NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

NEW ZEALAND JOURNAL OF ARCHAEOLOGY

A Stone Tool Basalt Source on ‘Ata, Southern Tonga

Marshall I. Weisler[1]

ABSTRACT

A geochemical analysis of debitage from the only known fine-grained basalt source (quarry) in Tonga is described, thus filling a geographical gap that will enhance artefact source assignments for prehistoric interaction studies. Four pieces were analysed from the most southern Tongan island of ‘Ata: two flakes from an adze workshop above a cobble beach and the source of the basalt, and two additional flakes from a habitation terrace on the upper plateau. All material is geochemically similar and from the same source. The flakes from the habitation terrace were associated with Polynesian plainware ceramics dated to about 2000 BP, which makes the ‘Ata source one of the oldest adze quarries now known in Polynesia.

Key words: PREHISTORIC INTERACTION, POLYNESIA, TONGA, BASALT SOURCE, X-RAY FLUORESCENCE ANALYSIS.

INTRODUCTION

Archaeologists have long been interested in tracking the movement of exotic artefacts during prehistory, as the spatial and temporal distribution of these commodities is thought to mirror changes in social organisation. In the Pacific ceramics, obsidian and basalt adze material linked between geologic sources and habitation sites have defined spheres of interaction within islands and archipelagoes as well as between distant island groups (Best *et al*. 1992; Green and Kirch 1997; Weisler [ed.] 1997; Weisler 1998). The last decade or so has seen increasing interest in the geochemical analysis of fine-grained basalt adze material in Polynesia as it is widely distributed and readily found in datable habitation contexts — unlike obsidian and ceramics, which have a limited distribution in East Polynesia. What hampers these so-called sourcing studies is adequate knowledge of the geologic sources that occur throughout Polynesia. For example, only a third of the more than 33 known fine-grained basalt sources in Polynesia have more than four geochemical analyses that define the variability of the geological source (Weisler and Sinton 1997: Table 10.2) and there is little information for the Society Islands and none for the Australs.

This paper presents the first geochemical data from a fine-grained basalt source on ‘Ata, southern Tonga and fills a geographical gap, thus facilitating artefact source assignments for prehistoric interaction studies in Polynesia. Additionally, some of the analysed debitage was associated with Polynesian plainware ceramics dated to at least *ca*. 2000 BP, making the ‘Ata debitage one of the oldest dated fine-grained basalt sources in Polynesia.

---

[1]School of Social Science, The Michie Building, University of Queensland, Brisbane, Qld 4072 Australia. Email: m.weisler@uq.edu.au (formerly Department of Anthropology, University of Otago, P.O. Box 56, Dunedin, New Zealand)

New Zealand Journal of Archaeology, 2004, Vol. 25 (2003), pp. 113–120.

This area of west Polynesia is of additional importance since Tonga was situated at the nexus of a late prehistoric interaction sphere that included Samoa and Fiji. Nearly all the commodities exchanged within this greater sphere were perishable and it is only ceramics and basalt adze material that have archaeological visibility (Weisler 1997: Figure 1.2). With the identification of the ‘Ata basalt source we can now track more precisely the directionality (Plog 1977) and temporal depth of the interaction sphere as defined historically (Kaeppler 1978).

Situated some 80 nautical miles south-southwest of Tongatapu in southern Tonga, the small volcanic island of ‘Ata is geographically isolated (Fig. 1), which may have been one reason why it was not permanently occupied until late in Tongan prehistory (after AD 1500). The island has no reef and is, for all intents and purposes, one giant volcanic rock with sheer cliff most of the way around (Johnstone 1978; Vallier *et al*. 1985). Consequently, effecting a landing is quite hazardous. One reason that Polynesians visited this island early in Tongan prehistory was to acquire stone-tool quality basalt for adze manufacture. The geochemical analysis of this source rock and the potential role of this material in prehistoric exchange relations is the subject of this paper.

Basalt debitage and adze preforms were found on the central plateau of ‘Ata where a sample of flakes was collected (Burley *et al*. 2004, this volume). I report the x-ray fluorescence analysis of two flakes from a working area and two other specimens from a habitation terrace located *ca*. 10 m above the beach. Although current archaeological survey and excavation data for the island are limited (Anderson 1978), ‘Ata may conform to a marginal exploitation model where it was visited for short periods *ca*. 2000 BP to acquire basalt for adze manufacture, although clear evidence for permanent habitation does not appear until some 1500 years later, reflecting changes in population growth and changing settlement patterns. It is at this time that ‘Ata may have developed into a specialised adze production centre servicing the rest of the archipelago. Future geochemical characterisation studies from dated habitation contexts throughout Tonga will be needed to test this hypothesis. Adze material may have entered into long-distance interaction spheres that were widespread in East Polynesia during the few centuries before AD 1500 (Weisler 2002). However, this geochemical characterisation study is but the initial step in identifying changes in prehistoric inter-island interaction within Tonga and complements data obtained through ceramic sourcing (Dickinson 2004, this volume) and artefact stylistic studies.

‘Ata does not have a single, well-defined source of stone-tool quality basalt, but is a locale where material was selectively procured from beach cobbles. The few small beaches are covered in basalt cobbles and large blocks have fallen from the cliff face as a consequence of seismic and erosional activity. Five lava flows, from 5–13 m thick, are exposed in the cliff face and contributed material to the beach below (Johnstone 1978: 159). Consequently, the geochemistry of the beach cobbles reflects the variability in the parent material, which, as a group, is related and ultimately derives from the same volcano that appears to have a unique signature. This geological and geomorphologic context at the beach, although not well defined at present, is what I call the ‘Ata *source* (after Weisler and Sinton 1997: 180). It is here that water-rounded cobbles from this coastal area were selectively chosen for adze manufacture.

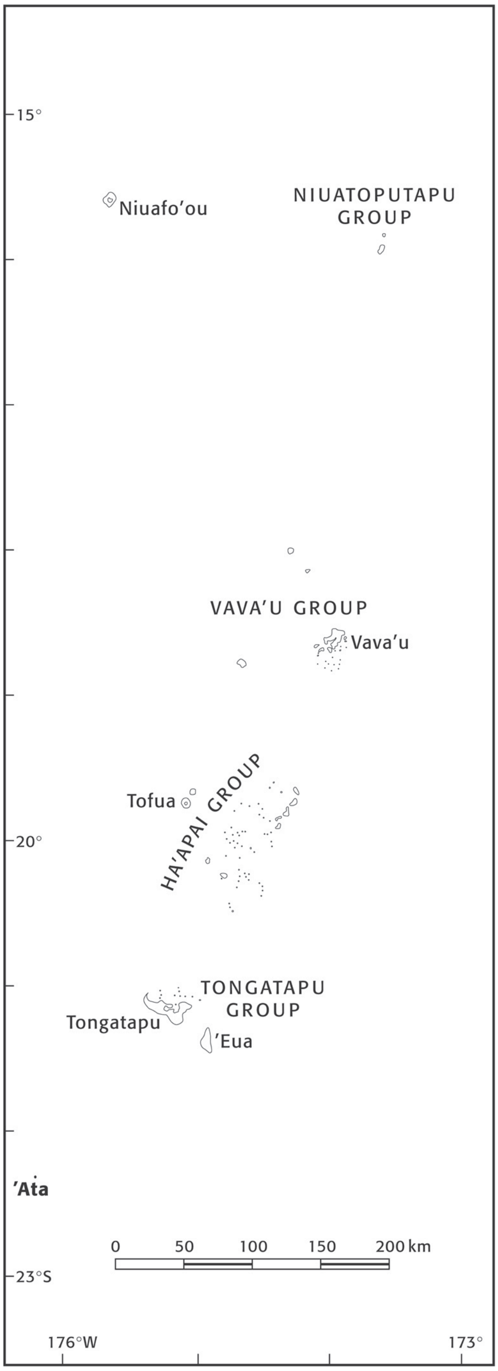

Figure 1: Map of Tonga showing the marginal position of 'Ata, 80 nautical miles south of Tongatapu.

MATERIALS

The sample consists of four pieces of debitage. Specimens A and B were collected at the Upper Plateau site, while C and D were obtained from the Mid Terrace (see site descriptions in Burley *et al*., this volume). Specimen A is a secondary flake, without cortex, exhibits two dorsal flake scars and a snap termination. It measures 44.34 mm long, 31.50 mm wide, 7.29 mm thick and weighs 13.3 g. The bulb is diffuse. The platform is 29.40 mm wide and 9.70 mm thick (Fig. 2a). Specimen B is also a secondary flake without cortex, exhibiting a diffuse bulb and a combination feather and hinge termination. This expanding flake measures 26.99 mm long, 46.48 mm wide, 7.59 mm thick and weighs 9.5 g. The platform is 27.58 mm wide and 7.19 mm thick (Fig. 2b). Specimen C is a piece of shatter with about 40% smooth, water-rounded cortex. It measures 46.19 mm long, 35.51 mm wide, 11.42 mm thick and weighs 21.2 g (Fig. 2c). Specimen D is probably a broken flake without cortex. It measures 29.15 mm long, 28.00 mm wide, 6.53 mm thick and weighs 6.3 g (Fig. 2d).

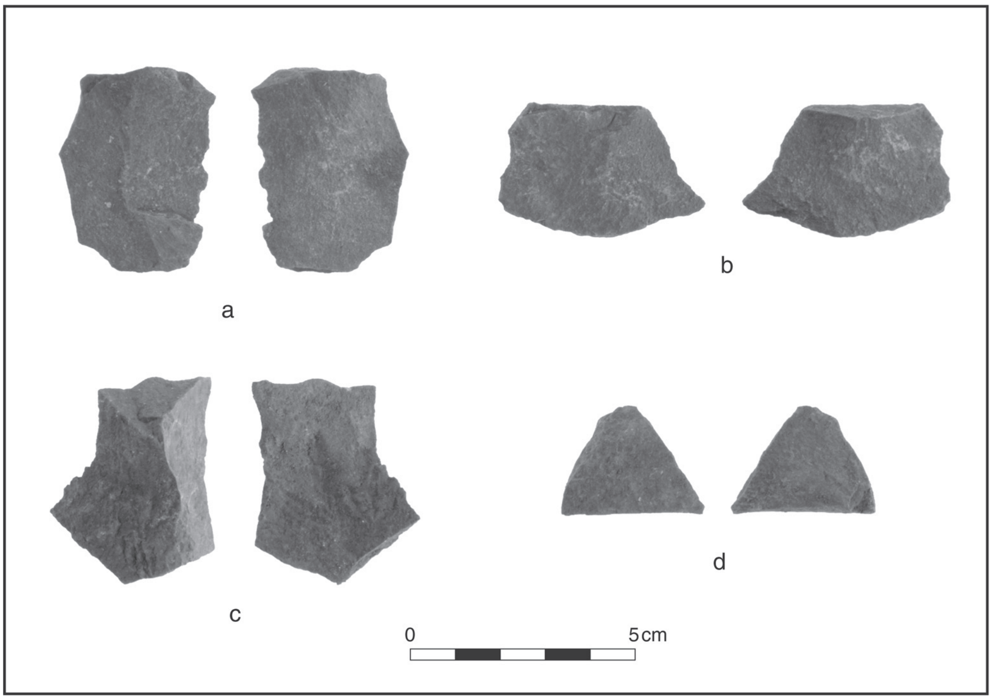

Figure 2: Dorsal and ventral sides of debitage geochemically analysed by the x-ray fluorescence technique. Specimens a and b are from the Upper Plateau surface and were associated with plainware ceramics dating to *ca*. 2000 BP; c and d were recovered from the Middle Terrace, unit 1, stratum II, level 4 and are late prehistoric, *ca*. 300–400 BP.

TABLE 1

Wave-length-dispersive x-ray fluorescence analysis of Tonga samples
See Johnson *et al*. (1999) for analytical details. Figures in this Table have been rounded to conform to NZ Journal of Archaeology style.

Oxides	**Upper Plateau A**	**Upper Plateau B**	**Mid Terrace C**	**Mid Terrace D**
SiO_2	53.7	53.8	52.2	53.5
Al_2O_3	15.8	15.8	17.1	15.7
TiO_2	0.90	0.93	0.75	0.90
FeO	11.6	11.7	10.7	11.4
MnO	0.21	0.21	0.19	0.20
CaO	9.6	9.5	11.1	9.4
MgO	4.6	4.6	5.0	4.7
K_2O	0.68	0.72	0.53	0.71
Na_2O	2.3	2.2	1.9	2.2
P_2O_5	0.18	0.18	0.13	0.16
Total	**99.5**	**99.7**	**99.6**	**98.9**
Parts-per-million				
Ni	7	7	10	11
Cr	25	28	28	26
Sc	43	50	42	44
V	372	387	333	406
Ba	196	188	151	195
Rb	10	12	9	9
Sr	243	241	247	243
Zr	43	44	36	45
Y	20	22	17	21
Nb	1.4	1.7	1.4	2.1
Ga	17	17	18	16
Cu	73	122	133	132
Zn	92	94	76	89
Pb	0	0	0	1
La	5	13	8	5
Ce	10	12	13	16
Th	2	1	1	1

METHODS

The methods of sample preparation and the analytical procedure of the wavelength dispersive x-ray fluorescence analysis are briefly summarised here. More details may be found in Johnson *et al.* (1999). The samples, A (13.3g), B (9.5g), C (21.2g) and D (6.3g), were reduced to small chips and then ground in a swingmill with tungstun carbide surfaces. Some 3.5 g of sample powder was removed and mixed with flux, then fused in a muffle furnace. After cooling, these samples were then reground and refused. This preparation takes about 45 minutes per sample, after which time the specimens are loaded in the Rigaku 3370

XRF Spectrometer. The concentrations of 27 elements in the unknown samples are measured by comparing the x-ray intensity for each element in reference to nine United States Geological Survey (USGS) standards. Precision is measured by comparison to USGS internal standards BCR-P and GSP-1. Accuracy is compared to published values of known standards analysed by a range of techniques at different labs (Govindaraju 1994).

RESULTS

The ‘Ata rock is classified as basaltic andesite within the tholeiitic series of rocks (Bryan *et al*. 1972: 1577; Cox *et al*. 1979). These rocks typically have low alkali (Na_2O and K_2O) and mid-silica values. The ‘Ata rock is distinct from all other reported sources in Polynesia (Weisler and Sinton 1997:182), but is most similar to the Waiāhole and Kailua sources on O‘ahu, Hawaiian Islands in terms of the three important oxides used to discriminate quarries/sources from the Oceanic Island Basalt province in Polynesia. Values for silica (SiO_2) and potassium (K_2O) overlap amongst the three sources, while titanium (TiO_2) for ‘Ata is clearly different and readily separates ‘Ata from Waiāhole and Kailua. The analytical results of the ‘Ata samples are presented in Table 1. Samples A, B and D are most similar, while C is geochemically related but has slightly different amounts of some oxides and elements. The difference between the samples probably represents separate flows, albeit from the same volcano. Minor geochemical variation is expected given that the beach cobble material derives from five distinct lava flows.

CONCLUSIONS

The geochemistry reported here will facilitate source assignments in central Polynesia and perhaps beyond. However, no published analyses for any unassignable artefacts can be linked to the ‘Ata source. The ‘Ata basalt may have entered into long-distance interaction spheres that were widespread during the few centuries before AD 1500 (Weisler 1998) and it is likely that future sourcing studies will document the spatial extent of the ‘Ata source, perhaps providing temporal depth to the historically-documented Fiji-Tonga-Samoa interaction sphere (Kaeppler 1978). Within Tonga, changing social conditions can be monitored by documenting the scale, frequency and temporal duration of fine-grained basalt imported from ‘Ata over the course of two millennia, thus providing another commodity in which to track the evolution of these ancient patterns of interaction.

ACKNOWLEDGEMENTS

I thank Dave Burley for making the ‘Ata debitage available for analysis and for reading a draft of this paper. A comment from one anonymous referee was greatly appreciated as well as geological references and discussion from Bill Dickinson. Thanks also to Les O’Neill (University of Otago) for preparing the figures.

REFERENCES

Anderson, A. 1978. Archaeological explorations on 'Ata island, Tonga. *In* M.M. Cresswell (ed.), *Lau-Tonga 1977. Reports from the Expedition of June-July 1977 sponsored by the Royal Society of New Zealand*, pp. 1–21. The Royal Society of New Zealand Bulletin 17.

Best, S., Sheppard, P., Green, R.C. and Parker, R. 1992. Necromancing the stone: Archaeologists and adzes in Samoa. *Journal of the Polynesian Society* 101: 45–85.

Bryan, W.B., Stice, G.D. and Ewart, A. 1972. Geology, petrography, and geochemistry of the volcanic islands of Tonga. *Journal of Geophysical Research* 77: 1566–1585.

Burley, D.V., Steadman, D.W. and Anderson, A.J. 2004. The volcanic outlier of 'Ata in Tongan prehistory: Reconsideration of its role and settlement chronology. *New Zealand Journal of Archaeology* 25 (2003): 89–106.

Cox, K.G., Bell, J.D. and Pankhurst, R.J. 1979. *The Interpretation of Igneous Rocks*. George Allen and Unwin, London.

Dickinson, W.R. 2004. Petrography of Polynesian Plainware from 'Ata, Tonga. *New Zealand Journal of Archaeology*, 25 (2003): 107–111.

Govindaraju, K. 1994. *Geostandards Newsletter* Special Issue 18: 1–158.

Green, R.C. and Kirch, P.V. 1997. Lapita exchange systems and their Polynesian transformations: Seeking explanatory models. *In* M.I. Weisler (ed.), *Prehistoric Long-Distance Interaction in Oceania: An Interdisciplinary Approach*, pp. 19–37. New Zealand Archaeological Association Monograph 21, Auckland.

Johnson, D.M., Hooper, P.R. and Conrey, R.M. 1999. XRF analysis of rocks and minerals for major and trace elements on a single low dilution Li-tetraborate fused bead. *Advances in X-ray Analysis* 41: 843–867.

Johnstone, R.D. 1978. 'Ata, the most southerly volcanic island in Tonga. *In* M.M. Cresswell (ed.), *Lau-Tonga 1977. Reports from the Expedition of June-July 1977 sponsored by the Royal Society of New Zealand*, pp. 154–164. The Royal Society of New Zealand Bulletin 17.

Kaeppler, A.L. 1978. Exchange patterns in goods and spouses: Fiji, Tonga and Samoa. *Mankind* 11: 246–252.

Plog, F. 1977. Modeling prehistoric exchange. *In* T.K. Earle and J.E. Ericson (eds), *Exchange Systems in Prehistory*, pp. 127–140. Academic Press, New York.

Vallier, T.L., Stevenson, A.J. and Scholl, D.A. 1985. Petrology of igneous rocks from Ata Island, Kingdom of Tonga. *In* D.W. Scholl and T.L. Vallier (eds), *Geology and Offshore Resources of Pacific Islands Arcs — Tonga Region*, pp. 301–316. Circum-Pacific Council for Energy and Mineral Resources Earth Science Series volume 2. Circum-Pacific Council for Energy and Mineral Resources, Houston.

Weisler, M.I. (ed.) 1997. *Prehistoric Long-Distance Interaction in Oceania: An Interdisciplinary Approach*. New Zealand Archaeological Association Monograph 21, Auckland.

Weisler, M.I. 1997. Introduction. *In* M.I. Weisler (ed.), *Prehistoric Long-Distance Interaction in Oceania: An Interdisciplinary Approach*, pp. 7–18. New Zealand Archaeological Association Monograph 21, Auckland.

Weisler, M.I. 1998. Hard evidence for prehistoric interaction in Polynesia. *Current Anthropology* 39: 521–532.

Weisler, M.I. 2002. Centrality and the collapse of long-distance voyaging in East Polynesia. *In* M.D. Glascock (ed.), *Geochemical Evidence for Long-Distance Exchange*, pp. 257–273. Bergin and Garvey, London.

Weisler, M.I. and Sinton, J.M. 1997. Towards identifying prehistoric interaction in Polynesia. *In* M.I. Weisler (ed.), *Prehistoric Long-Distance Interaction in Oceania: An Interdisciplinary Approach*, pp. 173–192. New Zealand Archaeological Association Monograph 21, Auckland.

Received 12 March 2003
Accepted 27 June 2003