DETERMINING THE FUNCTION OF POLYNESIAN VOLCANIC GLASS ARTIFACTS: RESULTS OF A RESIDUE STUDY

Marshall I. Weisler and Michael Haslam

Volcanic glass artifacts are commonly found throughout Polynesia, and their function has been debated for several decades. Microscopic edge damage—usually small flake scars along only one edge of the glass flake—was previously thought to result from cutting, scraping, or boring tasks when scaling and gutting fish, butchering dog and pig, scraping vegetables, or preparing fiber or bark. However, none of these explanations have been tied directly to empirical microscopic evidence (such as residues) of these inferred tasks. We examined 14 volcanic glass flakes from late prehistoric habitation sites along the north coast of Moloka'i and 15 flakes from several sites on Henderson Island (Pitcairn Group) to determine the presence and kind of residues found near the working edges of these diminutive artifacts. Twenty-eight percent of the flakes exhibited microscopic residues suggesting plant preparation and shell working functions. Further analysis on an expanded sample of properly collected artifacts from a broader range of sites should elucidate additional functions of this nondescript artifact class.

KEYWORDS: volcanic glass artifacts, use-wear, residues, Moloka'i, Henderson Island (Pitcairn Group)

Marshall I. Weisler is a Senior Lecturer (Associate Professor in the U. S. system) at the University of Queensland in Australia. He has conducted archaeological research across the Pacific for the past 25 years, enjoying immensely his time spent on uninhabited, remote islands. He is perhaps best known for his geochemical analysis of Polynesian basalt adze material for reconstructing ancient patterns of interaction. *m.weisler@uq.edu.au*

Michael Haslam is a Ph.D. candidate at the University of Queensland. His doctoral research involves the microscopic residue analysis of stone artifacts and sediments from Copan, Honduras. He is particularly interested in developing the technical scope and theoretical application of residue analyses.

Hawaiian Archaeology, 10, 2005, pp. 1-17.

Studies of artifact function have played a central role in shaping the archaeological view of past human activities. Over the past three decades, the characterization of residues adhering to artifact surfaces has proved valuable by providing empirical evidence for artifact function (Bruier 1976; review in Odell 2001). Many materials have been examined for residues, including ceramics, stone, metals, bone, and wood, employing a variety of research questions and characterization techniques (including light microscopy, scanning electron microscopy, and various chemical analyses). In stone-tool residue analysis, one of the more common analytical techniques involves examining artifacts categorized by typological or raw material attributes (e.g. Attenbrow, Fullagar, and Szpak 1998; Akerman, Fullagar, and van Gijn 2002; Perry 2004). These studies typically assess the validity of previous interpretations of artifact function, which may have been based on ethnographic analogy or typological inference.

During the past 15 years virtually all stone-tool residue analyses from Pacific Island archaeological sites have been undertaken by Australia-based researchers, focusing on New Britain, New Ireland, and the northern Solomon Islands assemblages (Brown 1988; Fullagar 1992; Loy,

Spriggs, and Wickler 1992; Barton and White 1993; Fullagar 1993; Barton, Torrence, and Fullagar 1998; Fullagar, Loy, and Cox 1998); however, no systematic study of particular stone materials or artifact types has been conducted in Oceania. Past studies typically focus on questions of subsistence and the timing of the introduction or initial cultivation of various plant species—in particular starchy storage organs (e.g. Loy, Spriggs, and Wickler 1992; Haslam 2004a). Integration of residue results with social activities outside the subsistence sphere has been typically absent from such reports. While limited research outside of Near Oceania has been conducted (e.g. Haslam 2004b), there remains much potential for stone-tool residue analyses in assessing prehistoric activity in the Pacific. The present study provides functional evidence for small volcanic glass flakes with a microscopic analysis of artifacts from Molokaʻi and Henderson Island (Pitcairn Group). Our objective is to establish a list of uses discernible from a small sample of artifacts, with further extensive analyses required to determine if definitive statements can be made regarding these artifacts as a class.

We chose volcanic glass artifacts as our primary object of inquiry since flakes and cores of this material are commonly found throughout Polynesia (Weisler 1990, 2004) and determining the uses of these artifacts has engendered much speculation based primarily on ethnographic analogy and edge damage attributes. A half century ago William J. Bonk (1954) collected "obsidian" from four west Molokaʻi sites, noting the site and level from which they were recovered but little else. A decade later, Lloyd Soehren recognized Hawaiian volcanic glass artifacts and commented on the source of the material and uses from sites on the Big Island (Soehren 1962). During the 1970s to 1980s, Rosendahl, Barrera, Kirch, Schousboe, and Riford speculated on the uses of small volcanic glass flakes, reduced by bipolar reduction, that are ubiquitous in Hawaiian archaeological sites (Barrera and Kirch 1973; Rosendahl 1976; Schousboe, Riford, and Kirch 1983). In this article we use the term *volcanic glass* as a general label to indicate non-crystalline glasses and *basaltic glass* to refer to Hawaiian glasses that are more or less basaltic in composition (Weisler and Clague 1998:104).

While this is the first microscopic study of residues on volcanic glass from Polynesia, an immunological residue study (Allen et al. 1995) was conducted on basalt and volcanic glass artifacts from Oʻahu, which also included four glass flakes from sites on Hawaiʻi Island. Allen et al. (1995) employed cross-over immunoelectrophoresis (CIEP) to detect proteins by their reaction to antigens specific to the family taxonomic level (using polyclonal antisera) (see also Spear 1999). They detected proteins on one out of 14 volcanic glass artifacts analyzed. However, strong concerns have been raised over the validity of results obtained via CIEP (see Downs and Lowenstein 1995; Eisele et al. 1995; Leach and Mauldin 1995; Fiedel 1996, 1997; Leach 1998; Smith and Wilson 2001). Problems have included false positive reactions such as identifying rabbit protein in a negative control sample and misidentifying both mouse blood and squash as human. This suggests caution is essential in interpreting results obtained by this method.

Leaving aside more general methodological concerns, the collection of samples by Allen et al. (1995) from only one area of each artifact (identified as "altered" under 10x magnification) is also problematic. Since proteins can come into contact with an artifact from sources other than directly processing an animal or plant (such as from fecal matter or deposition in a trash discard area), control samples need to be taken from several locations on each artifact to demonstrate that the association with an identified used edge is not fortuitous. In our view, immunological or other biochemical

techniques (such as DNA analysis) should only be undertaken in conjunction with, and following, detailed microscopic analysis at high magnification. The loss of residue structural integrity during biochemical analyses, especially of plant structural components, results in the permanent loss of potentially valuable information.

MATERIALS

The volcanic glass artifacts analyzed in this study come from secure prehistoric contexts on the islands of Molokaʻi, Hawaiʻi and Henderson, Pitcairn Group, southeast Polynesia. Brief details of their chronological and stratigraphic contexts are provided below.

The Molokaʻi Assemblage

Fourteen flakes were selected from four late prehistoric habitation sites, dating between the 16th and 17th centuries, situated along the dry north coast of Molokaʻi between Moʻomomi Bay and Hinanaulua (Weisler et al. 2005) (Figure 1). At four residential complexes, four of the flakes were collected from surface contexts lying atop typical lateritic soils that are slightly acidic; one additional flake (although not included in the present analysis) was recovered from 14 cm to 27 cm below surface. At the large sandy midden at Moʻomomi Bay (State Site -2421), ten flakes were recovered from 49 cm to 73 cm below surface in coralline sand (with a neutral pH) and were associated with abundant artifacts, features, and food remains. All flakes averaged 0.99 g (± 1.29 g), length 14.41 mm (± 4.90 mm), width 11.81 mm (± 3.54 mm), and thickness 4.49 mm (± 1.79 mm). Individual measurements are presented in Table 1, and some of the specimens are illustrated in Figure 2.

The Henderson Assemblage

The 15 Henderson Island flakes are all from subsurface contexts and come from four rockshelters (HEN-3, -6, -10, and -11) and one coastal midden (HEN-5), all dating between the 10th and 16th centuries (Weisler 1995) (Figure 3). The rockshelters exhibit fine stratification and are generally dry with excellent preservation—even including abundant plant material (Weisler 1997; Hather and Weisler 2000). The coastal midden has one main cultural layer dominated by typical marine-oriented fauna, artifacts, and combustion features (Weisler 1998). Sediments from all sites are coralline sand with a neutral pH. The flake material is classified as ignimbrite (a type of volcanic glass) and specimens averaged 2.84 g (± 4.72 g), length 19.75 mm (± 9.99 mm), width 16.94 mm (± 6.84 mm), and thickness 5.07 mm (± 2.84 mm). Individual measurements are presented in Table 2, and some of the specimens are illustrated in Figure 2.

METHODS

The chief method employed in this study was light microscopy. Depending on the magnifications used and artifact size, this method may take from one to two hours per artifact, but it has the advantage of simultaneously allowing for assessment of both use-wear and residues at high magnifications and for recording the spatial patterning of residues across an artifact surface. Many of the studies conducted on stone tools in the Pacific and elsewhere in the past few decades have successfully

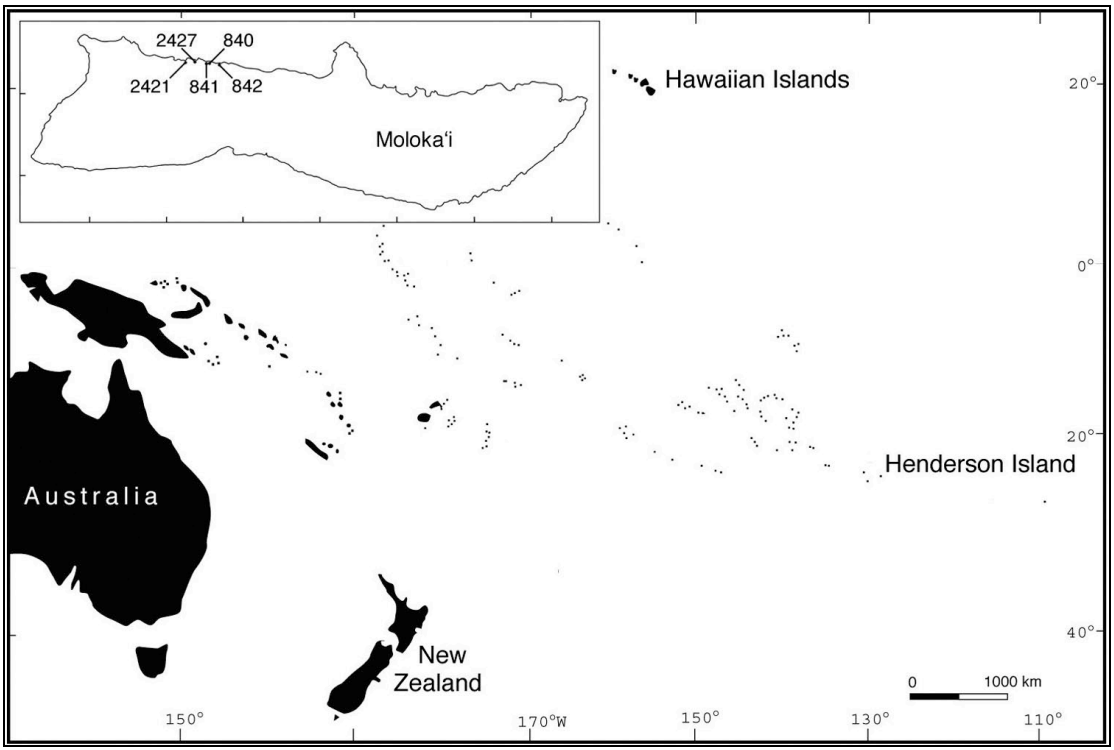

Figure 1. Map of Moloka'i and site locations.

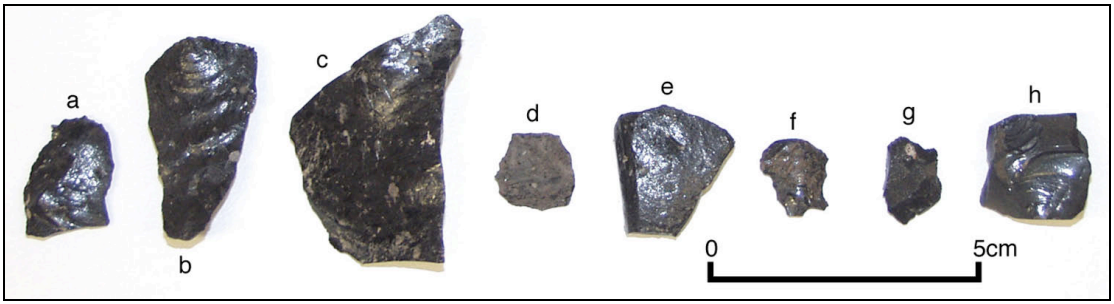

Figure 2. Volcanic glass artifacts with uses identified in this study: a.) HEN5-TP8/3-44, b.) HEN5-TP3/6-4, c.) HEN Kitchen pit backdirt, d.) HEN5-TP16/3-2B, e.) HEN6TP4/5-1, f.) HEN3W2S0/3-9, g.) 50-60-02-2427-SA-2, and h.) 50-60-02-842-SA-8.

Table 1. Molokaʻi volcanic glass artifacts.

Artifact Number*	Weight (g)	Length (mm)	Width (mm)	Thickness (mm)
840-SA-5	0.67	15.7	10.8	4.9
841-1/3-7	0.48	12.8	9.8	4.4
842-SA-8	5.32	21.0	19.9	9.1
842-SA-25	0.61	14.2	11.7	4.5
2421-N25W5/7-5	0.13	1.7	7.2	2.1
2421-N25W5/4-3	0.14	11.7	8.0	1.8
2421-N25W6/5-13	1.36	23.0	16.7	3.0
2421-N25W6/6-8	0.90	16.8	16.0	5.0
2421-N25W6/6-10	0.36	11.5	8.6	4.1
2421-N26W7/1-6	0.73	16.1	11.5	5.0
2421-N26W7/4-11	0.50	13.7	12.8	3.1
2421-N26W7/6-10	0.82	13.7	11.5	4.9
2421-N25W7/10-4	0.93	13.8	10.0	5.9
2427-SA-2	0.85	16.1	10.9	5.0
Mean	0.99	14.4	11.8	4.5
Standard deviation	1.29	4.9	3.5	1.8

* All artifact numbers are prefaced with the site designation 50-60-02

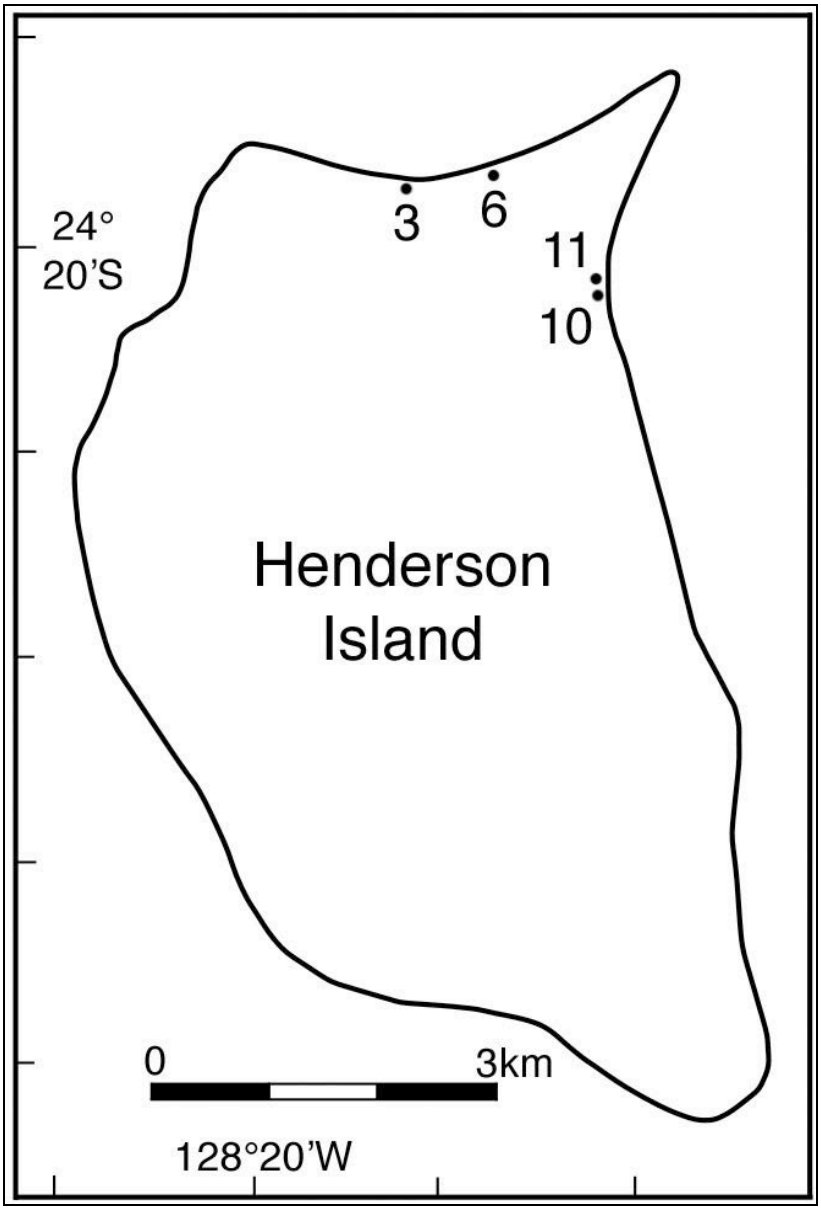

Figure 3. Map of Henderson Island (Pitcairn Group) and location of sites mentioned in this study.

Table 2. Henderson Island volcanic glass artifacts.

Artifact Number.	Weight (g)	Length (mm)	Width (mm)	Thickness (mm)
HEN3-W2S0/3-4	0.13	10.8	8.7	1.7
HEN3-W2S0/3-9	0.43	14.6	12.9	2.6
HEN3-W2S0/4-35	0.13	10.3	5.8	2.8
HEN3-W3S0/3-19	0.59	15.9	13.8	4.0
HEN3-W4S0/4-1	0.39	9.4	13.3	3.7
HEN5-TP3/6-4+	5.91	38.5	21.3	6.7
HEN5-TP7/2-6+	3.10	21.8	19.5	5.1
HEN5-TP8/3-4+	1.62	21.0	17.0	4.4
HEN5-TP16/3-2A	1.85	21.4	18.8	5.7
HEN5-TP16/3-2B	0.72	14.6	15.0	4.0
HEN6-TP1/8-6A+	1.05	18.6	13.2	4.8
HEN6-TP4/5-1	5.76	23.7	22.3	8.9
HEN10-TP1/5-1+	1.58	18.4	25.0	4.2
HEN11-TP2/5-1	0.77	12.5	14.0	4.2
HEN Kitchen pit backdirt	18.52	44.7	33.5	13.2
Mean	2.84	19.8	16.9	5.1
Standard deviation	4.72	10.0	6.8	2.8

+ indicates artifact had previously been subject to XRF analysis

employed light microscopy to answer a range of functional questions (e.g. Loy, Spriggs, and Wickler 1992; Denham et al. 2003; Piperno et al. 2004).

All artifacts were received individually in resealable plastic bags, and they were handled with starch-free latex gloves. Examinations were conducted at up to 30x magnification using a Wild M7S stereobinocular microscope and from 50x to 1000x magnifications using an Olympus BX60 microscope fitted with rotating polarizing filters and bright- and dark-field illumination. Bright-field illumination reflects light directly from the artifact surface, whereas dark-field lighting blocks the central path of the light beam and allows the microscopist to see more readily into a reflective but transparent residue. Residue materials (for example starch, cellulose, or shell) show typical reactions under these different lighting conditions, as well as under polarized light, and polarizing filters can be used as a diagnostic tool by changing the orientation of the light waves striking the residue. Color digital microphotographs were taken of all residues and use-wear with an Olympus DP10 camera attached to the microscope.

Assessment of artifact function is based on the location of use-wear and residues on the tool edges and surface in a pattern consistent with use of the tool rather than incidental contact or taphonomic factors (Figure 4). The ease with which volcanic glass artifacts are damaged is of particular concern in this regard, and edge-damage alone is often insufficient cause to postulate use of the artifact. For example, an assessment of shell working requires not only the presence of shell residues on the artifact but also the coincident location of those residues with abrasion/fracturing of nearby edges and/or ridges. Similarly, the types of edge fractures and other instances of use-wear present provide clues to the use-action (scraping, slicing, or pounding), and any residues linked to those actions should be consistent with the expected or known actions for processing that material type. An artifact used to slice soft tubers, for example, possesses both different residues and use-wear than one used to scrape dense hardwood, and explanations built upon such interpretations need to plausibly account for both types of evidence.

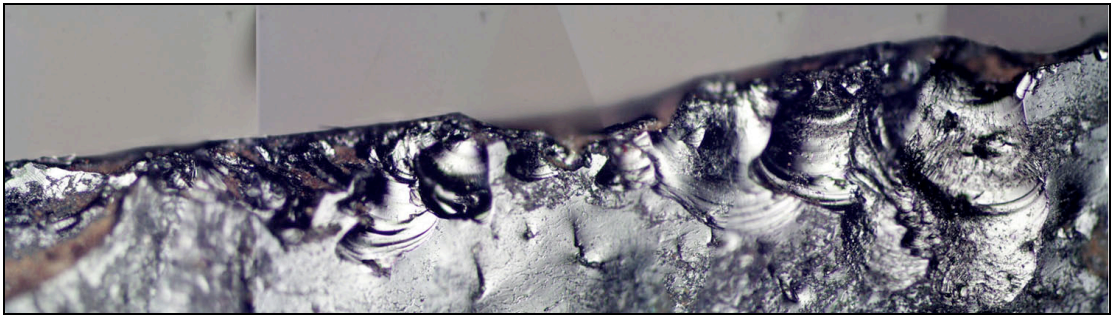

Figure 4. HEN Kitchen pit backdirt. A composite photograph of use-wear (predominately bending and feather fractures, indicating a scraping motion) along one edge (100x).

The final component of this study was to undertake a preliminary assessment of the efficacy of microscopic residue analysis following potentially destructive X-ray fluorescence (XRF) procedures used in sourcing studies. Five of the 29 artifacts analyzed in this study (all five from Henderson Island) had previously undergone XRF treatment, which involves sonication in a bath of distilled water followed by radiation of the artifacts for 300 seconds (for complete details see Weisler 1993:171–172). In each of the five cases the artifacts had been subjected to XRF analysis twice. We anticipated that this procedure would have a detrimental effect on residue preservation through breakdown of diagnostic structural tissues and residue removal, although quantification of these effects was not possible.

RESULTS

Six out of 15 artifacts from Henderson Island, and two of 14 artifacts from Molokaʻi possessed adhering residues that could be attributed to tool use (Table 3). The majority of the 29 artifacts in the sample also possessed a carbonate residue resulting from their deposition in calcareous sediments. The carbonate residues were readily distinguished by their location commonly found between flake scars and along the ridges on the artifact surface (Figure 5). All of the residues ascribed to tool-use were found in association with non-random use-wear in the form of striations, fractures, and rounding. The most common residues observed were derived from plants and included cellulose and starch. Faunal material was limited to shell and a feather fragment. It could not be determined microscopically whether a fatty/oily deposit on Henderson Island artifact HEN3-W2S0/3-9 was derived from an animal

Table 3. Observed residues on volcanic glass artifacts.

Island	Artifact no.	Observed residues
Henderson	HEN3W2S0/3-9	Fatty/oily deposit
Henderson	HEN5TP3/6-4*	Feather
Henderson	HEN5TP8/3-4*	Cellular plant tissue
Henderson	HEN5TP16/3-2B	Cellulose and starch
Henderson	HEN6TP4/5-1	Shell
Henderson	HEN Kitchen pit backdirt	Cellulose
Molokaʻi	50-60-02-842-SA-8	Cellulose
Molokaʻi	50-60-02-2427-SA-2	Matted cellulosic tissue

* indicates artifact had previously been subject to XRF analysis

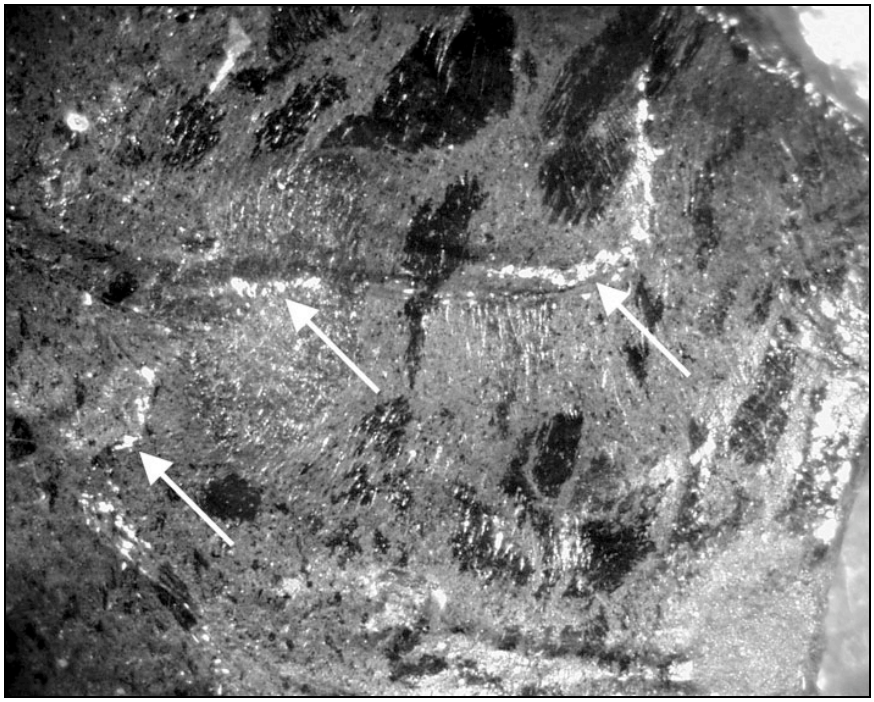

Figure 5. HEN10-TP1/5-1. The white residue (arrowed) is a non-use-related carbonate deposit which follows the flake-scar ridge line (6x).

or plant. All observed residues were compared with a comparative reference collection of plant and animal residues curated at the University of Queensland.

Henderson Island

Activities revealed by the Henderson Island artifacts included slicing soft plant materials (possibly leaves or green plant stems), working a material containing fatty/oily components in a liquid state (possibly coconut), and using a right-angled tip of one artifact to grave or carve shell (Figures 6 through 9). Additionally, one of the artifacts possessed a feather fragment embedded in an opaque residue (Figure 10). Comparison of feather barbule morphology and size with published keys and photographs (e.g. Chandler 1916; Brom 1986) suggests that the feather residue is from one of the Procellariformes, Pelecaniformes, or Charadriformes; however this still leaves a range of some 25 possible species from Henderson Island including endemic land species and sea birds (Wragg 1995:407). At this stage we do not possess a large enough comparative reference collection to further restrict the possibilities.

Of particular interest were two artifacts that retained distinctive residues despite previous XRF treatment (HEN5-TP8/3-4 and HEN5-TP3/6-4). In both of these cases, the structural integrity and detail present is clear and unambiguous, proving that residue survival is possible following sonication

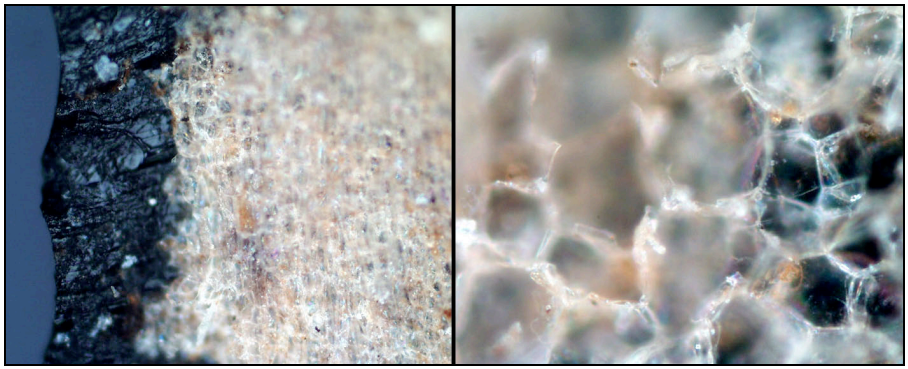

Figure 6. HEN5-TP8/3-4. The plant-tissue residue is slightly inset from the artifact working edge (left, 100x); and (right, 500x) a close-up of the cellular structure.

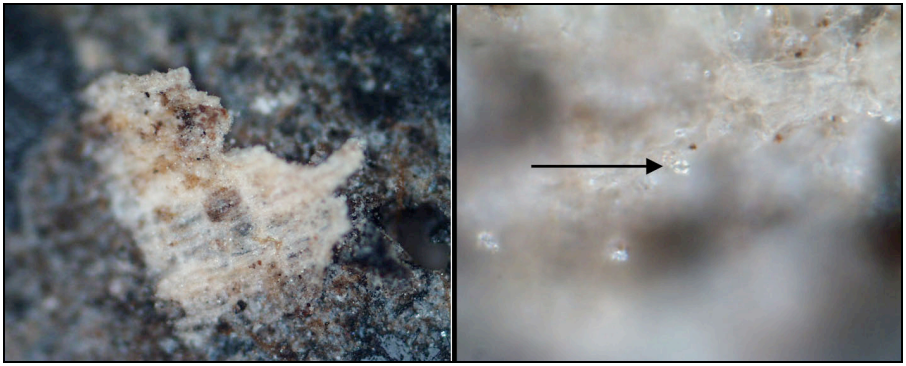

Figure 7. HEN5-TP16/3-2B. Two views of the same cellulosic residue, at 100x (left) and 1000x (right) magnification. The starch grain (arrowed) has a 3µm diameter.

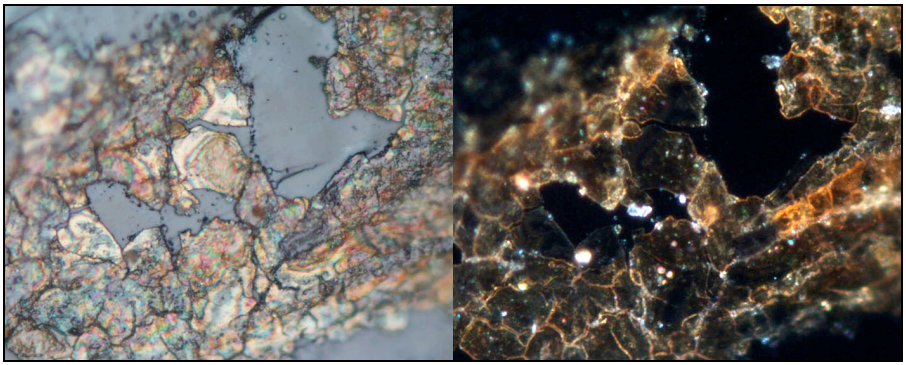

Figure 8. HEN3-W2S0/3-9. Oily/fatty deposit as evidenced by the interference colours and residue cracking displayed in plane-polarised (left) and cross-polarised (right) lighting conditions. Both photographs at 500x magnification.

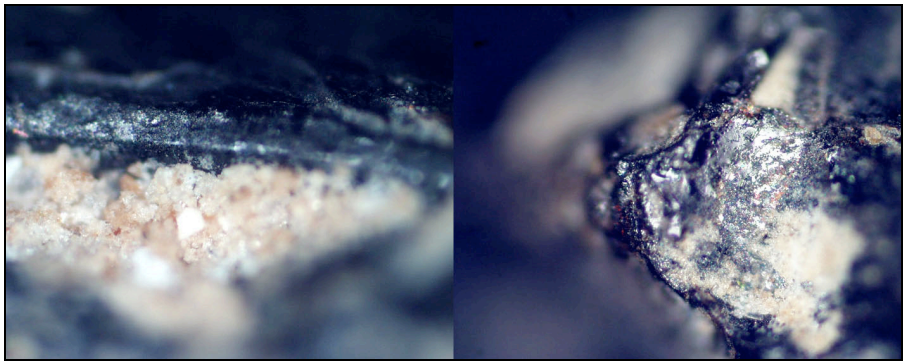

Figure 9. HEN6-TP4/5-1. Evidence for shell working in the form of granular shell residue (left, 100x) and rounding of the point used to process shell (right, 100x).

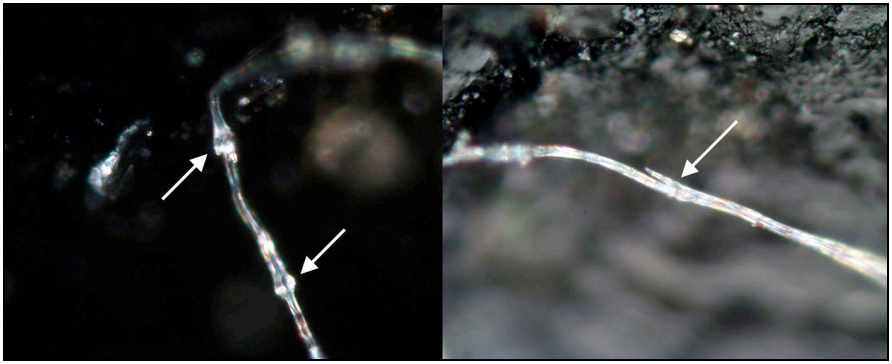

Figure 10. HEN5-TP3/6-4. Two photomicrographs (500x) of the feather residue, showing the shapes of the barbs and nodes (arrowed) on the feather shaft. The internodal distance is constant along the shaft at 64μm.

and XRF analysis. In addition, the proportion of Henderson Island artifacts with residues following XRF (two of five) is the same as for the non-XRF treated sample (four of ten). While the sample size is admittedly small, these results may suggest therefore that the XRF treatment does not have a significant detrimental effect on adhering residues. This finding is encouraging; however, it is not known what residues were present and in what extent prior to XRF study. We recommend therefore that microscopic residue analyses should be conducted prior to any other potentially damaging procedure whenever possible.

Molokaʻi

A lower percentage of volcanic glass artifacts from Molokaʻi possessed evidence of use than from Henderson Island, although it is not clear to what extent taphonomic preservation factors and/or sampling biases may have influenced this result. Additionally, the two artifacts with identifiable use-residues from Molokaʻi possessed cellulosic traces (Figure 11), which could not be identified further to taxon.

Figure 11. Artifact 50-60-02-2427-SA-2 from Moloka‘i showing matted birefringent tissue (500x).

DISCUSSION AND CONCLUSIONS

There are steps that can aid in both the preservation of residues and the limitation of contaminants during both the collection and curation of assemblages. These include (adapted in part from Lampert and Sim [1986]) the following.

1. Keep artifact handling to a minimum. If residue analysis is planned for any stage of a project, collection of newly-excavated artifacts should be made wearing starch-free latex gloves. If gloves are not available, avoiding rubbing the artefact. Bagging it as quickly as possible will prevent residue removal and transfer of contaminants from the excavator to the artifact surface. Any subsequent handling should be with starch-free latex gloves.

2. Do not wash the artifacts. Again, this is not always practical as washing is often a necessary step to identify artifact features or to undertake studies such as conjoining, and in these cases a representative sample should be kept unwashed.

3. Do not write identification or catalogue numbers directly on the artifact surface, and do not coat any part of the artifact with any form of sealant or polish.

4. Store all artifacts individually in resealable plastic bags, with the catalogue number recorded on the bag. If a catalogue tag needs to be placed in the bag as well, double-bag the artifact and place the tag in the outer bag, where it cannot come into contact with the artifact.

5. When possible, keep artifacts intended for residue studies in a cool, dry environment to limit subsequent fungal growth. Artifacts not stored under these conditions may possess a number of fungal structures which can obscure/mimic other residues and may even contribute to residue breakdown (Haslam 2005). Refrigeration is acceptable, but freezing may damage both artifacts and attached residues.

The key point to remember is that an artifact will accumulate residues from any materials it contacts, including human skin, packaging materials, and graphite pencils (during artifact tracing for illustration). While these can usually be distinguished from authentic ancient residues during analysis, keeping such contact to a minimum increases the chances that any residues present will not be removed or contaminated.

Our study has shown that artifacts from surface and subsurface contexts, and from lateritic (acidic) as well as neutral pH coralline sediments exhibited microscopically-identifiable residues regardless of whether they were found in open sites or from deposits in well-protected rockshelters. It is also of note that these artifacts were up to 600 years old. Consequently, residues can preserve in a range of depositional and preservational environments, and the survival of structurally-intact residues on artifacts subjected to XRF analysis further demonstrates the resilience of these biological components.

Of the 29 volcanic glass flakes examined from late prehistoric habitation sites on Moloka‘i and Henderson Island, 28 percent had residues found near the working edges of these artifacts. The residues suggested plant preparation, shell working, and bird/feather processing functions and are the first empirical evidence directly related to tool function without recourse to ethnographic analogy, artifact typology, or disassociated immonulogical or use-wear evidence. Further studies should aim to integrate light microscopy with biochemical techniques to aid in the identification of residue types. We note that the analyzed sample is not sufficiently large to draw general conclusions regarding the prehistoric use of Polynesian volcanic glass artifacts, although the results do begin to establish the range of tasks undertaken with this material. Apart from identifying specific tasks, the value of residue studies of this scale significantly adds to other archaeological and ethnographic evidence to provide more holistic evidence of past lifeways and activities (Haslam 2004c).

This first microscopic examination of residues on Polynesian volcanic glass artifacts has produced some encouraging results towards understanding the functions of these ubiquitous stone tools. While one must be mindful of the points raised above when collecting artifacts for residue analysis, we believe future studies will produce even more empirical evidence towards understanding a more complete range of functions for these common tools.

ACKNOWLEDGEMENTS

We thank Hui Malama o Mo‘omomi (especially Mac Poepoe) for allowing us to conduct fieldwork on Moloka‘i and Walter and Kathy Mendes for help and hospitality during the project. Comments on the manuscript by Mike Carson, Scott Williams, and James Bayman are appreciated.

REFERENCES

Akerman, K., R. Fullagar, and A. van Gijn. 2002. Weapons and Wunan: Production, Function, and Exchange of Kimberley Points. *Australian Aboriginal Studies* 1:13–42.

Allen, J., M. E. Newman, M. Riford, and G. H. Archer. 1995. Blood and Plant Residues on Hawaiian Stone Tools from Two Archaeological Sites in Upland Kaneohe, Koolau Poko District, Oahu Island. *Asian Perspectives* 34:283–302.

Attenbrow, V., R. Fullagar, and C. Szpak. 1998. Stone Files and Shell Fish-hooks in Southeastern Australia. In *A Closer Look: Recent Australian Studies of Stone Tools*, edited by R. Fullagar, pp. 149–178. Sydney: Archaeological Computing Laboratory, University of Sydney.

Barrera, W. Jr., and P. V. Kirch. 1973. Basaltic Glass Artefacts from Hawaii: Their Dating and Prehistoric Uses. *Journal of the Polynesian Society* 82:176–187.

Barton, H., R. Torrence, and R. Fullagar. 1998. Clues to Stone Tool Function Re-examined: Comparing Starch Grain Frequencies on Used and Unused Obsidian Artefacts. *Journal of Archaeological Science* 25:1,231–1,238.

Barton, H., and J. P. White. 1993. Use of Stone and Shell Artefacts at Balof 2, New Ireland, Papua New Guinea. *Asian Perspectives* 32:169–181.

Bonk, W. J. 1954. Archaeological Investigations on West Molokai. M.A. thesis, University of Hawai‘i, Honolulu.

Briuer, F. L. 1976. New Clues to Stone Tool Function: Plant and Animal Residues. *American Antiquity* 41:478–484.

Brom, T. G. 1986. Microscopic Identification of Feathers and Feather Fragments of Palearctic Birds. *Bijdragen tot de Dierkunde* 56:181–204.

Brown, P. 1988. Residue Analysis of Stone Artefacts from Yambon, West New Britain. Unpublished B.A. (Honors) thesis, University of Sydney, Sydney.

Chandler, A. C. 1916. A Study of the Structure of Feathers, with Reference to Their Taxonomic Significance. *University of California Publications in Zoology* 13:243–446.

Denham, T. P., S. G. Haberle, C. Lentfer, R. Fullagar, J. Field, M. Therin, N. Porch, and B. Winsborough. 2003. Origins of Agriculture at Kuk Swamp in the Highlands of New Guinea. *Science* 301:189–193.

Downs, E. F., and J. M. Lowenstein. 1995. Identification of Archaeological Blood Proteins: A Cautionary Note. *Journal of Archaeological Science* 22:11–16.

Eisele, J. A., D. D. Fowler, G. Haynes, and R. A. Lewis. 1995. Survival and Detection of Blood Residues on Stone Tools. *Antiquity* 69:36–46.

Fiedel, S. J. 1996. Blood from Stones? Some Methodological and Interpretive Problems in Blood Residue Analysis. *Journal of Archaeological Science* 23:139–147.

———. 1997. Reply to Newman et al. *Journal of Archaeological Science* 24:1,029–1,030.

Fullagar, R. 1992. Lithically Lapita: Functional Analysis of Flaked Stone Assemblages from West New Britain Province, Papua New Guinea. In *Poterie Lapita et Peuplement*, edited by J.-C. Galipaud, pp. 135–143. Noumea: ORSTOM.

———. 1993. Flaked Stone Tools and Plant Food Production: A Preliminary Report on Obsidian Tools from Talasea, West New Britain, PNG. In *Traces et Fonction: Les gestes retrouvés*, vol. 50, edited by P. C. Anderson, S. Beyries, M. Otte, and H. Plisson, pp. 331–337. Liège: ERAUL.

Fullagar, R., T. Loy, and S. Cox. 1998. Starch Grains, Sediments and Stone Tool Function: Evidence from Bitokara, Papua New Guinea. In *A Closer Look: Recent Australian Studies of Stone Tools*, edited by R. Fullagar, pp. 49–60. Sydney: Archaeological Computing Laboratory, University of Sydney.

Haslam, M. 2004a. The Decomposition of Starch Grains in Soils: Implications for Archaeological Residue Analyses. *Journal of Archaeological Science* 31:1,715–1,734.

———. 2004b. Residue and Use-wear Analysis of Prehistoric Lithic Artefacts from Palau. Unpublished report (MARS 450) for Pacific Archaeological Services, LLC.

———. 2004c. Theoretically Possible: Action, Agency, and Narrative in Stone Tool Residue Analysis. Paper presented at the Australian Archaeological Association Annual Conference, Armidale.

———. 2005. Potential Misidentification of In Situ Archaeological Tool-residues: Starch and Conidia. *Journal of Archaeological Science* (in press).

Hather, J., and M. I. Weisler. 2000. Prehistoric Giant Swamp Taro *(Cyrtosperma chamissonis)* from Henderson Island, Southeast Polynesia. *Pacific Science* 54:149–156.

Lampert, R., and R. Sim. 1986. Residues on Artefacts: Implications for Handling and Storage. *Australian Archaeology* 22:157–159.

Leach, J. D. 1998. A Brief Comment on the Immunological Identification of Plant Residues on Prehistoric Stone Tools and Ceramics: Results of a Blind Test. *Journal of Archaeological Science* 25:171–175.

Leach, J. D., and R. P. Mauldin. 1995. Additional Comments on Blood Residue Analysis in Archaeology. *Antiquity* 69:1,020–1,022.

Loy, T. H., M. Spriggs, and S. Wickler. 1992. Direct Evidence for Human Use of Plants 28,000 Years Ago: Starch Residues on Stone Artefacts from the Northern Solomon Islands. *Antiquity* 66:898–912.

Odell, G. 2001. Stone Tool Research at the End of the Millennium: Classification, Function, and Behavior. *Journal of Archaeological Research* 9:45–100.

Perry, L. 2004. Starch Analyses Reveal the Relationship between Tool Type and Function: An Example from the Orinoco Valley of Venezuela. *Journal of Archaeological Science* 31:1,069–1,081.

Piperno, D. R., E. Weiss, I. Holst, and D. Nadel. 2004. Processing of Wild Cereal Grains in the Upper Palaeolithic Revealed by Starch Grain Analysis. *Nature* 430:670–673.

Rosendahl, P. 1976. *Archaeological Investigations in Upland Kaneohe.* Departmental Report Series 76-1. Honolulu: Department of Anthropology, Bernice Pauahi Bishop Museum.

Schousboe, R., M. Riford, and P. V. Kirch. 1983. Volcanic Glass Flaked Stone Artifacts. In *Archaeological Investigations of the Mudlane-Waimea-Kawaihae Road Corridor, Island of Hawai'i: An Interdisciplinary Study of an Environmental Transect*, edited by J. T. Clark and P. V. Kirch, pp. 348–370. Departmental Report Series 83-1. Honolulu: B.P. Bishop Museum.

Smith, P. R., and M. T. Wilson. 2001. Blood Residues in Archaeology. In *Handbook of Archaeological Sciences*, edited by D.R. Brothwell and A.M. Pollard, pp.313–322. Chichester: John Wiley and Sons.

Soehren, L. 1962. *Archaeological Investigations at City of Refuge National Historic Park, Honaunau, Kona, Hawai'i*. Honolulu: B.P. Bishop Museum and National Park Service.

Spear, R. L. 1999. Use-wear and Residue Analysis, Site 19039, Block E, Kailua Kona, Island of Hawai'i. Paper presented at the 1999 Society for Hawaiian Archaeology Annual Conference.

Weisler, M. I. 1990. Sources and Sourcing of Volcanic Glass in Hawai'i: Implications for Exchange Studies. *Archaeology in Oceania* 25:16–23.

———. 1993. Chemical Characterization and Provenance of Manu'a Adz Material Using a Non-destructive X-ray Fluorescence Technique. In *The To'aga Site: Three Millennia of Polynesian Occupation in the Manu'a Islands, American Samoa*, edited by P. V. Kirch and T. L. Hunt, pp. 167–188. University of California Archaeological Research Facility Contributions No. 51. Berkeley: University of California.

———. 1995. Henderson Island Prehistory: Colonisation and Extinction on a Remote Polynesian Island. *Biological Journal of the Linnean Society, London* 56:377–404.

———. 1997. Prehistoric Long-distance Interaction at the Margins of Oceania. In *Prehistoric Long-distance Interaction in Oceania: An Interdisciplinary Approach*, edited by M. I. Weisler, pp. 149–172. Monograph No. 21. Auckland: New Zealand Archaeological Association.

———. 1998. Issues in the Colonization and Settlement of Polynesian Islands. In *Easter Island and East Polynesian Prehistory*, edited by P. Vargas, pp. 79–94. Santiago: Easter Island Studies Institute, FAU, University of Chile.

———. 2004. Polynesian Volcanic Glass: Uses, Sourcing, and Distribution. Paper presented at the Obsidian Summit International Workshop, Rikkyo University, Tokyo, Japan.

Weisler, M.I., and David A. Clague. 1998. Characterization of Archaeological Volcanic Glass from Oceania: The Utility of Three Techniques. In *Archaeological Obsidian Studies: Method and Theory*, edited by M. Stephen Shackley, pp. 103–128. Advances in Archaeological and Museum Studies 3. New York: Plenum Press.

Weisler, M. I., K.D. Collerson, Y-X Feng, J-X Zhao, and K-F Yu. 2005. Thorium-230 Coral Chronology of a Late Prehistoric Hawaiian Chiefdom. *Journal of Archaeological Science* (in press).

Wragg, G. M. 1995. The Fossil Birds of Henderson Island, Pitcairn Group: Natural Turnover and Human Impact, a Synopsis. *Biological Journal of the Linnean Society* 56:405–414.