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– ARTICLE –

A Prehistoric Quarry/Habitation Site on Molokaʻi and a Discussion of an Anomalous Early Date on the Polynesian Introduced Candlenut (*kukui, Aleurites moluccana*)

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ABSTRACT

According to studies in the early 1990s, quarry/habitation site (MO-B6-161) on leeward Molokaʻi may have been occupied about a century earlier than regional settlement models imply. In the first instance, we dated nut shell fragments from the Polynesian introduced candlenut (*kukui, Aleurites moluccana*), from the original radiocarbon sample collection curated at the Bishop Museum, producing a calibrated age (at 2 σ) of AD 690–895 (Beta-336756). Our renewed excavations obtained appropriate short-lived twig wood for dating in addition to another date on candlenut. Four dates produced a calibrated median age of AD 1770, more in line with expectations for late prehistoric settlement in these marginal leeward regions. However, the oldest date was not contaminated with old carbon and satisfies all aspects of 'chronometric hygiene'. Because of this unusually early date (especially on a Polynesian introduced plant), we report in detail its leeward site context, additional dates, depositional context, stratigraphic sequence and the cultural inventory of the MO-B6-161 site as well as the details of sample pretreatment and discuss the absence of sources of carbon contamination. High-quality geochemistry of adze source rock is also presented, thus facilitating island and archipelago-wide interaction studies.

Keywords: early Hawaiian settlement, AMS dating, *Aleurites moluccana,* adze quarry, ICP-OES geochemistry, adze technology

INTRODUCTION

Most island colonisation models relegate the dry, leeward zones of high volcanic Polynesian islands to the latter periods of human settlement. In Hawaiʻi only a couple anomalies to this rule include isolated site activities that target specific resources such as collecting birds on the ʻEwa Plain, leeward Oʻahu (Athens *et al.* 2002), perhaps obtaining high-quality tool stone throughout west Molokaʻi (Weisler 2011), sparse settlement activity at Mapulehu along the southeast shore of the island (Byerly and Liston 2013: 29) and the timing of landscape change along the south leeward shore at ʻŌhiʻapilo Pond (Denham *et al.* 1999; Figure 1). More than 200 new AMS ^{14}C dates on identified short-lived wood from habitation and garden-ing contexts and U-series dates from religious architecture from throughout leeward Molokaʻi, document occupation no earlier than cal AD 1400 (Weisler, in prep.). Dixon *et al.* (1994) reported a radiocarbon age determination (Beta-49700) on unidentified wood charcoal calibrated to cal AD 1225–1455 (2 σ) which potentially is the earliest date for west Molokaʻi and the island as a whole (Weisler 1989). To determine the veracity of this date we selected charred nut shell fragments from the candlenut (*kukui*, *Aleurities moluccana*) – a Polynesian introduction (Wagner *et al.* 1990: 598) – from the same radiocarbon sample collection that had been curated since the early 1990s at the Bishop Museum. Because this new date (Beta-336756) returned a calibrated age of AD 690–895 (2 σ) we conducted further excavations at the site to collect short-lived wood charcoal for AMS dating from stratified contexts – some of which were adjacent to previously dated samples. After these new dates were obtained we also dated another fragment of candlenut shell from the original radiocarbon sample collection that produced the earliest calibrated date. This sample was sent to another lab to determine if the earliest date could be duplicated. The earliest date on a Polynesian introduced plant for Molokaʻi and, indeed, in the Hawai-

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ian Islands, now comes from the MO-B6-161 (Bishop Museum site number) site on the leeward side of the island (Figure 1). This anomalous early date and its leeward site context makes it essential to report the additional dates, depositional context, stratigraphic sequence and the cultural inventory of the MO-B6–161 site as well as the details of sample pretreatment and possible sources of contamination. Additionally, new high-quality geochemical data is provided adding to the ongoing inventory of fine-grained basalt used for adze manufacture thus enhancing island and archipelago-wide sourcing studies.

SITE MO-B6–161

Archaeological site MO-B6-161 (GPS: NAD 83, 0677137/2334969) was originally recorded by Dixon *et al.* (1994; Dixon & Major 1993) during an extensive archaeological survey of south-west Moloka'i Island during 1990–91. Located ~0.5 km from the west coast at ~45 m elevation, the site is situated on a hill which forms part of the south extent of the Kamāka'ipō drainage. The view west is clear to the coast and also east towards the uplands. Dixon *et al.* (1994: 9) referred to this site as an 'open-air basalt quarry … consist[ing] of one C-shaped workshop enclosure (their Feature 1), two short walls or windbreaks (their Features 2 and 3) and nine loci of raw material reduction from two distinct parts of the site'. While Feature 2 is a short low windbreak wall of loosely piled stones, Feature 3 (Dixon *et al.* (1994:Figure 8) is more likely a substantial house site which is discussed below. In Feature 1, they excavated a 0.5 × 1.0 m test pit (Test Unit 1) described as having 'three layers overlying a sterile clay'. As reported, their Layer I appeared to be an historic to modern deposit of windblown soil with no cultural remains, Layer II contained abundant basalt flakes, adze blanks and midden, while Layer III consisted of banded layers of ash and silt.

After extensive site clearing with chain saw to remove most of the *kiawe* (*Prosopis pallida*) trees and dense brush, the site complex was re-mapped in 2012 by Weisler and Mendes noting four constructed shelters (one new C-shape shelter not recorded during the original survey), numerous debitage concentrations, more than 15 adze blanks and preforms, almost 40 large cores of raw material, and domestic artefacts including a basalt file, line sinker and flake tools (Figure 2). So, while it is correct that this site was a place where stone adzes were made, surface artefacts and additional excavations in two shelters (conducted by Weisler and colleagues in December, 2012) also revealed a thick cultural deposit with adze making debris as well as fireplaces, oven stones and midden; that is, a clear habitation component. The objectives of the fieldwork were to: (1) clear and then survey the immediate area to determine the surface site boundaries; (2) make a 1:100 detailed plane-table map noting the constructed shelters, surface concentrations of debitage and formed artefacts as well as larger marine food shells; (3) remove backfill from the Dixon *et al.* (1994:11) 0.5 m × 1 m test pit and re-draw the stratigraphic sections, especially their north

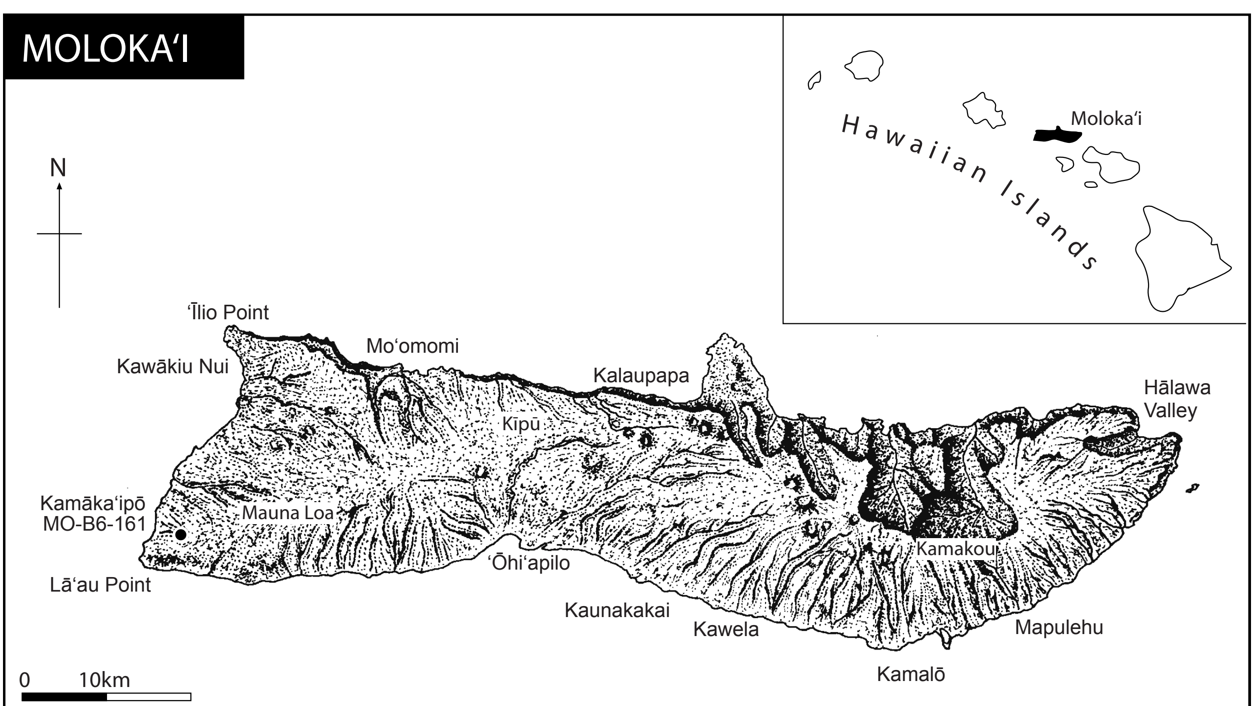

Figure 1. Map of the Hawaiian Islands (inset) and Moloka'i Island showing the location of the Kamāka'ipō site and locations mentioned in the text.

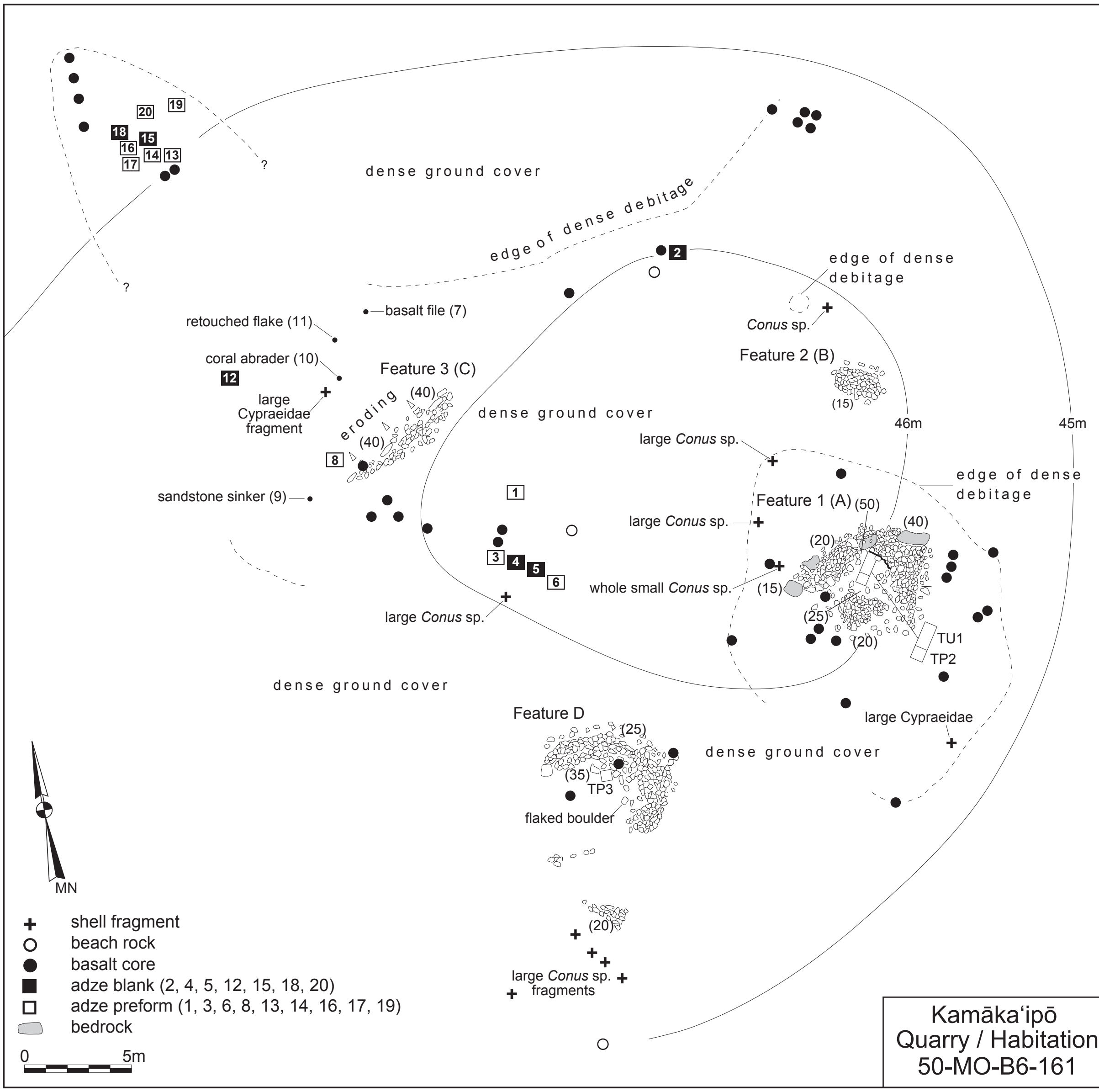

Figure 2. Plane-table map (1:100 scale) of MO-B6–161 showing four constructed features, formed surface artefacts, approximate boundaries of basalt debitage where not obscured by dense grasses, locations of excavation units in Feature A and D, and larger fragments of marine shellfish. Mapped on 18 December 2012 by M. Weisler and W. Mendes.

sidewall – which was not previously reported – that documents the stratigraphic position of the surface shelter to the subsurface cultural deposits; (4) extend the Dixon *et al.* (1994) TU1 for collecting new dating material and a fine-sieved midden assemblage; and (5) test excavate the newly recorded structure to collect an artefact assemblage, midden component and dating material. To be consistent with previous archaeological survey recording protocols used by the senior author, the site features were labelled as follows: Feature A (Feature 1 of Dixon and colleagues), Feature B (Feature 2), Feature C (Feature 3) and Feature D (newly recorded). Test units or TU of Dixon and colleagues are Test Pits (TP) or units used here (Figure 2).

EXCAVATION METHODS AND STRATIGRAPHY

Two 50 × 50 cm test pits were excavated: one unit was placed south and contiguous to the 0.5 m × 1.0 m TU1 (Dixon *et al.* 1994:11), while a second unit was excavated just inside the north wall of C-shape shelter D (Figure 2). Excavations proceeded in 5 cm arbitrary levels or spits with depths taken below surface from the nearest sidewall. Sediments were dry-sieved through 6.4 mm and 3.2 mm sieves and all cultural material sorted and bagged by class (e.g., shellfish, bone, urchins, charcoal and basalt debitage). Due to the isolation of the site, it was not practical to pack out the site matrix for water screening. The x, y and z coordinates of individual formed artefacts encountered *in situ* during excavation were bagged separately. The stratigraphic layers were recorded using the Munsell Color chart system and the U. S. Department of Agriculture soil nomenclature noting depth, layer topography, texture, consistence, plasticity, etc. It was difficult to isolate *in situ* charcoal particles for dating due to the dark, powdery nature of the sediments; consequently, charcoal particles were collected with tweezers mainly from the 3.2 mm sieve.

Stratigraphy

The stratigraphy is illustrated in Figure 3 which shows the ~20 cm thick ashy cultural layer (I) atop the sterile subsoil (layer II) in Feature A excavations. The layer descriptions are as follows:

Layer I

Cultural deposit consisting of a very dark greyish brown (10YR3/2, taken dry in sun) silt with abundant ash, charcoal flecks, marine shellfish, bones of fish, rat, pig, as well as urchin and crustacean, basalt flakes, slab-lined fireplace; abrupt, smooth boundary; structureless, very fine, crumb; loose, non-sticky; abundant roots and pores. The layer was easily excavated with a trowel. The densest basalt debitage was 10–16 cm below surface in TP2 and 5–10 cm below surface in TP3.

Layer II

Culturally sterile subsoil, dark reddish brown (5YR3/4) silt; weak, fine, crumb structure; weakly coherent, weakly friable; slightly sticky, slightly plastic; abundant roots and pores. Excavation was with rock hammer and trowel.

This description differs from that of Dixon *et al.* (1994: 9) as their Layer I, as we observed, was a discontinuous lens with few basalt flakes and no historic material. The dense concentration of basalt flakes that we encountered in the adjoining TP2, was 5–16 cm below surface which occurred in the Dixon *et al.* (1994: Figure 9) layers II and III. We decided, based on the cultural content and sediment characteristics, to group their layers I–III into a single cultural layer as described above.

Combustion feature descriptions

Feature A, TP2, slab-lined fireplace

This combustion feature was exposed in the east profile of TP2. It consisted of two basalt slabs (23.0 cm high by 11.4 cm thick and 23.1 cm high by 8.4 cm thick) resting of sterile subsoil layer II. The contents consisted of a grey ashy matrix similar to layer I, with a 4.5 cm thick lens of white ash towards the base. Several oven stones measured 6–9 cm in maximum length (Figure 3, upper right).

Feature D, TP3, oven

Measuring 20.5 cm deep by 19.0 cm in diameter, this pit, resting on sterile subsoil layer II, was filled with an ashy dark brown (7.5YR 3/4), silty matrix and vesicular basalt cobbles up to ~8 cm long (Figure 3, bottom).

CULTURAL CONTENT

Because all collected artefacts and midden must be returned to the site, we describe the cultural material in detail.

Formed artefacts (non-adzes)

Coral

Four *Porites* sp. coral artefacts were collected. The largest, SA10, is an abrader fragment weighing 66.4 g and measuring 51.54 mm long, 47.74 mm wide and 24.34 mm thick with one flat used surface (Figure 4c). During excavation of TP2 (10–16 cm below surface), two angular pieces of eroded *Porites* were encountered which may have been used as abraders. They weigh 2.88 and 7.52 g with maximum lengths of 29.54 and 42.61 mm, respectively. Seven other small pieces of angular coral were recovered from TP2 spits 3–5 weighing 4.17 g. A tip from a coral file was retained in the 3.2 mm sieve weighing 0.06 g and measuring 8.08 mm long, 4.20 mm wide and 2.26 mm thick with an elliptical cross-section. These coral artefacts were likely used to shape bone and pearl shell into fishhooks.

Worked shell

Also from TP2 10–16 cm below surface was a large chipped fragment of Cypraeidae *Mauritia mauritiana* weighing 28.38 g with a maximum length of 71.18 mm. The shell is chipped along the margin of the opening, to remove the animal, which is typical of these large cowries that are used for octopus lures. A pearl shell (*Pinctada margaritifera*) fishhook tab weighs 0.9 g and measures 28.53 mm long, 15.86 mm wide and 1.38 mm thick (Figure 4a).

Worked mammal bone

Two pieces of worked mammal bone were also collected from TP2 10–16 cm below surface. One specimen might be the unfinished base of a two-piece fishhook weighing 1.9 g, and measuring 24.80 mm long, 13.40 mm wide and 6.97 mm thick. It is ground on all four sides and the base which forms a 45° angle to the long axis. The largest specimen is a left proximal tibia fragment of a juvenile pig (*Sus scrofa*) that exhibits striations and a cut-off end typical when removing and fashioning 'tabs' for fishhook manufacture (Figure 4b). It weighs 1.6 g with a maximum length of 41.09 mm.

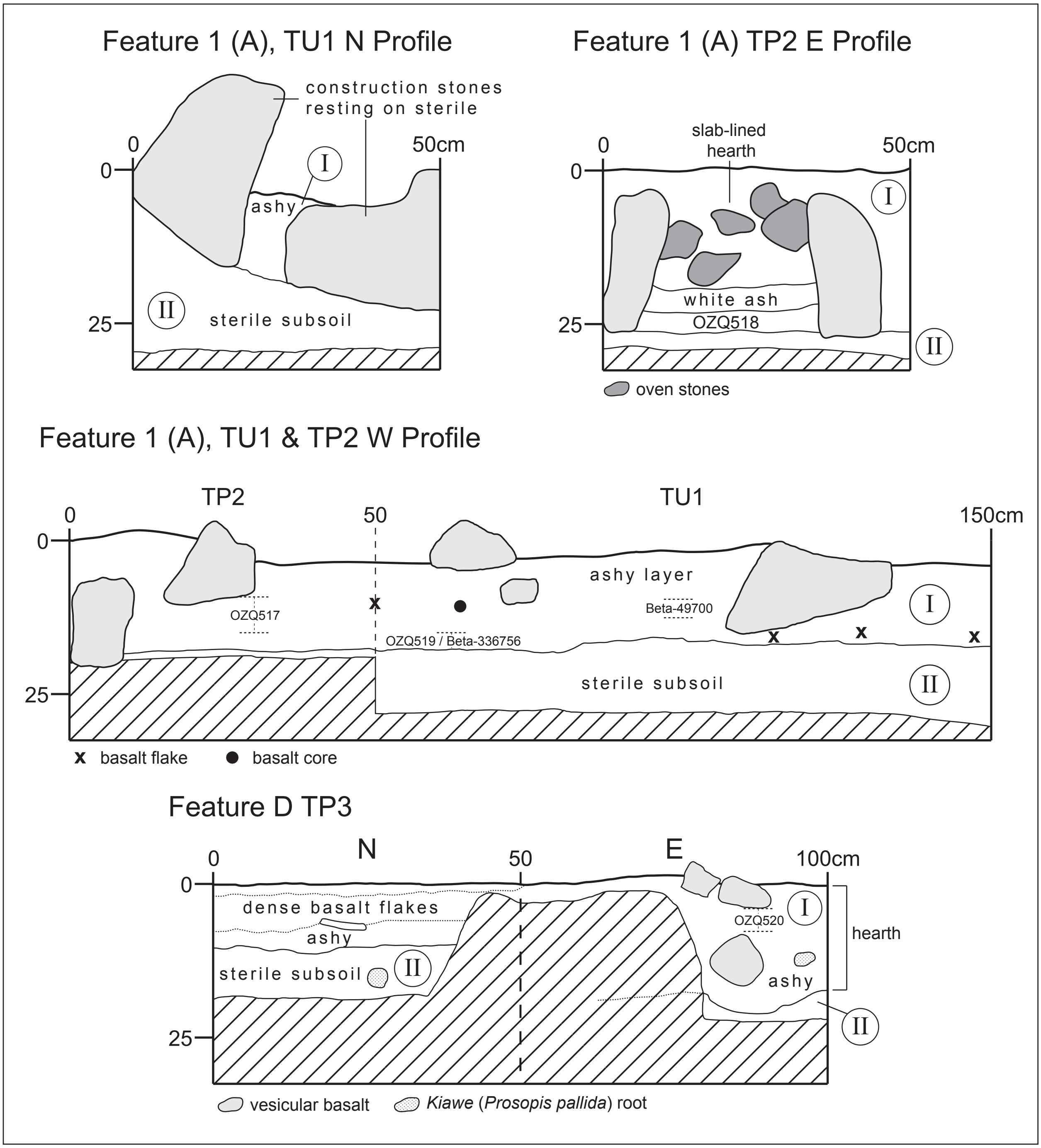

Figure 3. Stratigraphic profiles of excavations in Features A and D. Although there is some internal lensing not shown here, the cultural layer is primarily ~20 cm thick of a dense ashy very dark greyish brown silt resting atop culturally sterile dark reddish brown silt. The north profile of TU1 shows that Feature A contacts sterile subsoil confirming that in this area of the site, at least, there is no occupation prior to that represented by the structure and its contents. Radiocarbon samples consisted of identified short-lived charcoal collected while sieving and the stratigraphic position of samples in shown on the profiles. I and II depict layers I and II, respectively.

Sinker

This coffee-bean style sinker consists of angular coarse (0.5–1.0 mm) calcium carbonate sands cemented to form beach rock. Weighing 129.2 g, it measures 66.75 mm long, 51.24 mm wide and 38.63 mm thick. It is typically oblong in plan, plano-convex in section with a groove running medially around the long axis (SA12; Figure 4e).

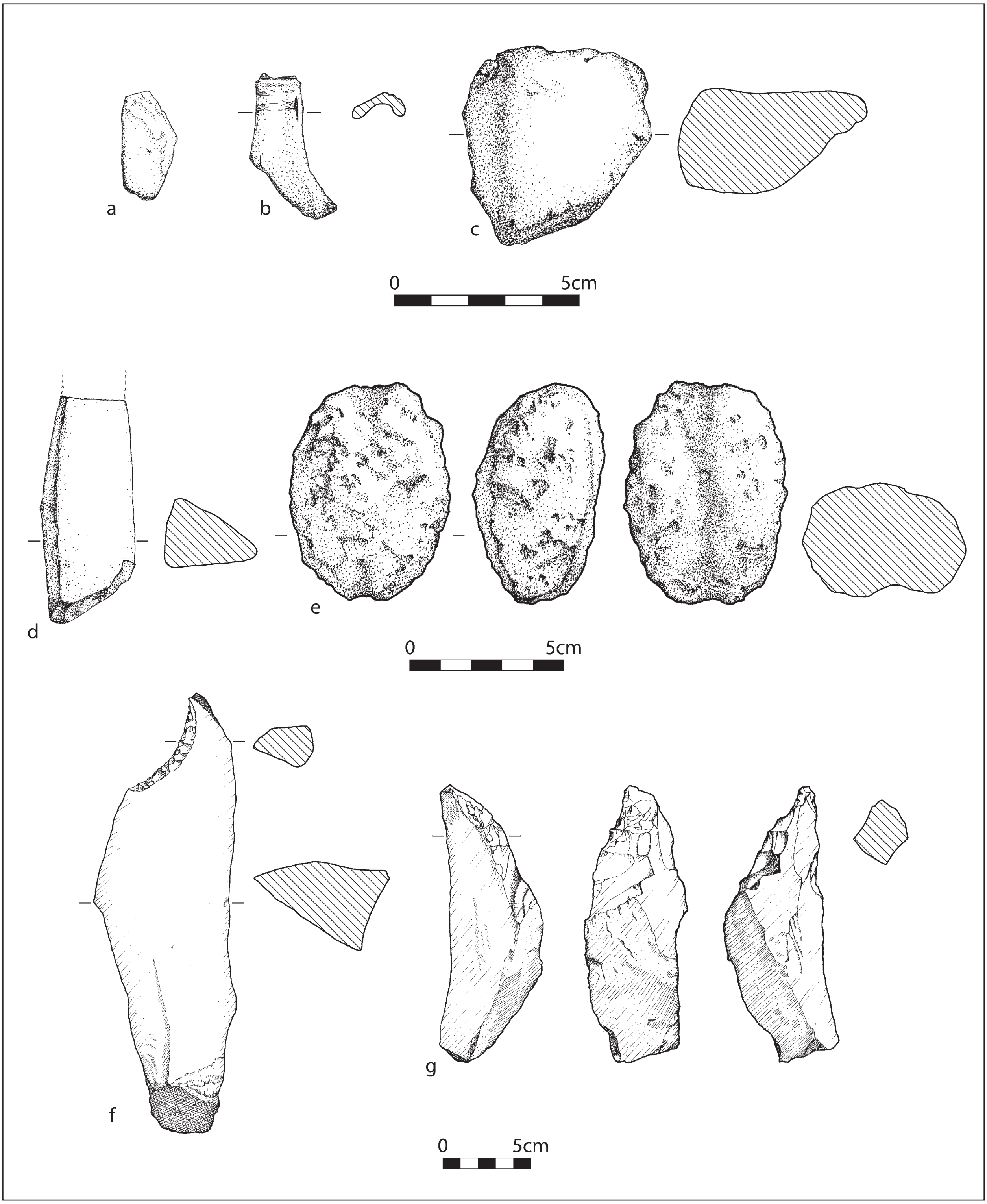

Figure 4. Artefacts from surface and excavated contexts. a) pearl shell (*Pinctada margaritifera*) fishhook tab (Feature A, TP2/3); b) worked proximal left tibia of a juvenile pig (*Sus scrofa*; Feature A, TP2/3, object 1); c) *Porites* sp. coral abrader (SA10); d) fine-grained basalt abrader (SA7); e) coarse sand beach rock coffee-bean style sinker (SA9); f) retouched basalt flake (SA11); and g) retouched flake awl (Feature A, TP2/2, object 1).

Basalt abrader

A relatively rare artefact in Hawaiian archaeology, this triangular cross-sectioned abrader is made from fine-grain basalt and is completely polished on both sides, 60 per cent of the top and less than half of the flat end (SA7; Figure 4d). The pointed end is truncated, but appears to have been used subsequently, as inferred from the wear patterns. The specimen weighs 66.8 g and measures 72.10 mm long, 28.51 mm wide and 15.09 mm thick. The length/width ratio using both the existing length and the estimated total length (~92 mm) prior to truncation, documents that this specimen fits the size range for the most numerous basalt abraders reported recently for Nuʻalolo Kai (Calugay & McElroy 2005: Figure 5). Fine striations parallel the long axis near the apex which is slightly blunted. High gloss polish, possibly the result of working against softer material such as bone or wood, is located along the edges of the specimen.

Retouched flakes

The two retouched flakes are similar in manufacture with secondary flaking along one or two edges – but they probably had different uses. A large secondary flake, SA11 exhibits unifacial flaking forming a concave working edge near the distal margin of the flake (Figure 4f). The specimen weighs 503.7 g and is 194.55 mm maximum length. Also a secondary flake, this tool was recovered from TP2 5–10 cm below surface, and exhibits flaking from the ventral face, along two edges, forming an awl-like tool (Figure 4g). It weighs 211.3 g and has a maximum length of 166.79 mm.

Cores

The locations of 39 fine-grained basalt cores were mapped (Figure 2) and discrete and metric attributes were collected for 24 of them (Table 1), while Figure 5 illustrates typical sizes and shapes. These cores probably represent a range of activities including: 1) material quality determination; 2) removal of relatively smaller flakes for the production of flake tools (e.g., Figure 4f and g); 3) removal of large flakes for manufacturing adze blanks and preforms (flake reduction series); and 4) selection of suitable small boulders and cobbles for manufacture into adze blanks and preforms

Table 1. *Metric and discrete data for whole basalt cores*

SA No.	Length	Width	Thickness	Wt kgs	Bilateral Flaking	No. of right angles	Multi-direct	Cross-section	% Total Cortex	Comments
1	240.93	219.93	167.84	14.05	1	1	yes	?	0	
2	129.38	107.26	76.60	2.31	0	0	yes	?	0	
3	166.01	127.31	98.98	3.60	0	1	yes	quad?	15	
4	170.61	117.43	107.04	2.72	1	1	no	quad?	<5	
5	144.02	128.57	81.37	2.03	0	1	no	quad?	30	
6	163.41	127.76	92.85	2.27	0	0	no	?	30	
7	253.73	195.83	89.39	8.52	0	0	no	quad	85	tabular small boulder flaked at 1 end.
8	332.47	295.40	105.66	19.47	0	1	no	?	70	tabular small boulder.
9	184.78	130.14	118.91	4.53	0	0	no	?	40	Figure 5.
10	357.31	233.80	157.56	23.00	1	1	no	?	50	flaked small boulder. Figure 5.
11	279.13	208.49	159.65	27.85	0	0	no	quad	40	flaked small boulder, blocky.
12	264.32	187.08	133.94	11.30	1	1	no	?	70	flaked small boulder.
13	253.64	178.63	112.52	7.91	1	1	no	?	50	flaked large cobble.
14	152.36	122.49	117.68	4.20	0	0	no	?	50	angular flaked cobble.
15	192.23	144.06	97.51	4.59	0	0	no	?	45	split cobble.
16	183.44	136.17	107.50	3.67	0	1	no	?	20	
17	179.85	140.97	125.96	4.78	1	0	no	?	30	split cobble.
18	175.65	127.15	106.99	5.10	0	2	no	?	20	
19	166.07	153.40	144.72	8.86	0	1	no	?	70	flaked small boulder.
20	171.75	155.12	115.75	3.98	1	2	no	?	15	flaked cobble, possibly split.
21	232.33	185.83	127.14	8.39	0	1	no	?	60	flaked cobble, good example. Fig. 5.
22	206.65	176.68	107.92	4.76	0	0	no	?	60	split cobble.
23	250.54	154.99	147.51	8.51	1	3	no	?	35	flaked cobble.
24	188.31	157.70	146.16	7.14	1	2	no	?	75	

Figure 5. Multiple views of fine-grained basalt cores. a) SA21 is a flaked cobble weighing 8.39 kg with ~60 per cent cortex cover; b) SA9 weighs 4.53 kg and is a more reduced rejected core; c) SA10 weighs 23.0 kg and was made from a small boulder exhibiting large flake scars and ~50 per cent cortex cover. Photos, M. Weisler.

(core reduction series). Continuous attributes averaged 209.96 ± 58.53 mm in length (range = 129.38–357.31 mm), 163.01 ± 44.31 mm in width (range = 107.26–295.40 mm), 118.63 ± 25.09 mm in thickness (range = 76.60–167.84 mm) and weight 8.06 ± 6.76 kg (2.03–27.85 kg). Additionally, per cent cortex cover averaged 40.00 ± 23.91 (range 0–85 per cent). To separate the possible uses of cores the presence of bilateral flaking, number of right angles and presence of multi-directional flake scars and possible cross-sections were noted. It was difficult to assign a definitive cross-section as cores, by definition, are near the beginning of a reduction continuum. Bilateral flaking and the presence of right angles on cores (perhaps very early adze blanks) are normally associated with adze production as opposed to flake tool manufacture – the latter is normally not found on Hawaiian flake tools, while the former is quite common (Clarkson *et al.* 2014, ms). Some 15 of 24 (62.5 per cent) of the sampled cores had one to three right angles, while nine of 24 (37.5 per cent) had one bilaterally flaked edge. Multi-directional flaking (only three of 24 or 12.5 per cent of cores) implies random removal of flakes for non-adze tool making.

Adze blanks and preforms

Data were collected from seven adze blanks and nine preforms for determining: 1) reduction strategies; 2) cross-section form; and 3) average dimensions. The production of adze blanks and preforms was on a continuum where it can be difficult to clearly separate blanks from preforms (Clarkson *et al.* 2014; McCoy *et al.* 1993: 120–24; Weisler 1990: 34). Therefore, we adopted a definition where medial cross-sections are clearly defined for preforms; whereas the cross-section of blanks is either indeterminate or refined just sufficiently to propose a likely cross-section form (Weisler *et al.* 2013: 44–45). Table 2 presents the metric and discrete data for the adze blanks and preforms.

Adze blanks

Of the seven blanks, six were whole and one was a butt fragment as a result of end shock. Three specimens were quadrangular in cross–section, the remaining were indeterminate. Four of the blanks had cortex, mostly on the back where it varied from 10–100 per cent coverage. In all examples, this reflected the exterior surface of the cobble selected for reduction. Only three of the blanks were reduced from a flake. An excellent example of the flake reduction strategy is illustrated in Figure 6a. However, most of the blanks were made from the core/cobble reduction strategy. Average dimensions are: weight 4.57 kg (n=6), length 222.70 mm (n=6), width 104.55 mm (n=7) and thickness 79.49 mm (n=7). The flake blanks were typically smaller than those made from a core.

Adze preforms

Six of the nine preforms were whole, two were butt fragments and one was a fragment including the cutting edge. Two of the fragmented preforms were the result of end shock. All preforms, save one, were quadrangular in cross-section and were made using the flake reduction strategy which is also evident from the occurrence of cortex on the adze preform back, corresponding to the dorsal face of the flake. Here, cortex was present on 56 per cent of the specimens and varied from 15–40 per cent on the back where it was most commonly found. Average dimensions are: weight 0.80 kg (n=6), length 132.71 (n=6), width 62.75 mm (n=9), thickness 38.72 mm (n=9), cutting edge

Table 2. *Metric and discrete data for adze blanks and preforms.*

SA No.	Blank or Preform	Portion	Fracture Type	Cross-Section	Length	Max at Midsection Width	Max at Midsection Thickness	Wt kgs	Cut Edge Width	Poll Width	Poll Thick.	Reduction Strategy	% Cortex Present
2	blank	whole	n/a	quad	133.42	99.84	58.64	1.33				3?	
4	blank	whole	n/a	quad	245.29	116.69	90.74	5.02	n/a	n/a	n/a	1	75-B+P, 50-F
5	blank	whole	n/a	quad	303.51	129.49	106.69	8.17	n/a	n/a	n/a	1	100-P,F,B, 1 side
12	blank	whole	n/a	?	220.16	106.94	91.52	3.29	n/a	n/a	n/a	1	10-B
15	blank	whole	n/a	?	132.16	67.05	45.83	0.60	52.27	n/a	19.15	3a	0
18	blank	mid+butt	end shock	?	n/a	45.61	33.66	n/a	n/a	n/a	n/a	3?	0
20	blank	whole	n/a	?	301.64	166.25	129.32	9.01	n/a	n/a	n/a	1	55-F, 30-B
1	preform	whole	n/a	quad	78.18	39.50	15.11	0.96	42.13	37.20	11.70	3	0
3	preform	whole	n/a	quad	191.16	80.12	62.82	1.76	72.31	73.74	43.99	3a	20-B
6	preform	whole	n/a	quad	121.70	77.03	35.42	0.62	69.15	78.92	36.89	3a	95-P, 15-B
8	preform	whole	n/a	quad	179.76	92.9	48.45	1.42	86.31	76.80	24.60	3a	35-F blade
13	preform	whole	n/a	quad	129.98	65.50	34.02	0.59	61.68	57.23	16.91	3a	0
14	preform	butt+mid	end shock	trapezoidal	n/a	52.15	27.32	n/a	n/a	39.23	18.01	3a	100-Poll
16	preform	whole	n/a	quad	95.49	50.17	40.91	0.29	49.63	33.46	21.12	3a	0
17	preform	ce+mid	reworked?	quad	n/a	53.28	62.75	n/a	64.12	n/a	n/a	3	40-B
19	preform	mid+butt	end shock	quad	n/a	54.14	21.68	n/a	n/a	44.08	12.61	3?	0

Reduction Strategy: 1=from a selected cobble that is flaked, 3=flake technology (unspecified) and 3a=flake technology with flakes removed from ventral surface.
Cortex present: B=back, F=front, P=poll

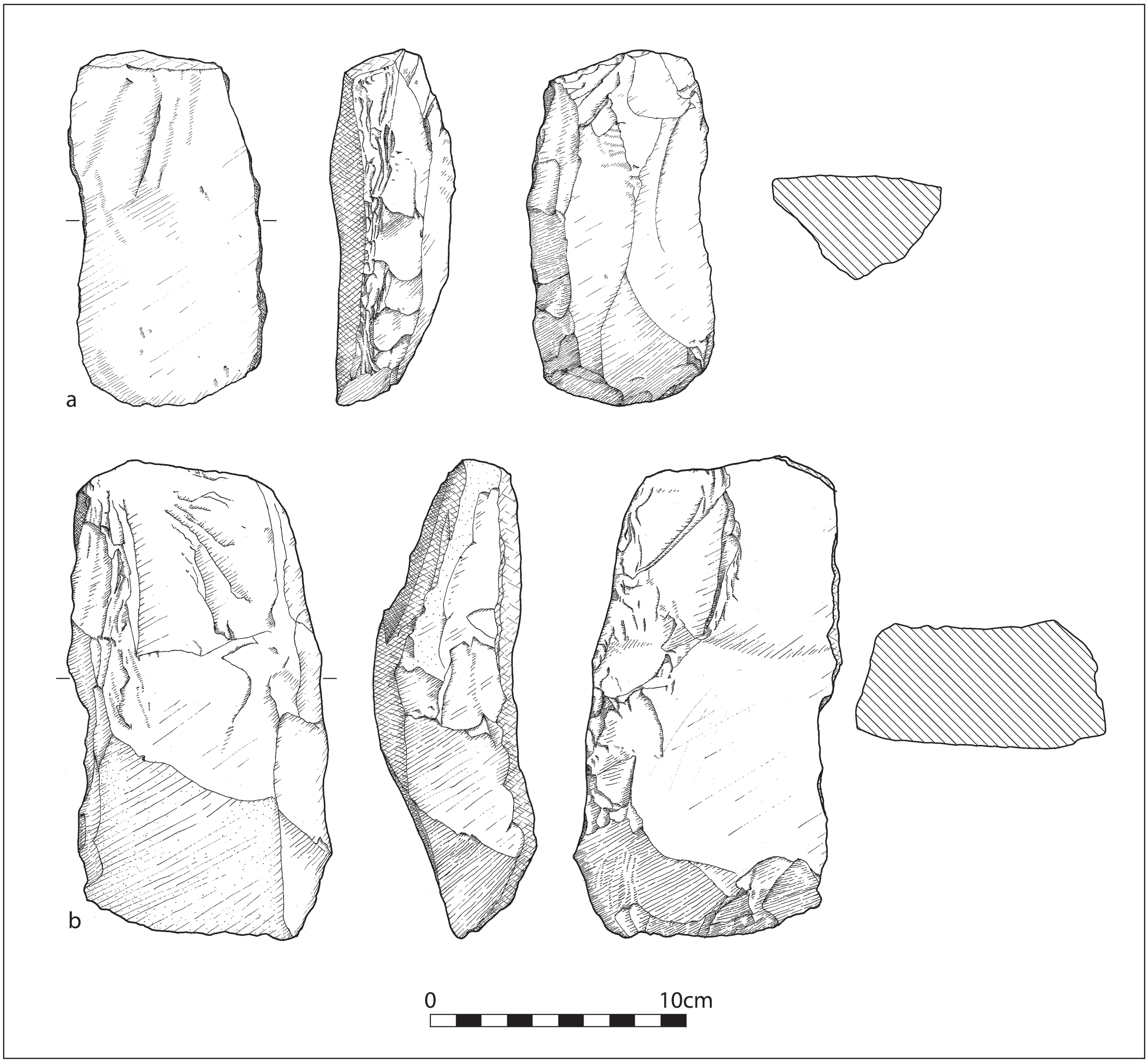

Figure 6. An adze blank (a) with the ventral face (in the first view) which corresponds to the front of the adze blank (SA13). The flake platform is the poll of the adze. The medial ridge in the last view could not be removed, thus resulting in a reverse triangular cross-section of this discarded specimen. b) An unusual adze preform where the dorsal face of the flake (first view) is the front of the adze (SA8). This is the opposite of most blanks and preforms made from a flake. Bevel preparation is evident at the distal flake margin corresponding to the back of the adze preform.

width 63.62 mm (n=7), poll width 55.08 mm (n=8) and poll thickness 23.23 mm (n=8). Figures 6 and 7 illustrate the size and shape variability of adze preforms. Figure 6b is an unusual example of a preform made from a flake where the dorsal flake surface corresponds to the front of the adze. The ventral face of the flake most often corresponds to the front of adze blanks and preforms in the flake reduction series. Bevel preparation is evident at the distal margin of the ventral flake surface (Figure 6b). The smallest well reduced adze preform (SA1), weighing just 96 g, is illustrated in Figure 7a. Although it is not possible to be sure, the flake ventral surface seems to correspond to the back of the adze preform – an uncommon occurrence as mentioned above. Bevel preparation is located at the distal flake margin. Figure 7b shows a possible trapezoidal cross-section preform made from a flake.

Debitage

Figure 8 illustrates the distribution of basalt debitage by weight and count per spit in TP2 showing the densest concentrations in spits 2 and 3. This is in contrast to Dixon *et al.* who reported a low even distribution through much of their TU1 with a marked increase at the top spit (1994:13,

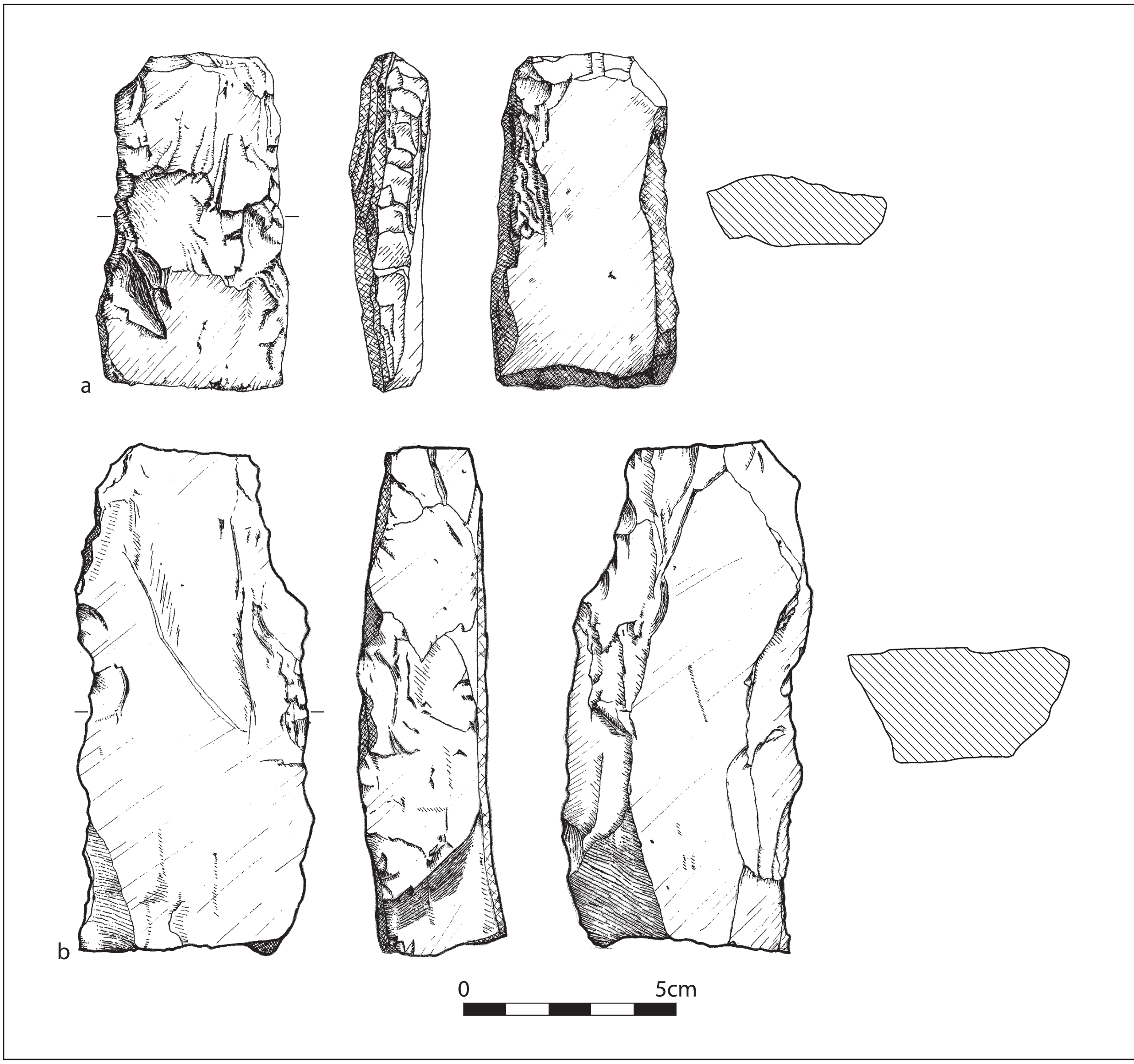

Figure 7. Adze preforms. a) Quadrangular section adze preform (SA1) probably made from a flake showing bevel preparation; b) Adze preform (SA14) with distal end truncated by end shock.

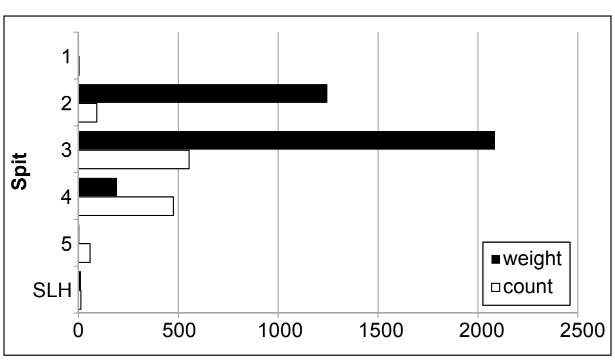

Figure 8. Distribution of debitage in Feature A (1) TP2. AMS radiocarbon age determination (OZQ517) is from spit 3 – the period of greatest debitage deposition.

Figure 11). The analysis of basalt flakes and shatter can add to our understanding of the reduction strategies employed at different locales of the MO-B6-161 site. The two major pursuits of debitage studies can be divided into 'aggregate analysis' where the entire assemblage is stratified by a uniform criterion such as weight or length (Andrefsky 1998: 131) and the 'individual flake analysis' that examines specific flake attributes (e.g., Sullivan & Rozen 1985). Both have their strengths and weaknesses (Amick & Mauldin 1989; Andrefsky 2001; Ensor & Roemer 1989; Prentiss 1998), but most would agree that some combination of both techniques provides robust outcomes. An overriding truth is that 'as the reduction process goes from beginning to end, … debitage will get progressively smaller as well' (Andrefsky 1998: 132). Consequently, we should be able to identify the relative stage of adze blank to preform reduction by determining the distribution of average flake size by length class for a given assemblage.

Although we did not systematically analyse the debitage at the surface concentrations (Figure 2), we agree with Dixon *et al.* (1994: 13) that there was a high percentage of primary flakes; that is, those flakes with a majority of cortex cover. We also noted that the average flake size appeared to be larger than that in the excavated samples. The analysis by Dixon *et al.* was an aggregate study facilitated by separating flakes by amount of cortex: primary flakes had >50 per cent, secondary flakes had 1–50 per cent and tertiary flakes had no cortex (1994: 13, Figure 11). The analysis here separated flakes into maximum length categories (after Turner & Bonica 1994: 7); for example, 200–101 mm, 100–51 mm, 50–21 mm, 20–10 mm and <10 mm. This was more consistent with recent studies of debitage from west Molokaʻi quarries (Scotman 2011) and is a fast and accurate technique. The debitage groups can then be subsampled for noting flake completeness, cortex cover, flake termination, flake shape, kind of bulb of percussion, platform size, etc.

The debitage from Feature A TP2 totalled 1191 flakes and shatter weighing 3544.1 g (mean size = 2.98 g). Figure 9 illustrates the frequency distribution of the weight classes showing the correlation between declining mean flake size and increasing flake number. The majority of flakes by weight (50.9 per cent) were in the 100–51 mm size class – this, alone, suggests that blank production was a significant component represented by the debitage. Some 78.3 per cent of all flakes and shatter by count were <20 mm in length which may be correlated to the latter stages of blank manufacture and preform production. The debitage assemblage as a whole consisted mostly of broken flakes and shatter. A random sample of up to 10 specimens from each length class was taken to record individual flake attributes. A maximum of 43 flakes were analysed. Only eight flakes were complete, defined here as having a platform, bulb of percussion and intact margins. The average

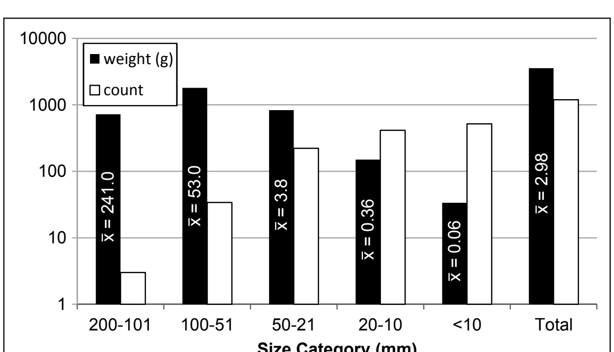

Figure 9. From Feature A (1) TP2, the counts and weights of basalt debitage for the entire TP organised by length size class (in mm). Mean weights given per size class.

flake length to thickness ratio was 4.49 ± 1.88 (n=22); that is, relatively long and thin. Striking platforms had a width/thickness ratio of 4.27 (n=9) which equates to broad and thin platforms. The same ratio at the Nānākuli quarry was 6.21 documenting even thinner and longer flakes that were associated with adze preforms and small, discoid hammerstones (Weisler *et al.* 2013: 42, Figure 7c-f). It may be that the Feature A assemblage more closely represents adze blank production due to the thicker size of the flakes. Some 62.7 per cent of flakes at Feature A had cortex, almost exclusively on the dorsal flake face (only one has cortex on the side). Using the defined cortex groups of Dixon *et al.* (1994), 25.6 per cent were primary flakes, 14.0 per cent were secondary flakes and 60.4 per cent were tertiary flakes – most of these latter specimens were broken flakes and shatter. More than 90 per cent of intact bulbs of percussion were diffuse.

In summary, the debitage at Feature A TP2 may more closely represent adze blank production due to the relatively high percentage of primary flakes, the relatively larger size of flakes (most in the 100–51 mm size class), the high percentage of broken flakes and shatter assumed to result from less controlled flaking, and the width/thickness ratio of the striking platforms which are larger than those more closely associated with preform production (Weisler *et al.* 2013: 42). In this regard, no blanks or preforms were found in and around the surface of Feature A, while almost all blanks and preforms are found immediately north and south of Feature C. Perhaps blanks were produced at Feature A and reduced further to preforms in the vicinity of Feature C.

GEOCHEMISTRY OF SOURCE ROCK AND ARTEFACTS

Discovering new sources and comprehensively analysing the geochemistry of fine-grained basalt quarries remains a fundamental challenge for Polynesian archaeologists seeking to understand prehistoric interaction by documenting the spatial and temporal distribution of exotic adze material (see papers in Weisler, ed. 1997). Weisler and Sinton (1997: 187–189; see also Weisler 1993a: 76) outlined a procedure for field sampling sources which includes: 1) identifying the geological event that formed the fine-grained basalt; 2) collecting source rock and artefacts to unequivocally link the source rock to the adze material; and 3) demonstrating the geochemical variability of the source. There is no specific number of samples required to characterise the geochemistry of a particular fine-grained basalt source; consequently, the overall size and geological complexity of the source (e.g., dyke, flow, cone, secondary source, etc), will dictate the number of samples required to document internal variability. For example, the Nānākuli source on leeward Oʻahu is an exposed dyke or sill 9.0 m long and 2.4 m high (Weisler *et al.* 2013: 38, Figure 6) so only a few samples were required to document the geochemistry of the *in situ* source. We disagree with Mills and Lundblad (2014: 33) who suggest that the Nānākuli source was not adequately sampled for geochemical variability. This belies a fundamental misunderstanding of the need to sample quarries or sources based on the size and complexity of the geological event that contains the source rock. In this regard, the ʻAmikopala quarry, Molokaʻi consists of multiple thoeliitic flows spread across more than 700 m (Weisler 2011: 301, Plate 1) which requires far more samples to document the geochemical variability than well-defined and smaller geological events such as the Nānākuli and Kamākaʻipō sources.

The Kamākaʻipō source consists of subrounded small boulders and cobbles eroded from a thoeliitic flow which now spreads over ~300 m². Seven samples were collected in the field: two from the surface and five from excavated contexts that were associated with radiocarbon age determinations. Sample 2013–288 is a primary flake with 100 per cent cortex which was struck from a source cobble. Table 3 lists the sample provenance and artefact attributes. Geochemical analysis of the standard 10 oxides (major elements) was analysed by inductively coupled plasma optical emission spectrometry (ICP-OES) at the University of Queensland using only ~50 mg of rock powder since these fine-grained basalts are homogeneous. Using the standard alkali-silica diagram (Figure 10), all samples from Kamākaʻipō plot within the thoeliitic basalt field. This is a useful plot since only three oxides can clearly discriminate the thoeliitic quarries or sources from those of alkali origin such as Mauna Kea (Hawaiʻi Island), Moʻomomi (Molokaʻi) and Haleakalā (Maui). The Kamākaʻipō source has similar silica and alkali content to the Nānākuli

Table 3. *Provenance and attributes of artefact samples for geochemistry.*

Year Collected	Lab No.	Provenance	Flake Type	Weight	Length	Width	Thickness	Comments
2008	2009-033	surface	secondary flake	428.0				
2008	2009-034	surface	secondary flake	93.8				
2012	2013-288	TP2/3	primary flake	87.3	94.41	59.11	14.56	From a cobble; 100% dorsal cortex. Associated with OZQ517.
2012	2013-289	TP2/3	seconday flake	153.0	117.03	79.07	14.49	Associated with OZQ517.
2012	2013-290	TP2/3	tertiary flake	21.0	44.05	39.33	6.01	Associated with OZQ517.
2012	2013-291	TP3/3	secondary flake	88.6	77.88	62.58	13.73	Associated with OZQ520.
2012	2013-292	TP3/3	tertiary flake	30.6	46.47	66.16	7.91	Associated with OZQ520.

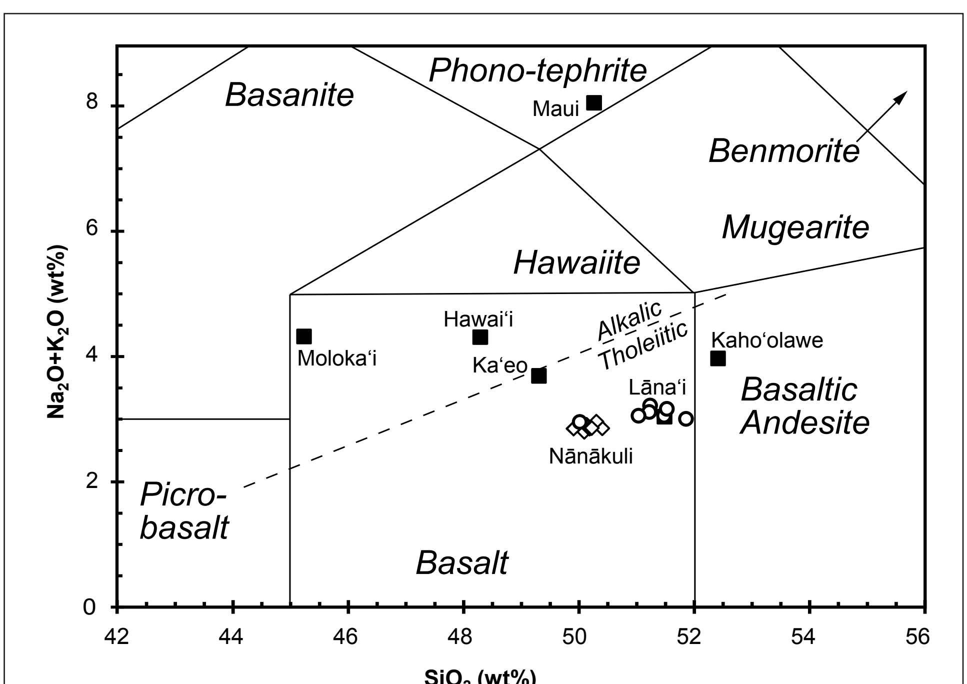

Figure 10. Silica (SiO2) and alkali (K2O+Na2O) plot for select adze quarries. The Kamākaʻipō source (circles) overlaps with Nānākuli (Oʻahu) and Lānaʻi (Kapōhaku) sources within the thoeliitic basalt field.

(O'ahu) and Kapōhaku (Lāna'i) quarries. The 10 oxide values for the seven Kamāka'ipō samples are similar suggesting that most of the geochemical variability within the source is accounted for (Table 4). Again, this is a small source so oxide variability should not be great. Analyses of trace elements and isotopes are planned for the future.

MIDDEN

The sediments from the 0.5 × 1.0 m test unit excavated by Dixon and Major was dry-sieved with 6.4 and 3.2 mm screens, yielding 8.4 g of shellfish (Cypraeidae, Conidae and unidentified), 2.8 g of bone (a human tooth, unidentified mammal and fish), 3.4 g of candlenut shell (*Aleurites moluccana*) and a seed of the hairy morning glory (*Merremia aegyptia*) (1993: Appendix 1). Weisler and Mendes excavated TP2 and Pūlama Lima contributed to the work at TP3. As discussed previously, all sediments were dry-sieved in the field with stacked 6.4 and 3.2 mm screens. All cultural material was retained and described here. In total, 120.01 g of marine shellfish, 35.82 g of bone, 6.6 g of urchins and 0.1 g of crustacean were retained. Surface shellfish plotted on the site map (Figure 2) included four MNI of the large *Conus leopardus*, one whole small *Cypraea* sp. and one *Nodolatirus nodatus*.

Shellfish

The weights, numbers of identified specimens (NISP) and minimum number of individuals (MNI) of all shellfish are listed by TP and screen size in Tables 5 and 6. The total MNI was 56 (aggregated by TP), only four of which were in TP3. Gastropods represented 96.4 per cent of all mollusc MNI and are dominated by shellfish that inhabit rocky substrates in the splash zone (such as the nerites) and benches and rocky shorelines with heavy surf (limpet, cowries, thadids). This is typical habitat fronting Kamāka'ipō. It is unlikely that more than 100 g of edible meet are represented by the entire assemblage.

Bone

Vertebrate

Some 13 bone fragments that could not be identified to at least the family level were placed in this taxon (Table 7). They are most likely fragments of pig or dog, but not fish or bird, due to size and texture.

Pig

Aside from the worked proximal tibia of a juvenile pig described under the artefact section, a burnt molar crown fragment (0.2 g) of a similar age pig was found in TP2 spit 3, retained in the 3.2 mm sieve.

Rat

One rat of *Rattus exulans* size was represented by a humerus and one vertebra.

Fish

The dominant faunal class, fish totalled 17.77 g, 520 NISP and 10 MNI representing 10 families (Table 7). The standard five-paired cranial bones, an expanded set of paired bones, 'special' elements and selected vertebrae (such as those of moray eel) were used for identification to nearest taxon. We acknowledge that an expanded range of vertebrae will yield more NISP and possibly more MNI (Lambrides & Weisler 2013). The inventory included one each of: unicorn fish (Acanthuridae *Naso* sp.), triggerfish (Balistidae), trevally (Carangidae), hawkfish (Cirrhitidae), flyingfish (Exocoetidae), wrasse (Labridae), moray eel

Table 4. *Major element data for the Kamāka'ipō source.*

Sample name	2009-033	2009-034	2013-288	2013-289	2013-290	2013-291	2013-292	2013-292_r	Average
Major elements (wt%)									
SiO_2	51.12	50.09	51.56	51.32	51.30	51.94	51.76	51.61	51.30
Al_2O_3	13.23	12.99	14.13	13.62	13.36	13.53	13.51	13.80	13.48
TiO_2	2.88	2.83	2.99	2.91	2.92	2.94	2.93	2.91	2.92
Fe_2O_3	13.83	13.54	13.58	13.28	13.22	13.49	13.43	13.32	13.48
MnO	0.20	0.23	0.20	0.19	0.16	0.16	0.16	0.17	0.19
CaO	8.96	9.08	8.77	9.13	9.16	9.22	9.19	9.01	9.07
MgO	5.31	5.06	5.11	5.10	5.12	5.37	5.37	5.34	5.21
K_2O	0.60	0.54	0.67	0.66	0.67	0.63	0.63	0.64	0.63
Na_2O	2.47	2.43	2.40	2.57	2.47	2.39	2.48	2.54	2.46
P_2O_5	0.36	0.31	0.39	0.36	0.40	0.35	0.35	0.34	0.36
Total	**98.96**	**97.10**	**99.79**	**99.15**	**98.78**	**100.03**	**99.82**	**99.69**	**99.09**

r = repeated

Table 5. *Invertebrate remains from Feature A, TP 2*

	Spit 2				Spit 3				Spit 4				Spit 5				Slab-lined hearth				Total		
	6mm		3mm		6mm		3mm		6mm		3mm		6mm		3mm		6mm		3mm				
Taxon	**wt.**	**NISP**	**wt.**	**NISP**	**wt.**	**NISP**	**wt.**	**NISP**	**wt.**	**NISP**	**wt.**	**NISP**	**wt.**	**NISP**	**wt.**	**NISP**	**wt.**	**NISP**	**wt.**	**NISP**	**wt.**	**NISP**	**MNI**
Shellfish																							
Molluscs																							
Cellana sp.	1.60	15	0.42	3	0.30	3	0.13	3			0.14	3									2.59	27	5
Conus sp. (small)	2.80	8	0.84	4	3.40	3	0.99	4	2.51	6	0.29	1			0.09	1	0.99	1			11.9	28	9
Conus sp. (medium)	5.90	5			14.80	14											6.05	1			26.8	15	4
Conus sp. (large)	22.70	3																			22.7	3	1
Cypraeidae (small)					0.80	2	0.60	4	1.93	1	0.33	2									3.66	9	4
Cypraeidae (large)					2.00	1															2.0	1	1
Drupa morum					1.60	1															1.6	1	1
Mauritia mauritiana					12.30	1															12.3	1	1
Nerita picea			0.03	1	0.90	7	0.23	11	0.70	3	0.56	7			0.57	19			0.38	14	3.4	62	17
Nerita sp.			0.01	1			0.12	5			0.18	6			0.12	4					0.4	16	5
Nodolatirus nodatus					7.20	1															7.2	1	1
Thaididae									0.51	1											0.51	1	1
Unidentified molluscs	0.60	6	1.03	27	3.60	10	4.57	1	2.58	5	0.74	24			0.04	3			0.02	2	13.2	78	
Unidentified gastropods			0.38	2			1.47	16	1.31	10	0.21	3			0.25	8					3.62	39	
Bivalves																							
Pteriidae	1.70	1			0.90	1															2.6	2	2
Unidentifiedf bivalves							0.11	1													0.11	1	
Urchins																							
Urchin sp.					0.10	5	3.02	132	0.70	3	0.20	5			0.85	39	0.18	1	1.12	24	6.17	209	1
Echinothrix diadema							0.05	1			0.06	3			0.30	2					0.41	6	1
Crustacea							0.08	1													0.08	1	1

No midden recovered in spit 1. Total weights are rounded to one decimal place. Identifications by M. Weisler.

Table 6. *Shellfish from Feature D, TP3*

	Spit 2						Spit 3						Hearth/pit						Total		
	6mm			3mm			6mm			3mm			6mm			3mm					
Taxon	wt.	NISP	MNI	wt.	NISP	MNI	wt.	NISP	MNI	wt.	NISP	MNI	wt.	NISP	MNI	wt.	NISP	MNI	wt.	NISP	MNI
Conus sp. (small)	0.45	1	1	0.31	2	1													0.76	2	1
Conus sp. (medium)							2.32	2	1							0.38	1	1	2.70	2	1
Drupa ricinus	0.78	1	1																0.78	1	1
Cypraeidae (small)	0.75	1	1																0.75	1	1
Unidentified molluscs				0.08	2											0.12	1		0.20	3	
Unidentified gastropods				0.26	1	1													0.26	1	

Identifications by M. Weisler.

(Muraenidae), boxfish (Ostraciidae), bigeye (Priacanthidae) and parrotfish (Scaridae *Calotomus* sp.). The moray eel taxon had 155 bones, probably from one individual of considerable size. The majority of the inventoried fish can be caught by net, although triggerfish, trevally, hawkfish, wrasse and moray eel will take a hook. Where fish size could be determined by comparisons to individuals in the reference collection, the bigeye was <300 g, wrasse <200 g and the parrotfish >600 g. Of note here is the presence of flyingfish, identified by the posterior third of a right otolith (see Weisler 1993b). Polynesia wide, these fish are normally caught offshore at night when the fish are attracted to a torch. Dip nets are used to catch the fish as they approach the canoe. In Hawaiʻi, flyingfish sorties could involve more than 30 canoes (Kahāʻulelio 2006: 89), although one canoe would also result in a catch, as used today in the Marshall Islands.

Urchins

Of the 215 urchin test and spine fragments, only 6.2 per cent were retained in the 6.4 mm sieve. *Echinothrix diadema* was represented by six spines (Table 5). This species is most common above 5 m of depth along turbulent rocky shores (Hoover 1998: 314) and the coast along Kamākaʻipō is ideal habitat.

Crustacean

Only one piece of crustacean was recovered in TP2 spit 3 which is tentatively assigned to crab and not lobster due to the thinness of the carapace.

Charcoal

Wood charcoal was systematically collected from the 6.4 and 3.2 mm sieves and the weights, by TP and spit, are listed in Table 8. Candlenut (*Aleurites moluccana*) was found in TP2 10–16 cm below surface and TU1 18–23 cm below surface and *ʻakoko* (Chamaesyce) shrub twigs were identified for AMS radiocarbon dating.

SAMPLE SELECTION, PRETREATMENT AND DATING RESULTS

Charcoal from each 5 cm level was identified to nearest taxon by Gail Murakami (wood anatomist at International Archaeological Research Institute, Inc., Honolulu) and appropriate short-lived twig wood charcoal Euphorbia (Chamaesyce) and candlenut nut shells were used for dating. We selected two samples of short-lived taxa (OZQ518 and OZQ519) from the base of the cultural deposit (~20 cm below surface) and also two samples (OZQ517 and OZQ520) from the 5–10 cm level below surface associated with dense basalt debitage resulting from adze blank and preform manufacture. These four samples provided: 1) three samples (one previously dated) from the earliest level in order to evaluate the early date and/or provide a spread of dates from the same cultural context; and 2) samples from higher in the cultural deposit to demonstrate the time-depth correlation. After dating results were obtained we also selected a small fragment of candlenut nut shell (OZQ958) from the same level – species identification confirmed and photographed by Andrew Fairbairn – from the same bulk sample from which candlenut was subsampled and produced the earliest date on identical material. The original field sample consisted of unidentified wood charcoal and candlenut shell. Candlenut is an ideal sample material since it is short-lived and a Polynesian introduced plant species (Wagner *et al.* 1990: 598). This sample was sent to the Australian Nuclear Science Technology Organisation (ANSTO). We therefore dated two samples of charred candlenut nut shell from the same level (Beta-336756 and OZQ958), collected by Dixon *et al.*

Table 7. *Vertebrate remains from Feature A, TP2.*

Taxon	Spit 1				Spit 2				Spit 3				Spit 4				Spit 5				Slab-lined hearth				Total		
	6mm		3mm		6mm		3mm		6mm		3mm		6mm		3mm		6mm		3mm		6mm		3mm				
	wt.	NISP	wt.	NISP	wt.	NISP	wt.	NISP	wt.	NISP	wt.	NISP	wt.	NISP	wt.	NISP	wt.	NISP	wt.	NISP	wt.	NISP	wt.	NISP	wt.	NISP	MNI
Vertebrate			0.1	1			0.07	1	1.0	4	0.60	5			0.06	1					0.30	1			2.13	13	
Sus scrofa											0.20	1													0.2	1	1
Rattus cf. *exulans*							0.02	1											0.10	1					0.12	2	1
Acanthuridae *Naso* sp.							0.09	1																	0.09	1	1
Balistidae					0.09	1					0.04	2													0.13	3	1
cf. Carangidae													0.44	1											0.44	1	1
Cirrhitidae																					0.04	1			0.04	1	1
Exocoetidae																			0.05	1					0.05	1	1
Labridae															0.10	1									0.10	1	1
Muraenidae									0.20	1	0.08	1	0.18	11											0.46	13	1
Ostraciidae											0.01	1													0.01	1	1
Priacanthidae																					0.05	1			0.05	1	1
Scaridae *Calotomus* sp.													1.00	1											1.00	1	1
Unidentified fish					0.50	1	0.75	33	0.64	4	3.09	95	0.15	1	5.54	163			0.85	37	0.03	2	3.85	160	15.40	496	
Total fish					**0.59**	**2**	**0.84**	**34**	**0.84**	**5**	**3.22**	**99**	**1.77**	**14**	**5.64**	**164**			**0.90**	**38**	**0.12**	**4**	**3.85**	**160**	**17.77**	**520**	**10**

Identifications by M. Weisler.

Table 8. *Charcoal from test pits.*

Spit	Weight (g)	Comments
Feature A, Test Pit 2		
Spit	**Weight (g)**	**Comments**
1	0.1	
2	2.1	most debitage by weight
3	8.1	OZQ517
4	7.3	
5	0.6	OZQ518
SLH	2.1	
Total	**20.3**	
Feature D, Test Pit 3		
Spit	**Weight (g)**	**Comments**
2	6.3	most debitage by weight. OZQ520
3	7.8	
Total	**14.1**	

SLH = slab-lined hearth
3.2 and 6.4 mm size classes combined

(1994), and sent each sample to different labs for AMS dating to see if the unusually early date could be duplicated.

Standard preteatment was used prior to dating for sample Beta-49700. This sample was submitted by Dixon and Major (1993: 335 and Table 7) for conventional radiocarbon dating (sample weight was not reported); the remaining material was dated by accelerator mass spectrometry (AMS). For sample Beta-336756 a very robust and aggressive pretreatment was carried out at Beta Analytic Inc. and included acid/alkali/acid (AAA) wash to remove carbonate and humic acid contaminants. There was an initial application of 1M HCl at ~70°C for 2 hours to remove carbonate contaminants. The sample was then rinsed to neutral with deionized H_2O. The sample then received two applications of a 2 per cent concentration of NaOH at ~70°C for 4 hours each. The sample was rinsed to neutral following each application of the alkali solution to insure that all humic acid contamination was removed. The sample was then given a final 1M HCl treatment for 2 hours at ~70°C and then rinsed to neutral prior to drying at ~70°C overnight in an oven. These above pretreatments were effective at removing any carbonates or humic acids present. The $\delta^{13}C$ of −24.9 0/00 for Beta-3367564 reported in Table 9 indicates that there were no carbonates remaining after these retreatments.This sample 'provided plenty of carbon for a precise measurement and the analysis proceeded normally' (letter from Darden Hood, dated 7 December 2012). The other five samples processed at ANSTO were pre-treated using the standard AAA method. This included 2M HCl at 60°C for 2 hours to remove carbonates and a portion of infiltrated fulvic acids; 0.5 per cent NaOH at 60°C until the alkali solution was clear (3–5 hours) to remove infiltrated humic acids and the remaining fulvic acids; then 2M HCl at room temperature for 2 hours to remove any atmospheric CO_2 absorbed during the alkali step. Between these steps, the samples were washed with

Table 9. *Radiocarbon age determninations for site MO-B6-161*

Lab No.[1]	Sample ID	Provenance	Sample Material	$\delta^{13}C$ (0/00)	Conventional ^{14}C ages ± 1σ BP	Calibrated ages (AD)[2]		
						1σ range	2σ range	median
Beta-49700[3]	HRC1383	TU1, layer III/1, 13–18cmbs	Unidentified wood charcoal	−17.5	600 ± 90	1295–1410	1225–1455	1355
Beta-336756[4]	B6-161-TU1-III/2	TU1, layer III/2	Aleurites sp. nut shell	−24.9	1210 ± 30	775–875	690–895	815
OZQ517[4]	B6-161A-TP2/3	Feature A, TP2/3	Aleurites sp. nut shell	−23.9	135 ± 25	1680–1940	1675–1945	1815
OZQ518[4]	B6-161A-TP2/5	Feature A, TP2/5	Chamaesyce twig wood	−10.8	180 ± 25	1665–1955	1655–1955	1770
OZQ519[4]	B6-161-TU1.18–25cmbs	Feature A, TU1, 18–23cmbs	Chamaesyce twig wood	−11.0	175 ± 30	1665–1950	1655–1955	1770
OZQ520[4]	B6-161D-TP3/2	Feature D, TP3/2	Chamaesyce twig wood	−10.2	170 ± 30	1665–1950	1655–1955	1770
OZQ958[4]	B6-161-TU1.18–25cmbs-2	Feature A, TU1, III/2, 18–23cmbs	Aleurites sp. nut shell	−24.3	210 ± 30	1650–1955	1645–1955	1770

Notes:
1 'Beta' and 'OZ' samples were prepared and measured at Beta Analytic Inc. and ANSTO, respectively
2 Age calibration was performed using IntCal09 data set (Reimer *et al.*, 2009) and the OxCal program (Bronk Ramsey, 2009)
3 Sample dated by Dixon and Major (1993)
4 Samples dated in this study

excess deionised water. Finally, the pre-treated samples were washed with deionised water and oven-dried at 60˚C for 2 days. The pre-treated samples were combusted using the sealed-tube technique and the evolved CO_2 was converted to graphite using the Fe/H_2 method (Hua *et al.* 2001). AMS measurements were performed using the STAR Facility at ANSTO (Fink *et al.* 2004) with a typical precision of 0.3–0.35 per cent.

Table 9 lists the sample names, provenance, dated material, conventional radiocarbon ages and calibrated ages for the seven dates from Kamāka'ipō. Age calibration was made using the IntCal09 data set (Reimer *et al.* 2009) and the OxCal calibration program (Bronk Ramsey 2009) and reported at 1 and 2 σ age ranges. Four samples (OZQ518-OZQ520 and OZQ958) are from different levels, yet are identical with a median age of cal AD 1770. Although another sample (OZQ517) has a median age of AD 1815, its 2 σ range overlaps completely with these four samples. The other two samples, with median ages of AD 815 and AD 1355, are clearly outside this tight cluster of calibrated ages and are discussed below. We note also that all sample material for Beta-336756 was completely used during analysis by Beta Analytic so there was no material left for another AMS analysis by Beta or ANSTO.

DISCUSSION AND CONCLUSIONS

Adze production

The production of adze blanks and preforms is highly visible at the site especially when considering the distribution of debitage (Figure 2). However, it is unlikely that all the adze material produced there would have required more than a week of full time work by one person. This equates to about two blanks or preforms per day which is less than a morning's work (Clarkson *et al.* 2015, ms). Even if the number of adze preforms is increased by several fold to account for successfully finished preforms that were taken from the site, the entire evidence for adze production may only represent less than a month of full time work. The average length of preforms is ~130 mm with cutting edges of ~64 mm and average weight of ~800 g. Finished adzes with these dimensions, if used at upland or coastal habitation sites, could have been used for typical wood working activities such as house building, canoe making or land clearance. Dixon *et al.* (1994: 15) interpreted adze production at the site to coincide with later prehistoric agricultural expansion on the eastern areas of the island – a point adopted by Kirch and McCoy (2007: 399). While this may be correct, it is hard to imagine that less than 20 adze blanks and preforms from a single site could signal regional agricultural intensification, especially since there are no other adze-making areas known within a 5 km radius of the site. It is likely that this is a 'small adze production locale', defined as containing <50 adze blanks and preforms (Weisler 2011: 307–309), used by 'individual households as their supply of tools required" (Dixon & Major 1993: 342).

Subsistence

With only 0.1 m^3 excavated by us, there was a high diversity of food taxa: 12 marine gastropods and 1 bivalve from ~120 g, at least 1 urchin from 7 g, 10 fish families (NISP = 520, MNI = 10), juvenile pig (NISP=2), rat (MNI=1) and <0.1 g of crustacean. The marine shellfish, crustacean and urchins could easily have been collected along the rocky coastline that fronts Kamākaʻipō. All fish taxa are inshore species that are routinely captured by net or baited hook; the moray eel by spear, hook or basket trap. The juvenile pig which can be considered a status food, may symbolise the importance of the people that occupied this adze making locale (Weisler & Kirch 1985:Table 3, 148). In total, though, the food remains from the excavated sample probably represents <2 kg of food, considering the individual reconstructed size of the specimens.

Source/quarry geochemistry and sourcing studies

We believe it is essential to characterise sources or quarries with the highest quality geochemical techniques that examine the variability in the broadest range of oxides, elements and isotopes (e.g., Weisler *et al.* 2013), a position also taken by the geochemist John Sinton (University of Hawaiʻi; pers. comm., December, 2013). Once differences are clearly documented between sources, then it may be possible to 'target' specific combinations of oxides, trace elements and/or isotopes that are unique for a source. For example, of the numerous quarries and sources in west Molokaʻi (Weisler 2011) that have comprehensive geochemical data, artefacts with high yttrium (Y), point to an ʻAmikopala source. In this example, less expensive techniques can then be used to analyse a larger sample of artefacts. This staged sourcing approach, using various techniques, has been outlined in Weisler and Sinton (1997: 185–187). Analysing *source or quarry material* with techniques that examine a greatly restricted range of oxides and elements (e.g., Mills & Lundblad 2014: 33; Mills *et al.* 2008; Mintmier *et al.* 2012; Weisler 1993c:Table 5.4) should be avoided as oxides, elements and, perhaps, isotopes useful for uniquely identifying a source (and thus facilitating artefact source assignments), may not be analysed. While a full suite of oxide values have been reported here for the Kamākaʻipō source, trace elements and isotopes will be analysed in the future.

Site chronology and dealing with anomalous radiocarbon age determinations

The median age of site occupation and adze manufacture is represented by four samples and one additional sample that overlap at AD 1770. Beta-49700 (submitted by Dixon and colleagues) consisted of unidentified wood and was analysed in the early 1990s when the effects of 'old wood' were not demonstrated for tropical species. Hawaiian archaeologists were slow to acknowledge the groundbreaking work of McFadgen (1982) who demonstrated the effects of 'old wood' for dating New Zealand prehistory. Consequently, it is not possible to determine if the age of sample Beta-49700 represents a true target event (Dean 1978) and therefore this date should be discarded from further consideration. Sample Beta-336756, calibrated to AD 690–895 at 2 σ, presents a different set of issues for interpretation.

In a recent critical examination of 1434 radiocarbon age determinations from East Polynesia Wilmshurst *et al.* (2011: 1815) list three criteria that are essential for accepting dates as valid: (1) samples are clearly linked to cultural activity, (2) samples have the fewest intrinsic sources of potential error (e.g., from inbuilt age, dietary, or post-depositional contamination), and (3) samples are capable of providing a calibration close to the 'true' age of the actual event (i.e., human activity). The earliest date from site MO-B6-161 (Beta-336756) satisfies all three criteria as the sample was (1) obtained from a basal cultural layer consisting of an ashy lateritic sediment with food remains (marine shellfish, sea urchins and fish bone), charcoal chunks, oven stones and stone flakes (the by-products of stone tool manufacture; (2) the dated sample consisted of short-lived nut shell from the candlenut tree (*Aleurites moluccana*) which is a Polynesian introduction (Wagner *et al.* 1990: 598) and (3) the sample conventional age has a small 1-sigma uncertainty of only 30 years and, hence, provided a calibration close to the 'true' age of the actual event. At 2 σ, the age of the sample falls between cal AD 690 to 895; that is, a span of only 205 calendar years. Consequently, there is no intrinsic reason to dismiss this early date, although it is acknowledged that this calibrated range is older than many settlement dates for other East Polynesian archipelagos from which Hawaiʻi was probably settled (Kirch 2011: 22). The fact that the sample consists of a Polynesian prehistorically introduced plant, incapable of natural dispersal to the isolated Hawaiian archipelago due to the pattern of winds and currents (Kirch 2000: map 4), means that this sample represents prehistoric human activity regardless of its stratigraphic context and associations, a point also made recently by Bayman and Dye (2013: 24; see also Athens *et al.* 2014: 148). Additionally, it is worth noting that this date is acceptable when evaluated against the criteria employed by Spriggs and Anderson's 'chronometric hygiene' where about 80 per cent of the earliest radiocarbon age determinations from Hawaiʻi were rejected because of: (1) unreliable laboratories or laboratory procedures were used; (2) unreliable materials were dated; and (3) problematic archaeological contexts are represented by the dated sample (1993: 207–208). While this oldest date satisfies all the rigid criteria for accepting dates as valid, and the lab reported no unusual conditions during pretreatment and radiocarbon measurements, we certainly acknowledge that this date is anomalous.

We also can rule out contamination by older materials.

Carbon contamination of a sample buried a long time in the ground usually includes carbonates from groundwaters and limestone, and humic acids and fulvic acids from upper layers. Carbonate contamination is usually older, while humic and fulvic acids are likely younger than the sample. Carbonate contamination and a portion of fulvic acids are easily removed by acid treatment, while base or alkali solution is used to remove humic acids and the remaining fulvic acids. The only limestone or reef rock geology is located 0.5 km downslope at the coast and groundwater can't reach the site as it is on a hill and not downslope from any sheetwash. Therefore it is unlikely that the sample is contaminated by old carbon.

The youngest range of the calibrated age at 2 σ is still a century older than the earliest settlement of the Hawaiian Islands at AD 1000 as espoused by Kirch (2011) and Athens *et al.* (2014). The associated cultural context of the sample is also different than that of many early dates. That is, it is not associated with abundant food remains, some of which are of extinct or extirpated species, and it is not located near the coast as most colonisation period sites have been found. Using criterion D of Spriggs and Anderson (1993: 207), the oldest date does not 'overlap at 2 sd with younger results from the same context'. However, the anomalously old date is on a short-lived Polynesian introduced plant species so one could say that regardless of the archaeological context, the sample dates human activity. So what takes priority? Technically, both radiocarbon dating labs used state-of-the-art sample pretreatment protocols – which were described here in detail – and reported that all analytical procedures and results were normal. Three values for $\delta^{13}C$ of candlenut were within the range reported from Beta Analytic and ANSTO (–23.9 to –24.9%; see Table 9, sample Beta-336756). There was no evidence of sample contamination from carbonates that would produce dates older than the target event. Until such time as other similar dates are obtained from Hawaiʻi (or elsewhere in East Polynesia), we are inclined to simply report the cultural context and dating procedures of this early date and wait to see if other such dates are reported in the years to come. We advocate a future study that will compile all the radiocarbon age determinations on candlenut to determine if this sample material has a relatively higher incidence of anomalous dates.

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