The Use of Flaked Stone Artifacts in Palau, Western Micronesia

MICHAEL HASLAM AND JOLIE LISTON

INTRODUCTION

In the past decade, archaeological research in Palau (Fig. 1) has undergone a rapid acceleration in terms of both the quantity of research conducted and the variety of archaeological questions addressed. As a result, recent modeling of initial occupation (Athens and Ward 2001; Clark 2004; Clark et al. 2006; Fitzpatrick 2003*a*; Wickler 2001); cultural chronologies (Clark 2005; Liston 1999; Phear et al. 2003, Wickler et al. 2007); and settlement patterns (Liston in prep.*a*; Liston and Tuggle 2006; Masse et al. 2006) have dramatically advanced our understanding of Palauan and Micronesian cultural history. The recent recovery and specialized analyses of significant quantities of flaked stone artifacts allow for an interpretation of Palau's flaked stone tool use in the context provided by these new chronological and settlement models.

In this article, we summarize the archaeological analyses of Palau's chipped stone artifacts, review ethnohistorical sources for descriptions and potential use of lithic tools, and present the results of a recent microscopic use-wear and residue analysis of 20 flaked stone artifacts (Table 1; see also Fig. 2). Studies of microscopic residues found adhering to stone tools typically provide evidence of artifact function, ranging from a distinction between used and unused artifacts to species-level identification of exploited biota, and may include assessments of hafting (e.g., Rots 2003) or non-utilitarian artifact roles. In addition to identifying potential tool function, this analysed assemblage, chiefly derived from approximately 2000-year-old inland complexes of earthwork and village sites, can therefore provide insight into the cultural transformations between Palau's temporally distinct earthwork and stonework eras. Residue results are contextualized within the reconstructed social context and in light of the dominance of shell as a tool material on Palau.

The Republic of Palau is an archipelago of some 350 islands in the western Caroline Islands of Micronesia. With an area of 333 km^2, the volcanic island of Babeldaob is the largest island in the archipelago. The remaining 82 km^2 are

Michael Haslam is affiliated with the Leverhulme Centre for Human Evolutionary Studies, University of Cambridge, U.K. Jolie Liston is an archaeologist with Garcia and Associates in Kailua, Hawai'i.

Asian Perspectives, Vol. 47, No. 2 © 2008 by the University of Hawai'i Press.

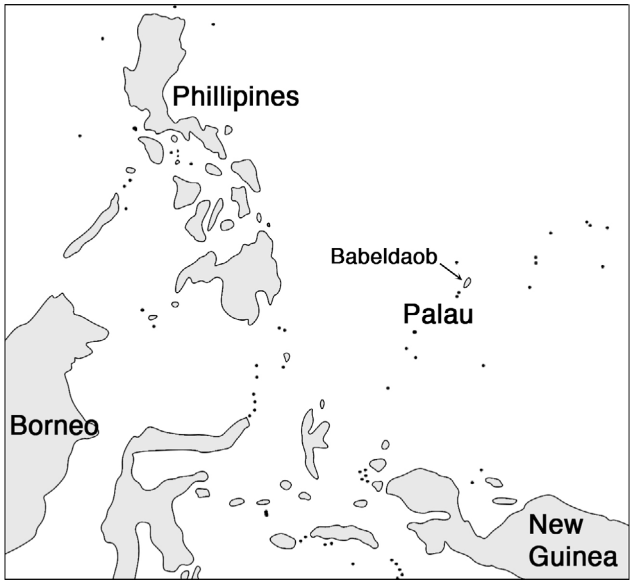

Fig. 1. Location of Palau in relation to surrounding islands.

divided among three primarily volcanic islands, two atolls, two platform-like reef islands, and a cluster of several hundred tectonically uplifted coralline limestone islands locally referred to as the "Rock Islands." Some 500 km southwest of the main group are the Southwest Islands—an isolated cluster of low limestone islands and atolls. Formed as a result of Oligocene volcanic activity, Babeldaob's substrate consists of basalt-andesite-dacite breccias and interbedded tuffs formed during the Oligocene with the smaller islands south of Babeldaob composed of Miocene and younger limestone (Dickinson and Athens 2007). A barrier and fringing reef complex encloses all but the southern reef island, the northern atolls, and the Southwest Islands creating a shallow lagoon that facilitates interaction between the islands.

PREHISTORIC PALAUAN TOOLS

In order to effectively interpret the functional evidence provided by microscopic residue and use-wear analysis of the flaked stone artifacts, it is necessary to place Palau's tools and their use in an environmental and social context. To this end, we review archaeological analyses of Palauan tools to ascertain availability of raw materials, manufacturing technology, and the spatial and temporal aspects of their prehistoric use. We also examine ethnohistorical documentation and palaeoenvironmental investigations to identify known and suspected activities involving flaked stone tools. In particular, subsistence practices, available foods, and handicrafts are considered, along with the possible residue types these may leave. Though all tool types are considered, we focus on flaked stone artifacts as these are both the largest component of the recovered tool assemblages and the ones that underwent residue and use-wear analysis.

Table 1. Provenience and Attributes of the Analyzed Artifacts

Site type; environmental zone	Associated radiocarbon date* (combined date range)	Provenience (cm below surface)	Raw material	Dimensions (mm): length-width-thickness	Weight (g)	Cat. no.
Ridgeline earthwork/village complex; upland	180 B.C.–A.D. 420	NA-4:12, SC	Chert/Limestone	35-37-7	12	883
		NA-4:12, SC^	Chert/Limestone	45-45-13	27	923
Ridgeline village; upland	390 B.C.–A.D. 270	NA-4:15, Fea. 6, Facing, II, (60)	Chert/Limestone	84-41-12	46	678
		NA-4:15, Fea. 7, SC	Chert	34-34-10	12	1194
Ridgeline earthwork/village complex; upland	390 B.C.–A.D. 270	NA-2:17, Fea. 3, SC	Chert/Limestone	37-30-9	11	7.1
		NA-2:17, Fea. 3, SC	Chert/Limestone	47-54-12	23	7.2
Ridgeline village; lowland	230 B.C.–A.D. 350	NI-1:4, Fea. 12, SC	Chert	23-19-5	2	1503
		NI-1:4, Fea. 5, SC 2	Chert	16-15-4	1	173.1
		NI-1:4, Fea. 7, SC	Chert	28-19-6	3	166.1
		NI-1:4, Fea. 7, SC	Chert	22-19-7	3	166.2
		NI-2a, Fea. 3, SC	Chert	39-36-12	12	1471.1
		NI-2a, TR 3, SC	Chert	34-41-4	4	306
Earthwork complex; lowland	—	NM-4:7, Fea. 9, SC^	Chert	51-42-12	35	1507.2
Earthwork complex; lowland	—	NT-3:10, SC* north side, (0–100^)	Basalt	71-45-16	29	1215
Earthwork complex; lowland	1120–400 B.C.	NT-3:10, Profile 4, SPro. 5, II, (5–30^)	Chert	18-27-7	3	1217
Earthwork complex; coastal	A.D. 1–420	NT-2:2, Profile 1, Ve, (150^)	Chert/Limestone	68-45-13	22	1683
Stonework village; lowland	—	NT-2:5, Profile 1, SC^	Chert	113-110-54	680	1218
		NT-2:5, Profile 1, XIV, (220–250^)	Chert/Limestone	61-38-19	40	1307
Stonework village; coastal	A.D. 1250–1640	NT-3:9, Fea. 38, SC^	Chert	41-30-14	13	1571.1
Stonework village; coastal	A.D. 1290–1450	NA-4:4, Fea. 61, TU 2, N extension, IV, (25–35)	Chert/Limestone	27-23-14	7	525.2

* Atmospheric data from Reimer et al. (2004); OxCal v3.10 Bronk Ramsey (2005); cub r:5 sd:2 prob[chron].
^ Graded surface.

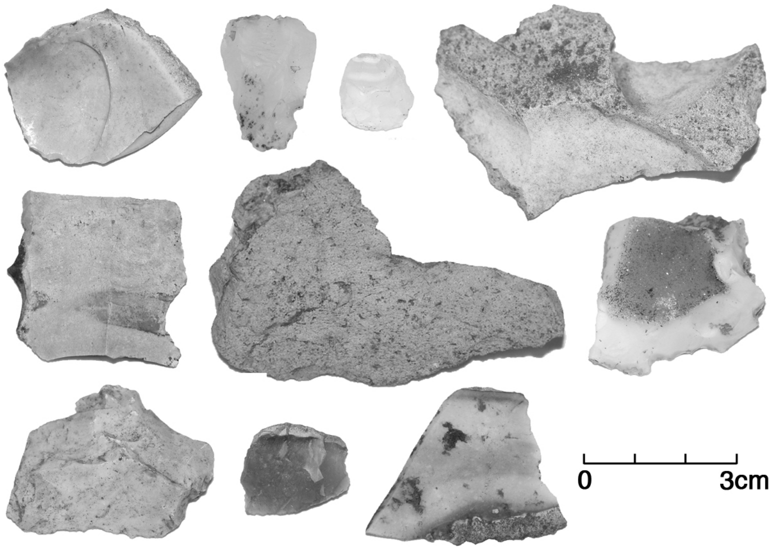

Fig. 2. A selection of the twenty chipped stone artifacts from Babeldaob analyzed in this study. Top row (L to R): #7.1, #166.1, #173, #1683. Middle row (L to R): #883, #1215, #1194. Bottom row (L to R): #1471, #1503, #306.

Archaeological Analysis

Shell is the usual though not exclusive tool source material unearthed in Palau's cultural deposits. The majority of adzes are of *Tridacna* sp., though *Terebra/Mitra* sp. and occasionally *Cassis* sp. were also employed (Beardsley 1996, 1997; Osborne 1979; Takayama et al. 1980). In addition to these species, *Conus*, *Anadara*, *Cypraea*, *Fragum*, *Spondylus*, and sea urchin spines were formed into knives/scrapers, chisels, gorgets, awls, pestles, spoons, and disks that are potential tools. Pearl shell (*Pinctada* sp.) produced fishhooks (Beardsley 1996 : 180), trolling shanks (Masse 1989 : 359), and scraper/graters[1] that are found as grave goods accompanying Rock Island cave and rockshelter burials (Fitzpatrick and Boyle 2002; Rieth and Liston 2001 : 44). The use of bone for spatulas, bait hooks, awls, needles, and potential tattooing picks has also been archaeologically documented (Beardsley 1997 : 192; Hunter-Anderson 2000; Masse 1989 : 359; Rieth and Liston 2001 : 52). Besides their contribution to serrated weapons, shark teeth might have been used as expedient cutting tools (Beardsley 1997 : 192). Perishable wooden implements have not been recovered in cultural deposits.

Stone artifacts are more common to the volcanic islands where, in the first extensive archaeological investigations of Palau, Osborne (1966 : 447, 1979 : 90, 214) encountered several agate flakes and pieces of debitage which he suggested were recently used cutting and scraping tools or parts of steel "strike-a-lights." He notes that "[c]ertainly these examples are few but they unite in pointing out that stone flaking was understood in these islands" (Osborne 1979 : 120). Though documenting some stone adzes, hammerstones, and pestles, Osborne came to the conclusion that

> [s]hell, primarily the heavy section of the *Tridacna gigas* hinge, was used in place of stone for tools. Stone is either not available or occurs in such small quantities of poor quality that it has never competed in the non-volcanic islands with shell as material for adzes, pestles, smaller items of art, and a few very heavy pieces of personal adornment. (1966 : 31)

Gumerman et al. (1981 : 127) observe that, despite the availability of lithic resources on the volcanic islands, they were apparently not taken advantage of. Contrary to previous investigations, Masse and Snyder (1982 : 303–305), demonstrated that lithics, particularly chipped stone, are a component of a significant number of sites. The nature of the first recovered lithic assemblages is unknown as none were analyzed or characterized in any detail, in part due to the small assemblage size restricting possible typological or technological comparisons. When Beardsley, a lithics specialist, directed her attention to prehistoric tools in her 1996 excavations on Peleliu and Babeldaob, she documented eight modified basalt, sandstone, or coral flakes with the remaining 93 pieces in the assemblage identified as stone and coral debitage. In Peleliu's Roischemiangel Midden, Beardsley (1997) recorded 80 formal and informal implements, 16 (20%) of which are modified stone, and 172 cores, flakes, and other debris with 102 (59%) composed of a raw material other than marine shell. Regardless, the generally few pieces of flaked stone recovered in these investigations as well as more recent ones at the raised limestone island of Ulong (Clark 2005; Wright 2005) are generally described as raw material or a by-product of tool manufacture rather than tools.[2]

The recovery of large quantities of formal and informal stone tools and debitage in the previously largely inaccessible interior of Babeldaob during the multiphase Compact Road project ended any speculation on the peripheral nature of lithic artifacts in prehistoric Palau. The Compact Road tool assemblage (from which the artifacts analyzed in the present study are drawn) constitutes 328 formal and informal tools and 6,840 pieces of raw material and manufacturing debris recovered from 50 archaeological sites on Babeldaob (Beardsley 2007; Williams and Markos 1999; Williams and Pope in prep.).[3] Stone comprises 82 percent (n = 269) of the formed tools and 99 percent (n = 6752) of the debitage. The lithic toolkit includes adzes, choppers, axes, awls or punches, hammerstones, grinders or burnishers, pestles, multi-platform percussion cores, simple flake implements, and chisels with the largest component being bipolar cores (n = 130+). Abraders and net sinkers have also been recorded in Palauan lithic assemblages (Masse 1989; Osborne 1966, 1979).

Over 90 percent of the raw material, debitage, and informal tools in the Compact Road assemblage are a translucent or waxy lustered micro-crystalline quartz, often referred to as chert (Leudtke 1992; also noted in previous studies as CCS: crypto-crystalline silicate), which occurs as tabular forms and nodules deposited in cracks and cavities in the igneous bedrock. Chert is easily obtainable as small deposits of varying quality are frequently encountered in exposed igneous rock throughout most of Babeldaob. Due to its ready availability, expedient tool formation, relatively rapid edge attrition, and evidently casual discard probably only the higher quality chert (e.g., harder, finer grained) was regarded as valuable on the volcanic islands. As chert occurs less frequently on the nonvolcanic islands it could have conceivably achieved some status as a trade good. However, as comparatively few chert artifacts are recovered from the non-volcanic islands, it is probable that there more accessible marine shell species were relied on to accomplish the majority of tasks performed with the chipped stone implements on Babeldaob. When unearthed in Rock Island deposits, chipped stone signifies a connection with the volcanic islands through trade, tribute, discard by visitors, or relocation of a clan or village.

Formal tools are commonly shaped from fine-grained basalt though small amounts of limestone/aragonite, quartz, chert, volcanic tuff, coral, and siltstone were also exploited (Beardsley 1997 : 114; Clark 2005 : 366; Osborne 1966 : 445, 1979 : 121, 459). XRF analysis of basalt tools collected on Ulong (Clark 2005 : 364) and Angaur (Clark and Wright 2005 : 78) point to a local origin of the stone though the results are tentative due to a lack of comparative data. Babeldaob's fine-grained basalt quarries have yet to be identified with ethnographic literature reporting sources on the "east coast" (Semper 1982 [1873] : 68). Judging by its relative scarcity in the lithic repertoire and its apparent use earlier in the prehistoric sequence, fine-grained basalt is likely a limited resource that might have served as a prestige item and heirloom.

Technological analysis of the debitage and the large number of recovered bipolar cores demonstrate that as much as 90 percent of the Compact Road assemblage's chert material is a result of the bipolar reduction technique (Williams and Markos 1999; Williams and Pope in prep.). Williams and Pope (in prep.) conclude that this preferred reduction method was the most efficient means of producing usable flakes with sharp cutting edges from the small chert nodules and plates that were available as raw material. The analyses suggest a stable lithic technology based primarily on the bipolar reduction of chert nodules throughout Palau's archaeological record. Formal basalt tools were shaped by pecking and grinding (Beardsley 1997 : 80; Clark and Wright 2005 : 77).

Though little is yet known of the material culture associated with Palau's colonizers and initial settlement, the use of informal or expedient flake tools probably spans Palau's cultural sequence as they are recovered from the entire range of temporally distinct prehistoric site types. Chert flakes, several a result of bipolar reduction (Williams and Markos 2007 : H13) and one identified by use-wear analysis as a scraping or engraving tool, were unearthed in coastal primary and secondary cultural contexts associated with radiocarbon dates of 1000 B.C. (Liston in prep.*a*). By c. 300 B.C., flaked stone is prevalent at ridgeline village sites (Liston in prep.*b*; Tuggle in prep.) and is found in Rock Island cultural deposits (Clark and Wright 2005 : 90; Wright 2005 : 52).

Stone implements, in particular flaked stone and basalt adzes, are more common in the earlier, ridgeline villages and earthwork complexes than in the coastal, stonework villages of the later period (Liston and Tuggle 2006 : 168). Dense surface lithic scatters[4], some with a traditional pottery component, are associated with the inland sites. Often a concentrated scatter, possibly reflecting the reduction of a single cobble in preparation for a specific purpose such as bird or bat processing, is found on ridgelines and hills displaying no other signs of cultural activity. In the stonework villages less significant amounts of flaked stone are prone to be unearthed in buried cultural horizons or secondary deposits resulting from construction events. The higher ratio of lithic to shell implements early in the sequence is also noted in the Ulong excavations by Clark (2005 : 366).

To some extent, the degradation of shell tools in Babeldaob's acidic soils and the continuous use of the interior for specific purposes that utilized flaked stone (potentially hunting) have generated a skewed record of the early prehistoric tool assemblage. The disparity found in Rock Island assemblages may be due to variable exchange patterns. Regardless of the mitigating factors, intersite distribution patterns suggest that there is evidence of a temporal shift to a greater reliance on bone, wood, and shell implements though the use of formal and informal stone implements was never entirely discontinued. This transformation is potentially due to a combination of factors including changes in subsistence practices, tool technology, control of resources, and quarrying limitations, among others. Stone tool use was not revived later in the cultural sequence, despite fine-grained basalt being preferred over the shatterprone *Tridacna* for adze material (Palauan master woodcarver Ling Inago, pers. comm.).

Ethnohistorical Context

Ethnographical and historic documents can provide direct information on the raw material, technology, and use of traditional tools in the late prehistoric era. More often than not, tool use must be implied from the more lengthy descriptions of subsistence practices, day-to-day activities, and handicrafts. Though caution must be exercised when recent cultural practices are applied to the interpretation of activities in the distant past, the historic documentation provides a rough foundation for piecing together the scientific evidence. Subsistence resources available to prehistoric Palauans and requiring tool use for cultivation and preparation can also be elucidated from the material remains found in archaeological and palaeoenvironmental investigations.

Islanders quite naturally relied on the exploitation of the easily accessible rich and diverse littoral and marine resources for dietary protein. A few of the common fish families unearthed in archaeological midden include parrotfish and wrasse (Labridae), snapper (Lutjanidae), emperor (Lethrinidae), bream (Nemipteridae), and sea bass (Serranidae), while some of the most common recovered shellfish species are *Anadara*, *Atactodea*, *Conus*, *Fragum*, *Hippopus*, *Nerita*, *Strombus*, *Tridacna*, and *Turbo* (Beardsley 1997; Carucci 1992; Fitzpatrick 2003*b*; Fitzpatrick and Kataoka 2005; Masse 1989; O'Day 1999; Osborne 1979; Wright 2005). Other marine organisms in the traditional diet include sea worm (*Sipuncula*), sea cucumbers (*Holothurioidea*), sea urchins (*Echinoidea*), starfish (*Asteroidea*), octopus and squid (*Cephalopoda*), crustaceans such as spiny lobsters (*Palinuridae*), shrimp (*Nantantia*), and crabs (*Reptantia*) (Kramer 1926 : 73–75). High-ranking individuals controlled the catching and distribution of shark and dugong (*Dugong dugon*) that were not commonly consumed (Kubary 1892 : 173). Turtle (*Chelonia mydas*, *Eretmochelys imbricate*) is alternatively reported to have been eaten only in the event of illness or as a sacrificial offering (Kubary 1892 : 188), or being a popular meal of the chiefs (Kramer 1926 : 94).

There is no archaeological evidence for domesticated chicken and dog (Pregill and Steadman 2000) perhaps due to recent events (such as World War II activities) destroying the integrity of cave and rockshelter deposits, the limited amount of archaeological investigations conducted in the Rock Islands, and the rapid degradation of midden remains in Babeldaob's acidic soils. Historic sources relate that the wild chicken was sacred and not eaten (Keate 1788; Kubary 1892: 167). Archaeological evidence exists for the consumption of pigs (*Sus scrofa*), although they were apparently extirpated by the first substantial Western contact with the islands in 1783 (Keate 1788; Masse et al. 2006). Keate (1788) and Kubary's (1892) inventory of terrestrial protein sources is limited to crabs (*Burgis latro, Cardisoma rotundus*), bats (*Emballonura semicaudata*, *Pteropus* spp.), and birds such as duck, several species of pigeon (*Ducula*, *Caloenas*), and the eggs, rather than the meat, of the Micronesian megapode (*Megapodius* sp.).

Dietary staples of Palau's colonizers likely included wet and dryland taro, coconut, and banana. Palaeoenvironmental cores (Athens and Ward 2005) and analysis of charcoal recovered in archaeological contexts (Murakami 1999, 2007, in prep.) reveal the presence of edible resources such as coconut, breadfruit, pandanus, gourds, taro, and the Malay apple early in the prehistoric sequence. The limited coastline suitable for wetland crops at colonization (Athens and Ward 2005; Dickinson and Athens 2007) soon led to a subsistence strategy dependent on arboriculture and dryland cultivation in the interior where, by at least the middle of the first millennium B.C., settlements were concentrated (Liston in prep.*a*; Liston and Tuggle 2006).

Long before initial Western contact, the population had relocated to the coastal margin where the subsistence economy relied on pondfield cultivation, house gardens, and gathering of wild fruits and vegetables for necessary starches and vitamins. Important food plants recorded in early historic records include the dietary staples of taro (*Colocasia esculenta*, *Cyrtosperma chamissonis*, and *Alocasia macrorrhiza*) and coconut palm (*Cocos nucifera*), as well as the tropical almond (*Terminalia catappa*), Polynesian chestnut (*Inocarpus edulis*), banana (*Musa* spp.), breadfruit (*Artocarpus altilis*), the Malay apple (*Syzygium malaccense*), sugarcane, soursop, lemons, and oranges (Hunter-Anderson 1991; Keate 1788; Kramer 1926; Kubary 1892). Wild varieties of the greater yam (*Dioscorea*) were present but not cultivated or listed as a food source (Kubary 1892: 162).

Historical sources provide detailed descriptions of the Palauan fishing, hunting, gardening, woodworking, cooking, and weaving methods and implements used in the late eighteenth to nineteenth century (Hockin 1803; Keate 1788; Kramer 1926; Kubary 1873, 1892; Semper 1982 [1873]). Materials used ethnographically include: bamboo and hard wood for arrows, spear shafts, and points; shell and bamboo for scraping, cutting, and grating tasks; turtle shell, wood, marine shell, and the ribs of Pandanus leaves to fashion fishhooks; and tree thorns, turtle shell, bone, and stingray spines to provide sharp points for barbs or needles. The only stone tools listed as playing a role in the activities are the taro pestle (Kubary 1892: 170, 208), stone sinkers (Kramer 1926: 82, 88), and pottery smoothing and polishing stones (Kramer 1926: 134; Kubary 1892: 199). No longer made by the end of the nineteenth century, with some implements' original function no longer known, the rarely found, formally shaped basalt tools had become prized possessions (Kramer 1926: 236; Kubary 1892: 204). The only stone tool included in the Palau Society of Historians' (2001) detailed list of traditional items and properties is the whetstone (*olad*). According to Andrew Shiro (pers. comm.), a woodworker and member of the Society of Historians, pumice was once used for abrading though other stone, specifically chipped pieces, is not now or ever known to be used as tools.

Flaked stone is recorded as the raw material for drill bits used to produce the polished shell disks composing the women's belt (*btek el kai*) that was regarded by Kubary (1892:185) as "among the most splendid articles of adornment in all Oceania." The laborious task of boring holes into the *Hippopus* and *Conus* disks was accomplished with a pump drill whose bit was of shark teeth or "an indigenous kind of chalcedony" (Kubary 1873:24, 1892:186). Kramer (1926:162) describes the perforation of glass beads by means of a pump drill though he lists pointed long snails and sea urchin spines as drill bits. It is possible chert drill bits were used for the perforations in the prized dugong belts worn by older women and household items such as coconut shell ladles, *Tridacna* lids, wooden dishes, and taro pestles (Kramer 1926:2; Kubary 1892:206). The only other mention of flaked stone in the ethnohistorical sources is in Kramer's (1926:163) description of the sawing and cutting of some money beads with shell or "the hard red and white *basag* stones that resemble our flint."

Potential Residues on Stone Tools

Having reviewed the contact period subsistence economy, resources, tools, and activities detailed in the ethnographic record, and the toolkits recorded in the archaeological literature, some consideration of possible residue types can be undertaken. In terms of subsistence, the obvious candidates for processing are the various types of taro and the tree-crop species with a probable less likely use in processing faunal remains. Taro processing may involve slicing/cutting the corms, or scraping either raw or charred corms to remove offensive raphide concentrations (Fullagar et al. 1998). Processing other foods would most likely involve similar actions, whether through husking coconuts and removing the meat or scraping and cutting animal flesh and bones.

The distinctive residues left by each of these sources would therefore be important in determining what, if any, tasks were carried out with an artifact. Animal processing would leave blood, collagen (if contact was made with bone), and keratin deposits if the skin was scraped or otherwise modified. Typical plant residues would include taro starch and raphides (which would be expected to occur simultaneously on an artifact), banana starch, coconut starch and fibers, and structural tissues.

Although not designated as a woodworking tool in the early historic documents, flaked stone could be a valuable woodworking implement. Palau has a strong tradition of woodworking with master builders and carvers held in high veneration (Kramer 1926:169–172; Palau Society of Historians 1990:68–72). Common wood objects include containers and implements, statues, sailing vessels, structures, fishhooks, and combs. Wooden dishes were the most important part of Palau's domestic equipment, with specific styles sanctioned for preparing and serving liquids, fish, taro, and other foodstuffs and certain vessels dedicated to festivals or offering vessels (Kubary 1892:201–205). Fashioning and embellishing dishware was a special branch of the woodworking industry as was construction of the *bai* (meeting houses).

Inlay, primarily of mother-of-pearl (*Pinctada* sp.), although *Conus*, *Tridacna*, and *Turbo* were also used, adorned war canoes, wood earrings, figural sculpture, combs, lime containers, sword handles, the array of containers, and occasionally the *bai* (Keate 1788; Kramer 1926:33; Kubary 1892:206). More often, the wooden *bai* beams were elaborately painted and incised with symbolic designs and illustrations of Palauan myths and legends called *lochukle* (Jernigan 1973). Different sizes and types of adzes are suitable for shaping the variety of utilitarian pieces, structural components, and other wooden objects but are inappropriate for fine woodwork or excising wood for shell inlay or *bai* designs. Chisels or like tools, perhaps of shell or chert flakes, are needed for the intricate carving (Ling Inabo, pers. comm.).

Similarly, while stone was not necessarily employed in the manufacture of shell and bone tools (for example Osborne [1966:31–32] notes the ease with which shell could be worked solely through the application of heat), the use of flaked stone for this purpose remains a possibility. The residue types left by woodworking or creating shell or bone artifacts depend on the condition of the material worked, such as whether the wood or bone was fresh or dried; the residue could be expected to be much more extensive than that left by incidental contact with these materials during food preparation or proximal deposition.

Residue and Use-Wear Analysis

Systematic observation of in situ microscopic residues adhering to the surface of stone artifacts, and the interpretation of these residues for making inferences about past activities, is an established archaeological practice (Fullagar et al. 1996; Odell 2001). The technique has been used worldwide, and particularly by Australian and South African researchers, to investigate issues such as the early processing of plant foods (Denham et al. 2003; Fullagar 1993; Fullagar and Field 1997; Loy et al. 1992) and the use of typological classes of stone implements (Akerman et al. 2002; Attenbrow et al. 1998; Lombard 2007; Wallis and O'Connor 1998; Weisler and Haslam 2005). In the Pacific, investigations have been limited largely to the areas surrounding New Britain, New Ireland, and the Solomon Islands, with stone tool residue studies supplemented by a handful of microscopic analyses conducted on other material types (e.g., Crowther [2005] on Lapita pottery; Barton and White [1993] on shell artifacts).

Concurrent analysis of use-wear patterning, including edge damage, polish formation, and linear gouges (striations) on tool faces, is recognised as an essential component of any microscopic residue study. The two approaches are complementary as use-wear provides a means of identifying working edges, indicates the action (such as scraping or sawing) and direction with which the tool was used, and through the extent and nature of damage may guide initial assessment of the hardness of the worked material. Information on specific residues is then correlated and cross-checked with expectations set by the wear patterns to provide a robust interpretation of artifact use.

Twenty flake tools from the Compact Road lithic assemblage underwent residue and use-wear analysis (Haslam in prep.). The tools, including one basalt and the remainder chert, were selected based on size, the presence of flake scars that might indicate retouch or use-wear, and the appearance of edges or areas potentially used as a tool (Williams and Pope in prep.). Eleven archaeological sites spanning a date range of over 2000 years are represented in the assemblage with the majority of the lithics (n = 16) recovered in inland villages and earthwork complexes radiocarbon dated to 1120 B.C.–A.D. 420.

High magnification microscopy (50×–1000× diameter) formed the core of the combined residue and use-wear study, although initial macroscopic and low magnification (6×–30× diameter with a Wild stereobinocular microscope) inspection was undertaken to discern gross use-wear and residue deposits. All facets of each artifact were examined in incident (from above) white light using an Olympus BX60 microscope fitted with 10× magnification eyepieces, with 5×, 10×, and 20× objective lenses, and with 50× and 100× long working distance (LWD) objective lenses. This allowed a maximum resolution on the artifact's surface of 1 μm, or one thousandth of a millimeter. The microscope is also fitted with bright and dark field illumination, rotatable polarizing filters, and a moveable (X–Y) stage. The majority of scanning was conducted using the 50× and 100× magnifications, with higher magnifications used whenever necessary to allow closer inspection of possible archaeological features. Transects were used to completely cover the artifact surface, not just suspected working edges, as residues may accumulate away from those areas of an artifact directly in contact with a worked material. Any features of interest were recorded both in writing and as color digital images with an Olympus DP10 camera set at the highest resolution (in excess of 1.4 million pixels).

Two forms of illumination were employed using incident light: dark-field and bright-field. Bright-field illumination reflects light directly from the surface of the tool or residue. Dark-field illumination blocks the central path of light allowing the analyst to see into a reflective but transparent residue. Polarizing filters were also used to characterize and identify residues according to their reaction to different polarized lighting conditions. These filters can only be used in incident bright-field illumination. The size of some artifacts precluded the use of the 200× objective lens due to its short working distance.

Where necessary, residues were removed from the artifact for examination using transmitted light. This form of microscopy differs from incident microscopy in lighting the observed specimen from below, and is therefore most useful when observing objects transferred to glass slides. Residues were transferred by gently detaching them from the tool surface with a sterile scalpel, using the Wild low-magnification microscope to give fine control. Removal of material is useful in two cases: when a residue is sited at a position on the artifact that cannot be adequately examined in incident light, and when further identification (for example of fibres) requires light to pass through the object to reveal characteristic properties.

Results of Analyses

Nine of the artifacts analysed possessed a combination of use-wear (e.g., Fig. 3) and residue traces. A further two artifacts possessed wear patterns that showed the use-action and hardness of the worked material, but did not exhibit residues that would allow for more precise identification. The remaining nine artifacts did not

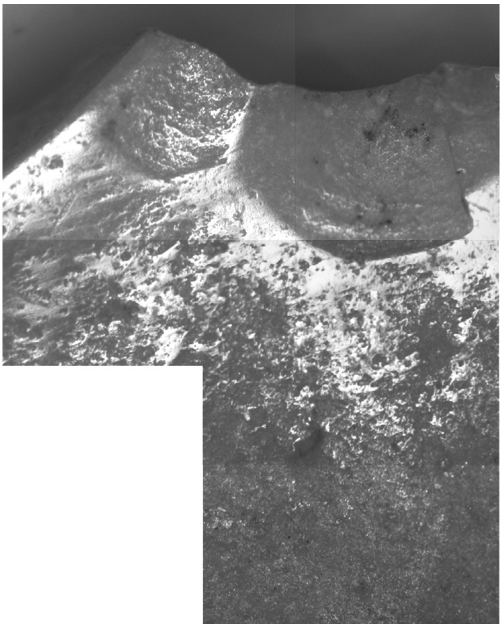

Fig. 3. Composite photograph showing fracturing and edge polish deposited both prior and subsequent to fracture (50× magnification, artifact #7.1).

have observable wear or residue traces, although this does not necessarily mean they were never used.

The most common function observed among the twenty artifacts was some form of plant processing (e.g., Fig. 4). This category can be further subdivided into starchy plant processing, wood carving/shaping, and scraping charred plant tissue. In all, seven artifacts were used to work plants, including one that involved processing a charred plant with small starch grains (#1471; Fig. 5). One possibility is that the starchy plant was taro (*Colocasia esculenta*), processed by scraping the charred exterior of the tuber as described by Fullagar et al. (1998) for Papua New Guinea, although the absence of raphides does not support such a conclusion.

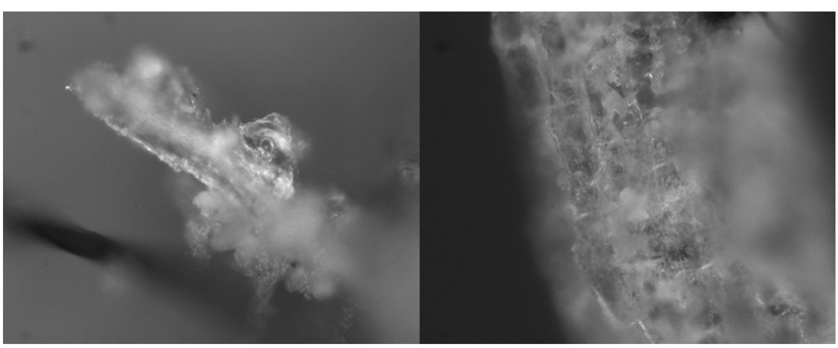

Fig. 4. Examples of woody tissue, from artifacts #173 (left, 500× magnification) and #1215 (right, 500× magnification).

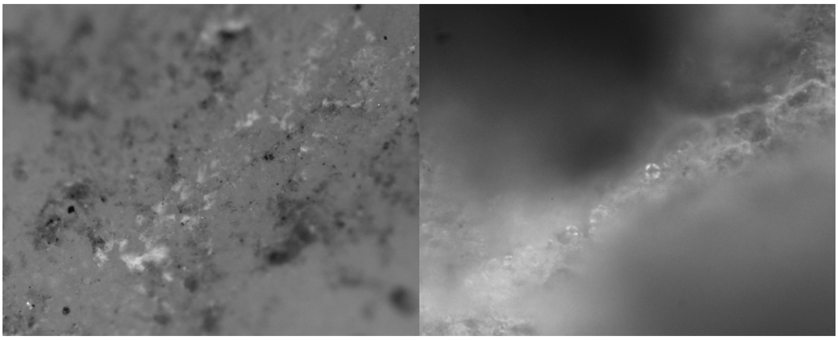

Fig. 5. Starch residue on artifact #1471 (left, 50× magnification; right, 1000× magnification).

Clear residue and use-wear evidence for woodworking on two of the smaller flakes (#173 and #1571), each measuring less than 4 cm in maximum dimension, raises interesting interpretative questions. These artifacts are not large enough (and do not possess the requisite use-wear patterns) to have been used for chopping or large-scale curation (planing, adzing) of wooden objects. Instead, they appear to have been used to carve or drill small portions of wooden pieces, suggesting they were used for incising decorations or other fine work. Ethnographic sources describe pump drills with chert flakes as drill bits to bore through marine shell and potentially glass. Also described is the hanging of the multitude of wooden containers on the wall via a cord strung through a hole in the vessel. Though not explicitly stated, it is conceivable that a chert drill bit perforated these wooden containers. Also documented is a strong tradition of craft activity in decorative wood carving which included the relaying of legends and myths through painting and carving. It is therefore possible to posit a connection between these tools and past artisans.

Resinous deposits were observed on many of the artifacts (including some of those for which use could not be determined) (Fig. 6). The presence of this residue would be better explained by an examination of the cultural use of resin-

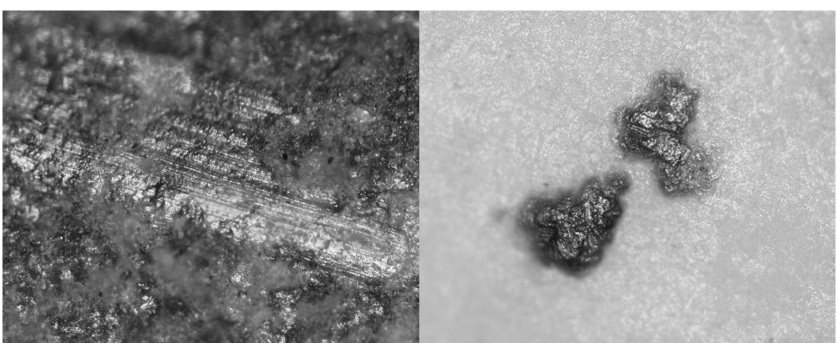

Fig. 6. Resinous deposits on artifact #883 (left, 100× magnification; note smearing of resin) and #1194 (right, 100× magnification).

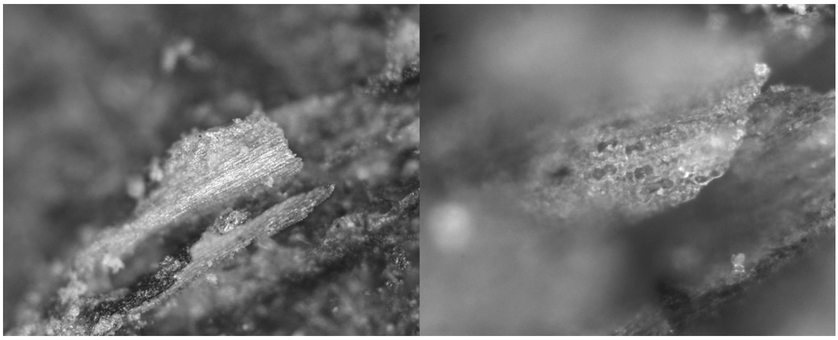

Fig. 7. Plant tissue with dumbbell-shaped phytoliths on artifact #306 (left, 100× magnification, note cut tissue; right, 500× magnification, showing phytoliths).

producing species in Palau. Without a resin reference collection for comparative purposes the identification of resin-producing genera or species represented is not possible. The possibility of hafting is not supported by the random distribution of the resinous spots across many of the artifact surfaces (in fact no clear wear or residue hafting evidence was observed for any of the artifacts studied). It is possible that the residue relates to prehension of the artifacts by people with resinous material on their hands. One potential candidate is betel nut (*Areca catechu*), well known for the stains it leaves when chewed, which palaeoenvironmental evidence shows was present in Palau at c. 2000 B.C. (Athens and Ward 2005) and archaeological data indicates was being chewed by c. 1000 B.C. (Fitzpatrick et al. 2003). It is conceivable that storage in a freshly made wooden container could also leave some resin traces, but further ethnographic and archaeological comparisons are required before this possibility can be considered.

Dumbbell-shaped (bilobate) phytoliths and elongate cells observed on one artifact (#306; Fig. 7) indicate processing of some form of grass (Lu and Liu 2003). As the University of Queensland's phytolith reference collection does not include many of Palau's plant genera, no species identification has been attempted. Grass can be collected for a multitude of reasons such as processing plant foods, cutting grasses or splitting fibers for use in weaving baskets and mats, or making roofing material, cordage, and skirts, and a specific cultural activity can not be assigned. The artifact, recovered in a ridgeline village bordering agricultural step-terraces, also displays charred plant material adhering to its surface and an associated flake tool revealed processing of a charred plant with small starch grains. Therefore, a domestic activity is implied, possibly related to nearby slash-and-burn agriculture.

Apart from plants, the other major finding was bone/skin working on two artifacts (#166.1 and #1503; Fig. 8). It is not immediately apparent which activities, involving which animals, would result in a need to work or shape fresh bone or skin. There is no archaeological evidence for large terrestrial animals on Palau other than the pig which was extirpated by Western contact (Masse et al. 2006). These tools were recovered in a ridgeline village dating to between 230 B.C. and A.D. 350, a time and location when pig could have been present. Ethnographic literature records dugong skin belts, its vertebrae used as chiefly bracelets, and, at the time of documentation, its rare consumption (Kramer 1926:2; Kubary

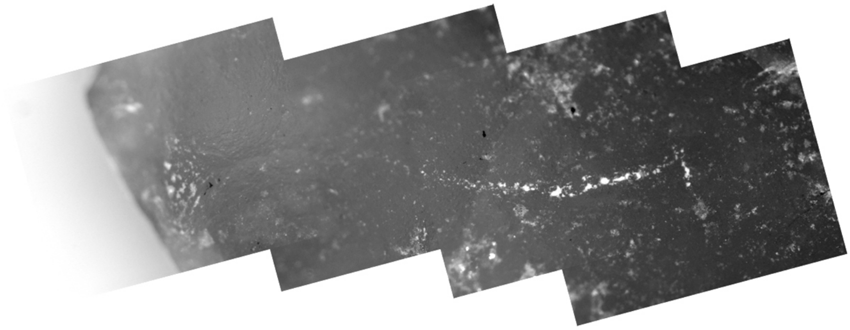

Fig. 8. Composite photograph showing collagen both on, and lineated in from, edge of artifact #1503 (50× magnification).

1892:174). The keratin deposits could be a result of contact with human skin as drinking cups of human crania and cannibalism are documented and headhunting was an important component of warfare in the later period, though in the latter the shark tooth knife is reported to be the weapon of choice (Kramer 1926:63, 128). It is possible that the exceedingly sharp stone flakes were used in medical procedures necessitating cutting the skin or bone. Keratin deposits on chipped stone tools could have likely only resulted from contact with human, pig, or dugong skin.

These three are also potential candidates for the identified boneworking tools. Contact with bat and bird bone is unlikely as they were boiled whole without any field dressing, a practice that is apt to extend far into the past. Interestingly, along with evidence of resinous woodworking one of the artifacts (#883) possessed a grouping of feather fragments (identified as such via node morphology and the typical dull blue shine of keratin under cross-polarized light), but these could not be taxonomically assigned and the associated activity is not known. Shell residues were not observed, however ornamental *Tridacna* shell carving is known (though rare in the historic era; Osborne 1966:222, 241), and analogous bone carving may have occurred during prehistory. Except for a few small items such as fishhooks and trolling shanks, shell tools did not call for meticulous shaping. Whittling down and carving bone into fishhooks, awls, and needles, however, could have required the stone artifacts examined.

Other than those related to artifact use, the most obvious residue found on the artifacts as a group is fungal remains (Fig. 9). These remains bear only an indirect relationship to use-related residues, through the colonization of nutrient-rich locations, while providing some indication of the post-discard stability of the artifacts. For example, it is unlikely that these artifacts have undergone any form of reuse or reincorporation from the archaeological to the systemic contexts (to use Schiffer's [1972] terms), as this would have resulted in a complex layering of residue and fungal deposits. Such complexity was not observed on the sample analyzed. The possibility that fungal concentration on an artifact surface is an indicator of the past location of now-degraded residues should also be borne in mind. The influence of depositional environment is demonstrated by the very low fungal occurrence on one of the artifacts from a more recent coastal site (#525) when

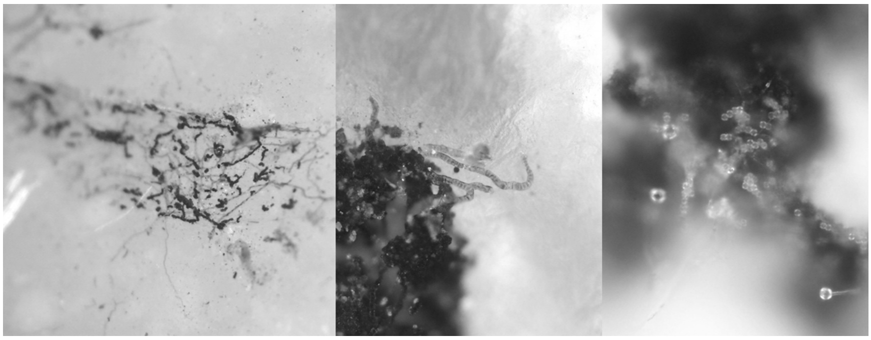

Fig. 9. Examples of fungal residues on the artifacts. Left: fungal hyphae and spores forming a pattern suggestive of a former residue deposit (artifact #306, 100× magnification). Center: banded hyphae and spores (artifact #166.1, 500× magnification). Right: hyphae and conidia (2–3 μm and 6–7 μm), note the conidia extinction cross which should not be confused with starch (artifact #1683, 500× magnification).

compared to the majority of the other analyzed pieces, and further investigation of the role of site matrices in encouraging or inhibiting fungal growth (and secondarily therefore potential residue survival) is warranted.

Of the various fungal components found, the most useful for identification purposes (for a non-mycologist archaeologist) were the conidia. The chain forms, the size, and the shape of these are very similar to those seen in two common fungi, *Aspergillus* sp. and *Penecillium* sp. Both are commonly found in soils, although *Aspergillus* is not presently known in Palau, whereas *Penecillium* is (McKenzie and Jackson 1990). Unfortunately, the more diagnostic conidiophores that produce the conidia were not observed in the residues, and therefore no taxonomic identification was undertaken. It should also be noted that the conidia display many of the characteristics of starch grains, including size, shape, and a rotating cross under cross-polarized light (Haslam 2006*a*), so care needs to be taken in interpreting these residues in terms of starchy plant processing.

DISCUSSION

Archaeological studies indicate that a lithic technology based on bipolar reduction had emerged in Palau by at least the beginning of the first millennium B.C. The majority of chert flakes, the most frequently occurring component of the Palauan lithic toolkit, are found in earthwork and ridgeline village sites which suggest they were a common component of the domestic toolkit, possibly related to cultivation of the adjacent fields, food processing, everyday construction activities, or handicraft production. The elevated setting of some sites defined solely by lithic scatters implies their use in hunting (e.g., to process the carcasses of larger birds) or perhaps defense (e.g., making bone or wood weapons).

The number of chert flakes unearthed in the later period stonework villages diminishes so that by Western contact they are relatively rare items in the toolkit. The decline in lithics thus seems to coincide with the shift in the subsistence economy from dryland to wetland cultivation and the accompanying change in settlement pattern from the interior to the coastal margin though the incentive behind this technological transformation is unknown. It is unlikely stone was supplanted by shell due to convenience as marine resources were always exploited by the interior settlements. However, political reorganization or tightening of control on the interior's resources might have resulted in lithic raw material sources becoming inaccessible or socially limited. Or perhaps chert flakes served a specialized function in the earthwork era that was either no longer needed or able to be performed (e.g., the extirpation of pigs), though the use-wear and residue traces on the flakes show the variety of activities performed rather than any particular tasks. Conceivably the more durable edge found on chert flakes was now dispensable.

Ethnohistorical accounts imply that stone implements, though a very minor component of the native toolkit by the nineteenth century, were once of some importance as the few remaining formally shaped basalt tools were held in high regard. It is likely they were used in the far distant past as by Western contact, the function of some of the shaped lithic implements had been forgotten. The richly detailed ethnographic documentation only mentions flaked stone in passing as one of several materials forming drill bits and possibly a cutting tool. This, along with today's master woodworkers lacking any knowledge or memory of stone tools, intimates they were rarely used in the late prehistoric era. However, the widespread occurrence of large numbers of flaked stone artifacts on Babeldaob, particularly in the interior, reveals that lithic resources were a long-term and important component of Palau's material culture and contradicts the historical documentation of an almost sole reliance on wood, bone, and shell tools.

The majority of the Compact Road lithic assemblage is classified as debitage, however, as Williams and Pope (in prep.) point out:

> The general lack of obvious use-wear or retouch on the chert flakes does not necessarily mean the flakes were not utilized. As with many reduction technologies, the majority of the flakes may not have been used as tools, and simply are waste materials that resulted from the preparation of cores or the manufacture of other tools. Also, some flakes may have been used as tools without showing any obvious retouch or use-wear: six unmodified flakes were submitted for residue analysis, and three of these exhibited definite residues indicating use.

Additionally, in Palau's tropical climate, identifying characteristics (e.g., flake morphology) on the non-polished forms of igneous rock and limestone tools are often weathered away. Even polished versions of tools, such as adzes, often exhibit high degrees of weathering. Thus, the Palauan lithic assemblages, heavily weighted to simple chert flakes and often found in surface scatters where weathering is extreme, rely on residue and use-wear analysis not only to identify what the implement was used on but to discern debitage from tools.

Residue analysis also plays an important role in the reconstruction of Palau's prehistoric subsistence strategy. An accurate reconstruction based on faunal analysis is difficult due to the scarcity of Babeldaob middens that quickly disintegrate in the acidic soils. Residue analysis of flaked stone tools can complement faunal analysis to establish the presence and timing of extirpation of Palau's terrestrial fauna, particularly pig.

The role of fungi in modifying the residue suite of an artifact is one that deserves brief consideration. There is no doubt about either the abundance of fungi in soils, or the important role fungi play in the decomposition of organic materials and the recycling of carbon and other minerals (e.g., Haslam 2004). That these organisms may affect the types and number of residue traces left on archaeological artifacts is not a matter that has been adequately addressed by residue analysts, however. One issue to be examined before any definite conclusions can be drawn is the mechanism of residue preservation on archaeological artifacts in the first place. In itself this issue has been a contentious one for some time in residue studies, although discussions have usually centered on blood residue survival (e.g., Eisele et al. 1995; Smith and Wilson 1992). If artifacts provide a long-term protective mechanism for organic components, as seems possible, then certain fungi may have restricted access or ability to consume tool residues. More information would therefore be required both on burial conditions and the habits of specific soil-borne fungi before an assessment of the likelihood of fungal digestion could be made. The extensive fungal deposits on these artifacts emphasize the need for residue analysis to consider the role of these decomposers in destroying residues, acting as taphonomic indicators, and potentially confusing identifications of genuine use-residues.

CONCLUSION

Microscopic residue and use-wear analyses have added significantly to interpretations of stone tool function in regions such as Australia and Papua New Guinea, where flaked stone artifacts have been extensively debated for decades. In Palau, where flaked stone has until recently received only passing attention, the interpretation of residues offers a particularly significant benefit by suggesting artifact functions in the absence of ethnohistorical evidence of stone tool use. In particular, the identification of woodworking activities using small lithic artifacts is suggestive of fine carving rather than gross processing of wood, which may link these tools to past artisans and potentially specialized tasks. Connections between specific artifacts and past social roles are often difficult to document with empirical evidence, and residue studies offer interpretations that may then be combined with ethnographic, linguistic and other lines of evidence to help complete our picture of past activities.

What are essentially nondescript, nonformal artifacts (typically disregarded beyond basic cataloging), can therefore be viewed as links to past lives, important not because they reveal unsuspected facets of Palauan prehistory, but because they act as tangible evidence regarding socially important actions (Haslam 2006*b*). It is not possible, or desirable, to use these results to suggest any degree of commonality of woodworking or related practices for the flaked stone assemblage of Babeldaob as a whole. These small artifacts do, however, provide an entry point for broader narrative discussions of social practices on the island. In this case, the narrative reaffirms oral traditions regarding archaeologically invisible activities, and provides a connection with the past desired by many present-day Palauans (Smith 1997). In a broader context, the current study also demonstrates the value of the information microscopic residue analysis may obtain from even a small sample size.

The suggested change in the temporal and spatial distribution of simple flake tools is an intriguing conundrum that deserves focused exploration. Additional residue analysis of chert flake tools collected from securely dated contexts is needed to build an adequate sample size for spatial and temporal comparisons of tool use.

Stone implements, particularly informal flaked tools, are demonstrated to be an extensive and important component of Palau's prehistoric material culture. The data collected from the archaeological and residue and use-wear analyses indicate reliance on a bipolar reduction technology for the expedient reduction of a readily available raw material to accomplish not only generalized tasks but that may have extended to use by a specialized class of artisans. The implements were applied to a wide variety of materials representing tasks potentially associated with the gamut of domestic, defensive, hunting, and artistic activities. Despite their importance during several millennia of Palauan prehistory, the archaeological and ethnohistorical records concur on the relative obscurity of stone tool use in the final stages of prehistory that might coincide with shifts in the settlement pattern and subsistence economy. Additional data is needed to sort out the reasons behind this transformation to a drastically reduced exploitation of stone as a tool source.

ACKNOWLEDGMENTS

Residue and use-wear analysis was performed for Phase III (monitoring and emergency data recovery) of the Palau Compact Road project conducted by International Archaeological Research Institute, Inc. (IARII) for the U.S. Army Corps of Engineers. We thank J. Stephen Athens of IARII for his support, as well as Scott Williams of Pacific Archaeological Services, Olympia, WA. The U.S. Army Corps of Engineers and the U.S. State Department kindly gave permission to publish the results. Ian Lilley, Marshall Weisler, Alison Crowther, and Scott Williams commented on a draft of the article. The pioneering studies of the late Thomas H. Loy made much of the residue work presented here possible.

NOTES

1. Mother-of-pearl shell taro graters (*chesiuch*) are a form of woman's money used in exchange and as gifts in funeral ceremonies (U. Basilius, pers. comm.).
2. The large quantity of flowstone debitage in Palau's Yapese quarries is identified as resulting from quarrying disks of Yapese stone money (Fitzpatrick 2003*c*) not of Palauan tool manufacture and are thus not included in this study.
3. Flakes modified for use as tools or those that exhibit edge damage that could be inferred from macroscopic inspection to have resulted from use were categorized as tools as were cores (Williams and Markos 1999:96; Williams and Pope in prep.).
4. Surface artifact scatters in Babeldaob's interior do not necessarily represent recent events as erosion of the silty clay soils in the heavily modified landscape is common.

REFERENCES CITED

Akerman, Kim, Richard Fullagar, and Annelou van Gijn
2002 Weapons and *wunan*: Production, function and exchange of Kimberley points. *Australian Aboriginal Studies* 2002/1:13–42.

Athens, J. Stephen, and Jerome V. Ward
2001 Paleoenvironmental evidence for early human settlement in Palau: The Ngerchau core, in *Pacific 2000: Proceedings of the Fifth International Conference on Easter Island and the Pacific*: 164–177, ed. C. Stevenson, G. Lee, and F. J. Morin. Los Osos, CA: Bearsville Press.
2005 *Compact Road Archaeological Investigations, Babeldaob Island, Palau*. Vol. IV: *The Holocene Paleoenvironment of Palau*. Prepared for U.S. Army Corps of Engineers, Pacific Ocean Division, Fort Shafter, Hawai'i. International Archaeological Research Institute, Inc., Honolulu.

Attenbrow, Val, Richard Fullagar, and Cheryl Szpak
1998 Stone files and shell fish-hooks in southeastern Australia, in *A Closer Look: Recent Australian Studies of Stone Tools*: 127–148, ed. R. Fullagar. Sydney: Archaeological Computing Laboratory, University of Sydney.

Barton, Huw, and J. Peter White
1993 Use of stone and shell artifacts at Balof 2, New Ireland, Papua New Guinea. *Asian Perspectives* 32:169–181.

Beardsley, Felicia R.
1996 *Fragments of Paradise: Archaeological Investigations in the Republic of Palau, Palau Rural Water System Survey and Testing*. Prepared for Winzler and Kelly, Consulting Engineers. International Archaeological Research Institute, Inc., Honolulu.
1997 *Fishponds, Taro Patches and Shell Middens: Archaeological Investigations on Peleliu, Republic of Palau, Data Recovery and Monitoring for the Palau Rural Water System Program*. Prepared for Winzler and Kelly, Consulting Engineers. International Archaeological Research Institute, Inc., Honolulu.
2007 Lithic analysis, in *Intensive Archaeological Survey for the Palau Compact Road, Babeldaob Island, Palau. Historic Preservation Investigations Phase I.* Vol. I: *Scope, Background, Results, Evaluation, and Recommendations*: 319–345, ed. M. J. Tomonari-Tuggle, H. David Tuggle, and D. J. Welch. Prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu. (Draft 1998)

Carucci, James
1992 Cultural and natural patterning in prehistoric marine foodshell from Palau, Micronesia. Ph.D. diss. Southern Illinois University, Carbondale.

Clark, Geoff
2004 Radiocarbon dates from the Ulong site in Palau and implications for western Micronesian prehistory. *Archaeology in Oceania* 39:26–33.
2005 A 3000-year culture sequence from Palau, western Micronesia. *Asian Perspectives* 44:349–380.

Clark, Geoff, and Duncan Wright
2005 On the periphery? Archaeological investigations at Ngelong, Angaur Island, Palau. *Micronesica* 38(1):67–91.

Clark, Geoff, Atholl Anderson, and Duncan Wright
2006 Human colonization of the Palau Islands, Western Micronesia. *Journal of Island and Coastal Archaeology* 1:215–232.

Crowther, Alison
2005 Starch residues on undecorated Lapita pottery from Anir, New Ireland. *Archaeology in Oceania* 40:62–66.

Denham, Tim, Simon Haberle, Carol Lentfer, Richard Fullagar, Judith Field, Michael Therin, Nick Porch, and Barbara Winsborough
2003 Origins of agriculture at Kuk Swamp in the Highlands of New Guinea. *Science* 301:189–193.

Dickenson, William R., and J. Stephen Athens
2007 Holocene palaeoshorelines and palaeoenvironmental history of Palau: Implications for human settlement. *Journal of Island and Coastal Archaeology* 2(2):175–196.

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.

Fitzpatrick, Scott M.
2003*a* Early human burials in the western Pacific: Evidence for a ca. 3000 year old occupation on Palau. *Antiquity* 77:719–731.
2003*b* Shellfish assemblages from two limestone quarries in the Palau Islands. *Journal of Ethnobiology* 23(1):101–123.
2003*c* An archaeological study on the extraction of flowstone from caves and rockshelters for producing stone money in Western Micronesia. *Cave and Karst Science* 30(2):75–82.

Fitzpatrick, Scott M., and Jenna E. Boyle
2002 The antiquity of pearl shell (*Pinctada* sp.) burial artifacts in Palau, Western Micronesia. *Radiocarbon* 44:691–699.

Fitzpatrick, Scott M., Greg C. Nelson, and Ryan Reeves
2003 The prehistoric chewing of betel nut (*Areca catechu*) in western Micronesia. *People and Culture in Oceania* 19:55–65.

Fitzpatrick, Scott M., and Osamu Kataoka
2005 Prehistoric fishing in Palau, Micronesia: Evidence from the northern Rock Islands. *Archaeology in Oceania* 40:1–13.

Fullagar, Richard
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*: 331–337, ed. P. C. Anderson, S. Beyries, M. Otte, and H. Plisson. Liège: ERAUL.

Fullagar, Richard, and Judith Field
1997 Pleistocene seed-grinding implements from the Australian arid zone. *Antiquity* 71:300–307.

Fullagar, Richard, Judith Furby, and Bruce Hardy
1996 Residues on stone artifacts: state of a scientific art. *Antiquity* 70:740–745.

Fullagar, Richard, Thomas H. Loy, and Stephen 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*: 49–60, ed. R. Fullagar. Sydney: Archaeological Computing Laboratory, University of Sydney.

Gumerman, George J., David Snyder, and W. Bruce Masse
1981 *An Archaeological Reconnaissance in the Palau Archipelago, Western Caroline Islands, Micronesia*. Carbondale: Center for Archaeological Investigations, Southern Illinois University.

Haslam, Michael
2004 The decomposition of starch grains in soils: Implications for archaeological residue analyses. *Journal of Archaeological Science* 31:1715–1734.
2006*a* Potential misidentification of in situ archaeological tool-residues: Starch and conidia. *Journal of Archaeological Science* 33:114–121.
2006*b* An archaeology of the instant? Action and narrative in archaeological residue analyses. *Journal of Social Archaeology* 6:402–424.
in prep. Residue and use-wear analysis, in *Archaeological Monitoring and Emergency Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations, Phase III*. Vol. XII: *Lab Analyses, Discussion, Syntheses*, ed. J. Liston. Draft prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.

Hockin, Reverend John Pierce
1803 *A Supplement to the Account of the Pelew Islands*. Privately printed by W. Bulmer and Co., London.

Hunter-Anderson, Rosalind L.
1991 A review of traditional Micronesian high island horticulture in Belau, Yap, Chuuk, Pohnpei, and Kosrae. *Micronesica* 24(1):1–56.
2000 Ethnographic and archaeological investigations in the southwest islands of Palau. *Micronesica* 33:11–44.

Jernigan, Earle Wesley
1973 Lochukle: A Palauan art tradition. Ph.D. diss. University of Arizona, Tuscon.

Keate, George
1788 *An Account of the Pelew Islands, situated in the Western Part of the Pacific Ocean, Composed from the Journals and Communications of Captain Henry Wilson, and Some of his Officers, who, in August 1783, were there Shipwrecked, in the Antelope, a Packet Belonging to the Honourable East India Company*. London: G. Nicol.

Krämer, Augustin
1926 II. Ethnographie; B. Mikronesien, in *Ergebnisse der Südsee-Expedition 1908–1910*:1–362, ed. G. Thilenius. Friederichsen, Hamburg. (Human Relations Area File typescript, translated by Anonymous)

Kubary, Johann Stanislaus
1873 Die Palau-Inseln in der Sudsee. *Journal des Museum Godeffroy* 1:181–238. (Human Relations Area File typescript, translated by Anonymous and R. W. Force)

1892 Die industrie der Pelau-Isulaner, in *Ethnographische Beitrage zur Kenntnis desKarolinen Archipels*: 118–299. Leiden: P.W.M. Trap. (Human Relations Area File typescript, translated by Anonymous)

Leudtke, Barbara E.
1992 *An Archaeologists Guide to Chert and Flint.* Institute of Archaeology, University of California at Los Angeles.

Liston, Jolie
1999 *Archaeological Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations, Phase II.* Vol. V: *Lab Analyses, Syntheses, Recommendations.* Draft prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.
in prep.*a* *Archaeological Monitoring and Emergency Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations, Phase III.* Vol. XII: *Lab Analyses, Discussion, Syntheses.* Draft prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.
in prep.*b* *Archaeological Monitoring and Emergency Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations, Phase III.* Vol. X: *Monitoring Field Reports.* Draft prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.

Liston, Jolie, and H. David Tuggle
2006 Prehistoric Warfare in Palau, in *Archaeology of Warfare: Prehistories of Raiding and Conquest*: 148–183, ed. E. Arkush and M. W. Allen. Gainesville: University Press of Florida.

Lombard, M.
2007 Finding resolution for the Howiesons Poort through the microscope: Micro-residue analysis of segments from Sibudu Cave, South Africa. *Journal of Archaeological Science* [doi:10.1016/j.jas.2007.02.021]

Loy, Thomas H., Matthew Spriggs, and Stephen Wickler
1992 Direct evidence for human use of plants 28,000 years ago: Starch residues on stone artifacts from the northern Solomon Islands. *Antiquity* 66 : 898–912.

Lu, Houyuan, and Kam-Biu Liu
2003 Morphological variations of lobate phytoliths from grasses in China and the south-eastern United States. *Diversity and Distribution* 9 : 73–87.

Masse, W. Bruce
1989 The Archaeology and Ecology of Fishing in the Beleu Islands, Micronesia. Ph.D. diss. Southern Illinois University, Carbondale.

Masse, W. Bruce, Jolie Liston, James Carucci, and J. Stephen Athens
2006 Evaluating the effects of climate change on environment, resource depletion, and culture in the Palau Islands between AD 1200 and 1600. *Quaternary International* 151 : 106–132.

Masse, W. Bruce, and David Snyder
1982 *The Final Report of the 1981 Field Season of the Southern Illinois University Palau Archaeological Project.* Prepared for Historic Preservation Office, U.S. Trust Territory of the Pacific Islands, Saipan. Center for Archaeological Investigations, Southern Illinois University, Carbondale.

McKenzie, Eric, and Grahame Jackson
1990 *The Fungi, Bacteria and Pathogenic Algae of the Republic of Palau.* Technical Paper No. 198. Noumea: South Pacific Commission.

Murakami, Gail M.
1999 Identification of charcoal taxa, in *Archaeological Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations, Phase II.* Vol. V: *Lab Analyses, Syntheses, Recommendations*: 126–140, ed. M. J. Tomanari-Tuggle, H. D. Tuggle, J. Liston, and D. J. Welch. Draft prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.
2007 Identification of charcoal taxa, in *Intensive Archaeological Survey for the Palau Compact Road, Babeldaob Island, Palau. Historic Preservation Investigations, Phase I.* Vol. I: *Scope, Background, Results, Evaluation, and Recommendations*: 269–285, ed. M. J. Tomonari-Tuggle, H. David Tuggle, and D. J. Welch. Prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu. (Draft 1998)

in prep. Identification of charcoal taxa, in *Archaeological Monitoring and Emergency Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations, Phase III.* Vol. XII: *Lab Analyses, Discussion, Syntheses*, ed. J. Liston and M. J. Tuggle. Draft prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.

O'Day, Sharyn
1999 Invertebrate and vertebrate faunal remains, in *Archaeological Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations, Phase II.* Vol. V: *Lab Analyses, Syntheses, Recommendations*: 106–126, ed. M. J. Tomanari-Tuggle, H. D. Tuggle, J. Liston, and D. J. Welch. Draft prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.

Odell, George
2001 Stone tool research at the end of the millennium: Classification, function, and behavior. *Journal of Archaeological Research* 9:45–100.

Osborne, Douglas
1966 *The Archaeology of the Palau Islands: An Intensive Survey.* B.P. Bishop Museum Bulletin 230. Honolulu: Bishop Museum Press.
1979 Archaeological test excavations. Palau Islands 1968–1969. *Micronesica* Supplement 1.

Palau Society of Historians
1990 *Rechuodel: Traditional Culture and Lifeways Long Ago in Palau.* San Francisco: Micronesian Endowment for Historic Preservation, U.S. National Park Service.
2001 *Traditional Items and Properties of a Household, Clan, and Village.* Traditional and Customary Practices Series 7. Division of Cultural Affairs, Koror, Palau.

Phear, Sarah, Geoff Clark, and Atholl Anderson
2003 A radiocarbon chronology of Palau, in *Pacific Archaeology: Assessments and Prospects*: 255–263, ed. C. Sand. Les Cahiers de l'Archéologie en Nouvelle-Calédonie 15. Nouméa: Musee de Nouvelle-Calédonie.

Pregill, G. K., and D. W. Steadman
2000 Fossil vertebrates from Palau, Micronesia: A resource assessment. *Micronesica* 33(1/2): 137–152.

Rieth, Timothy M., and Jolie Liston
2001 *Archaeological Data Recovery at Ngermereues Ridge, Ngesaol, Koror, Republic of Palau.* Prepared for Winzler and Kelly, Consulting Engneers, Republic of Palau. International Archaeological Research Institute, Inc., Honolulu.

Rots, Veerle
2003 Towards an understanding of hafting: The macro- and microscopic evidence. *Antiquity* 77:805–815.

Schiffer, Michael B.
1972 Archaeological context and systemic context. *American Antiquity* 37:156–165.

Semper, Karl
1982 *The Palau Islands in the Pacific Ocean*, trans. Mark L. Berg. University of Guam, Micronesia Area Research Center. [Original 1873] *Die Palau-Inseln im Stillen Ocean.* Leipzig, Germany: F. Brockhaus.

Smith, DeVern R.
1997 *Micronesian Resources Study: Palau Ethnography.* Vol. 2: *Recommendations for the Preservation of Historic and Cultural Resources in Palau.* San Francisco: Micronesian Endowment for Historic Preservation, U.S. National Park Service.

Smith, P. R., and M. T. Wilson
1992 Blood residues on ancient tool surfaces: A cautionary note. *Journal of Archaeological Science* 19:237–241.

Takayama, Jun, Michiko Intoh, and Hiroaki Takasugi
1980 *The Brief Archaeological Survey on Kayangel and Angaur in the Palaus.* Reports of Pacific Archaeological Survey, No. VII. Tezukayama University, Nara City, Japan.

Tuggle, H. David
in prep. Nagaraad Reports, in *Archaeological Monitoring and Emergency Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic preservation investigations, Phase III.* Vol. IX: *Planned Data Recovery Field Reports*, ed. J. Liston and M. J. Tuggle. Draft prepared for

Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.

Wallis, Lynley, and Sue O'Connor
1998 Residues on a sample of stone points from the west Kimberley, in *A Closer Look: Recent Australian Studies of Stone Tools*: 149–178, ed. R. Fullagar. Sydney: Archaeological Computing Laboratory, University of Sydney.

Weisler, Marshall I., and Michael Haslam
2005 Determining the function of Polynesian volcanic glass artifacts: Results of a residue study. *Hawaiian Archaeology* 10:1–17.

Wickler, Stephen
2001 The colonization of Western Micronesia and early settlement in Palau, in *Pacific 2000: Proceedings of the Fifth International Conference on Easter Island and the Pacific*: 185–196, ed. C. M. Stevenson, G. Lee, and F. J. Morin. Los Osos, CA: Bearsville Press.

Wickler, Stephen J., David J. Welch, M. J. Tomonari-Tuggle, Jolie Liston, and H. David Tuggle
2007 *Intensive Archaeological Survey for the Palau Compact Road, Babeldaob Island, Palau. Historic Preservation Investigations Phase I.* Vol. I: *Scope, Background, Results, Evaluation, and Recommendations.* Prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu. (Draft 1998)

Williams, Scott S., and Jeffrey A. Markos
1999 Lithic and shell tools, in *Archaeological Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations Phase II.* Vol. V: *Lab Analyses, Syntheses, and Recommendations*: 90–105, ed. M. J. Tomanari-Tuggle, H. D. Tuggle, J. Liston, and D. J. Welch. Draft prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.
2007 Lithic and shell tool raw data, in *Archaeological Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations, Phase II.* Vol. VI: *Appendices*: H1–H22. Prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.

Williams, Scott S., and M. Clark Pope
in prep. Lithic and shell tools, in *Archaeological Monitoring and Emergency Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations, Phase III.* Vol. XII: *Lab Analyses, Discussion, Syntheses*, ed. J. Liston and M. J. Tuggle. Draft prepared for Honolulu Engineering District, U.S. Army Corps of Engineers. International Archaeological Research Institute, Inc., Honolulu.

Wright, Duncan
2005 The Archaeology of Aulong Island and the Colonisation of Palau. M.A. thesis, Australia National University.

ABSTRACT

This paper summarizes current research into flaked stone assemblages from the Republic of Palau, Micronesia. We review archaeological analyses of Palau's flaked stone artifacts, examine ethnohistorical sources for descriptions and potential uses of lithic tools, and present the results of a recent microscopic use-wear and residue study of twenty flaked stone artifacts. We find that while a lithic technology based on bipolar reduction had emerged by at least the beginning of the first millennium B.C., the archaeological and ethnohistorical records demonstrate the relative obscurity of stone tool use in the final stages of prehistory. The artifacts analyzed for residues are associated with radiocarbon dates ranging from ca. 1120 B.C.–A.D. 1640, with the majority recovered from inland earthwork and village complexes radiocarbon dated to approximately two thousand years ago. Residue evidence for wood and bone/skin working is discussed in terms of past social activities and changes in settlement patterns, and in light of the perceived dominance of shell as a tool material on Palau. The potential for soil fungi to influence the interpretation of artifact residues is also considered. The study emphasizes the unique position of residue analyses in contributing to studies of artifact function in the Pacific, and suggests future directions for flaked-stone research on Palau. Keywords: Palau, Micronesia, stone, residue analysis, microscopy.