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TRACKING ANCIENT ROUTES ACROSS POLYNESIAN SEASCAPES WITH BASALT ARTIFACT GEOCHEMISTRY

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Much has been written about landscape archaeology from a multitude of perspectives—all extolling a holistic approach to understanding humans within their environmental, social, and ideological contexts at various geographic scales and throughout many time periods. In considering the human colonization of Oceania, nowhere do more "scapes" interweave to form the inseparable whole of landscapes, seascapes, and starscapes. In the Pacific, the open ocean was anchored by nearby and distant islands to form spheres of interaction between parent and daughter communities for trade and exchange of goods, services, and marriage partners (Kaeppler 1978; Kirch 1988; Weisler 1995). In Remote Oceania (Green 1991), where landfalls are generally smaller and spaced wider than islands in the western Pacific, the starscape was of unparalleled importance, because it was the sequence of stars rising on the horizon that guided voyagers to their destination and return (Finney 1979: 332-35; Lewis 1976). During the day, skilled navigators could read other important "seascape" signposts such as permanent patches of seaweed, submerged reefs, currents that carry colder or discolored water, and turbulent patches and swell and wind patterns. By observing seabirds returning to island roosts after traveling more than 100 kilometers to feed, navigators expanded the location of islands and could follow the birds to land (Di Piazza and Phearthree 2004: 19; Finney 1996: 100). In essence, it is thus not possible to talk about island colonization detached from the three "scapes" of land, sea, and sky.

This chapter reviews the development of interaction studies utilizing the petrographic and geochemical characteristics of Polynesian basalt adze material and source rocks for documenting prehistoric long-distance interaction (so-called trade and exchange) and colonization routes; it then briefly outlines some significant results. Mapping this "seascape" and determining colonization routes by plotting the spatial and temporal distribution of adze material is of no small significance, since scholars have not always accepted that the colonization of the Pacific was purposeful and intentional; during the past nearly 200 years, debates have polarized between accidental drift voyages and those that were planned (for recent summaries, see Finney 1979; Irwin 1992: 13-16). Sharp (1956) was a proponent of accidental, one-way voyaging; he believed that ancient mariners could not account for drifting off course (set) and that they did not have the ability to navigate through different wind belts to small island targets. However, the innovative computer simulations of Levison and associates (1973) demonstrated that island colonization must have been purposeful. They considered current, wind direction and speed, length of voyage, and
time of year from different islands, demonstrating that it was impossible to settle all the Pacific islands by chance or accidental drift voyages.

When Captain Cook entered Polynesian waters two centuries ago, he marvelled at the similarities of language, custom, and physical appearance across the region and pondered the origin of the "Indians of the South Seas." Thor Heyerdahl popularized the American origin hypothesis of the Polynesians with his Kon Tiki drift voyage from South America to Polynesia (1950), although there is little support today for an eastern origin for Pacific islanders. Conversely, there is overwhelming evidence for west-to-east settlement from the radiocarbon corpus, where archaeological sites are progressively younger from west to east across Oceania (Irwin 1990; Kirch 1997). Physical characteristics of the Polynesians (Howells 1970), routes of the commensal Pacific rat (Matisoo-Smith and Robins 2004), connections based on human mtDNA (Hill and Serjeantson 1989; Lum and Cann 1998), language origins and dispersals (Kirch and Green 2001; Pawley and Ross 1993), and the spread of agriculture (Bellwood 2005) all chart the west to east dispersal of Polynesian peoples.

Voyaging in an easterly direction against the dominant tradewinds may seem a deterrent, but sailing close to the wind was an effective exploration and colonization strategy (Finney 1988; Irwin 1989, 1992). Experimental voyages using replica canoes and traditional voyaging techniques such as celestial navigation have recreated ancient sailing routes (Finney 1977, 1979; Finney et al. 1986).

One way to empirically determine settlement routes, to understand colonization strategies, and to document the extent of postcolonization interaction is by charting the scale, frequency, and duration of exotic artifacts found in distant habitation sites (Weisler 1998). In Polynesia, the woodworking adze was a fundamental component of the prehistoric tool kit (Figure 52.1). Although whole finished forms are somewhat rare in the archaeological record, the byproducts of their manufacture—stone flakes, unfinished and reworked adzes—are relatively common artifacts found in habitation sites. There is another reason why fine-grained basalt adze material occupies an important niche in Polynesian interaction studies: obsidian and pottery, used the world over for charting prehistoric interaction, have a limited occurrence in East Polynesia (Weisler and Woodhead 1995: 1881). Indeed, only New Zealand and Easter Island have obsidian deposits, and their isolation at the far corners of the region makes it unlikely that this resource was traded to tropical Polynesia. Although pottery is common in West Polynesia, only a few sherds have been recovered from East Polynesia. Consequently, fine-grained adze material occupies a prominent role in East Polynesian interaction studies.

**Figure 52.1** Fine-grained basalt adzes: upper, a preform from Moloka‘i, Hawaiian Islands and lower, a finished late prehistoric adze from Pitaian Island.

### Some Working Definitions and the Notion of Scale

Trade and exchange are commonly referred to in the Polynesian archaeological literature, yet the necessary and sufficient conditions for these ethnographically charged terms is the identification of exotic artifacts in archaeological contexts that represent the two-way movement of material—a condition that is usually assumed and less often documented empirically (Renfrew 1969: 152; Weisler, Kirch, and Endicott 1994: 214). The two-way movement of artifacts has been conclusively documented only in the Pitaian Group-Mangareva region of southeast Polynesia.
(Weisler 1997a; Weisler and Woodhead 1995; Woodhead and Weisler 1997). For this reason, it is more accurate to talk about an interaction sphere (Caldwell 1964), where the movement of material within a geographically defined region can be archaeologically documented.

The identification of exotic materials in habitation sites distant from their geological origin is generally referred to as sourcing studies; interaction studies and provenance studies are synonyms (see Summerhayes, this volume). Within interaction sphere, at least two kinds of sites are identified. In the Polynesian context, quarries are geological sources of fine-grained basalt that is surface collected, extracted from excavated pits, or removed from outcrops. The Tataga-matau, Samoa, quarry is one of the few places where extraction pits have been identified (Leach and Witter 1987). Tabular material was removed from outcrops atop Mauna Kea, Hawai‘i Island (McCoy 1990), but most often source rock is simply surface collected as erosional products near the geological source (Weisler and Sinton 1997: 180). Sources are secondary geological deposits such as an accumulation of cobbles downslope in a gulch bottom, river mouth, or seashore (Weisler 2004a: 114). Sources can be archaeologically unknown but identified by artifacts from a geologically well-known area. In this instance, artifacts can be traced to a particular volcano, flow, dike, or outcrop by the geochemistry provided in the geological literature (Weisler and Sinton 1997: 180).

Because most sourcing studies in East Polynesia use fine-grained basalt adze material to track prehistoric interaction, it is necessary to understand the term fine-grained basalt from archaeological and geological perspectives. Basalt is a dark-colored igneous rock, commonly extrusive, and fine-grained. There are many kinds of basalt that are distinguished further by their chemistry (for example, alkali vs. tholeiitic) and common location (oceanic island, mid-ocean ridge, and continental). Nunn (1994) provides a good discussion on the origins and development of ocean islands and their rocks. Perhaps the most confusion when describing fine-grained basalt is the term fine-grained. Geologists define fine-grained as particles that have an average diameter of < 1 mm (Bates and Jackson 1984: 183). However, in a review of the petrographic characteristics of eight Hawaiian basalt adze quarries, Cleghorn and associates (1985) defined very fine-grained as > 130 grains/mm, fine-grained as 100-130 grains/mm, and coarse-grained as < 90 grains/mm. In geologic-al perspective, all these values refer to fine-grained basalt.

Scale is a useful term in Polynesian sourcing studies, because it defines the geographic limits of the study (for a general discussion of "scale" in landscape archaeology, see also Head, this volume). In geological terms, scale can refer to the petrologic province (oceanic island basalt), archipelago (Mangareva), island (Pitcairn), volcano (Mauna Kea), geologic feature (cone or dike swarm), geological event (flow, dike), or geologic sample (rock). This is a hierarchical relationship, whereby each unit is contained within the larger scale above it (Weisler 1993a: 62-63; Weisler and Sinton 1997: 180-82). Scale is helpful in archaeological sourcing studies as certain unique hand specimen; petrographic or geochemical characteristics are useful at assigning artifacts to source at different spatial scales. For example, a high abundance of yttrium (Y) is found only at one quarry when one is considering the eight fine-grained basalt sources of west Moloka‘i, a region composed of a single volcano. However, if the geographic scale is enlarged to the whole of Polynesia, then high Y is not necessarily unique.

**Analytical Techniques**

Whenever the scale of interest is expanded, more powerful analytical methods might be required. Petrographic thin-sections were the first exploratory method used to determine the characteristics of Hawaiian basalt quarries and sources and to assign artifacts to source (Cleghorn et al. 1985; Lass 1994; Powers 1993). However, not all characteristics are described consistently, rendering comparisons between studies problematic. X-ray fluorescence (XRF) analysis was quickly adopted as the preferred method, because results are quantitative, analytical accuracy is routinely evaluated to worldwide standards (e.g., Govindaraju 1989), and precision can be controlled by careful sample preparation and close attention to analytical procedures (Weisler 1993a: 64). The XRF method is described in Summerhayes (this volume; Weisler and Sinton 1997: 175-77), so it will not be discussed here in detail. Briefly, samples are bombarded with X rays, and fluorescent X rays are emitted from the sample that is characteristic of the kind and amount of the sample's chemical composition. Specimen sample sizes can be as low as 3–5 grams for destructive wavelength dispersive XRF, where the results are fully quantitative. Energy-dispersive XRF can accommodate whole specimens (an obvious advantage when using museum artifacts or borrowing specimens from traditional owners), but results are often best used as ratio-level data (Weisler 1993a: 73-74).

Each analytical method comes with its limitations and XRF, despite its obvious advantages
when assigning artifacts to source at the scale of archipelago (Allen and Johnson 1997; Rolett et al. 1997; Weisler, Conte, and Kirch 2004), encounters problems when considering the entire petrologic province of Polynesia. As summarized by Weisler and Woodhead (1995: 1882; Woodhead and Weisler 1997), variation in oxides and trace elements is largely controlled by near-surface magma-chamber processes such as fractional crystallization and crustal assimilation. Because crystal fractionation history is broadly similar between most oceanic islands, individual parameters are rarely unique to a single volcano. Ratios of highly incompatible trace elements are relatively insensitive to these processes and can be used to discriminate; however, there can be considerable overlap between volcanic centers. Importantly, radiogenic isotope variations of lead (Pb), strontium (Sr), and neodymium (Nd) are a function of both parent/daughter elemental ratios in the mantle source of oceanic island basalts (OIB) and the age of this source. The 1–2 billion year age of OIB has resulted in a diversity of isotopic compositions for volcanoes (quarries and sources), facilitating source assignments of artifacts at the Polynesia-wide scale. Additionally, only 100 mg of sample is needed for routine analysis. The first application of lead isotope analysis of source rocks and artifacts was in southeast Polynesia (Mangareva and the Pitcairn Group), where adze material from the Tautama, Pitcairn Island source was identified in Mangareva, 400 km to the west (Weisler and Woodhead 1995).

Polynesian Interaction Studies

There is ample evidence accumulating from basalt sourcing for interaction at the intra-island, intra-archipelago, and inter-archipelago scales for Tonga (Weisler 2004b), Samoa (Best et al. 1992; Clark, Wright, and Herdrich 1997; Weisler 1993b; Winterhoff et al. 2007), the Phoenix and Line archipelagos (Di Piazza and Pearthree 2001, 2004), the Cook Islands (Allen 1996; Allen and Johnson 1997; Sheppard, Walter, and Parker 1997; Walter 1998; Walter and Sheppard 1996, 2001; Weisler and Kirch 1996; Weisler, Kirch, and Endicott 1994), the Marquesas (Rolett 1998; Rolett et al. 1997), Hawai‘i (Mills and Lundblad 2006; Weisler 1990), the Australas (Boltt, in press), the Society Islands (Weisler 1998), Mangareva (Weisler 1996, 2004b; Weisler and Green 2001; Weisler, Conte, and Kirch 2004), the Pitcairn Group (Weisler 1995, 1997a, 1998, 2002; Weisler and Woodhead 1995; Woodhead and Weisler 1997), and Norfolk Island (Anderson et al. 1997). At one fundamental level, the results demonstrate contact between source locations and habitation sites at different spatial scales, but more sophisticated interpretations are emerging.

Interaction as a Colonization Strategy

In the most detailed study to date, Weisler (1995, 1997a, 2002; Diamond 2005: 120–35) identified not only fine-grained basalt but also imported volcanic glass, oven stones, and artifact styles, as well as transferred plants and animals over ca. 800 years in the Pitcairn Group-Mangareva interaction sphere (Weisler 1998: fig. 1). The resource-poor, raised limestone (makatea) island of Henderson is 100 km north of the volcanic Pitcairn Island. Both landfalls are isolated and small, with limited potable water and arable land, and narrow encircling reefs. Under the best conditions, islands such as these tested the limits of permanent Polynesian occupation. Settled from the more ecologically diverse Mangareva, some 400 km west, the culture-historical record of Henderson shows six centuries of importation of goods (and undoubtedly services and marriage partners) from parent communities on Mangareva. When imports cease in Henderson’s sequence at about A.D. 1500, local Tridacna clamshell is fashioned into inferior adzes to replace those of stone. For making fishhooks, small local pearlshell replaced the large black-lipped pearlshell from the Mangareva lagoon. Most devastating was probably the inability to communicate with Mangareva for planting stock and marriage partners to add genetic diversity to the small population. Consequently, the long-term provisioning from Mangareva to the isolated outposts in the Pitcairn Group was a colonization strategy for resource-poor islands, and the cessation of interaction was clearly tied to changes in the material culture record and eventual abandonment of the Pitcairn Group.

Intensity of Interaction

The changing abundance of fine-grained basalt during a culture-historical sequence can also be tied to the relative contribution of various stone sources over time, signaling changing relationships with different social groups. Allen and Johnson (1997) have shown that the changing frequency of fine-grained basalt from the Ureia coastal habitation site on Atuataki, southern Cook Islands, was related to the intensity of use of different extra-archipelago sources over time. In the Marquesas, Rolett and associates (1997) identified the decline of intra-archipelago voyaging in the Marquesas as signaled by an absence of imports in habitation sites around A.D. 1500.
Assessing the Frequency and Scale of Postcolonization Interaction

It is important to point out that basalt adzes were only a small component of ethnographically known Polynesian interaction networks (Weisler 1997b: fig. 1.2). In the Fiji-Tonga-Samoa interaction sphere (Kacppler 1978), fewer than 10% of the items circulated have preserved in archaeological contexts. The interaction sphere between the high volcanic Society Islands and the northwest Tuamotu atolls, as recorded historically (Oliver 1974: 1148 n.2), contained, most notably, shells and white dog hair but no basalt adzes. Changing from presence-absence to frequency-ranked data brings increased uncertainty for interpretations. For example, the cessation of inter-island voyaging is assumed when imports are no longer present in the excavated sequence, and this seems reasonable. Changing frequencies, however, are more problematic. Issues of quantification must also be addressed since artifact counts (and not weights) may reflect reworking of imported whole adzes.

Other factors should also be considered, such as the distance that an imported object is moved. One would expect that less exotic adze material might be found as distance increases from the source (Renfrew 1969). The number of archipelagos where exotic adze material is found is a good ubiquity measure that defines the geographic scale of imports that might relate to the frequency of voyaging. Large-scale interaction systems might develop over longer periods of time than smaller ones.

The largest interaction sphere in East Polynesia is centered at the Eiao quarry in the northern Marquesas (Figure 52.2). Basalt from Eiao has been identified from four archipelagos: the Line Islands, some 2,400 km to the northwest; the Tuamotus (1,100 km southwest), the Society Islands (1,425 km southwest), and Mangareva (1,750 km to the south-southeast) (Di Piazza and Peirce 2001; Weisler 1998 and unpublished). This is clear evidence of postcolonization interaction, especially since the finished Eiao adzes sourced to the Tuamotus, Societies, and Mangareva are all late.
prehistoric forms (Weisler 1998: fig. 2). What the intensity of this interaction represents is uncertain, but voyagers were traveling great distances after initial colonization. Anderson suggests that “interaction between archipelagos was limited in extent” (2003: 173), but the geographic extent of the Eiao source covers ca. 4,000 km from end to end—a remarkable achievement for prehistoric voyagers.

Conclusions

There is much to be learned from the geochemical sourcing of fine-grained basalt adze material in Polynesia, which has provided insights into how Pacific navigators used the seascape as a bridge to reach even the most distant and isolated landfalls. Determining the scale and the frequency of exotic adze materials by geochemical characterization of artifacts and source rocks is a powerful means for understanding colonization strategies and the changing dynamics of trade and exchange. Acquiring additional source rocks from the leeward Society Islands and the Australs remains a priority, and determining the intrasource variability of each quarry or source is integral to unequivocally assigning artifacts to sources. Highly accurate isotopic studies (Weisler and Woodhead 1995) have shown great promise in determining artifact sources using small (~100 mg) samples. This method has also been particularly useful when suspected prehistoric interaction regions are large, resulting in the greater likelihood of geochemical overlap between volcanoes. In these circumstances, artifact assignments using XRF are most problematic.

The methods and protocols described here should be effective in volcanic regions worldwide (Japan is an excellent example), thus providing archaeologists another tool for tracking ancient routes across land and seascapes. Future studies will become only more sophisticated and address a wider range of issues that are only briefly canvassed here.

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References


