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– ARTICLE –

Current Perspectives on Hawai'i's Stone Tool Economies

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ABSTRACT

Patrick Kirch's publication of *Feathered Gods and Fishhooks* in 1985 emphasized the value of sourcing stone tools to delineate precontact interaction spheres and the evolution of social complexity in Hawai'i. Throughout the 1990s, however, published sourcing studies included just over 200 specimens, limiting our ability to generate well-substantiated conclusions related to stone tool production over nearly a millennium of Hawaiian prehistory. Recent geochemically-based analyses of archaeological basalt and volcanic glass in Hawai'i include over 21,000 samples of basalt and volcanic glass. We present a review of this expansive data set. Findings point to regionally divergent patterns in production and distribution, and other basalt sources that could rival the well-known Mauna Kea Adze Quarry in their extent of interisland distribution.

Keywords: exchange, archaic states, adzes, XRF, sourcing, basalt, volcanic glass, Hawai'i

INTRODUCTION

Twenty-eight years ago Patrick Kirch (1985: 189) challenged us to explore the cultural implications of an enormous basalt adze quarry on Mauna Kea, Hawai'i Island where the principal extraction areas are located at elevations above 3,800 m (12,000 ft):

> How widely were adzes from Mauna Kea distributed? Did quarries in other localities just serve their immediate communities, or did they fit into wider networks for exchange or trade? These questions may be answered through an extensive program of petrographic analysis, of both quarry rock and adzes and adze flakes from excavated sites. The results of this study will be a major contribution to Hawaiian prehistory.

Kirch's questions in his now iconic book *Feathered Gods and Fishhooks* relate to native Hawaiian economic systems, social relations, and the organization of labor during the formation of Hawai'i's archaic states. As Kirch realized, if we establish how far quarried stones were transported from their geologic sources, and who had access to these various sources, we can infer a great deal about the social dynamics underpinning the evolution of Hawai'i's political economy. For example, anthropologists have portrayed *ahupua'a* (traditional Hawaiian land districts at the time of Western settlement) as largely self-sufficient land divisions that run in narrow bands from the sea to the mountains (Cordy 2000: 31–33; Earle 1977, 1997; Handy and Handy 1972: 46–48; Handy and Pukui 1958; Hommon 2013: 13–15; Sahlins 1992: 17–22), but *ahupua'a* – as constructed at Western contact – are only the end-product of a process of indigenous Hawaiian social evolution that began when the first group of settlers arrived (Hommon 1986: 63–64). As Polynesian settler populations expanded and social complexity increased, Hawaiian land tenure developed in significantly different ways than other parts of Polynesia (Kirch 2012: 139–142). Although theories on precontact Hawaiian exchange systems abound (Bayman and Moniz-Nakamura 2001, 2004; Earle 1977; Lass 1994, 1998; McCoy 1990; Sahlins 1972, 1992), there are few archaeological datasets that can demonstrate the extent to which interdistrict exchange occurred in any given era, or the extent to which chiefs were involved in redistributive networks. By studying people's transport of materials over the Hawaiian landscape through time, archaeologists might be able to address how the *ahupua'a* system developed and better understand the intricacies of the economic system (Mills 2002).

Because most Hawaiian material culture was made of perishable goods, there are few opportunities to test the extent of self-sufficiency maintained in the production and consumption of many domestic products. But basalt adzes, volcanic glass cutting tools, poi pounders, 'scoria' abraders and a variety of other Hawaiian stone implements (e.g., Brigham 1902; Kirch 1985: 181–198) offer abundant opportunities to quantify ancient Hawaiians' transportation of stone between different districts and islands.

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STONE TOOLS AND HAWAIʻI'S POLITICAL ECONOMY

Kirch wrote his musings about adze quarries in the decade following the first systematic surveys and excavations at the Mauna Kea Adze Quarry (McCoy 1977; McCoy and Gould 1977). Initial estimates suggested the quarry covered over 18 km² (Cleghorn 1982, 1986; McCoy 1977: 236), but later fieldwork (McCoy 1986, McCoy 1991) further expanded site boundaries, making the Mauna Kea Adze Quarry larger than all other known Hawaiian quarries combined. In addition to the quarry's location at hypoxia-inducing elevations (often covered in snow in winter months) well above most sources of food and fuel, the quarry is enigmatic because it defies the general tenets of the *ahupuaʻa* system.

According to many economic models, chiefs were responsible for most social integration beyond the level of the *ahupuaʻa*, and negotiated the political economy through redistributive exchange, alliance, and competition. Hawaiian *makaʻāinana* (commoners) supposedly traveled outside of their respective *ahupuaʻa* much less often than chiefs. They harvested local resources from the ocean and land, participated in interhousehold reciprocal exchanges within their respective *ahupuaʻa*, and supported the chiefs with their surplus goods. The most fundamental and oft-repeated characteristic of *ahupuaʻa* is that they were designed for economic self-sufficiency (Earle 1977, 1997; Handy and Handy 1972: 400; Handy and Pukui 1958). On Hawaiʻi Island over 600 *ahupuaʻa* were organized into six larger districts, or *moku o loko* by the early 19th Century (Cordy 2000: 31). The Mauna Kea Adze Quarry, however, is located within the single *ahupuaʻa* of Kaʻohe in the *moku* of Hāmākua. It clearly produced many more adzes than would have been needed in the single *ahupuaʻa,* which suggests that other *ahupuaʻa,* and potentially other *moku* relied on its products. If the generalizations about *ahupuaʻa* presented above are accepted at face value for the Mauna Kea Adze Quarry, then we would expect that commoners from Kaʻohe made adzes at the quarry, used some for their own purposes, and gave the (massive) surplus to the chiefs for redistribution elsewhere.

Timothy Earle acknowledged that some interdistrict exchange occurred particularly in relation to high quality stone used to make tools (Earle 1977: 224–225, 1997: 234), but he claimed, primarily on ethnohistoric data, that interdistrict exchange in Hawaiʻi was "relatively rare" (Earle 1977: 225), and "quite limited" (Earle 1997: 234). Marshall Sahlins, on the other hand, argued for the regular exchange between *ahupuaʻa* within a larger political district, or *moku* (Earle 1992: 19–20). *Moku* often functioned as independent polities controlled by a high-ranking chief, but were sometimes combined into larger political units under one ruler. The boundaries of Kaʻohe itself may be an indication of the kind of structured exchange that Sahlins refers to, at least within the *moku* of Hāmākua. As Cordy (2000: 30–32) illustrates, Kaʻohe is an irregular *ahupuaʻa* because it only occupies a narrow (and relatively resource-poor) band along the coast where most of the residents would have lived. But as Kaʻohe ascends the eastern slope of Mauna Kea and emerges above the forest near 1800m (6000ft) in elevation, it expands to occupy the entire summit region. The uplands of Kaʻohe would have contained few food resources beyond ground-nesting birds. The primary evidence of precontact human utilization of Kaʻohe's vast mountain region is the adze quarry, which would have provided Kaʻohe with a valuable resource to exchange with other *ahupuaʻa*.

Some early historical texts also hint at other kinds of interdistrict exchange, including low-class peddlers who traveled with goods between districts (Kamakau 1976: 123; Whitman 1979: 60), regular exchange of foodstuffs, woods, and plaiting fibers between *moku* (Handy and Handy 1972: 314–315), and even 'fairs' for barter between different districts (Ellis 1963: 229–230). Kelley (1967), however, has cautioned against projecting early 19th century ethnohistorical accounts into the precontact era because of the massive cultural transformations that occurred with the introduction of foreign trade items that Hawaiians used as status goods (Sahlins 1992).

Without a way to quantify precontact interdistrict exchange archaeologically, any characterizations based on ethnohistoric data are difficult to substantiate or refute. When Kirch wrote *Feathered Gods and Fishhooks*, we could demonstrate very little about who was responsible for producing and distributing adzes from the Mauna Kea Adze Quarry and how widely these products were distributed. We similarly lacked data on distribution of stone tools from other quarries in the Hawaiian archipelago.

SOURCING BASALT ADZES IN HAWAIʻI

By the 1980s, a few archaeologists and geologists had already laid a foundation for Kirch's desired 'extensive program of petrographic analysis' for basalt adzes. In Hawaiʻi, some petrographic descriptions of adze basalt appeared as early as the 1930s (Powers 1939), and by the 1980s, several studies built systematic descriptions of quarry sources by employing thin-sections and optical petrography (Cleghorn 1982; Cleghorn *et al*. 1985; McCoy 1986: 14–15). Also in the 1980s, Simon Best (1984) published some of the first wavelength dispersive x-ray fluorescence (WDXRF) data on basalt quarries in Oceania, including some data from Hawaiʻi. These preliminary studies, however, did not take the additional step of attempting to source lithics in domestic Hawaiian assemblages, which is what would be necessary to understand where materials from various quarries had been distributed. Furthermore, thin-sectioning and conventional WDXRF techniques are both permanently alter the artifacts being studied, which can conflict with conservation ethics with museum collections and can exacerbate strained relations with descendant communities who might be more concerned with preserving artifacts intact.

In a first attempt at a diachronic study of adze distribution in Hawaiian domestic sites, Barbara Lass (formerly Barbara Withrow) employed thin-sections to examine basalt artifacts from domestic sites on Hawai'i Island in the 1990s (Lass 1994, Withrow 1990, 1991). Her studies included 155 adzes and polished flakes, and assigned samples to the most similar-looking source material in a limited reference collection. This technique necessarily involved some subjective, qualitative source assignments. Lass's ability to reach valid conclusions were constrained by various factors, including the validity of source assignments generated by petrography, the geographic and temporal sampling coverage, and the reliance on radiocarbon dates that suffered from 'old wood' and other interpretive problems that archaeologists were not addressing at the time (Dye 1992; Mills *et al.* 2011). Nonetheless, Lass inferred that Mauna Kea Adze Quarry material was distributed around the entire island of Hawai'i, and that several other sources appeared in significant quantities at residential sites. She concluded that two of these sources included a quarry at Pololū Valley in North Kohala (see Tuggle 1976), and another quarry near Kīlauea Caldera (Brigham 1909: 90–91).

By the late 1990s, *geochemical* sourcing techniques such as electron microprobe, wavelength dispersive x-ray fluorescence (WDXRF), energy-dispersive x-ray fluorescence (EDXRF), instrumental neutron activation analysis (INAA), and inductively coupled plasma mass spectrometry (ICP-MS) were replacing (or at least augmenting) optical petrography in Pacific Island archaeological sourcing studies (Best *et al.* 1992; Graves 1992; Lass 1997; Lichens 1997; Walter 1998; Walter and Sheppard 1996; Weisler 1990, 1993, 1997, 1998; Weisler and Clague 1998; Weisler and Kirch 1996; Weisler and Woodhead 1995). These methods avoided the somewhat qualitative analytical classifications of thin-sections, and relied on quantitative compositional measurements of major oxides and trace elements in rock samples. Marshall Weisler (1997) edited a particularly valuable compilation entitled *Prehistoric long-distance interaction in Oceania: an interdisciplinary approach*. In that volume, Sinton and Sinoto (1997: 200) published WDXRF analyses of twelve basalt adze quarries throughout Hawai'i as part of a Pacific-wide survey of basalt and volcanic glass quarries. This data set only included 58 samples from all Hawaiian quarries. By Sinton and Sinoto's own assessment, these data were far too limited to identify the range of geochemical variability in each quarry. For example, the geochemistry of the sprawling Mauna Kea Adze Quarry was derived from eight samples for major elements, with only two samples for trace elements. The paucity of geochemical sampling at major quarries in Hawai'i continued to limit the ability of analysts to assign unknown samples in domestic assemblages to specific quarries with any degree of confidence. There were few published efforts to geochemically examine adze basalt in domestic assemblages at all.

Four years later, Bayman and Moniz-Nakamura (2001) conducted WDXRF analyses on 4 basalt samples recovered from small adze production workshops located in the saddle-region between Mauna Kea and Mauna Loa (see also Bayman *et al.* 2004). From the geochemical results and the presence of cobble cortex on some of the debitage, they inferred that Hawaiians were making adzes from basalt cobbles obtained in nearby Pōhakuloa Gulch. From these findings, they conclude that adze production on Hawai'i Island involved multiple scales of production. For example, small quarries like the Pōhakuloa workshop may have been used by local populations during embedded resource procurement activities. In contrast, Mauna Kea quarry likely contributed to intensified chiefly controlled production involving mass production for a larger interaction sphere. In our opinion, however, it is still possible that adzes from the Pōhakuloa workshops were entering the same interaction spheres as those from the Mauna Kea Quarry, but were obtained from a more accessible source where food and fuel were available. Without establishing how far Hawaiians distributed adzes from the Pōhakuloa workshops, it is impossible to know whether or not Pōhakuloa adzes were incorporated within the same interaction sphere occupied as the Mauna Kea Adze Quarry, or if they were distributed separately from it.

Lebo and Johnson (2007) also completed a small-scale WDXRF analysis combined with ICP-MS, focusing on seven geological samples and six artifacts from Nihoa and Mokumanamana (Necker) in the Northwest Hawaiian Islands. The authors concluded that the six analyzed artifacts were made of local materials. While Lebo and Johnson characterized the study as 'preliminary' due to the small sample size, they suggested that the data supported a pattern of local tool production on each island. The difficulty here in expanding the sample size to reach more than preliminary conclusions is that because Nihoa and Mokumanamana are sacred landscapes (Kikiloi 2012) cultural practitioners might consider the large-scale drilling of artifacts for WDXRF, or even relatively minor damage caused by ICP-MS, to be inappropriate.

Recognizing the need for both larger sample sizes and non-destructive analysis of archaeological basalts and volcanic glass deriving from the Hawaiian Islands, the University of Hawai'i at Hilo (UHH) acquired an EDXRF spectrometer in 2004. The UHH lab has produced a quantum change in the number of stone tool samples analyzed in the archipelago in the last decade, with over 21,000 artifacts and geological samples analyzed. The technique offers less analytical precision than the other approaches mentioned above. Its great utility, however, lies in creating large analytical sample sizes at relatively cheap cost and allowing for non-destructive analysis of culturally significant material.

By 2004, non-destructive EDXRF had been used extensively with great success on archaeological obsidian assemblages in the American Southwest (Shackley 1988, 1995). There also had been a promising early EDXRF study of archaeological basalt on the US Mainland (Latham *et al.* 1992). Craig Skinner had attempted some initial characterizations of Mauna Kea basalts (Skinner 1999), while Weisler and Clague (1998) had done the same with Oceanic volcanic glass. Sourcing basalt artifacts in Hawai'i, however, is more complicated than matching archaeological obsidian to a relatively finite number of potential obsidian sources. To securely determine the source of a basalt artifact in the Pacific, one faces the daunting task of associating samples with myriad basalt lava flows throughout the archipelago (if not beyond). Luckily, lava flows from different eruptive phases in Hawai'i follow relatively predictable trends in geochemistry, so that analysts can often identify a limited range of geological sources for unknown samples.

Lundblad *et al.* (2008, 2011) published an analytical method for EDXRF tailored to Hawaiian basalts. The studies demonstrated that samples above 1 cm in diameter with typical weathering of the surface over several centuries can produce reliable results especially for 'mid-Z' trace elements Rb, Sr, Y, Zr, and Nb. Concurrently, Mills *et al.* (2008) published the first extensive EDXRF characterizations of the Mauna Kea Adze Quarry using 955 flakes from the 1970s excavations at four rock shelters. The publication also contained analyses from 46 geological samples derived from basalt exposures throughout the quarry complex (see also Mills and Lundblad 2006). Similar extensive quarry characterizations have followed on Hawai'i Island for the Pololū Adze Quarry (Geoarchaeology Lab, UH Hilo 2013) and a volcanic bomb quarry complex surrounding Kīlauea Caldera (Mills *et al.* 2011), in addition to quarries on Maui (Kahn *et al.* 2008; Mintmier *et al.* 2012) and Waiāhole, O'ahu (UHH Geoarchaeology Lab 2013).

These studies provide *measured ranges* in geochemistry for each source with EDXRF. The measured range differs from the *actual range*, or what would be detected with an instrument with perfect precision and accuracy (which does not exist). The measured range generated with EDXRF includes error introduced by irregular shapes, weathering, and inherent heterogeneity in the basalt samples, among other factors. Characterizations with higher-precision instruments will be better at identifying intra-source variation and long-distance exchange (Collerson and Weisler 2007), assuming an adequate sampling of quarry complexes. Currently, however, high-precision approaches have not demonstrated the ability to generate the sample sizes necessary to address many anthropological questions addressed below. High-precision characterizations of quarries conducted without EDXRF analyses such as Weisler *et al.*'s (2013) report on a 'major' basalt quarry at Nānākuli, O'ahu are actually of less comparative utility when thousands of unknown samples are being analyzed with EDXRF. This is because the measured ranges in the quarry samples with high-precision instrumentation (only 12 samples in the case of Nānākuli) will not match the measured range for Nānākuli samples obtained with EDXRF, both because of the limited sample size and because of the different levels of precision in the different techniques.

With robust EDXRF geochemical characterizations of adze quarries, constructing better inferences about the sources of basalt tools in domestic assemblages is possible. The first large domestic assemblage analyzed with EDXRF was from Kaua'i. The collection included 807 basalt artifacts from Nu'alolo Kai, a stratified fishing village on the north shore, in combination with 34 adzes from the Kaua'i Museum (Mills *et al.* 2010). A highly significant finding was the lack of Mauna Kea material in the entire sample. Because the Mauna Kea Adze Quarry's geochemistry is not similar to Kaua'i basalts (or apparently any other basalts that were being transported to Kaua'i through exchange networks), EDXRF proved to be an effective technique for confirming the absence of Mauna Kea material. The finding demonstrated the suitability of non-destructive EDXRF in helping to address Kirch's first question in *Feathered Gods and Fishhooks* 'How widely were adzes from Mauna Kea distributed?' The conclusion was only possible with the large sample size. Furthermore, the inference remains readily testable as additional large domestic assemblages from Kaua'i are analyzed.

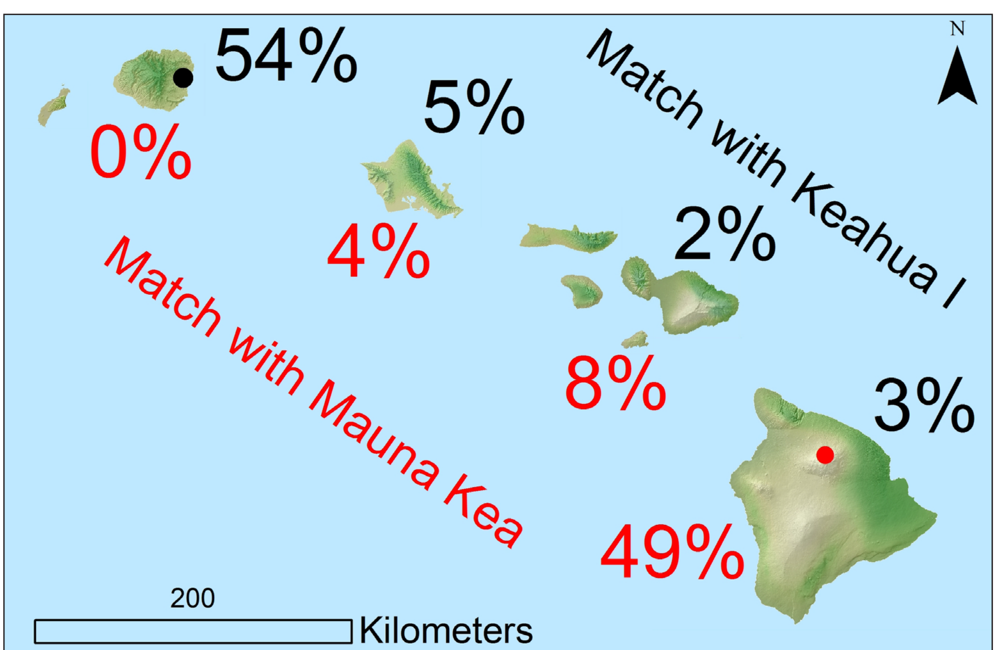
Another significant finding from the Kaua'i EDXRF study was that approximately half the analyzed adzes displayed a geochemical signature consistent with what Sinton and Sinoto had labeled the 'Keahua I' basalt source on Kaua'i. This source was not locally available at Nu'alolo Kai; Hawaiians would have had to bring it across the island to supply the fishing village in significant quantities. Although still poorly understood, the Keahua I source is geochemically consistent with the Kōloa Volcanic Series covering much of the eastern half of Kaua'i. Sinton and Sinoto's samples derived from an adze workshop in the Wailua River Valley where stream cobbles and perhaps some parent bedrock were reduced to adze blanks (Yent 1988). Unlike the Mauna Kea quarry, this site has been affected by erosion and burial. Despite the low archaeological visibility of the quarry complex, the EDXRF study of Kaua'i artifacts demonstrated that the Keahua I source was highly coveted on Kaua'i. This finding also demonstrates that our definitions of 'major' quarries solely from the visibility of quarries themselves can be flawed. Fortunately for archaeology, the geochemistry of the Keahua I source appears to be uncommon in Hawai'i with a Zr:Sr ratio of nearly 1:4, while most known adze sources in the archipelago have a ratio for those elements closer to 1:2 or lower.

The Kaua'i study was followed by EDXRF analyses of 955 basalt flakes and cores from a large domestic midden at Kahalu'u Habitation Cave on the Kona coast of Hawai'i Island (Mills *et al.* 2011). This stratified rockshelter adjacent to a major chiefly complex was occupied for the last two centuries of the precontact era. The *ahupua'a* of Kahalu'u sits in the center of a region covered in lava flows from Hualālai Volcano. The most surprising result of the study was that less than seven percent of the basalt debitage in the assemblage matched with Hualālai volcanics. When the basalt debitage that clearly matched Hualālai geochemistry was examined more closely, none had technological attributes associated with late stages of adze preform production or adze rejuvenation, and all could have been produced from activities unrelated to adze production (hammerstone spalls, wall-building, fire-cracked rock spalls). These findings would suggest that one of the largest population centers on Hawai'i Island was heavily reliant on non-local sources for their adzes, a condition that would foster interdistrict exchange either through chiefly intervention or commoner networks. Approximately half of the adze debitage at Kahalu'u Habitation Cave is consistent with the Mauna Kea Adze Quarry source and is present throughout the entire stratigraphic sequence. Eleven other geochemical groups were also present. One group that was poorly represented (only 3 potential matches) was the Pololū Adze Quarry from North Kohala on Hawai'i Island. In fact, in over 11,000 analyses from Hawai'i Island (Figure 1), the Pololū Adze Quarry shows little evidence of being distributed beyond Windward Kohala, thus offering some additional proof to Bayman and Moniz-Nakamura's (2001) contention that vastly different scales of production and distribution might have operated at different adze quarries in the archipelago.

One cluster that is present in greater abundance than the Pololū Adze Quarry at Kahalu'u Habitation Cave includes 25 flakes from seven strata that match the Keahua I source from Kaua'i (Figure 1). Although isotopic analysis of these samples would best confirm the association of the observed cluster at Kahalu'u with the Kaua'i source, at present there is no other known basalt source in Hawai'i with the same trace element geochemistry. To possibly find the Keahua I source on Hawai'i Island and to *not* find the Mauna Kea source on Kaua'i was an unexpected development. If isotopic analyses confirm that the samples from Kahalu'u derive from the Keahua I source, and no other Hawaiian adze basalts mimic the same geochemical signature, then future source determinations could be justifiably inferred solely with EDXRF.

High concentrations of the element yttrium (Y) provide additional evidence of interisland movement of 21 other samples in the Kahalu'u Habitation Cave assemblage. Geochemists have only found elevated Y concentrations on older islands in the Hawaiian chain (e.g., Patino *et al.* 2003). Thus, we can infer that there was a significant importation of basalt adzes between districts and between islands into the Kona district (at least adjacent to chiefly centers) of Hawai'i Island where local sources were not regularly exploited. Rieth *et al.* (2013) obtained similar geochemical clusters in the Hōnaunau region of South Kona, although the percentage of Mauna Kea material in that assemblage was significantly less than in Kahalu'u.

In contrast with the general domestic pattern of nearly complete reliance on imported adzes observed in Kona, several studies have demonstrated a heavy reliance on locally available materials, particularly in the Kahikinui dis-



Firgure 1. Percentages of lithic material by county that are consistent with Mauna Kea Adze Quarry geochemistry (Hawai'i Island), and Keahua I geochemistry (Kaua'i). Because other sources may mimic these quarries, these figures should be viewed as the *maximum* amount from each quarry that would be involved in down-the-line exchange.

trict of Maui (Kirch *et al.* 2012), and on Moloka'i (McElroy 2007; Spitzer 2006; Weisler 2011). Rather than developing well-bounded quarries on specific lava flows, Hawaiians in Kahikinui and on Moloka'i regularly engaged in opportunistic quarrying of various locally available fine-grained lava flows. The social implications of these disparate patterns indicate regional differences in craft specialization. The data suggest that many people could have been engaged in adze production in some districts, while people in other districts may have only rarely produced their own adzes by travelling to distant quarries, and this may have had implications for long-distance exchanges that may have been mediated through chiefly intervention.

Another way to infer patterns in direct access to adze quarries is to combine geochemical analyses with technological stages of reduction in different lithic assemblages. For example, the UH Hilo laboratory has analyzed three lithic assemblages from Hawai'i Island (Lālāmilo in South Kohala, Humu'ula in North Hilo, and Manowaiale'e Forest Reserve in Hāmākua) that all contain Mauna Kea Adze Quarry flakes with ratios of moderately-sized (3–6 cm length) unground basalt flakes to polished flakes of at least 100:1. The high volume of unpolished flakes and general lack of polished flakes is best explained as resulting from final stages of blank reduction immediately prior to blank polishing. It may seem counter-intuitive that a high-risk stage of percussion reduction did not take place at the Mauna Kea Adze Quarry before blanks were transported towards the coast. The pattern might be explained, however, by younger, less skilled knappers bringing partially finished blanks down to older, more experienced experts who no longer wished to, or were unable to, make the journey to the quarry. This inference would fit well with McCoy's (1999) ideas about shrines at the Mauna Kea Adze Quarry being part of rites of passage. More specifically, these findings indicate that some unpolished adze blanks came down from the quarry to South Kohala, North Hilo, and Hāmākua before final reduction and grinding occurred, but so far, no similar sites have been documented in the other three districts of Hawai'i Island (Kona, Ka'ū, or Puna). As additional assemblages involving final stages of Mauna Kea adze core reduction before grinding are documented in various districts of Hawai'i Island (or the absence of them), we will learn more about patterns of direct access to the quarry and be able to track patterns of distribution and exchange. If we identify entire districts with little to no evidence for any stages of blank reduction before initial grinding of adzes, then it should be possible to document regional patterns of down-the-line exchange and unequal access to quarry sources. Such studies must combine technological analyses of debitage assemblages with large-scale geochemical sampling. Projects of this nature are currently being prepared for publication from the Kohala and Ka'ū districts on Hawai'i Island, as well as East Moloka'i and O'ahu by the UHH lab.

SOURCING HAWAIIAN VOLCANIC GLASS

Concurrent with the sourcing of basalt adze debitage, several major studies of Hawaiian volcanic glass have recently been completed with EDXRF through the UH Hilo geoarchaoelogy lab and Mark McCoy's work at Otago University with a Bruker handheld EDXRF (McCoy *et al.* 2011; Lundblad *et al.* 2013). In the history of Hawaiian volcanic glass studies, Larry Olson (1983) took the lead in developing initial source characterizations which was followed seven years later by a more comprehensive discussion of potential geological sources throughout the chain (Weisler 1990). These initial studies paid little attention to source characterizations of domestic assemblages, other than Weisler and Clague's (1998) analysis of 55 volcanic glass samples on Moloka'i with electron microprobe analyses. In that study, the authors assigned 2 samples to a source on O'ahu and a third sample to a source on Mauna Kea, Hawai'i Island. In order for Weisler and Clague to assign samples to sources, they were forced to make deductions from an incomplete volcanic glass source database (see also Weisler 2012:133–134) and without the context provided by large regional samples of domestic assemblages. In the last several years, analyses of over 3,900 volcanic glass samples from various sites on Hawai'i Island with EDXRF has failed to identify even a single sample from the outcrop on Mauna Kea that was supposedly the source of one out of 55 artifacts analyzed by Weisler and Clague on Moloka'i. The context provided by the large EDXRF sample indicates that either Weisler and Clague happened to find a fragment of Mauna Kea volcanic glass on Moloka'i that rarely (if ever) appeared in Big Island economies, or they misidentified the source, even though they were using high-precision instrumentation.

Some have contended that the sourcing of Hawaiian volcanic glass faces fewer complications than the sourcing of Hawaiian basalt because there are many fewer potential sources (Weisler 1990). However, it is important to understand that much volcanic glass in Hawai'i is not obtained from dikes, but from chilled surfaces of pāhoehoe lava (e.g., Williams 2004). In some cases, geochemical groups of volcanic glass may be widely dispersed geographically. For example, chilled glass recovered from the surface of Mauna Loa pāhoehoe lavas may be geochemically indistinguishable from other Mauna Loa sources distributed over more than half the island.

One particularly large and isolated source of trachytic glass on Hawai'i Island that does not face this complication is found at Pu'uwa'awa'a. This source is geochemically distinguishable from all other potential sources on the island, and often by macroscopic qualities alone (Olson 1983). Relatively abundant Zr concentrations in the range of 1000 ppm serve as one geochemical characteristic of this source, when volcanic glasses from other island sources trend in the 100–200 ppm range. While EDXRF and higher-precision instruments can detect many other unique qualities of this glass, Zr concentrations alone are capable of ruling out virtually all other known volcanic glass quarries in Hawaiʻi.

Using the relatively unique and easily detectable geochemical signature from Puʻuwaʻawaʻa, McCoy *et al.* (2011) demonstrated that transportation of Puʻuwaʻawaʻa volcanic glass off of Hawaiʻi Island was highly uncommon. In addition, on Hawaiʻi Island the source's distribution follows a distance decay model in the Kona district irrespective of *ahupuaʻa* boundaries, and instead correlates significantly with distance travelled over island trails. Lundblad *et al.* (2013) identified two other groups of volcanic glass in Kona, Hawaiʻi, neither of which match well with Mauna Kea, or a Mauna Loa volcanic glass source found in the saddle region of Pōhakuloa (Williams 2004).

EXPANSION OF SOURCING TO OTHER STONE TOOL TYPES

So far, although most publication efforts have focused on basalt adze debitage and volcanic glass, there are several other classes of stone artifacts that can provide valuable information on Hawaiʻi's stone age economics. These include *poi* pounders, *ʻulu maika* game stones, architectural stone in monumental sites, *ʻiliʻili* (pebble) pavings, slingstones, hammerstones, abraders, mirrors, pestles, birdcooking stones, and oven stones (Dye 2010). Dye's study of oven stones demonstrates the utility of examining short-distance exchange patterns of common domestic materials in relation to increasing social stratification. Similar studies of scoria abraders, for example, may demonstrate how often fishermen (who used the abraders to make fishhooks) moved along the coast between districts, and might demonstrate vastly different patterns of social interaction than what is observed through adze exchange. Mills *et al.* (2010) also report that highly polished, fine-grained stone mirrors from Kauaʻi do not match the same sources of stone used to make adzes. Because mirrors are more likely to be curated over generations, they may be more powerful at demonstrating ancestral origins of the people who deposited the adze material in the same archaeological assemblage.

DISCUSSION AND CONCLUSIONS

The emphasis on economic self-sufficiency in Hawaiian *ahupuaʻa* resonates in our modern world with concerns for environmental and economic sustainability. But the general perception of *ahupuaʻa* self-sufficiency is quite different from demonstrated large scale movement of basalt and volcanic glass artifacts between island districts and sometimes between islands. Since Kirch's writing of *Feathered Gods and Fishhooks* in 1985, the collective studies of Hawaiian stone tool economies have documented substantially different production systems in Hawaiʻi, ranging from heavy dependence on imported adzes (Kona, Hawaiʻi; Nuʻalolo Kai) to common use of a broad range of local sources (Molokaʻi; Kahikinui, Maui). We therefore argue that no single exchange model will work for Hawaiʻi's stone tool economies. In addition, the inequities in economic systems throughout the chain would certainly create the potential for structured exchanges between commoners, or, in some cases through chiefs. It is important to realize that these departures from the pattern of self-sufficiency were not *determined* by the geological environment. Many sources of stone within most *ahupuaʻa* could have been used to make adzes (albeit of lesser quality). It was the structure of ancient Hawaiian culture that led to the development of preferred sources outside of *ahupuaʻa* being used (McCoy 1990; Mills *et al.* 2008).

Although we have a better understanding of interaction spheres that Hawaiians created for different lithic economies than we did in 1985, there remain a multitude of questions that large-scale sourcing studies can address. For example, are there geochemical signatures that predominate in chiefly households and not in commoner households? In this vein, there is much research that could be conducted on the social value of different stone artifacts. Although inequities in the distribution of fine-grained basalts and volcanic glass (at least) would have created regional differences in craft production that permeated local economic systems, quantifying the presence or absence of different sources alone is not equivalent to 'value.' We are just beginning to achieve sample sizes that will allow us to infer different regional patterns in domestic and elite lithic economies. Some adzes were undoubtedly storied objects carrying great significance (Desha 2000: 242–243) while others were more common domestic tools. Perhaps the adzes of greatest significance were quarried in relatively limited number and reserved for chiefs. If this is the case, we may find certain geochemical signatures in chiefly sites that do not appear in commoner domestic settings. Kirch *et al.* (2012) found only a few adzes on Maui that appear to be from Mauna Kea, and these were primarily from chiefly sites. One should recognize that the rarity of these adzes on Maui is not necessarily directly related to the cultural significance of the exchange. Such rare instances of transport or exchange may still be crucial indicators of regional socio-political and economic relationships in the evolution of Hawaiʻi's archaic states.

In order to address many economic questions of stone tool production, exchange, and value through time with lithic sourcing, it will be necessary to obtain better dated lithic assemblages, which has proven to be problematic in both the precontact and postcontact eras (Bayman 2003). Many house floors may have been occupied for generations. We lack tightly-dated assemblages to address changing intensity of use of the Mauna Kea Adze Quarry, although we can safely determine from the Kahaluʻu assemblage that it was a significant source from at least the AD 1600s through the early contact era.

Combining technological stages of reduction with geochemical data will be essential in identifying where adzes were being produced versus where adzes were being rejuvenated in down-the-line exchange networks. Mills *et al*. (2011) found that all the Mauna Kea adzes in the Kahaluʻu assemblage ended up as relatively small tools, less than 5 cm in length, and that nearly 1/3 of the Mauna Kea basalt debitage displayed polished dorsal surfaces or platforms. These traits support down-the-line exchange of Mauna Kea material rather than final production of large adzes on site. Ratios of unpolished:polished debitage, sorted by geochemical groups, should prove extremely useful in determining direct access vs. down-the-line exchange.

Finally, large scale sampling of lithic assemblages would benefit from a concerted effort to study other types of stone artifacts beyond adzes and volcanic glass (discussed above). By doing so, we may be able to identify different kinds of social connections in the archaeological landscape than those that will be exposed through adzes and volcanic glass.

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