THE IDENTIFICATION OF A MARQUESAN ADZE IN THE COOK ISLANDS

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The islands of East Polynesia were among the last places on Earth to be settled by humans. To embark on such an undertaking, involving hundreds of islands separated by thousands of kilometres of ocean, would almost certainly have required a high degree of organisation, and many of the questions that have interested archaeologists working in the region revolve around how this feat was achieved (see Allen and Kahn 2010, Kirch and Kahn 2007 for reviews of recent research). Irwin (1990, 1992) has shown that a deliberate and coordinated strategy of exploration provides the most plausible explanation for the discovery of habitable islands, while other researchers have argued that some degree of post-colonisation interaction would have been needed to maintain viable settlements on ecologically-marginal islands (e.g., Di Piazza and Pearthree 2001; Weisler 1993, 1997a).

Archaeologists have employed various lines of evidence to demonstrate this kind of mobility and interaction between communities. Some types of evidence, such as stylistic similarities of artefacts and architecture, shared genetics, common languages and the remains of introduced plants and animals, can demonstrate initial contacts (or common origins) but they will not necessarily reflect on-going relationships. A less ambiguous and more direct method of demonstrating interaction has been to identify the presence of exotic objects made from compositionally distinctive materials. In other parts of the world, such materials have included obsidian (e.g., Cann and Renfrew 1964, Hughes 1986), various metals (Hosler and Macfarlane 1996, Knapp 2000), manufactured glasses (Saitowitz and Read 2001), ceramics (Kennett, Anderson, Cruz *et al.* 2004) and shell valuables (Aswani and Sheppard 2003, Kirch 1988: 108). However, with the exception of obsidian and volcanic glass, which is common only in New Zealand, Rapa Nui and Hawai‘i (McCoy, Mills, Lundblad *et al.* 2011; Sheppard, Irwin, Lin *et al.* 2011; Ward 1972), these materials are absent or extremely rare in pre-contact East Polynesian assemblages (Weisler 1993: 19). For this reason, archaeologists working in Polynesia have for the most part concentrated on identifying the geographical origins of adzes and other tools made from basalt, a commonly-occurring volcanic stone, using X-ray fluorescence spectrometry (XRF) and related techniques (Parker and Sheppard 1997, Shackley 2010, Weisler and Sinton 1997).

GEOCHEMICAL BASALT ANALYSES IN POLYNESIA

Over the past three decades, geochemical analyses of basalt tools have been increasingly employed as the primary means of identifying interaction in Polynesia. Early provenancing studies were, however, somewhat limited by relatively small sets of reference data. For example, Best's (1984) pioneering study of Pacific adze geochemistry included only 35 reference specimens from across the region and some sources were represented by single samples. Since then, concerted efforts have been made to systematically sample and analyse most of the major Polynesian basalt sources (e.g., Allen and McAlister 2013; Best , Sheppard, Green *et al.* 1992; Bollt 2008; Hermann 2011; Johnson 2005, 2010; Kahn, Mills, Lundblad *et al.* 2008; Kahn, Sinton, Mills *et al.* 2013; McAlister 2011; Mills, Lundblad, Smith *et al.* 2008, Mills, Lundblad, Field *et al.* 2010; Mills, Lundblad, Hon *et al.* 2011; Mintmier, Mills and Lundblad 2012; Sheppard, Sand and Parker 2001; Sheppard, Walter and Parker 1997; Walter and Sheppard 2001; Weisler 1993, 1998; Weisler, Conte and Kirch 2004; Weisler, Kirch and Endicott 1994; Weisler, Collins, Feng *et al.* 2013; Winterhoff 2007), resulting in geochemical data for more than 2000 reference specimens. Consequently, analysts are now in a better position to understand the characteristics of various sources, including the ranges of their internal variability.

Provenancing studies have shown that most communities in Polynesia did not develop in isolation but remained in contact with one another for several centuries after colonisation. Weisler (1997b, 1998, 2008), who has been at the forefront of this research, has identified a number of distribution patterns, which he suggests reflect interaction spheres of varying scales. Two basalt sources in particular have very wide distributions (Fig. 1). Adzes from the Tataga Matau Quarry on the Samoan island of Tutuila have been identified in several West Polynesian assemblages, including the Polynesian outlier of Taumako in the Solomon Islands (Best *et al.* 1992), and were distributed eastwards to the Cook Islands (Allen and Johnson 1997, Sheppard *et al.* 1997, Weisler 1993). Similarly, tools sourced to Eiao, an extensive "island-quarry" of fine-grained basalt in the north of the Marquesas archipelago (Charleux, McAlister, Mills *et al.* in press; Linton 1925; Rolett 2001), have been found in several central East Polynesia assemblages (Collerson and Weisler 2007, Hermann 2011, Weisler 1998) and even as far north as the Line Islands (Di Piazza and Pearthree 2001).

A notable feature of large-scale distributions is that they tend to involve the transfer of materials from large, high-quality sources to islands either possessing basalts of lower quality or altogether lacking adze-quality stone. Within island groups possessing extensive sources of high-quality basalt, distributions often are limited to intra-archipelago sources. For example, four

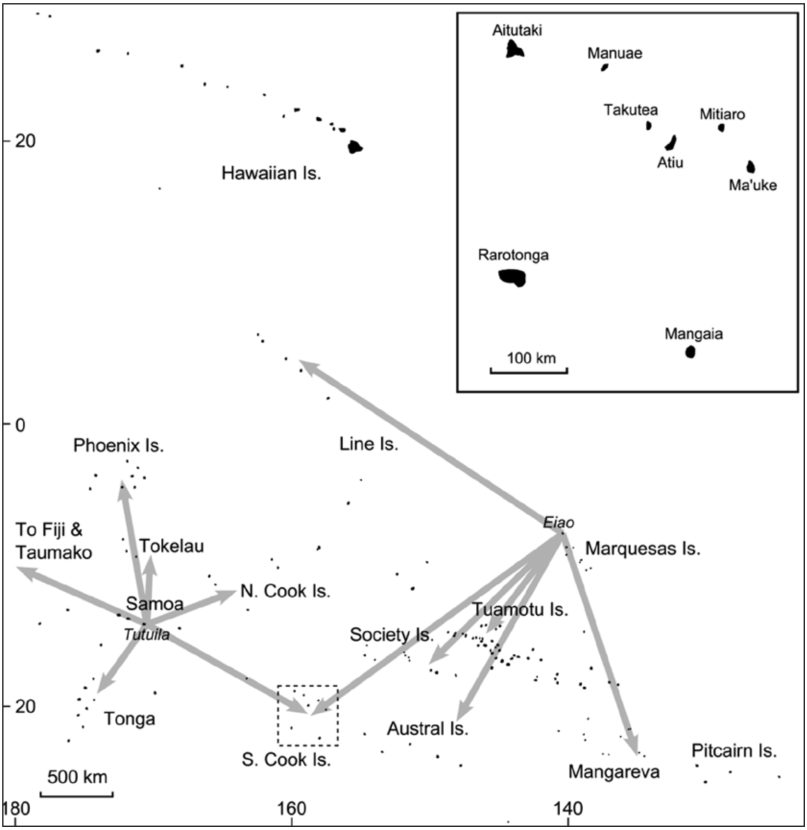

Figure 1.Central Polynesia, showing known distributions of basalt from Tutuila, Samoa (left) and Eiao, Marquesas Islands (right). Inset: the southern Cook Islands.

studies have geochemically analysed basalt tools from Marquesan sites (Allen and McAlister 2013; McAlister 2011; Rolett 1998; Rolett, Conte, Pearthree *et al.* 1997) and all have found that the assemblages contained only Marquesan stone. Additionally, basalt from Eiao was identified in all of the assemblages that were examined. Similarly, several studies of assemblages in the Hawaiian Islands, where high-quality fine-grained stone is widespread, have found that basalts from within the archipelago were widely distributed but, thus far, no examples of imported stone have been identified (see for example Kahn *et al.* 2008, 2013; Kirch, Mills, Lundblad *et al.* 2012; Mills *et al.* 2010).

In contrast, island groups without large reserves of fine-grained tool-quality basalt tend to have high proportions of imported stone from several sources. To date, Collerson and Weisler's (2007) analysis of adzes collected in the Tuamotu Islands, a group of mainly coral atolls completely lacking in basalt sources, has identified the greatest diversity of imported tools. From a relatively small sample of 19 specimens, they found adzes imported from several East Polynesian sources. These included examples from sources in the Society Islands, Rapa and Rurutu in the Australs, Pitcairn, Eiao in the Marquesas, and even one example from the Hawaiian island of Kaho'olawe over 4000 km to the north.

PROVENANCING STUDIES IN THE COOK ISLANDS

The Cook Islands, the focus of this communication, fall between the extremes represented by the Tuamotu and Marquesas Archipelagos. While there are several local sources of fine-grained basalt that were regularly worked into adzes and distributed within the group (see Allen and Johnson 1997; Sheppard *et al.* 1997: 87; Walter 1990, 1998; Weisler *et al.* 1994), no extensive quarries of high-quality basalt have been identified in the Cook Islands. Sheppard and Walter (Sheppard *et al.* 1997, Walter and Sheppard 2001) systematically surveyed the islands with aim of locating and sampling potential basalt sources for geochemical analysis and concluded that local basalt was primarily exploited from river cobbles and small localised dike exposures. Additionally, they suggested that the comparatively low silica content, and propensity to weathering typical of Cook Island basalts, might result in poor flaking properties. It is perhaps for these reasons that Cook Island provenancing studies have identified materials imported from other island groups. Stone from Samoa has been found on most of the southern Cook Islands, including Mangaia (Sheppard *et al.* 1997, Weisler 1993), Rarotonga (Sheppard *et al.* 1997, Walter and Sheppard 1996), Ma'uke (Best *et al.* 1992; Walter 1990, 1998), Aitutaki (Allen and Johnson 1997), and possibly also on Pukapuka in the northern Cook Islands (Best *et al.* 1992: 81). Several of these studies also have identified a smaller number of adzes from the Society Islands that were tentatively sourced to Ra'iatea Island (Allen and Johnson 1997, Sheppard *et al.* 1997, Walter 1990, Walter and Sheppard 1996).

In addition to collecting reference specimens, Sheppard *et al.* (1997: 86; see also Walter and Sheppard 1996) sampled 40 adzes from the Cook Islands Library and Museum Society collections. In their analysis, the majority of these were found to be compatible with intra-archipelago sources on Rarotonga, Ma'uke, and Aitutaki. They also identified imports from Samoa and the Society Islands, and noted that a few adzes possessed chemical compositions that could not be readily associated with known sources. One specimen that was considered both physically and geochemically distinct was an adze (identified as R68-1) with a reversed-triangular section (i.e., Duff Type 3A) that, according to the Museum's records, was collected on Rarotonga (Sheppard *et al.* 1997: Appendix 6a). The authors suggested that the adze was probably exotic on the grounds that it possessed a particularly low niobium concentration and plotted away from the other specimens in their sample (Sheppard *et al.* 1997: 101). Additionally, a thin-section taken from this adze showed that the specimen was atypical of Cook Island adze-stone in that it contained biotite, the groundmass was extremely fine-grained and phenocrysts were very rare.

In the following section, we report on a re-analysis of this adze, drawing on reference data from recent studies, and suggest that Eiao Island in the Marquesas is its most likely origin. When Sheppard, Walter and Parker conducted their analysis, not much was known about the geochemical properties of Marquesan tool-stone in general, or that of Eiao in particular. Best (1984: 403; see also Best *et al.* 1992) had analysed four Marquesan basalt samples from the Bernice P. Bishop Museum collections, including a flake from Eiao (AN42), for major oxides only. Since then, a number of studies have provided a more comprehensive understanding of the characteristics and variability of Eiao tool-stone. In 1997, Sinton and Sinoto published a quarry average for Eiao based on major element analyses of 19 adzes collected on various Marquesan islands and attributed to Eiao on the grounds of geochemical similarities (John Sinton pers. comm., 23 January 2008). In addition, trace element concentrations were determined for three of the specimens. It was not until 1998, however, the year after Sheppard, Walter and Parker's study, that the first securely-provenanced geochemical source data for Eiao were published. Weisler (1998: 523) selected three flakes from an assemblage of "shop fragments" collected on Eiao by Robert Suggs (1961) in the late 1950s and analysed them for both major and trace elements using Wavelength Dispersive X-ray Fluorescence (WDXRF). Collerson and Weisler (2007) subsequently re-analysed one of these flakes (832-1) for an extended range of elements and isotopes. More recently, McAlister (2011) analysed a large sample of adzes from the Marquesas and reported WDXRF data for one additional sample collected on Eiao and for 24 adzes collected on Nuku Hiva and attributed to Eiao. Overall, these studies have found that both source samples from Eiao, and artefacts assigned to the island, cluster closely together on plots and are geochemically distinct from all other known Polynesian adze-stone sources. Physical analyses of thin-sectioned specimens of Eiao basalt also have noted that the material has a distinctive dark grey colour, an extremely fine-grained matrix and few phenocrysts (Charleux *et al.* in press, McAlister 2011, Rolett *et al.* 1997).

RE-ANALYSIS OF THE R68-1 ADZE

While successive studies of many Pacific basalt sources are resulting in increasingly detailed insights into the production and distribution of stone tools in the region (Kahn *et al*. 2013, Kirch *et al.* 2012, Winterhoff 2007), the large geochemical datasets generated by such studies have, at the same time, complicated provenancing methods. The earliest investigations found that bivariate scatterplots or ternary diagrams allowed good discrimination among the relatively small sets of reference data available at the time (see for example Best 1984, Best *et al.* 1992, Weisler 1993). However, as reference databases are updated to include current information, a number of sources are becoming more difficult to separate by such simple means. As Figure 2 illustrates, bivariate plots of the trace element ratios niobium/strontium against zirconium/strontium, which served well in earlier studies (Allen and Johnson 1997, Sheppard *et al.* 1997, Weisler 1993), now show considerable overlap among many island groups.

One response to this situation has been to employ multivariate techniques, such as Principle Components and Discriminant Function Analyses (following Johnson 2005, McAlister 2011). While these sorts of techniques are useful for complex datasets, they tend to be methodologically involved, and the results often are difficult to present in a clear and concise format (e.g., Neff 1995). Another method of analysing large datasets that has been successful in geochemical provenancing studies is to use a recursive or nested approach, in which a complex problem is divided into a series of simpler steps by successively excluding the most dissimilar sources (see Baxter 1994, Hancock, Hancock and Hancock 2008, McAlister 2011, Weisler 1993: 143). Restricting the axes of the scatterplot shown in Figure 2 shows that reference samples from only three archipelagos—Hawai‘i, the Marquesas and Samoa—cluster near the R68-1 adze (Fig. 3). Additionally, these samples derive from single sources within each of those archipelagos: the Hawaiian samples are all from Kīlauea Caldera on Hawai‘i Island, the Marquesan samples are all from Eiao, while the single Samoan specimen, which is compositionally similar to the R68-1 adze, is from Malaeloa, Tutuila (Winterhoff 2007: Appendix C, Sample E). Despite the overlap in their element ratios, the three sources are easily separated when trace element concentrations are examined, and the adze repeatedly clusters closest to the Eiao specimens, suggesting that this is the most probable source (Fig. 4).

As Weisler and Sinton (1997: 180) suggested, the most secure way to match an unknown sample to a source is to examine the concentrations of all measured elements (Table 1). To quantify the similarity of artefacts to sources, Collerson and Weisler (2007) have employed a ratio measure (A/S),

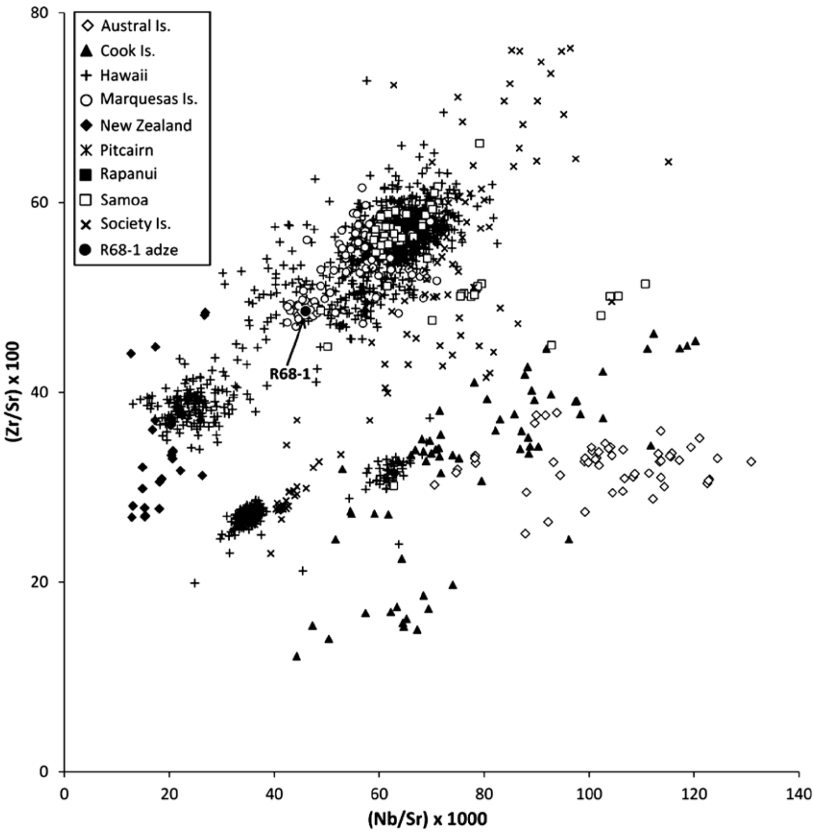

Figure 2. Bivariate scatterplot of trace element ratios for Polynesian basalt sources (1000 x Nb/Sr against 100 x Zr/Sr). Data are collated from all the works cited in the text that include values for the three trace elements.

which consists of dividing artefact values by source compositions, where a value of 1.00 represents an exact match to a source average and higher or lower values show increasing dissimilarity (see Table 1). Comparing the R68-1 adze to the source averages for Eiao and Kīlauea, and the single Malaeloa specimen, shows that Eiao is a much closer match for all elements except nickel. Moreover, the large differences between the adze and the Kīlauea and Malaeloa data for major elements silicon, sodium, aluminium, calcium and potassium suggest that the adze is unlikely to be derived from the same volcanic events that produced these deposits. Overall, our analysis indicates that the Eiao source provides the closest match for the Cook Island adze R68-1. While it is never possible to determine the origin of an artefact with absolute confidence, on the basis of our current knowledge, the adze is unlikely to have derived from any other known Polynesian basalt source.

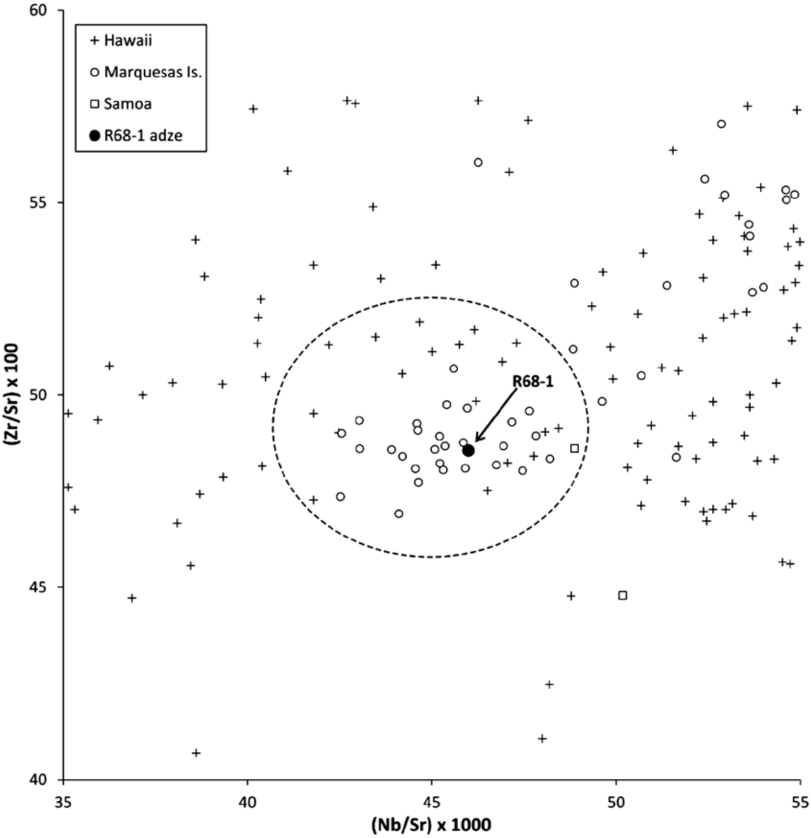

Figure 3. Bivariate scatterplot of Polynesian basalt source data clustering close to the R68-1 adze (1000 x Nb/Sr against 100 x Zr/Sr).

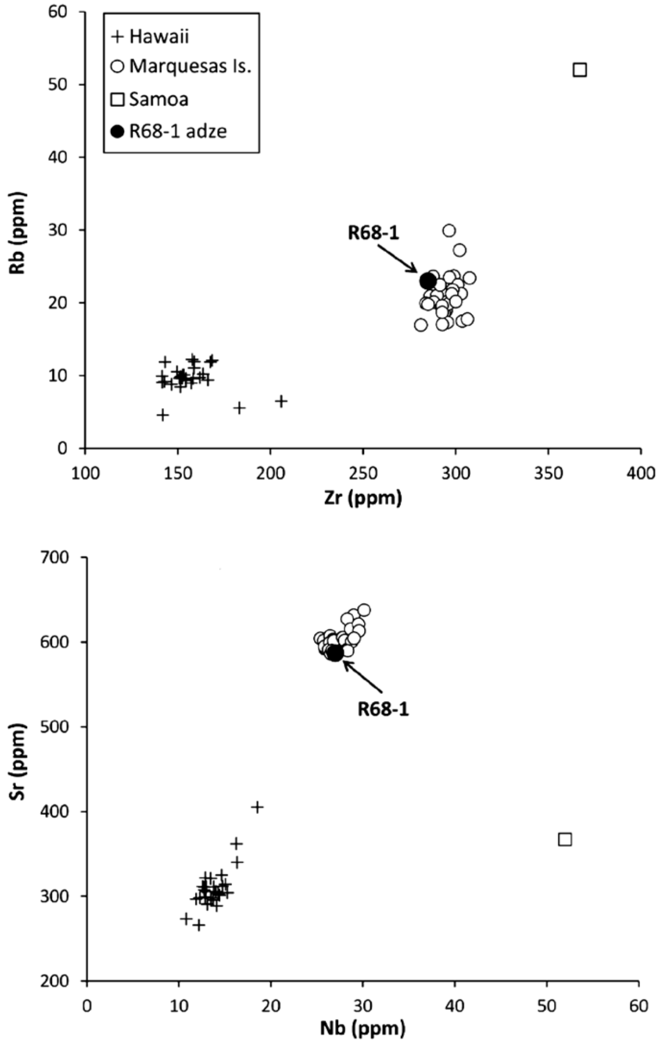

Figure 4. Bivariate scatterplots of Zr against Rb (top) and Nb against Sr (bottom) for source samples clustering near the R68-1 adze in Figure 3. Markers are jittered slightly (± 0.25 ppm) to avoid overprinting.

Table 1. Mean values and standard deviations for the Eiao, Kīlauea and Malaeloa sources compared to adze R68-1. Data for the adze, and the Eiao and Malaeloa source samples, are from WDXRF analyses and those for the Kīlauea source are from Energy Dispersive X-ray Fluorescence (EDXRF).

Element		R68-1 Adze	Eiao, Marquesas Mean	Eiao, Marquesas S.D.	Eiao, Marquesas A/S[3]	Kīlauea, Hawai‘i[1] Mean	Kīlauea, Hawai‘i[1] S.D.	Kīlauea, Hawai‘i[1] A/S	Malaeloa, Samoa[2] Value	Malaeloa, Samoa[2] A/S
SiO_2	%	45.86	46.85	0.36	0.98	61.1	14.08	0.75	49.5	0.93
TiO_2	%	3.78	3.89	0.08	0.97	2.4	0.23	1.58	3.3	1.15
Al_2O_3	%	15.23	15.05	0.15	1.01	9.5	2.57	1.60	14.8	1.03
Fe_2O_3 [4]	%	13.22	13.46	0.18	0.98	13.7	1.88	0.97	12.0	1.10
MnO	%	0.22	0.17	0.01	1.29	0.2	0.01	1.35	0.1	2.20
MgO	%	6.83	6.44	0.13	1.06	6.2	2.14	1.10	5.8	1.18
CaO	%	9.20	9.30	0.06	0.99	8.3	1.43	1.11	7.6	1.21
Na_2O	%	3.20	3.19	0.09	1.00	1.7	0.06	1.78	3.4	0.94
K2O	%	0.99	1.01	0.04	0.98	0.5	0.04	1.98	1.9	0.53
P_2O_5	%	0.51	0.52	0.03	0.98	-	-	-	0.8	0.64
V	*ppm*	290	298	10.1	0.97	348	36.0	0.83	218	1.33
Cr	*ppm*	121	70	12.4	1.73	-	-	-	164	0.74
Ni	*ppm*	129	100	30.4	1.29	142	20.4	0.91	142	0.91
Zn	*ppm*	135	128	13.1	1.05	123	8.4	1.10	180	0.75
Rb	*ppm*	23	21	3.6	1.10	10	2.0	2.30	52	0.44
Sr	*ppm*	587	597	7.5	0.98	301	31.6	1.95	755	0.78
Y	*ppm*	34	37	1.3	0.92	25	3.9	1.36	37	0.92
Zr	*ppm*	285	293	8.7	0.97	160	14.4	1.78	367	0.78
Nb	*ppm*	27	28	1.2	0.96	14	2.4	1.93	37	0.73
Ba	*ppm*	217	156	44.3	1.39	-	-	-	366	0.59

1 Data for Kīlauea basalt compositions were taken from the online resource maintained by the Georchaeology Laboratory, University of Hawai‘i, Hilo, and are available online at http://hilo.hawaii.edu/depts/geoarchaeology/.

2 Malaeloa source data for Sample E (Winterhoff 2007: Appendix C).

3 Ratio of artefact geochemical values to those of source (see text).

4 Iron values Kīlauea and Malaeloa recalculated as Fe_2O_3 to enable comparisons.

DISCUSSION AND CONCLUSION

As discussed above, previous studies have identified the importation of stone artefacts into the Cook Islands but, apart from small numbers of adzes from the Society Islands, extra-archipelago contacts seem to have been mainly with Samoa to the west (see Allen and Johnson 1997, Walter and Sheppard 1996, Weisler 1993). In addition to Samoan adzes, Walter and Dickinson (1989) have suggested a West Polynesian, possibly Tongan, source for two ceramic sherds recovered from a 14th century context on Ma‘uke. Archaeological findings of connections with West Polynesia are reflected in Cook Island oral traditions, which speak of direct contact with Samoa (Gill 1880, Nicholas 1892, Stair 1895; see also Allen 1996, Bellwood 1978, Walter and Sheppard 1996).

Although there has been no direct archaeological evidence until now, contact between the Cook Islands and Marquesas also is a recurring theme in Polynesian traditions. There are several versions of a Marquesan legend concerning the voyage of Aka, who travelled from the Marquesas to the Cook Islands to obtain red parrot feathers as gifts for his children (Handy 1930: 130, Kaiser and Elbert 1989, Terrell 1988), while the Rarotongan traditions recorded by Te Ariki-Tara-Are during the 19th century recount several episodes in a protracted conflict between Tangiia and his cousin Tu-tapu, a chief from the Marquesas (Te Ariki-Tara-Are 1920; see also Walter and Moeka‘a 2000). In another Rarotongan legend, two Marquesans, Tangaroa and Aumake, are reputed to have come to Rarotonga and constructed a road around the island (Browne 1897). There are also traditions of Cook Islanders visiting the Marquesas; one recounts the voyage of Rau Mataiapo and his son, from Puaikura in Rarotonga, who went to Nuku Hiva to deliver a shipment of red feathers as payment for “secret” tattoo designs that were obtained from a Marquesan chief, Tui, the year before—presumably during a previous voyage (Jonassen 1981: 27).

Our identification of an adze from Eiao provides the first physical evidence of the prehistoric links between the Cook Islands and the Marquesas that are indicated by oral traditions. This study also demonstrates the usefulness of re-examining results from previous studies in light of the more comprehensive reference data that has become available. More broadly, the Marquesas-Cook Islands relations evidenced here gives new insight into the potential scale of post-settlement interaction. Although more evidence is needed to place these contacts in a temporal context, and to make inferences regarding their frequency, the current find opens tantalising possibilities for future research.

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ABSTRACT

We report on the provenance of an adze from the Cook Islands that was previously geochemically analysed by Sheppard, Walter and Parker (1997) but could not be assigned a source at that time because of the paucity of reference data. Drawing on basalt characterisation studies from the last two decades, we can now demonstrate that the adze most likely derives from the Marquesan island of Eiao, over 2500 km to the east. This find extends the western distribution of the Eiao basalt source, which was previously limited to the Society Islands.

Keywords: archaeology, Cook Islands, interaction, stone tools, X-ray fluorescence