kingdom of Tonga

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ABSTRACT

Typological and geochemical analyses of stone adzes and other stone tools have played a significant role in identifying directionality of colonisation movements in early migratory events in the Western Pacific. In later phases of Polynesian prehistory, stone adzes are important status goods which show substantial spatial and temporal variation. However, there is a debate when standardisation of form and manufacture appeared, whether it can be seen in earliest populations colonising the Pacific or whether it is a later development. We present in this paper a stone adze and obsidian tool assemblage from an early Ancestral Polynesian Society Talasiu site on Tongatapu, Kingdom of Tonga. The site shows a wide variety of adze types; however, if raw material origin is taken into account, emerging standardisation in adze form might be detected. We also show that Tongatapu was strongly connected in a network of interaction to islands to the North, particularly Samoa, suggesting that these islands had permanent populations.

Keywords: Pacific archaeology, Tonga, lithics, adzes, geochemistry, obsidian

RÉSUMÉ

Les analyses typologiques et géochimiques des herminettes et autres outils lithiques ont joué un rôle essentiel pour identifier les directions des premiers mouvements migratoires dans le Pacifique occidental. Dans les phases ultérieures de la préhistoire polynésienne, les herminettes en pierre sont des marqueurs de statut qui présentent des variations spatiales et temporelles importantes. Cependant, la question de savoir quand la standardisation de la forme et de la fabrication est apparue, reste débattue : existe-t-elle dès le début de la colonisation du Pacifique ou s'agit-il d'un développement ultérieur. Nous présentons dans cet article un assemblage d'herminettes et d'outils en obsidienne associé à la Société Polynésienne Ancestrale, provenant du site de Talasiu, Tongatapu, Royaume de Tonga. L'étude montre une grande variété de types d'herminette, cependant, si l'on tient compte de l'origine des matières premières, on peut détecter une standardisation émergente dans la forme des herminettes. Nous montrons également que Tongatapu était fortement impliqué dans un réseau d'interactions avec les îles du Nord, en particulier Samoa, ce qui suggère que ces îles abritaient des populations permanentes.

Mots-clés: Archéologie du Pacifique, Tonga, lithiques, herminette, géochimie, obsidienne

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INTRODUCTION

It has been a long-standing narrative that the first colonisers of the Southern and Central Pacific, the Lapita people, brought with them not only highly decorative pottery, shell artefacts and obsidian but also a distinctive type of ground stone tool kit, which included fully ground stone adzes (Green 1979, 2003). In Lapita research, identifying a

distinctive stone tool kit has been useful for understanding factors beyond temporal classifications, particularly social values, which derive from assumed labour requirements necessary to manufacture some Lapita adzes as well as the distance raw material, such as obsidian, has been transported. Adzes are finely made technical objects, and their investigation might also provide an insight into social structures and division of labour (Kirch 2000). Whereas the importance of adzes as items with social value is undisputed, in recent years it has become contentious whether a distinctive type of adze kit is really unique for Lapita colonisation (Specht *et al.* 2014).

[Correction added on 16 February 2021, after first online publication: New affiliation has been added for the corresponding author.]

Fully ground adzes are very rare in Lapita contexts with only two regions showing large assemblages, both areas with intertidal sites: Buka (Wickler 2001) and New Georgia (Felgate 2003), in the Northern and Western Solomon Islands, respectively. However, although both areas contain ceramics with Lapita-style decoration, the lithic assemblages remain undated as the sites show significant disturbance (Spriggs 2003). The increased interest in Lapita archaeology in the last decade has not changed this picture, even in well-researched regions such as Vanuatu (Bedford pers. comm.) and New Caledonia (Sand 2010) where only a small number of stone adze fragments were recovered from Lapita contexts. In Polynesia in later periods, on the other hand, adzes play a significant social role and the morphological variability of adze variants might align with discrete spatial and temporal patterns (Burley & Addison 2015; Shipton *et al.* 2016). The general lack of detailed excavated and dated adze assemblages has led to conflating surface artefacts with excavated material to understand adze tool kits (Duff 1970; Felgate 2003; Green & Davidson 1969); unfortunately, these methodologies destroy any possibility of employing these assemblages as chrono-typological frameworks to understand Lapita-aged adze morphologies.

Here, we report on an obsidian and stone adze assemblage from the Talasiu burial and midden site on the Island of Tongatapu, Kingdom of Tonga. The site is securely dated to 2700–2500 BP (Clark *et al.* 2015), covering the transition into the immediate post-Lapita period, which coincides with the emergence of the Ancestral Polynesian Society (APS) (Burley *et al.* 2015). The assemblage includes a large number of complete and fragmented adzes and adze flakes, as well as several obsidian flakes (initial results of these have been published in Reepmeyer *et al.* 2012). The lithic assemblage provides detailed evidence of directionality and changing intensity of raw material movement at the beginning of the APS indicating the contacts with the West (Fijian islands) might decrease during this time, whereas contacts to the north, including the far northern islands of the Tonga Archipelago as well as the Samoan chain, including the islands of 'Uvea and Futuna, persisted throughout this period. The shift potentially correlates with an Ancestral Polynesian homeland consisting of Tonga, Samoa, 'Uvea and Futuna (for a discussion, see Burley *et al.* 2011).

SITE OVERVIEW, MATERIALS AND PRIOR RESEARCH

The Talasiu site

Site details of the Talasiu site (TO-Mu-2) have been published in Clark *et al.* (2015) and Valentin *et al.* (2020). The site is located on the palaeoreef, a limestone shoreline on the eastern coast of the Fanga 'Uta Lagoon immediately north of Lapaha Village, Tongatapu island (Figure 1). It is a dense shell midden some 40 m wide and 100 m long with a series of 19 burial contexts of late-Lapita age (Valentin *et al.* 2020). The upper 20 cm are a disturbed zone

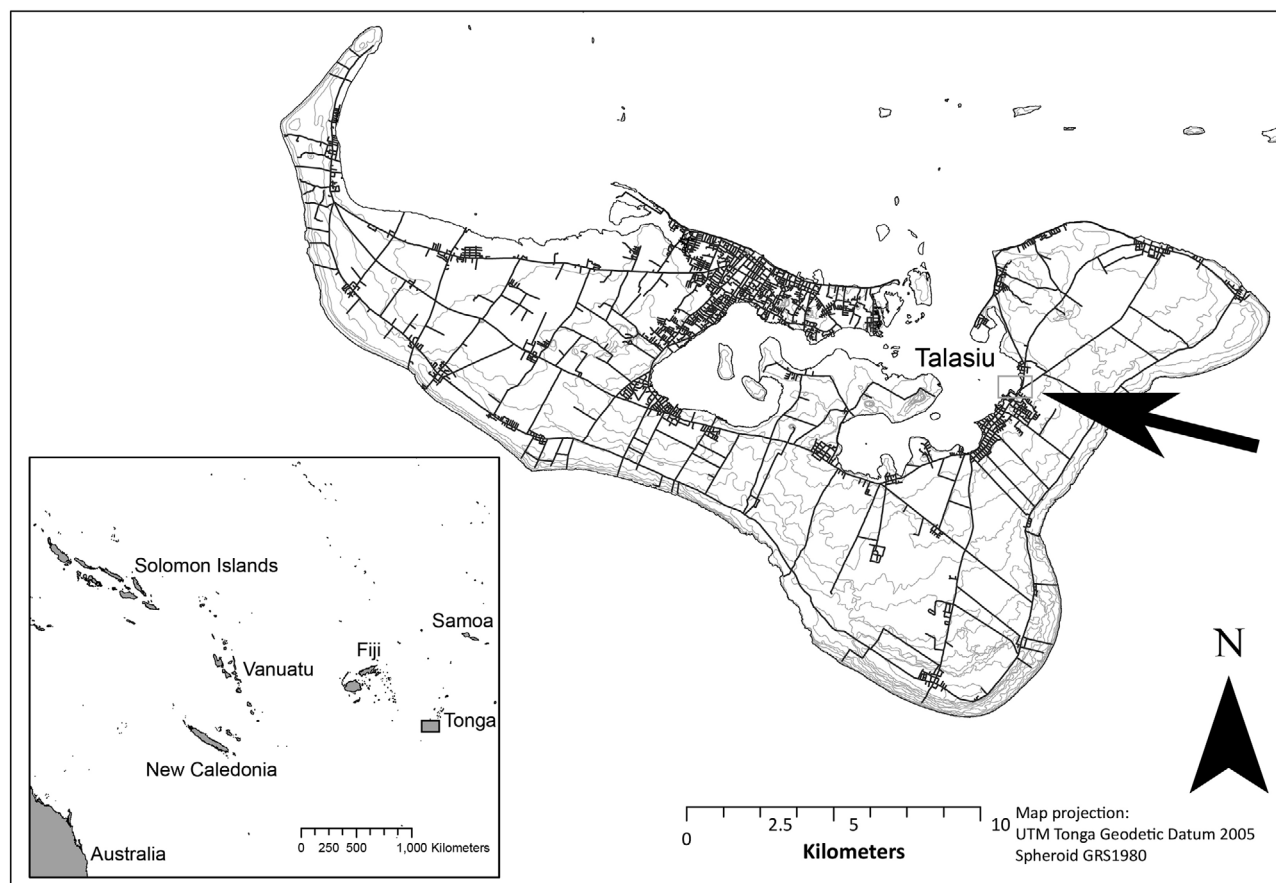
overlying shell layers including charcoal and ash lenses deposited on a basal layer of compacted clay. Talasiu has been dated to between 2870 and 2340 calBP on short lived charcoal samples, worked shell goods and human bone samples from burials (Valentin *et al.* 2020). There is little age differentiation between the layers deriving from a flattening of the C¹⁴ age curve. However, it has been suggested based on high-resolution U-Th data that Lapita ends in Tonga no later than 2650 calBP and that sea-level fall at 2500 calBP resulted in the closure of the Fanga 'Uta Lagoon and the disappearance of benthic environments in the vicinity of the Talasiu site (Clark *et al.* 2015). This might have caused a realignment of marine shellfish exploitation and site abandonment which makes a deposition of the cultural material at around 2700–2500 calBP highly likely.

Lithic artefacts were found throughout the site (Figure 2): two clusters of artefacts were detected in TP D2 and TP E2 where the midden was the thickest (Valentin *et al.* 2020). In addition, three complete adzes were found in TP A2 which is located slightly to the south of the first concentration, and in TP G slightly to the northwest, one complete adze and several adze flakes were found. These artefact concentrations overlap with a concentration of burials in TP D2/E2 (burial contexts Sk 9, 12, 16), in TPA2 (cluster of single burials Sk 10, 11, 14) and TP G (double burial Sk3); however, none of the adzes and adze flakes can be unambiguously identified as grave goods for specific interments. The remaining lithics recorded from the site do not show a distinctive discard pattern and are not associated with any burials but were found embedded in the shell midden deposits.

Prior geochemical results

Previous excavations (2008–2009) at Talasiu resulted in the detection of four obsidian artefacts, four basalt flakes, one adze and three manuports (including one hammerstone and one grinding tool) (Clark *et al.* 2014; Reepmeyer *et al.* 2012). Geochemical analysis was conducted with a combination of SEM-EDXA and LA-ICP-MS for obsidian artefacts and a Bruker Tracer III-V+ portable XRF analyser for basalt artefacts. Abundance of elements (ppm) collected with XRF was established with an in-house calibration curve for basalt raw material. The geochemical analyses were able to show that people living at Talasiu during the third millennium BP had contact with Samoa, Fiji and northern Tonga, and used not only local material from central Tonga and the island of 'Eua, but transported raw material and artefacts, both obsidian and other igneous rocks, over distances of more than 600 km of open ocean. Reepmeyer *et al.* (2012), based on high-resolution LA-ICP-MS data, suggested the origin of obsidian artefacts found in Talasiu was in northern Tonga, most likely from an outcrop (Hala'Uta) on the island of Tafahi. They mentioned, however, that obsidian deposits on neighbouring Niuaotuputapu had been identified, but that no geochemical data from this source was available. The island of Tafahi has long been suggested as an obsidian source, as several

Figure 1. The Talasiu site on the island of Tongatapu, Kingdom of Tonga.



thousand artefacts excavated on Niuatoputapu were tentatively sourced to Tafahi by Ward based on XRF data (Kirch 1988). Burley *et al.* (2011), analysing 75 artefacts from Niuatoputapu and seven source samples from Tafahi, challenged the idea that the island of Tafahi was the source for these artefacts. Following Dye (1988), Burley *et al.* also identified the potential of an additional source that might be located on the island of Niuatoputapu, based on the technological attributes of excavated obsidian material. However, they were not able to distinguish the new suggested source material from Tafahi obsidian, as the pXRF data produced for each group showed significant overlap.

Lapita and ancient Polynesian society adze morphometrics

Lapita adze typologies in the past have been used to detect commonalities between sites and to find evidence for a “community of culture” that the Lapita techno-complex is argued to represent (Green 2003; Spriggs 1997). There is an underlying assumption that typologies employed in this way might indicate the emergence of shared identities rather than a reflection of functional attributes and raw material requirements (for a critique, Best 1984: 391; Shipton *et al.* 2016). According to Green (2003: 110, Table 5) distinctive Lapita adze types include “(a) rectangular; (b) oval or rounded; (c) plano-lateral; (d) plano-convex” adzes, and

both plano-convex and plano-lateral forms are seen as a Lapita invention (Green 1971, 1991). The identification of these types as the “Lapita ground stone adze kit” has been criticised recently by Specht *et al.* (2014) as they identified all forms interpreted as Lapita introductions in pre-Lapita sites in the region.

Typologies used throughout Oceania have emerged from regional investigations into the Polynesian adze kit (Buck 1930; Cleghorn 1984; Duff 1959, 1970, 1977; Skinner 1943) and its relationship to Pacific and Asian adzes. Localised typologies have been developed for specific archipelagos to provide a more nuanced understanding of inter-island group interaction and exchange (Green & Davidson 1969). Many sites in the Western Pacific have adzes of exotic origins, demonstrating significant interaction networks maintained over long distances and timeframes. Adzes and adze flakes recovered from the Solomon Islands (Felgate 2003: 401), Fiji (Best 1984; Fankhauser *et al.* 2009), Tonga (Poulsen 1987: 163; Clark *et al.* 2014; Connaughton 2014) and Samoa (Best *et al.* 1992; Green *et al.* 1988) all contain artefacts from raw materials sourced outside their respective archipelagos. In Tonga, for example, 33% of Lapita-age adze flakes were exotic: 5% from Samoa and 28% from Eastern Fiji even though fine-grained adze raw material was available from local sources (Clark *et al.* 2014).

Table 1. Geochemical data and summary statistics of seven artefacts analysed with SEM-EDXA (major elements) and LA-ICPMS (trace elements).

	Tafahi										Tulasiu Group	
	Teftomaka								Hala'Uta		Average	SD
	NTT-1 (ANU1959)	NTT-3 (ANU1961)	NTT-4 (ANU1962)	NTT-5 (ANU1963)	NTT-6 (ANU1964)	NTT-7 (ANU1965)	NTT-8 (ANU1966)	n = 4	SD	ANU9372	n = 4	SD
SEM-EDXA (in wt%)												
Na ₂ O (%)	2.7	2.63	2.82	2.67	2.84	2.28	2.95	3.4	0.1	2.5	3	0.1
MgO (%)	1.08	1.05	0.84	1.04	0.98	0.92	0.95	0.5	0.1	2.6	1.2	0.1
Al ₂ O ₃ (%)	12.07	11.64	11.69	11.85	11.77	11.64	12.06	11.7	0.1	13.7	12.7	0.1
SiO ₂ (%)	66.96	64.97	68.14	66.7	67.46	66.26	67.18	74.4	0.3	63	68.6	0.3
K ₂ O (%)	1.12	1.1	1.19	1.15	1.15	1.26	0.85	1.5	0	0.9	1	0.2
CaO (%)	5.47	5.1	4.89	5.22	5	4.92	5.24	3.1	0.1	7	5.2	0.2
TiO ₂ (%)	0.52	0.38	0.38	0.52	0.42	0.48	0.44	0.4	0.1	0.6	0.5	0.1
MnO (%)	0.12	0.46	0.29	0.35	0.32	0.19	0.32	0.1	0.1	0.3	0.2	0
FeO (%)	7.1	7.02	6.66	7.28	7.12	6.71	7.27	4.5	0.1	9.2	7.5	0.5
LA-ICPMS (in ppm)												
P	36	32.8	33.4	33.6	34.3	33.7	33.9	595	14.2	946.9	936.2	161.7
Sc	2762	2648	2664	2685	2725	2665	2707	17.4	0.1	34.6	30.1	0.9
Ti	64.4	62	31	53.8	62.6	51.8	57.6	2252.1	47.1	3134.5	2853	71.9
V	0.3	0.6	0.9	0.1	0.5	0.3	0.2	19.2	0.6	239.9	58.7	6
Cr	1451	1383	1409	1406	1405	1379	1458	907.1	8.5	1426.1	1429.7	18.2
Co	11.5	11	9.1	10.7	11.2	10.4	11.1	6	0	21.8	10.9	0.5
Ni	0.6	0.9	0.5	0.7	0.7	0.5	0.7	51.8	1.7	90.5	39.5	5.6
Cu	58.7	38.9	29.5	45.4	52	36.9	88.7	11.2	0.7	13.1	12.3	0.2
Zn	131.6	128.8	134.8	129.6	131.9	127.3	133.5	5.7	0.3	3.5	3.7	0.2
Ga	11.5	11.7	11.7	11.6	12.1	11.3	11.9	26.1	0.6	17.3	20.6	0.8
As	3.5	3.6	3.7	3.7	3.4	3.4	3.4	212.2	22.9	241.8	222.8	7.6
Rb	17.6	18	19.7	18.1	18.6	17.6	17.9					
Sr	250	243.4	252.8	245.3	249.3	244	240.5					

(Continued)

Table 1. (Continued).

	Tafahi								Talasii Group					
									Tefitomaka		Hala'Uta		Average	
	NTT-1 (ANU1959)	NTT-3 (ANU1961)	NTT-4 (ANU1962)	NTT-5 (ANU1963)	NTT-6 (ANU1964)	NTT-7 (ANU1965)	NTT-8 (ANU1966)	n = 4	SD	ANU9372	n = 4	SD		
Y	19.7	17.9	20	18.8	18.5	18.9	18.8	17.2	0.4	12.1	15.4	0.5		
Zr	41.4	38.2	42.8	40.1	39.3	40.1	39.5	44.8	1.3	25.4	31.5	1.1		
Nb	4.2	4	4.4	4.2	4.2	4.2	4.1	5	0.1	3.7	3.9	0		
Mo	1.6	1.6	1.7	1.6	1.7	1.6	1.6	2.5	0.1	1.5	1.8	0.1		
Sn	1.4	1.9	1.6	1.1	1.3	0.8	0.9	0.6	0	0.4	0.5	0.1		
Cs	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.7	0	0.5	0.6	0		
Ba	258.5	251.2	275.7	262.9	260.4	257.7	258.8	350.5	8.7	223.6	247.4	6.1		
La	7.8	7.3	8.1	7.7	7.6	7.6	7.6	10	0.3	6.7	6.7	0.2		
Ce	14.2	13.5	14.7	14.1	14	13.9	14.3	19.3	0.5	13	13.4	0.5		
Pr	1.9	1.8	2	1.9	1.9	1.9	1.9	2.3	0.1	1.6	1.7	0.1		
Nd	8.9	8.4	9.2	8.8	8.7	8.8	9.1	8.9	0.2	6.3	7	0.2		
Sm	2.5	2.4	2.6	2.4	2.4	2.4	2.4	2.4	0.1	1.8	2.1	0.1		
Eu	0.8	0.7	0.8	0.7	0.7	0.7	0.8	0.7	0	0.6	0.7	0		
Gd	2.9	2.7	3	2.8	2.8	2.9	2.8	2.7	0.1	2	2.4	0.1		
Tb	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0	0.3	0.4	0		
Dy	3.3	3.1	3.5	3.2	3.1	3.2	3.2	3	0.1	2.2	2.7	0.1		
Er	2.3	2	2.3	2.2	2.1	2.2	2.2	2	0.1	1.4	1.8	0.1		
Tm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0	0.2	0.3	0		
Yb	2.4	2.2	2.5	2.4	2.3	2.4	2.3	2.2	0.1	1.5	1.9	0.1		
Lu	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0	0.2	0.3	0		
Ta	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0	0.2	0.2	0		
W								0.9	0	0.3	0.4	0		
Pb206								7.7	0.2	4.9	5.6	0.1		
Pb207								6.9	0.2	4.3	5	0.1		
Pb208	5.3	6.3	6.3	5.4	5.7	5.1	5.4	7.4	0.2	4.6	5.3	0.1		
Th	1.7	1.6	1.7	1.7	1.6	1.6	1.6	2.1	0.1	1.4	1.4	0		
U	0.5	0.4	0.5	0.5	0.5	0.4	0.5	0.9	0	0.4	0.5	0		

Table 2. Geochemical pXRF data (in ppm) of obsidian artefacts, basalt adzes and adze fragments analysed.

ID	Site	Bag-label	Source	Mn	Ti	Fe	Rb	Sr	Y	Zr	Nb
Basalt adzes, fragments and flakes											
1	Talasiu	TPA2_1	Fiji			54391	37	348	48	195	8
2	Talasiu	TPA2_2	Tonga			87782	12	291	34	65	4
3	Talasiu	TPA2_3	Tonga			98976	15	105	30	57	6
4	Talasiu	TPA2_4	Tonga	8861	1466	78638	6	298	20	81	6
5	Talasiu	TPB2	Fiji			61381	38	387	56	206	9
10	Talasiu	TPD2	Tonga			86557	9	168	28	68	6
21	Talasiu	TPD2_1	Fiji	8742	1164	66369	55	411	24	182	8
22	Talasiu	TPD2_2	Fiji	9257	1288	71788	54	431	27	168	14
23	Talasiu	TPD2_4	Fiji	8390	1110	65556	37	308	24	136	13
11	Talasiu	TPE2_1	Samoa			81795	22	1084	28	212	63
12	Talasiu	TPE2_2	Tonga			50603	8	178	23	90	1
6	Talasiu	TPE2_3	Tonga			85195	15	112	27	77	6
13	Talasiu	TPE2_4	Eua			90201	8	60	28	57	1
24	Talasiu	TPE2_5	Fiji	8610	1158	67636	57	410	25	191	10
14	Talasiu	TPG_3	Fiji	6068	1627	60622	41	377	51	196	9
25	Talasiu	TPG_1	Tonga	5954	1310	77716	14	337	32	80	3
26	Talasiu	TPG_2	Fiji	5636	1521	60176	39	357	44	186	5
7	Talasiu	TPH2	Tonga			84513	8	184	24	93	3
15	Talasiu	TPI2	Samoa			95065	29	773	48	365	51
27	Talasiu	TPI2_3	Samoa	18755	1243	86941	49	818	45	340	54
28	Talasiu	TPJ	Fiji	5726	1631	61728	39	375	52	193	10
29	Talasiu	TPJ or TPL	Fiji	8734	1132	66490	56	394	25	183	7
16	Talasiu	TPO	Eua	6521	1505	91610	19	67	27	67	5
17	Talasiu	TPQ_1	Tonga	6660	795	97558	22	209	14	50	1
30	Talasiu	TPQ_2	Tonga	7268	1392	77058	4	260	20	63	4
18	Talasiu	TPU	Tonga	6160	1397	90844	8	209	29	67	4
9	Talasiu	5 cm below BG3 skeleton	Tonga	4438	2252	46841	8	395	35	118	10
20	Talasiu	TP2	Tonga	8988	1426	80932	6	297	20	80	5
8	Talasiu	TPL surface	Samoa	24307	953	85940	31	742	39	334	52
19	Talasiu	Garden	Tonga	6145	1723	88196	11	224	35	76	5
Obsidian Flakes											
1		TPD2_3-1	Tafahi		1466	57865	25	234	18	52	5
2		TPD2_3-2	Tafahi		1538	63525	23	246	20	53	5
3		TAL_TPG_SK_sujet	Tafahi		1248	53536	23	282	17	50	4
4		TAL_TPH_60cm	Tafahi		1316	54373	25	288	18	52	5
5		TPI2_2	Tafahi		1396	55520	23	214	18	51	6

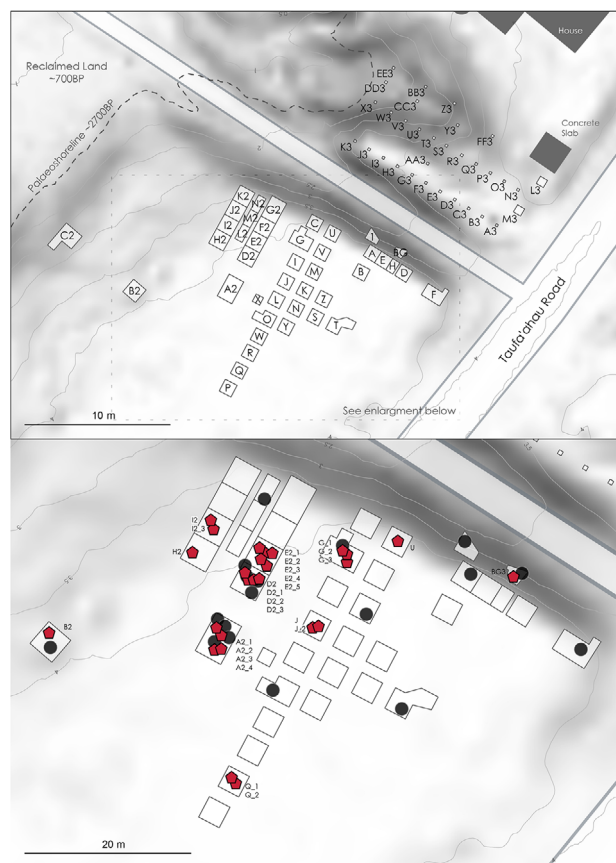
Lapita adze typologies are still heavily influenced by earlier classification systems in that the nature of cross section and butt modification are the two dominant attributes defining types. This approach has recently been criticised by Shipton *et al.* (2016: 361), due to its poorly defined types, lack of theoretical rationale and ambiguous boundaries between types. However, they concluded that the previously defined “natural groups” based on cross sections are at least partly the result of distinctive manufacturing sequences and therefore a valid approach for classifying adze technology (Shipton *et al.* 2016: 374).

Attempts to catalogue the chrono-spatial distribution of certain stone adze typologies are fraught as they are unable to provide temporal insights due to the majority of artefacts not being associated with well-dated deposits (Duff 1970: 9). This is a recurrent problem also in Lapita archaeology, where excavated ground stone assemblages are rare (Sheppard 2010). One common approach circumventing this issue is to include undated or surface finds in

assemblage presentation (Felgate 2003; Green & Davidson 1969; Wickler 2001), which unfortunately negates any attempt to categorise adze types as chronological markers. This is particularly apparent in the inclusion of quadrangular adzes in the Lapita adze tool kit as their occurrences are commonly inferred from so-called plano-lateral forms. These resemble adzes with oval cross section but flattened sides which are significantly different from rectangular and trapezoidal forms of later periods (Bedford & Galipaud 2010; Poulsen 1987; Sheppard 2010). Only three quadrangular adzes from early Lapita contexts are published: Yanuca Island, Fiji (Birks & Birks 1968:109, Figure 6; redated by Clark & Anderson 2001); the Wakea (101/1/196) site in the Lau group, Fiji (Best 1984: 396, cross Figure 6.3c); and site To.6 on Tongatapu, Tonga (Poulsen 1987: 165, Figure 71, E5).

Whereas adze typologies of the earliest colonisation period are based on very small numbers, adze assemblages in the following periods are larger. Adze typologies in

Figure 2. The Talasiu site with location of adzes, adze fragments and flakes (red polygon) and burial locations (black circle) (adapted from Valentin *et al.* 2020, (Figure 2) [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]



Western Polynesia defined by Green and Davidson (1969) and Green (1974) for Samoa – although not helpful in understanding Lapita adzes in Samoa as none of the described adzes were found in Lapita contexts; the two adzes from the Mulifanua site are oval to plano-convex in cross section and might have arrived from Tonga (Leach and Green 1989: 323) – and Poulsen (1987) and Green (1971) for Tonga, remain the formal sequence for later developments of the Western Polynesian adze kit as they are associated with relatively well-dated deposits (Kirch & Green 2001; Smith 2002). The early Samoan adze kit has been summarised as containing robust, heavy, bilaterally flaked plano-convex adzes with curved cutting edges (Type Va), triangular and high plano-convex adzes with narrow cutting edges (Types Vb, VI, VII), light rectangular adzes (Type III), sub-triangular or reverse trapezoidal adzes (Type IV) and widely quadrangular adzes of different forms (Type I/II and IX/X) (Leach 1996). The early Tongan sequence was established by Poulsen (1987) and Green (1971); it contained 10 classes divided into two groups. Group one is adzes with cross section shapes that are quadrangular and rounded quadrangular (1a), trapezoidal (1b, 1a/b, 1c), triangular (1d, 1e), and group 2 are oval or round (2a), plano-convex (2b, 2c) or rounded quadrangular (2d). Comparing adzes recovered from Samoa and Tonga, Kirch

and Green (2001: 178) and Green (1971) noted a lack of triangular, quadrangular and trapezoidal forms in early deposits of Central Tonga, and vice versa oval and plano-lateral forms are missing in the Samoan archipelago. The Fijian sequence has best been described by Best's (1984) work on Lakeba in the Lau islands, Fiji, presenting a detailed assessment of early coloniser settlements in the Central Pacific. He focused on a combination of cross section and functionality to create a typology of adzes, with cross section being the dominant attribute. Cross section categories included round to plano-convex (Types I–III), triangular to trapezoidal (Types V–VII) and rectangular to oval-rectangular (Types IX–XI). Adzes came from secure chronological contexts at the Wakea and Qaranipuqa sites and included plano-convex, triangular to trapezoidal and rectangular to oval-rectangular forms (Best 1984: 392). Best (1984: 397) pointed out that plano-convex forms (Type III in his classification) are the most common early forms, but that rectangular (Type IX) and bevelled-rectangular types (Type X) exist in the same context.

The current data paint a picture of interaction, but also innovation in isolation (Davidson 2012). It appears that the cultural sequence of West Polynesian adze designs is driven by substantial amounts of conservatism where early innovations persisted (Connaughton 2014; Smith 2002). Differences in adze morphologies, for example, the lack of triangular forms in Tonga and oval/round adzes Samoa, continued through a period of lower inter-island interaction in the Plainware Period of both island groups. Only when interaction increased in the latest phase do we see a broader spectrum of adze types reappearing in sites (Clark *et al.* 2014). However, these increases in differentiation are a direct result of more intense transportation of finished tools, rather than a diversification of local production (Burley *et al.* 2015; Burley & Addison 2015).

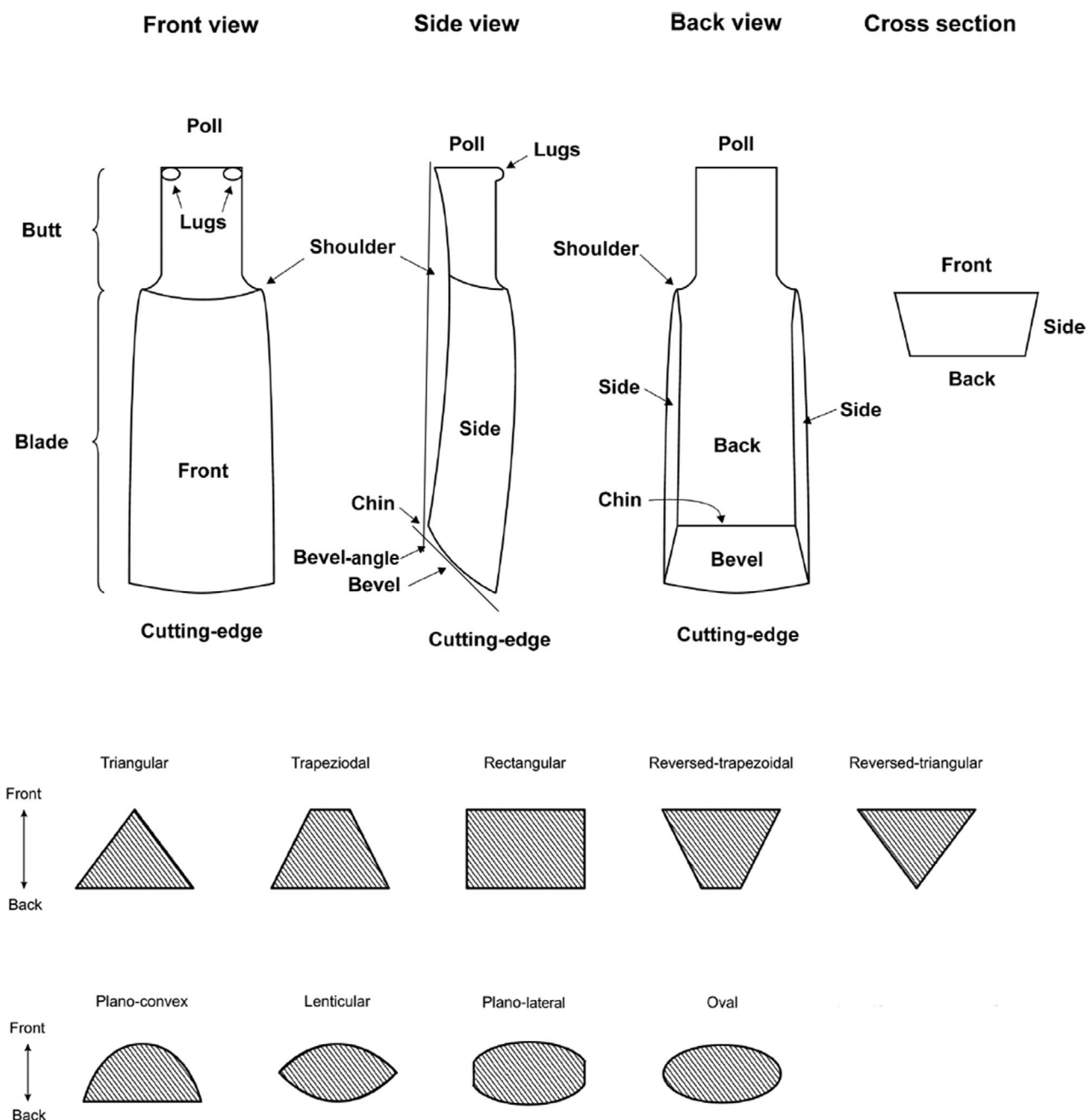
More recent engagements with adze manufacture have largely abandoned chrono-typological approaches, acknowledging that there is a complex interplay between adze morphologies and the *chaine operative* of adze use-life (Kneebone 2018; McAlister 2011; Turner 2000). These new approaches refocused analysis from identifying classification types to questions about direct connections between increase in use-life, including repolishing of surfaces or a complete reshaping after breakage, and size of artefacts and categorial attributes such as cross-section types. This is particularly important as the low recovery rate of adzes from Lapita sites is most likely associated with the long use-life of stone adzes (Felgate 2003: 398).

METHODS

Geochemistry

In this study, a Bruker Tracer III-SD portable X-ray fluorescence analyser (PXRF) equipped with a rhodium tube, Peltier-cooled Si-PIN detector at a resolution of approximately 170 eV full width at half maximum

Figure 3. Terminology for adze attributes and cross-section forms (McAlister 2011, adapted).



(FWHM) at the Mn $K\alpha$ peak (5.9 keV at 100000 counts per second) and a 1024 channel configuration multichannel analyser were used. Instrument parameters were 40 keV, 42 μ A, using a 0.1524-mm Cu, 0.0254 mm Ti and 0.3048 mm Al filter in the x-ray path and a 60-second live-time count at 185 FWHM. Interferences from air were minimised by placing the instrument as close as possible to the flat surface of a sample. Concentrations (in ppm) of Fe, Mn, Rb, Sr, Y, Zr and Nb were calculated using the online CloudCal tool (<http://www.xrf.guru/Apps/CloudCal/index.html>) by regression analysis against 14 international standards (AGV-1, BCR-1, BCR-2, BHVO-1, BHVO-2, BIR,

CRPG-BR, DNC-1, JB-1, NIST1633a, NIST1646, NIST2704, NIST278, NIST27D, RGM-1, WSE) and six in-house standards (GC-006, GC-11, GC-188, GC-200, KILAUEA 93-1489, TAFahi) (Clark *et al.* 2014).

Samples from Niuaotuputapu (Table 1) were analysed by scanning electron microscopy - energy dispersive X-ray analysis (SEM-EDXA) for major elements and laser ablation - inductively coupled mass spectrometry (LA-ICP-MS). The system used in this study is a Joel6400 SEM-EDXA and an Agilent 7500S inductively coupled plasma mass spectrometer combined with a Lambda Physik

Figure 4. Principal component analysis of obsidian artefacts with reference dataset of obsidian sources in the Western Pacific.

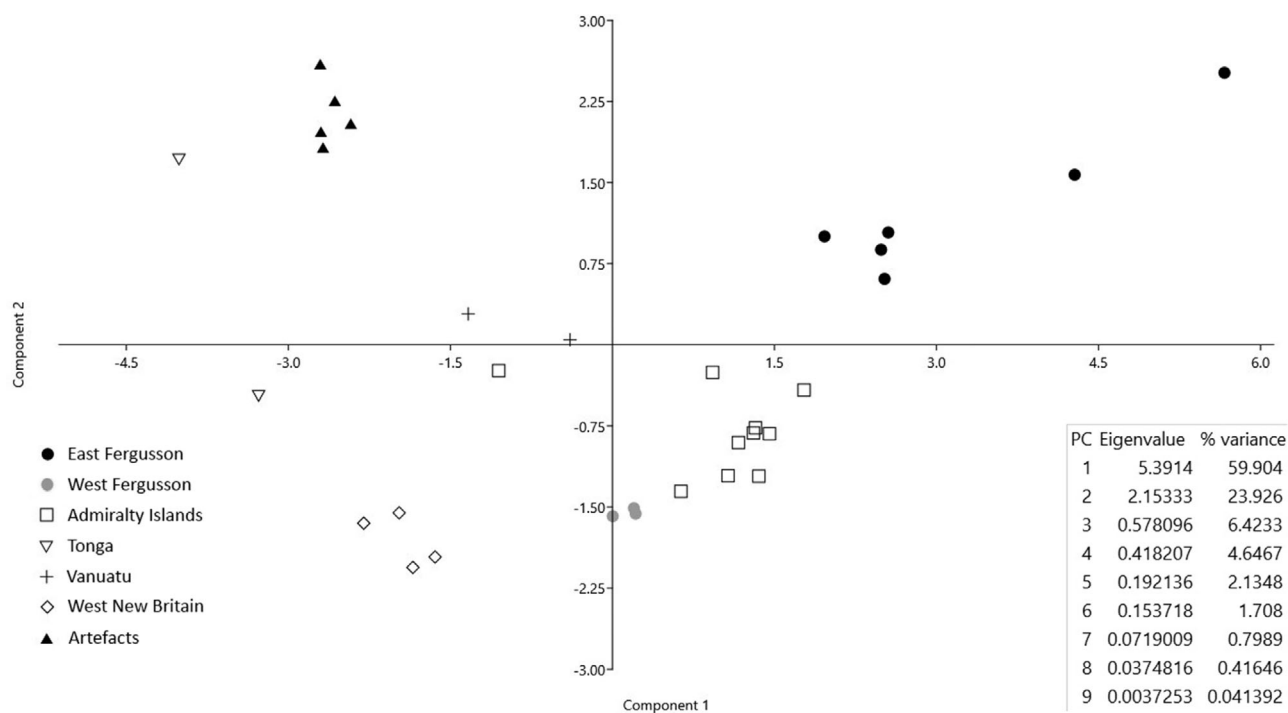
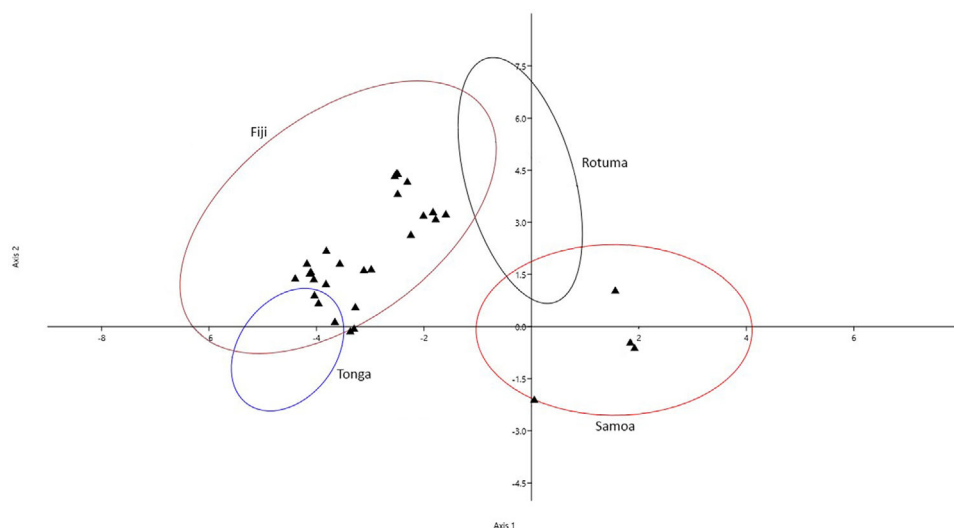


Figure 5. Discriminant function analysis of basalt adze raw material with reference collection from Clark *et al.* (2014). [Colour figure can be viewed at wileyonlinelibrary.com]

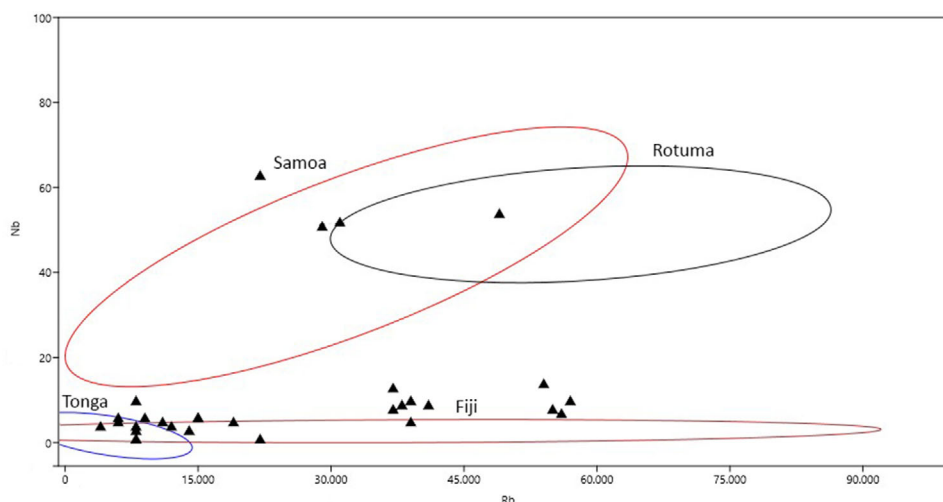


ArF laser ablation system (Longerich *et al.* 1996). The ArF laser, operating at a wavelength of 193 nm, is capable of ablating silicate, oxide and sulphide phases using an aperture to define pit diameters from about 20–200 μm . The pit diameter is controlled by the beam size, and only minimal residual melting occurs (Eggins *et al.* 1998). Beam diameters producing best ablation results depend on chemical and structural features of the sample (e.g. for clay >100 μm). Laser diameters of 86 μm (Lambda Physik laser) were chosen because they produced count rates of

103–106 per second for most trace elements, allowing use of the same low count rate part of the detector system.

Counts for nine major elements (Na_2O , MgO , Al_2O_3 , SiO_2 , K_2O , CaO , TiO_2 , MnO and FeO) and 31 isotopes (^{31}P , ^{45}Sc , ^{49}Ti , ^{51}V , ^{55}Mn , ^{63}Cu , ^{85}Rb , ^{88}Sr , ^{89}Y , ^{90}Zr , ^{93}Nb , ^{95}Mo , ^{118}Sn , ^{133}Cs , ^{138}Ba , ^{139}La , ^{140}Ce , ^{144}Nd , ^{147}Sm , ^{153}Eu , ^{158}Gd , ^{162}Dy , ^{166}Er , ^{174}Yb , ^{175}Lu , ^{181}Ta , ^{186}W , ^{206}Pb , ^{207}Pb , ^{208}Pb , ^{232}Th and ^{238}U) were determined by calculating the mean concentration for each element from three analysis runs per sample (Lee & Sneddon 1994).

Figure 6. Biplot of niobium (Nb) and rubidium (Rb) element abundances separating Samoan, Rotuman, Fijian and Tongan raw material. [Colour figure can be viewed at wileyonlinelibrary.com]



Morpho-metric analysis

Analysis of adzes were conducted using a mix of categorical data and measurements, following Turner (2000) and McAlister (2011) (Supplementary Table 1). Categorical attributes included cross section, cutting edge shape, bevel direction (front/back or back/front) and butt form (blunt, rounded, pointed, bevelled) (Figure 3); numerical attributes are measurements of weight, total length, width (butt, midpoint, bevel and maximum), thickness at midpoint, bevel angle and the amount of polishing at front, back and butt (in percentage). Indices of length and width were calculated. No detailed usewear analysis was conducted; however, gloss and chip marks were recorded if present.

RESULTS

Obsidian

Five additional large obsidian flakes were found in the 2013–2014 excavations (Table 2). Geochemical analyses of the artefacts indicate a signature similar to that of previously excavated artefacts. These artefacts were tentatively sourced to the Hala'Uta out crop on Tafahi in North Tonga (Reepmeyer *et al.* 2012) based on the high amounts of Mn and Fe detected in both samples (Figure 4). However, mid-Z elements are slightly different from the Hala-Uta outcrop, and the possibility of the third unknown source on the neighbouring island Niuatoputapu, mentioned in Dye (1988), was suggested as the possible location (see also Burley *et al.* 2011). This slight variation is also reflected in the analysis of new-found artefacts from Talasiu (Table 2). Source samples from the suggested Niuatoputapu source are not available; therefore, seven obsidian pieces from Niuatoputapu (NTT-1 to NTT-8) hosted in the ANU collection were reanalysed with LA-ICP-MS (Table 1). High Mn-counts presented in the analysis of Burley *et al.* (2011) were not replicated; however, results show similar

Fe, Sr and Zr values as analyses published by Reepmeyer *et al.* (2012) for the artefacts previously reported from Talasiu and Burley *et al.* (2011) for the Tafahi source (Table 1). The artefacts show the same slight variation in the mid-Z elements as identified in the Talasiu pieces, supporting the hypothesis that not the island of Tafahi, but an unidentified source on the island of Niuatoputapu, might be the possible source location of the obsidians from Talasiu.

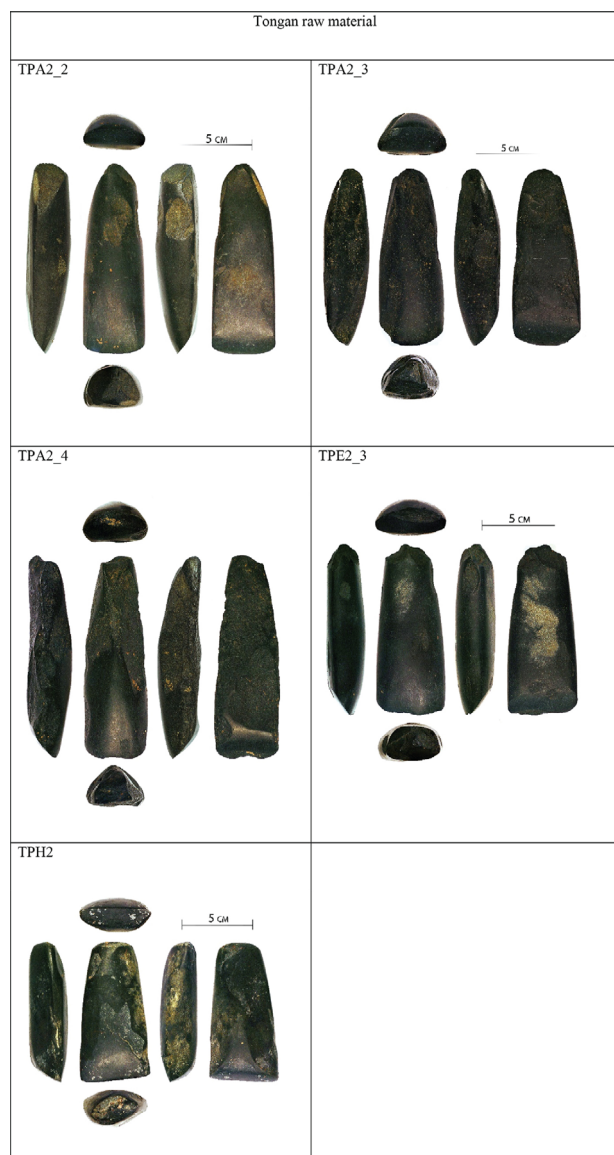
Adzes and associated flakes

Talasiu also contained a substantial assemblage of other igneous rocks, including adzes and adze fragments made from basalts, andesites and rhyolites. Clark *et al.* (2014) were able to allocate artefacts from the 2008 excavations based on pXRF, SEM-EDXA and LA-ICPMS data to source locations in Central Tonga and the islands of Fiji to the west – most likely from an island of the Lau group in east Fiji.

In total, 31 complete and fragments of adzes and flakes were found during the 2008–2016 field seasons (Table 2). The reference dataset for the analysis of adze raw material has been published in Clark *et al.* (2014). Discriminant function analysis (Figure 5) of samples from Samoa, Fiji and Tonga showed a clear separation of Samoa samples and Tonga/Fiji. Strong overlap could be seen in the source region of Fiji and Tonga. However, focusing on the Rb and Nb elemental distribution has been shown in the past to separate these source regions from each other (Clark *et al.* 2014). Tongan arc materials are strongly depleted in both Rb and Nb values, whereas Fijian material shows similarly low counts of Nb, reflective of an Island Arc origin, but with significantly higher Rb values (Figure 6).

Two complete adzes (TPA2_1 and TPB2) were sourced to Fiji, one adze (TPL), found on the surface of the site) originated from Samoa and five complete adzes came from one of the Tongan volcanic islands. Unfortunately, the only

Figure 7. Selected complete adzes made from Tongan raw material.



complete Samoan adze has no clear chronological association, but adze fragments from excavations were also identified as originating from Samoa (TPE2_1). One adze fragment was sourced to Fiji, and the remaining seven pieces are from the Tongan Archipelago. Adze flakes, primarily from excavated settings (one artefact was found on the road edge) were sourced to Fiji (seven pieces), Samoa (one piece) and Tonga (three pieces) indicating that raw materials from multiple areas were used at the site. The occurrence of Samoan adzes in early deposits on Tongatapu shows that raw material transportation, which intensified significantly in later deposits (Clark *et al.* 2014), most likely started very shortly after the initial colonisation phase on Tonga and almost immediately after the colonisation of Samoa by Lapita groups (Leach & Green 1989; Petchey 2001).

Adze morpho-metrics

Dominant adze cross sections are plano-convex forms represented by four complete adzes (TPA2_1-4) and six adze fragments (Supplementary Table 1). Complete adzes range in length from 90 to 131 mm, weighting 106–320 g. All adzes have upcurving bevels from the planar back of the adze, averaging at 23–44 degrees. Adzes show polishing on over 70% of the surface area; however, there are sufficient non-polished surfaces preserved to identify that all complete adzes were flaked in the process of manufacturing. Complete adzes and adze fragments where the butt section is preserved show evidence of gloss on the butt with the exception of one fragment, which might indicate hafted tools and show other forms of use-wear such as chipping at the bevel. A more detailed analysis of the adze use-wear is forthcoming.

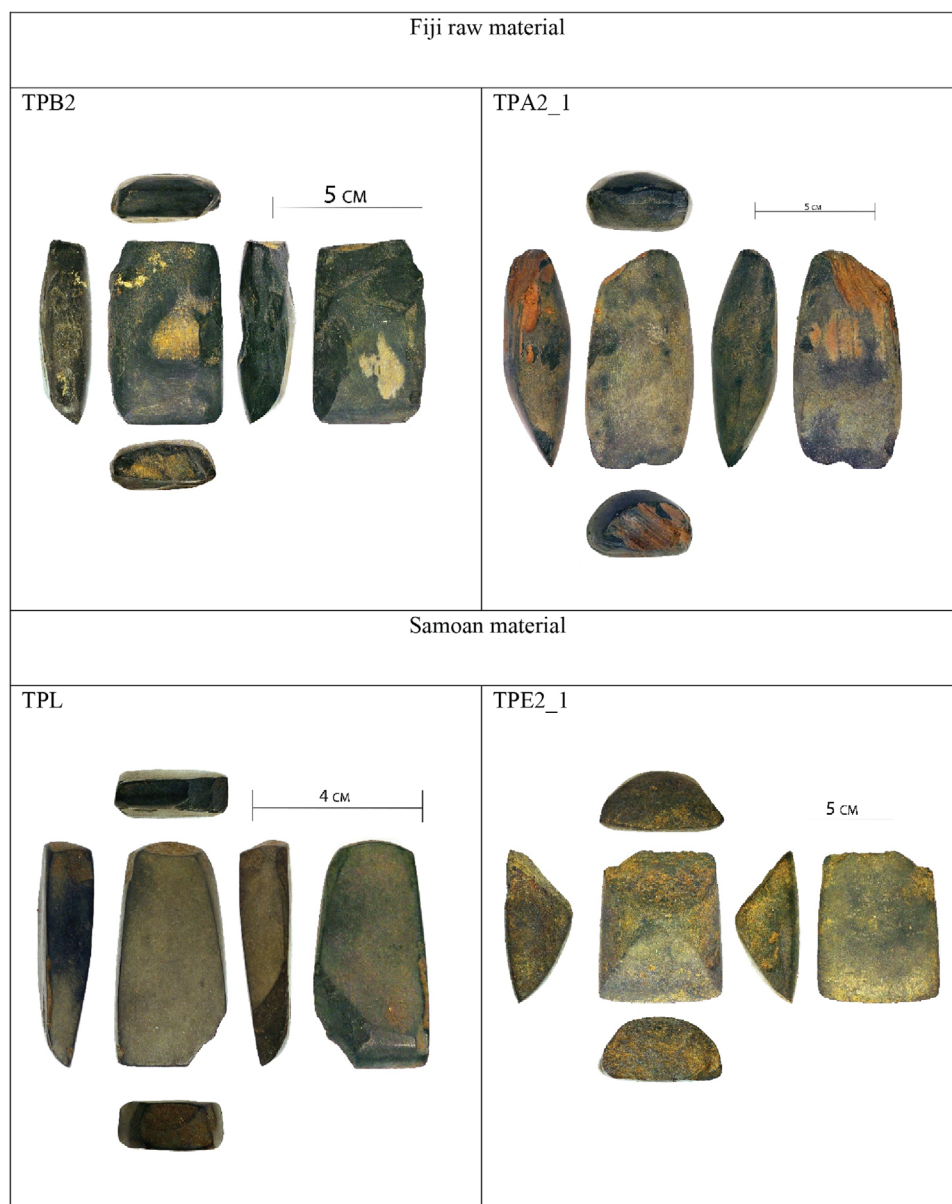
Two complete adzes (TPE2_3 and TPH2) have lenticular cross sections; they are slightly shorter than plano-convex forms, 94–111 mm, weighting 175–216 g. Similar to plano-convex adzes, they have an upcurving bevel for the planar back with a slightly steeper angle of 35–54 degrees. The remaining adzes have a plano-lateral cross section, and one adze fragment is round in its cross section. The complete plano-lateral adze is similar in size to the remaining adzes, 111 mm length and 215 g weight. It also has an upcurving bevel with an edge angle of 35 degrees.

In total, 11 flakes were found which were unambiguously identified as artefacts associated with adze utilisation, based on raw material and grinding/polishing traces on the dorsal surfaces. The low number of flakes suggest that there was no extensive reshaping of adzes by flaking, even if we assume occasional breakage which is suggested by the number of adze fragments ($n = 11$) found at the site. We assumed that all these flakes are associated with the use of adzes rather than with a reshaping of blunt or broken adzes.

Adzes morpho-metrics in relation to raw material provenance

One avenue of identifying initial standardisation in adze production is similarities in artefact shape and form produced from raw material originating near the place of discard. Plano-convex forms dominate the assemblage, particularly in adzes made from local material (Figure 7). These adzes share a distinctive length to width ratio of 2.7–3.2, with similar bevel angles (39–44 degrees). Sides of these adzes are mostly parallel, with thinning at the butt. Included in this assemblage is the plano-lateral adze TPE2_3, which shows similar attributes (length 111 mm, length/width ratio 2.5 and bevel angle of 35 degrees). Two lenticular and one round adze complete the assemblage made from local material. Non-plano-convex forms are in general shorter and show increased areas of polished surfaces (75–100% compared to plano-convex forms which have less than 50% surface polished). This might indicate that non-plano-convex forms are in advanced stages of their use-life (see also Clarkson & Smith 2009 for a discussion of changing elongation of adzes), including reshaping after

Figure 8. Selected adzes made from Fijian and Samoan raw material.



breakages (Turner 2000). Adze fragments with distinguishable cross sections support the pattern of complete adzes made from Tongan lithic material, contributing a further five adzes with plano-convex cross section, one lenticular cross section and one round cross section.

Lenticular adzes (TPB2) (Figure 8), typologically associated with early colonisation sites, such as Lakeba (Best 1984), are also present in the assemblage. The second adze potentially sourced to Fiji has a plano-convex cross section, but with a much lower bevel angle (28 degrees), it is shorter (90 mm) and has a much lower length to width ratio of 2.08 compared to adzes made from local material (2.96). It is fully polished on the convex front and planar

back, but has flaking surfaces preserved on both sides. This might indicate several consecutive repolishing episodes, also pointing to the possible age of the artefact.

New in the 2013–2014 assemblage is the detection of three artefacts sourced to Samoa. This is unusual as it is assumed that Samoa–Tonga interaction in the earliest colonisation phase was minimal and settlement sites on Samoa are rare (Burley *et al.* 2011; Cochrane & Rieth 2016). None of these samples are complete adzes, but adze fragments were identified where the cross section is preserved. TPE2_1 is a plano-convex bevel fragment. Unfortunately, the fracture of the object does not allow for an unambiguous identification of the front and back of the adze. Surfaces of the adze are completely polished, so it is

unclear whether the adze was flaked in the manufacturing process.

Quadrangular adzes were not found in the excavated area. However, one surface find was a fully polished adze with trapezoidal cross section (Green & Davidson 1969, Type IVa). The second identifiable adze was a broken fragment with only the blade preserved, plano-convex in cross section (most similar to Green & Davidson 1969, Type V, but with a straight blade). Both adzes might reflect later imports, as adzes with Samoan provenance are regularly found on Tongatapu, associated with the construction of large burial tombs in the second millennium AD (Clark *et al.* 2014; Clark & Reepmeyer 2014). These adzes were excluded from our analysis, as they were found on the surface and have to be classified as undated.

DISCUSSION

This paper presents the largest late Lapita – early Polynesian plainware period adze assemblage currently excavated in Tonga, which might provide some baseline data on the evolution of adze morphologies in Western Polynesia. Adzes during Lapita are claimed to be one of the defining aspects creating a “community of culture” for the earliest coloniser groups in the Western Pacific (Green 2003). Unfortunately, the evidence for a distinctive “Lapita adze kit” is scarce, with well-dated adzes a rare occurrence. Green (2003) identified rectangular, oval or rounded, plano-lateral and plano-convex adze cross sections as typical “Lapita”, and indeed, all of these adzes have been reported from Lapita sites. Plano-lateral and plano-convex forms have been classified as a Lapita innovation, as it was assumed that these adzes were not well represented in Papua New Guinea (PNG) assemblages. However, Specht *et al.* (2014) noted that both plano-lateral as well as plano-convex adzes can be found in assemblages of the PNG highlands.

Similar to adze assemblages in the Middle and Late phases of Lapita in New Guinea and the Western Solomon Islands, several adze forms are represented in the Talasiu assemblage, which include plano-lateral, plano-convex, oval/lenticular and round cross sections. It is unclear at this stage if we see an increase in standardisation of adze morphologies from the early stages of the Lapita cultural complex as all adze cross sections are represented in Middle and Late Lapita contexts (Specht *et al.* 2014). In the Talasiu assemblage, we also do not see a strong standardisation process towards particular adze morphologies. However, this picture changes slightly if raw material provenances are taken into account. It appears that Talasiu adzes made from local raw materials follow a pattern of plano-convex forms with similar dimensions and bevel design. This design is dominant and might indicate the need of these adzes for a specific task.

It has been noted that identifying adze-manufacturing processes in fully polished adzes is increasingly difficult as initial shaping procedures are superseded by grinding/polishing; it is commonly not possible to see whether reshaping of a water-rolled pebble using only

grinding and pecking or using initial flaking and then polishing of the flake scars, are the dominant technologies applied. This problem increases with the use-life of artefacts as they are continuously resharpened through grinding. The abundance of shaping pre-forms through flaking in later Polynesian typologies (Clarkson *et al.* 2014; Hermann 2016) might be a Lapita period innovation as the majority of adzes in the Talasiu assemblage show traces of flaking in the manufacturing process.

However, production debris was not found at the site; at this stage, it is safe to assume that only end products, such as whole adzes, were transported long distance and there was no raw material transportation for adze processing in situ. This pattern is also reflected in the grinding tools found at the site. The majority of manuports and grinding tools appear to derive from localised sources in Central Tonga, but long-distance interaction can also be seen in transports of raw materials from Fiji (Ferguson 2019).

The directionality of this exchange represents interaction spheres between Tongan islands, the Samoan chain (which might include the island of ‘Uvea) and Fiji, but at the same time shows that the colonisation process might have been highly complex. Talasiu is dated to ~2650 BP (Valentin *et al.* 2020) at the beginning of the Ancient Polynesian Plainware period in Tonga, some 200 years after arrival of people in the archipelago (Burley *et al.* 2015), but where people appear to still maintain high residential mobility. Fijian and northern Tongan adze material found in Talasiu supports the idea and suggests increased mobility persisted for at least a few hundred years after initial colonisation (Best 1984; Reepmeyer *et al.* 2012).

There is good lithic evidence for movement of artefacts and raw materials in Central Tonga, including the volcanic islands to the west and the neighbouring island ‘Eua to the southeast (Clark *et al.* 2014). The number of artefacts sourced to this region seems to present intensive interaction on a local level. Interactions with the far north, including the northern islands of the Tongan archipelago as well as the island in the Samoa chain, are more infrequent. However, the existence of Niuatoputapu obsidian material in Talasiu indicates contact with the north which was established before occupation at Talasiu began (Reepmeyer *et al.* 2012). This is also supported by the occurrence of Samoa adze material in Talasiu. At this stage, it is unclear whether adzes from Fiji prove continuing direct contact between Tongatapu and Fiji as the shorter dimensions and the extent of polishing on the surface indicate several repolishing episodes and might indicate that the artefact was an heirloom from the initial colonisation phase on Tongatapu. On the other hand, the larger number of flakes with polish on the dorsal surface suggests that adzes made from Fijian material were used frequently at the site.

Obsidian sources are absent in Fiji and obsidian imported as raw material, which is commonly the best indicator for a direct contact between islands, shows that there was no transport of Samoan obsidian material into the island groups of Vava’u and Ha’apai. However, one artefact made from Samoan material was found on Niuatoputapu

(Burley *et al.* 2011). Adze raw material from Samoa has also not been found in early sites on Vava'u and Ha'apai group (Cochrane & Rieth 2016). Therefore, the presence of Samoan adze material in both late Lapita and early APS sites might indicate that Tongatapu was included in early voyaging patterns of people from islands to the North.

Whatever the detailed transport pathway of adzes into Tongatapu might have been, it appears that contacts with Fiji in the west decreased at the end of the Lapita period. Adzes from Fijian material are more heavily reduced than adzes from raw materials sourced in closer vicinity. On the other hand, contact with the Samoan islands was established in the earliest colonisation phase and selectively maintained in later phases. Contacts with the northern Tonga islands and probably Samoa most likely persisted and intensified with the emergence of the Tongan maritime empire some 1500 years later (Clark *et al.* 2014).

CONCLUSION

This paper presents the lithic assemblage from the Late Lapita – early APS site of Talasiu, Kingdom of Tonga. Excavations of the site discovered a large flaked and ground stone tool assemblage. We focused on the geochemistry of obsidian tools and adzes made from volcanic rocks and discussed potentially emerging standardisation of adzes in the transition from Late Lapita period to APS. Results show that although there is a wide variety of adze types being utilised at the site, similar to that known from other Lapita sites, we see an abundance in plano-convex forms with a steep bevel angle made from more local, intra-archipelago volcanic sources. These adzes might indicate that adze forms for specific tasks become more prevalent in the late phases of the Lapita period and that they are indicative of APS as precursors to the differentiations of adze forms in the later phases of Polynesian prehistory.

The geochemistry of adzes and obsidian tools shows a strong connection to the north, both to the northern islands of the Tonga Archipelago as well as Samoa. This indicates that at least in the late phases of the Lapita period, Samoa was already well integrated in a network of raw material transportation and that the lack of early sites in Samoa might derive from a research gap rather than a very late colonisation of the islands. Adzes made of raw materials from Fiji show signs of heavy use as they tend to be smaller and fully polished with hardly any manufacturing attributes still detectable. These artefacts are best interpreted as heirlooms, travelling with colonising populations, and are not unambiguously evidence of a continuation of interaction spheres between Fiji and Tonga in the late phase of the Lapita period.

AUTHOR CONTRIBUTIONS

Christian Reepmeyer: Conceptualisation, Formal Analysis, Investigation, Methodology, Project Administration, Supervision, Visualisation, Writing (draft, review &

editing). Redbird Ferguson: Formal Analysis, Methodology, Visualisation, Writing (draft). Frederique Valentin: Investigation, Funding Acquisition, Project Administration, Resources, Writing (editing). Geoffrey Clark: Conceptualisation, Investigation, Funding Acquisition, Project Administration, Resources, Writing (review & editing).

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SUPPORTING INFORMATION

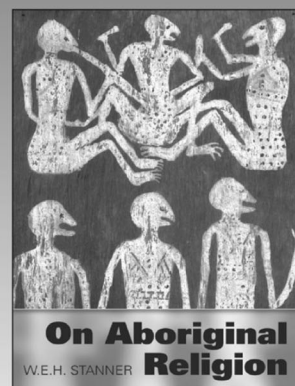
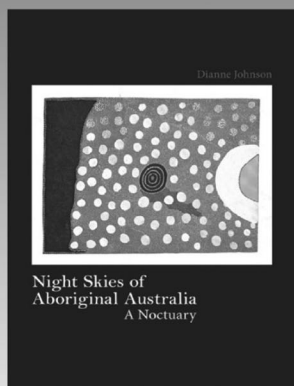
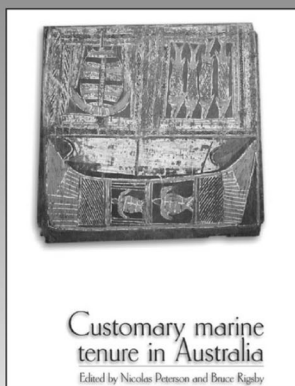
Additional supporting information may be found online in the Supporting Information section at the end of the article.

Supplementary Table 1: Summary statistics and technological measurements of adzes, adze fragments and flakes.



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