THE CONTRIBUTION OF USE-WEAR/RESIDUE STUDIES OF OBSIDIAN ARTEFACTS FOR UNDERSTANDING CHANGES IN SETTLEMENT AND SUBSISTENCE PATTERNS IN WEST NEW BRITAIN, PAPUA NEW GUINEA

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ABSTRACT

This paper considers how patterns in use-wear/residues relate to debates about the nature of the day-to-day lives of the people who created the Lapita Cultural Complex. Changes in subsistence and settlement patterns have often been proposed as being the result of the introduction of new kinds of agriculture to the Bismarck Archipelago by people using Lapita pottery (Green 2002:95-120; Kirch 1997:45-52; Spriggs 1997:67-106). In contrast, several recent use-wear/residue studies of stone tools in West New Britain, Papua New Guinea have reconstructed a complex pattern with a much longer term trend toward the intensification of resource exploitation and a decrease in mobility (Fullagar 1992:135-43; Torrence 1992:111-26; Torrence et al. 2000:225-44). To further examine the impact of Lapita on subsistence and settlement patterns, a use-wear/residue study was made of a large number of obsidian artefacts excavated from two test pits at the FAO site on Garua Island. The sample included artefacts dating from both before and during the time of Lapita pottery. My preliminary analyses indicate there were no differences between these periods in terms of the kinds of tool use or the nature of the activities apparent at the site.

INTRODUCTION

The middle-late Holocene period in the Bismarck Archipelago introduced dramatic changes in human behaviour. The archaeological record demonstrates an intensive movement of people into new landscapes and the development of complex maritime transportation patterns and the establishment of economic and social networks (Kirch 1997:39-42; Spriggs 1997:43-66). Crucial changes occurred in subsistence and settlement patterns about 3,500 years ago with the advent of the Lapita Cultural Complex and the associated development of pottery, agriculture and the domestication of pigs, dogs and chickens in the region. There are continuing debates among Pacific scholars about the origin of Lapita culture (Green 2003:95-120; Kirch 1997:45-52; Spriggs 1997:67-106). One group of scholars proposes cultural continuity among indigenous inhabitants and suggests the development of the Lapita Cultural Complex within the Bismarck Archipelago (Allen and White 1989:129-46; Specht *et al.* 1991:281-94; Torrence 1992:111-26; Torrence and Doelman in press).

Intensive research in West New Britain, Papua New Guinea, by Specht and Torrence has identified a number of sites containing both the pre-Lapita and Lapita periods of occupation (e.g. Specht 1974:302-6; Specht and Torrence in press; Specht *et al.* 1988:3-16; Torrence 1992:111-26; 2002:766-76; 2004:163-72; Torrence and Stevenson 2000:324-45;Torrence *et al.* 2000:225-44). The material from these sites provides a basis for Torrence's hypothesis that a gradual change in stone assemblages from a curated technology involving the stemmed tool tradition during the pre-Lapita period to the expedient production and use of unretouched flakes in the Lapita period is the result of a gradual increase in the intensification of land management and plant exploitation. Torrence (1992:111-26; 2004:163-72; Torrence, *et al.* 2000:225-44) has also inferred that, firstly, during the pre-Lapita period, plant collecting is likely to have been the primary source of food for highly mobile groups and, secondly, that the intensification in the use of land-based resources, gardening and the shift to a more sedentary lifestyle is associated with the Lapita period.

The beginning of the period characterized by Lapita pottery is marked by the devastating W-K2 eruption. Following this event, radical changes are observed on Garua Island that include the introduction of pottery, the disappearance of stemmed tools and the transformation of the pattern of artefact production, use and discard (Torrence 1992:111-26; 2004:163-72; Torrence and Stevenson 2000:324-45, Torrence *et al.* 2000:225-44). Although the increasing dependence on cultivated gardens is supported by recent phytolith and starch analysis of sediments at the FAO site on Garua Island (Lentfer and Torrence 2007; Torrence and Doelman in press), the explanation of pre-Lapita and Lapita subsistence and settlement patterns still relies heavily on the interpretation of stone tool technology and the distribution of obsidian artefacts within the landscape (Torrence 1992:111-26; 2002:766-76; Torrence and Doelman in press; Torrence *et al.* 2000:225-44).

The change in both subsistence strategy and lithic technology during the middle and late Holocene in West

New Britain, and on Garua Island particularly, suggests there must have been some differences in the organization of tool use. Use-wear/residue analysis by Fullagar of 140 tools from six sites located in the Kandrian region, on the Arawe Islands, and in the Talasea area demonstrates that a limited range of activities took place at sites in the pre-Lapita period. Fullagar (1992:135-43). interpreted these findings as reflecting a highly mobile pattern of subsistence.

In addition, results of use-wear/residue and phytolith analyses of 28 obsidian artefacts from the FAO site on Garua Island (Barton *et al.* 1998:1235, Kealhofer *et al.* 1999:530) and 35 artefacts from the FRL site in Talasea (Fullagar 1992:137; Kealhofer *et al.* 1999:530) allowed Kealhofer *et al.* (1999:527-46) to make inferences about chronological changes in tool use. They noted that pre-Lapita obsidian assemblages have both multi-functional and single purpose tools used primarily for processing plant materials such as (1) soft, non-siliceous, starchy plants (e.g. tubers), (2) soft siliceous plants (e.g. reeds or bamboo), (3) hard non-siliceous wood, and (4) very starchy and siliceous wood (e.g. palm). In contrast, Lapita stone assemblages represent a change to more expedient tool use, which involved a flake being used for only one task and then discarded. Moreover, during the Lapita period a wide range of activities took place at the sites, suggesting a decline in mobility over time (Fullagar 1992:135-43).

USE-WEAR AND RESIDUE ANALYSIS

The concept of technological organization involving raw material procurement, production, use, maintenance, transportation and discard of stone artefacts provides the foundation for the investigation of the relationship between subsistence activities and settlement patterns (Binford 1979:255-73; 1996:39-78; Bamforth 1986:38-50; 1991:216-34, Jochim 1989:106-11; Odell 1996:51-80, Torrence 1989a: 1-6, 1989b: 57-66). To study these many aspects of curated and expedient technologies, their relationship to subsistence and settlement patterns can be evaluated by interpreting the specific functions of stone tools. For this reason, lithic use-wear/residue research can contribute significant data which assists in answering significant questions relevant to general patterns of human behaviour: e.g. how were artefacts used; what materials were processed; what activities took place; how did settlements function within particular socio-cultural systems; and, how and what caused change within these systems (Fullagar 1994:210-24; Hayden and Kamminga 1979:1-13; Hurcombe 1992:64-6; Odell 1996:51-80; Odell *et al.*1996:377-92; Schiffer 1979:15-25).

Without more complete use-wear information, current interpretations of subsistence and settlement pattern leave many questions under-resolved. Despite results from use-wear/residue analyses of lithic artefacts from New Ireland (Barton and White 1993:169-81; Spriggs 1997:38) and New Britain (Fullagar 1992; 1993; Barton *et al.* 1998; Kealhofer *et al.* 1999:527-46), additional studies are required to improve knowledge of tool use and subsistence in both the Lapita and pre-Lapita periods. To further examine differences in the pattern of tool use between these two periods and to assess the impact of Lapita occupation on subsistence and settlement patterns on Garua island, a systematic use-wear/residue analysis of obsidian artefacts was made based on the collection recovered from the FAO site located on Garua Island, West New Britain province, Papua New Guinea (Figure 1).

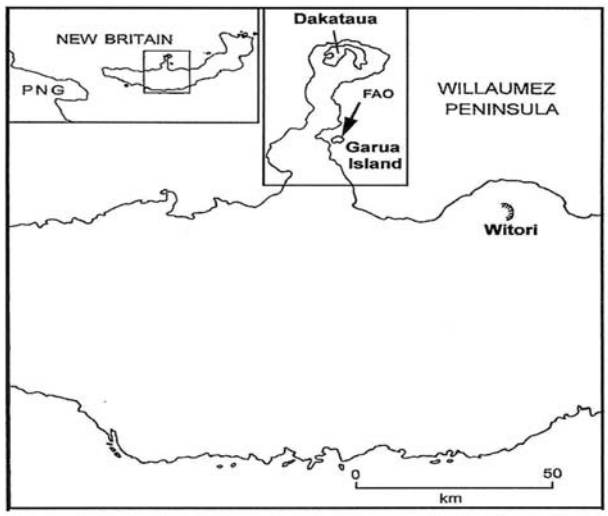

Figure 1. Location map of Garua Island showing the FAO site (from Lentfer and Torrence, 2007).

MATERIALS AND METHODS

The FAO site is located on the northern side of Garua Island on top of a hill c. 40 m. ASL. The site is on the slopes of Mt. Baki, the eastern lava dome on the island, and overlooks the sea. During two field seasons, 20 test pits were excavated at the site (Torrence 1993:5; Torrence and Webb 1992:6-7). The full stratigraphic sequence of the site was obtained in one test pit labelled 1000/1000 which was excavated to a depth of 3.1 metres. This stratigraphic profile demonstrates that cultural deposits are separated by distinctive airfall tephras derived from volcanic events which occurred during the Pleistocene and Holocene. At least five phases of occupation during the Holocene time period were identified (Torrence *et al.* 2000:225-44), each following a significant airfall tephra event. The analytical framework of my analysis are 1,036 obsidian artefacts (Table 1) recovered from pre-Lapita (5930-3440 BP) and Lapita (3340-1340 BP) levels (Petrie and Torrence submitted) in two test pits. Test pit 1000/1000 is located on the apex of the hill and test pit 970/1000 is situated 30 metres to the west (Parr *et al.* 2001:127).

All the obsidian artefacts were examined using both a stereomicroscope Orient SM 1 and an Olympus BX60M metallurgical microscope with reflected light and magnifications from ×50 to ×1000. Images showing use-wear/residue were taken using attached digital cameras Nikon Coolpix 950 and Color View II using the Soft Imaging System GmbHF**.** In the assessment of artefact function, four main features of use-wear have been used: scar-

ring, rounding, striations and polish. This allowed the identification of (1) the mode of use and (2) the worked material on which the tool was used. A variety of residues including starch, plant tissue, resin and blood-like residues associated with the worked material have been recorded. Data from phytoliths and starch studies obtained by Kealhofer and Fullagar (Kealhofer *et al.* 1999:527-46) were also used to support use-wear information.

The interpretation of use-wear/residue results involved a comparative study based on 275 experiments conducted in the laboratory and during fieldwork in West New Britain and 14 experiments made earlier by Fullagar. My experiments involved collecting obsidian at the Baki source on Garua Island and the Kutau-Bao source at Bitokara Mission, manufacture of flakes and stemmed tools, and their use in a range of tasks and actions.

RESULTS

A total of 1036 artefacts were examined. From these, evidence for use was identified on 144 artefacts of which 67 tools are dated to the pre-Lapita period and 77 tools to the Lapita period. The remaining 892 artefacts showed no signs of use (Table 1). The tools were used for processing both plant and non-plant materials by various modes of use: e.g. scraping, sawing, whittling, carving, cutting, slicing, peeling and piercing. On the basis of use-wear patterns and observed residues, eight categories of worked materials have been identified (Table 1): (1) soft wood, (2) soft, starchy wood (e.g. palm), (3) hard wood, (4) hard, starchy wood (e.g. black palm), (5) siliceous woody plants (e.g. bamboo, rattan), (6) soft, starchy plants (e.g. tubers), (7) soft, elastic material (e.g. skin, fish, meat) and (8) non-elastic material (e.g. shell).

Tools used for processing soft wood are generally characterised by light to medium degrees of edge rounding and closely packed striations oriented in response to the mode of use (e.g. parallel, diagonal or perpendicular to the edge). Edge damage usually occurs on woodworking tools as continuous or discontinuous scars. The scarring removes polish and only a few patches of developed, smooth polishes may be observed in the higher elevations of the surface and intersections of scars (Figure 2). A similar pattern of use-wear is observed on tools involved in processing soft starchy wood like palm, except that there is usually a concentration of starch grains preserved on the working edge. In contrast, tools used for processing hard, starchy wood are distinguished by their very intensive scarring, rough striations and, occasional patches of smooth polishes. The edges often preserve plant tissue and starch concentrations (Figure 3). Comparisons with experimental samples suggest that such tools were used for processing wood similar to black palm (*Caryota rumphiana*).

Artefacts involved in processing highly siliceous woody plants (e.g. bamboo and rattan) exhibit more intensive edge damage with noticeable scars and very light to medium edge rounding. Well defined and dense striations are common (Figures 4, 5) and patches of well-developed polish are usually observed at the intersection of scars and at the higher peaks of surface topography along the edge.

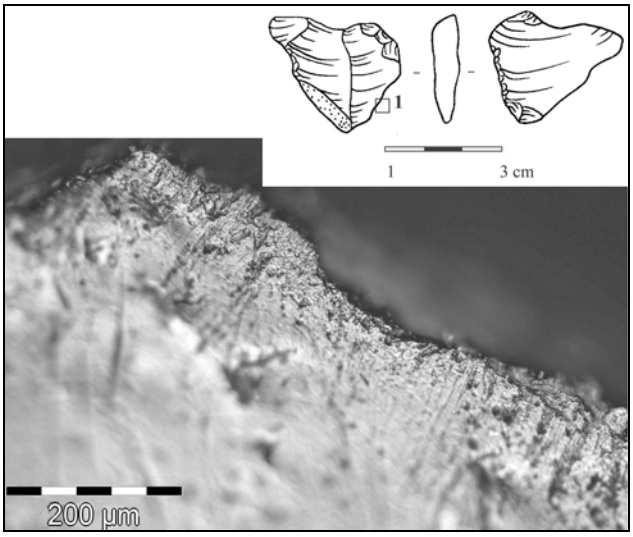

Figure 2. Obsidian artefact from the Lapita period (M1933, level 4, spit 2): Top: Shape of the tool and the point on the working edge where the microphotograph was taken (marked by number 1) (which applies to all the artefact illustrations). Inferred use-wear is scraping soft wood (× 200).

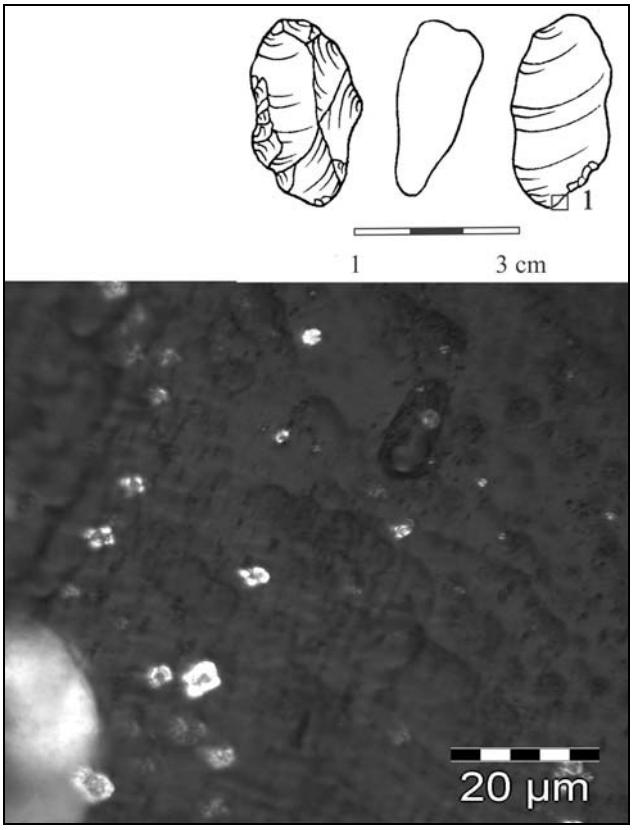

Figure 3. Obsidian artefact from the pre-Lapita period (M1979, level 6, spit 1). Starch grains on the working edge of the tool (×1000).

Both pre-Lapita and Lapita layers include a series of tools which reflect their use for cutting, slicing, peeling, and scraping starchy, relatively soft, plants like tubers and for the extraction of coconut meat. These tools are

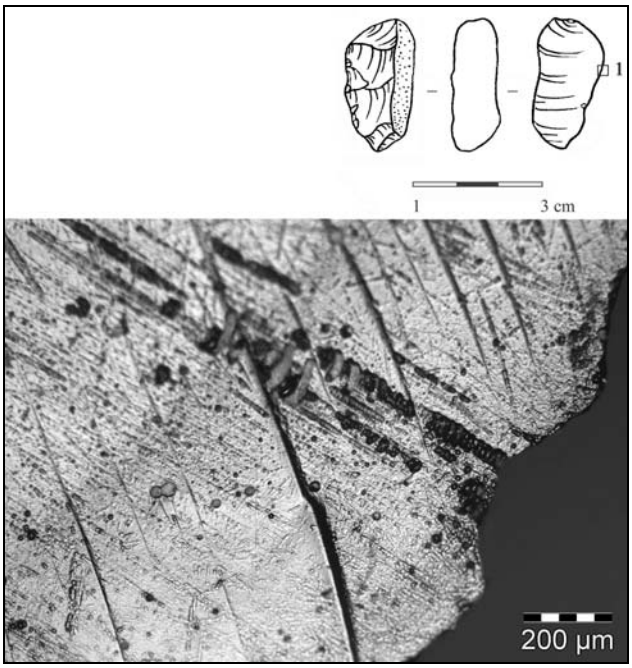

Figure 4. Obsidian artefact from the pre-Lapita period (M1997, level 6, spit 1). Inferred use-wear is whittling siliceous woody plants such as bamboo or rattan (×100).

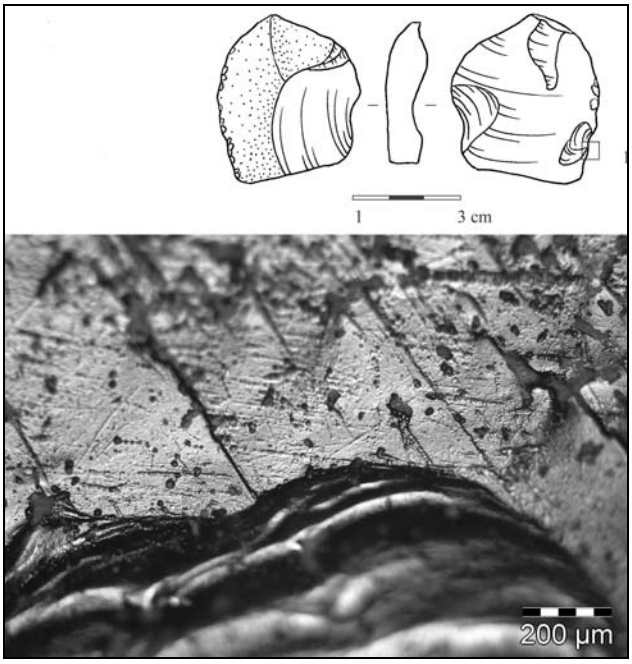

Figure 5. Obsidian artefact from the pre-Lapita period (M1976, level 6, spit 4). Inferred use-wear is sawing siliceous wood plants such as bamboo or rattan (×100).

characterised by a few irregular, discontinuous scars, light to medium edge rounding, and isolated, shallow sleeks, or intermittent striations (Figures 6, 7). Definite alignments and some patches of weakly developed, slightly penetrated polishes are common. Starch residue is often visible on the working edge of such tools.

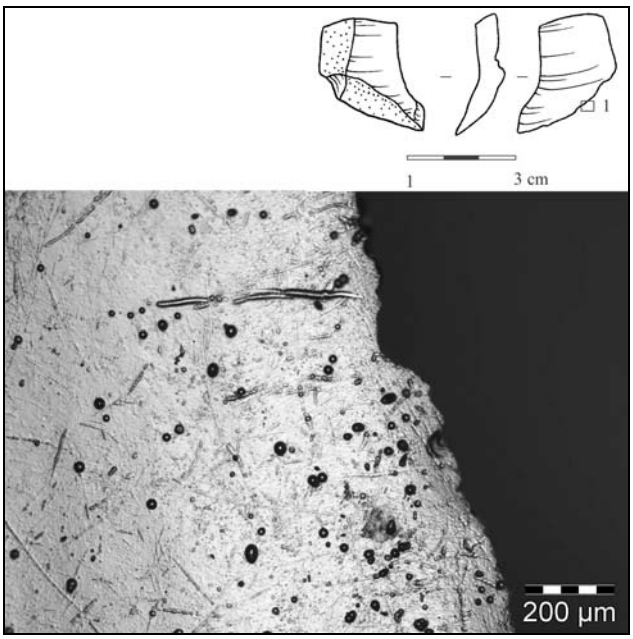

Figure 6. Obsidian artefact from the pre-Lapita period (M361, level 6, spit 3). Inferred use-wear is slicing soft starchy plants such as tubers (×100).

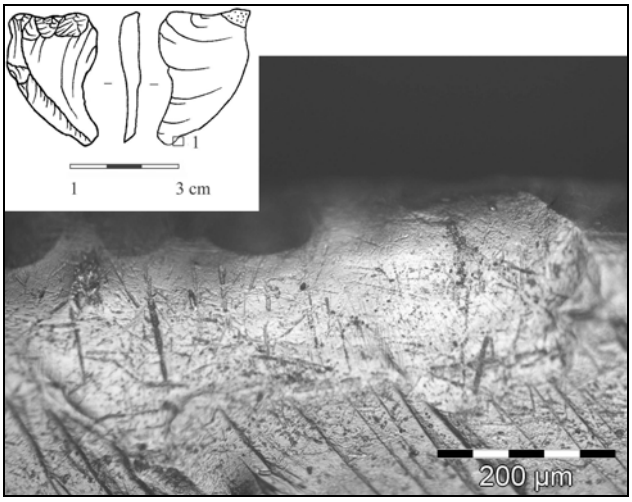

Figure 7. Obsidian artefact from the Lapita period (M2046, level 4, spit 3). Inferred use-wear is scraping soft starchy plants such as tubers (×200).

Tools associated with cutting and piercing soft elastic material (e.g. skin, fish or meat) occur in both periods. The identification of these tools is the most difficult because they rarely show intensive scarring, rounding or developed polishes. However, three of seven tools used for processing soft elastic material preserved white, black or dark-red residues which are probably related to human or animal tissue and blood, and on one tool such residues were mixed with pigments such as ochre (Fullagar, R., pers. comm. 17 May 2006). There were eight flakes found at the site which were used for gutting/cutting fish according to comparison with experimental data (Figures 8, 9). The slightly rounded edges of these tools contain a few

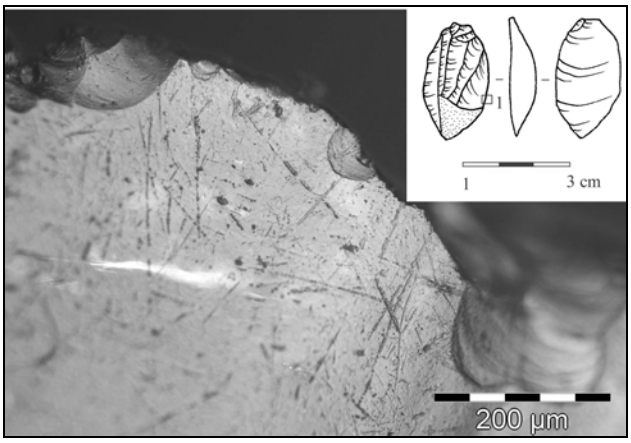

Figure 8. Obsidian artefact from the Lapita period (M1939, level 4, spit 3). Inferred use-wear is cutting soft elastic materials such as fish (×200).

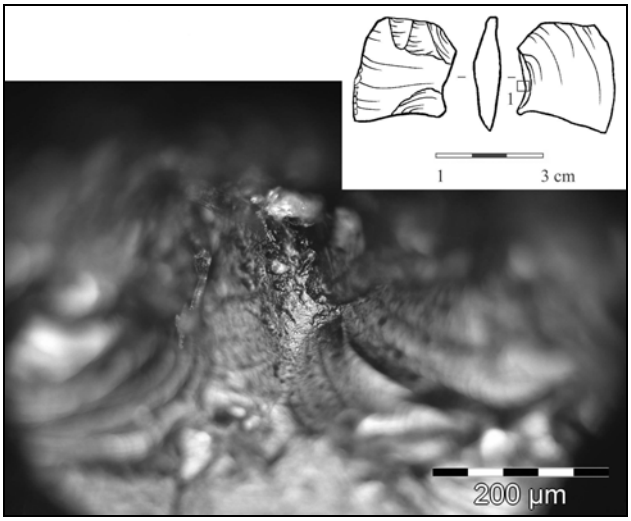

Figure 9. Obsidian artefact from the pre-Lapita period (M1940, level 6, spit 3). Inferred use-wear is cutting soft elastic materials such as fish. Polish and white residues (×200).

isolated and flat microscars. Along the edges, some isolated, long, deep and shallow striations can be observed. Some of the tools which were used intensively for soft elastic material exhibit patches of very smooth polish which is distributed from higher points of the surface to within surface depressions, indicating that the soft flexible material was constantly in contact with the working edge (Figure 9). Pointed flakes with this use-wear were often used for piercing skin.

There are a few flakes with distinctive use-wear patterns: very rounded edge; abrasion; rough intermittent and deep sleek striations perpendicularly oriented to the edge; and, patches of well developed, flat polishes with embedded white residues at the higher peaks of the edge (Figure 10B). This pattern of use-wear suggests scraping action used for dense and relatively hard materials such as shell. This is confirmed by comparison with experimental tools used for processing shell which exhibit very similar features of use-wear and residues (Figure 10 bottom).

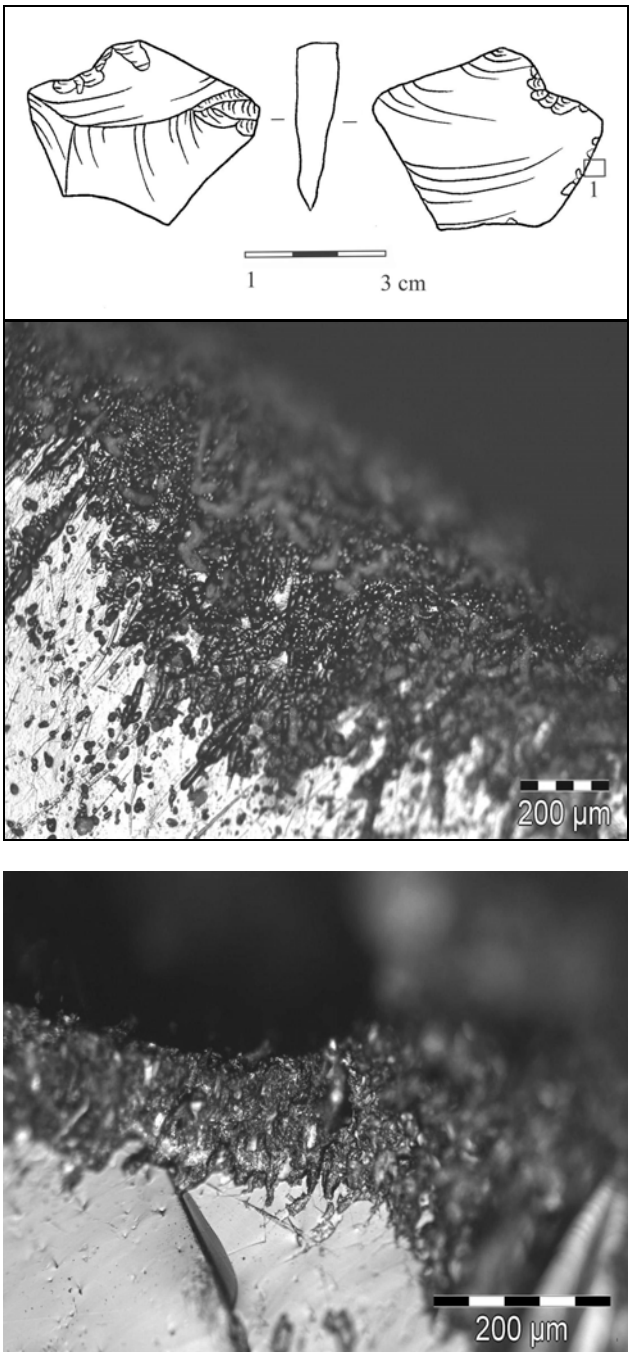

Figure 10. Top and middle: Obsidian artefact from the pre-Lapita period (M1968, level 6, spit 2). Inferred use-wear is scraping hard dense materials such as shells (×100). Bottom: Use-wear pattern on the experimental tool (Exp. 260) (×200). Intensive rounding, polish, and striations are observed on the working edge of both obsidian artefact and obsidian experimental tool used for sawing shell.

The summary of the results presented in Table 2 (at end of text) show that most flakes in both pre-Lapita and Lapita periods were used in an expedient manner and apparently for a relatively short time. Flakes were used both as single purpose tools (e.g. processing soft plants or wood) and also commonly for multifunctional actions (e.g. scraping and slicing or whittling and sawing). An

exception is one flake from the pre-Lapita layer which has evidence of its initial use for sawing soft starchy wood then, after re-sharpening, was reused for scraping soft wood. In addition, there are only 7 tools (9.1 % of 77) in the pre-Lapita layer and 11 (16.4% of 67) in the Lapita layer which preserved relatively intensive patterns of use-wear.

DISCUSSION

Based on this preliminary use-wear/residue study, it is apparent that a change in technology from the manufacture of stemmed tools during the pre-Lapita period to expedient flake production in the Lapita period is not closely associated with changes in the strategy of tool use. In both chronological periods obsidian artefacts at FAO were used to process a diverse range of plant and non-plant materials by a variety of actions and were used expediently. This does not support the previous proposal by Kealhofer *et al.* (1999: 544–45) that during the pre-Lapita period only a few tool-using activities with a limited range of tasks took place at the site reflecting high mobility. In contrast, the use-wear data clearly indicate that during the pre-Lapita period there were a wide variety of tool functions associated with subsistence and craft activities.

It is noticeable that the set of activities detected for the Lapita period is not significantly different from the pre-Lapita period (Table 2). The similarity in the patterns of tool use of both periods addresses the question of the degree of residential mobility between the pre-Lapita and Lapita populations which occupied Garua Island in the middle and late Holocene. If high mobility was a significant feature of pre-Lapita population, as emphasised by Fullagar (1992:135-43), Kealhofer *et al.* (1999:527-46) and Torrence (1992:111-26, 2002:766-76), then it is reasonable to suggest on the basis of use-wear/residue data that Lapita people who arrived on the island after W-K2 eruption maintained a similar mobile style of life associated with a diverse range of activities.

This hypothesis accords with the pattern of Lapita mobility in which people returned regularly to the site for gardening and other daily activities (Gosden and Pavlides 1994:162-71). Alternatively, similarities in the pattern of tool use observed in both periods at the site may be explained by a more sedentary way of life, not only for the Lapita period (Torrence 1992:111-26; 2002:766–76), but also for the pre-Lapita occupation. Although the use-wear study shows that there is little difference before and during the time of Lapita pottery, discriminating between mobile and sedentary lifestyles requires further analysis of archaeological data already obtained on Garua Island.

Use-wear/residue results of all stone artefacts found in two test pits at FAO support Fullagar's (Fullagar 1992:135-43; Kealhofer *et al.* 1999:527–46) conclusion that obsidian tools in both chronological periods were primarily used for plant processing and rarely on animals and human bodies (Table 2). However, detailed functional analysis and comparison with experimental materials detected the function of tools that was not previously identified. Firstly, tools used for processing shell were observed. Secondly, use-wear patterns observed on tools used for gutting/cutting fish, which can be differentiated from tools involved in piercing and cutting thin skin or thin hide, were also noted. In addition, in some cases it was possible to detect tools with a high probability of having been used for cutting greens and scraping coconut meat.

Using the data about the types of behaviours and use materials represented at FAO, a distinction can be made between artefacts related to subsistence and those involved in craft activities. These can be used to make a preliminary comparison of subsistence practises and craft activities in the pre-Lapita and Lapita periods. As shown in Table 2, there are only slight chronological changes in the proportion of tools used for processing food resources and tools involved in craft activities. During the pre-Lapita period a higher percentage of tools (32.5 %) was associated with food processing than in the Lapita period (25.4 %). The tools were mainly used for processing soft starchy plants (e.g. tubers, greens and coconut meat) in both periods, but a smaller number of such tools in the Lapita period does not indicate increasing dependence on cultivated gardens as has been suggested (Lentfer and Torrence 2007; Torrence and Doelman in press). The use-wear/residue data do not support Torrence's (2002:766–76) proposal that plant collecting was the primary source of food during the pre-Lapita period. Finally, the presence of tools used for processing fish provides evidence that marine resources were included in the diet in both periods.

In contrast, a slightly higher percentage of tools was used in craft activities in the Lapita period (74.6 % versus 67.5 %). There is a noticeable difference in the processing of soft starchy wood (e.g. palm) and siliceous woody plants (e.g. bamboo and rattan) over time. A larger number of functionally more diverse tools were used for starchy wood in the Lapita layer in comparison with the pre-Lapita period.

My identification of these tools was not based entirely on use-wear pattern but was also supported by the presence of starch residues. However, the preservation of starch residues on obsidian is somewhat problematic and depends on many factors including post-depositional processes and post-excavation cleaning of artefacts (Fullagar 2006:191). Most of the examined artefacts at FAO had been cleaned for use-wear analysis and it is possible to suggest that the number of tools used for processing starchy wood was much higher in both periods than is reflected in Table 2. In relation to the processing of siliceous woody plants, my data suggest that this plant material was more widely used during the pre-Lapita period.

CONCLUSIONS

The initial results from my use-wear/residue study of obsidian artefacts from the FAO site provide new insights into the activities undertaken during the pre-Lapita and Lapita periods. Although the number of tools identified by use-wear analysis is relatively small, the results indi-

cate a diverse range of activities in both periods. The distribution of activities over time is similar and this suggests either relatively high mobility for both pre-Lapita and Lapita periods, or, alternatively, a relatively sedentary way of life in both periods.

A very slight difference in subsistence and craft activities between the two periods can be observed. Additional use-wear/residue studies of obsidian artefacts from FAO and other sites on Garua Island would allow a more precise comparison of subsistence practices of the two periods especially if such studies are conducted in conjunction with technological analysis and more detailed investigation of the spatial distribution of discarded artefacts.

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Table 1. Distribution of artefacts within test pits 1000/1000 and 970/1000 at the FAO site, Garua Island, West New Britain, Papua New Guinea.

	Lapita period		Pre-Lapita period	
Test pits	**N of artefacts**	**N of identified tools**	**N of artefacts**	**N of identified tools**
1000/1000	108	13	358	22
970/1000	285	54	285	55
Total:	393	67	643	77

Table 2. Distribution of tools used in subsistence and craft activities during the pre-Lapita and Lapita periods at the FAO site, Garua Island, West New Britain, Papua New Guinea (continued on next page).

	Lapita period		Pre-Lapita period	
Activities, materials, mode of use	**N**	**%**	**N**	**%**
Subsistence activities	17	25.4	25	32.5
Soft starchy plants (e.g. tubers, greens, coconut meat)	14	20.9	20	26.0
Scraping	3		5	
Cutting	1		1	
Slicing	0		2	
Cutting/slicing	5		8	
Scraping/slicing	4		4	
Slicing/peeling	1		0	
Soft elastic materials (e.g. fish/meat)	3	4.5	5	6.5
Gutting/cutting	3		5	
Craft activities	50	74.6	52	67.5
Soft wood	14	20.9	20	26.0
Sawing	1		2	
Whittling	5		6	

Table 2, continued from previous page.

Activities, materials, mode of use	Lapita period N	%	Pre-Lapita period N	%
Scraping	2		5	
Cutting (burin)	1		1	
Scraping/sawing	1		1	
Whittling/sawing	2		2	
Whittling/scraping	1		1	
Cutting/scraping (carving)	1		0	
Cutting/whittling (carving)	0		1	
Soft starchy wood (e.g. palm)	25	37.3	11	14.2
Sawing	1		1	
Whittling	5		3	
Scraping	5		1	
Cutting (burin)	1		1	
Scraping/sawing	2		1	
Whittling/sawing	4		3	
Whittling/scraping	3		1	
Cutting/scraping (carving)	1		0	
Whittling/planing	1		0	
Whittling/sawing/cutting	1		0	
Scraping/sawing/whittling	1		0	
Hard wood	1	1.5	2	2.6
Scraping	0		1	
Scraping/sawing	0		1	
Whittling sawing	1		0	
Hard starchy wood (e.g. black palm)	2	3.0	4	5.2
Scraping	0		2	
Scraping/sawing	2		1	
Whittling/cutting (burin)	0		1	
Siliceous woody plants (e.g. bamboo, rattan)	5	7.4	9	11.7
Scraping	1		1	
Whittling	0		3	
Scraping/sawing	2		2	
Whittling/sawing	0		3	
Whittling/sawing/scraping	1		0	
Whittling/cutting (burin)	1		0	
Dense hard material (e.g. shell)	1	1.5	1	1.3
Scraping	0		1	
Sawing/scraping	1			
Soft elastic material (skin/hide, possible tattooing)	2	3.0	5	6.5
Piercing	2		2	
Cutting	0		2	
Piercing/cutting	0		1	
TOTAL:	67	100%	77	100%