Obsidian artefacts and land-use in the mid-Holocene of the Willaumez Peninsula, Papua New Guinea

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Abstract

This paper addresses the land-use strategy of people occupying Willaumez Peninsula, West New Britain, Papua New Guinea, between 5900 and 3600 BP to determine whether they were mobile or sedentary. The study employs the proposition that mobile and sedentary situations have different and distinctive characteristics in the manner of flaked stone tool production and use. It develops a model that outlines expected differences in flaked stone artefact manufacture and use by mobile and sedentary populations. Mobile land-use should show both intra- and inter-site variability reflecting distance from a raw material source, and spatial differences in the production and use of raw material within the source area. Sedentary land-use should show little intra- and inter-site variability due to the concentration of activities and similar patterns of utilisation at each site. The paper tests this model through the analysis of ten flaked obsidian assemblages from Willaumez Peninsula. It concludes there is some spatial patterning in obsidian reduction that supports a model of mobile land-use between 5900 and 3600 BP.

Introduction

This study examines the land-use strategies of people occupying part of the Willaumez Peninsula of West New Britain, Papua New Guinea, between 5900 and 3600 BP (Fig. 1). Based on an analysis of lithic reduction strategies at two locations at Bitokara Mission (FDQ and FRL), Torrence (1992) found evidence to support a model of population mobility during the middle Holocene. The present study tests her results by applying a model of the characteristics of flaked stone reduction likely to reflect mobile and sedentary patterns of land-use to a larger sample of sites across a wider region. The analysis of ten obsidian assemblages recovered by Torrence near a major obsidian source area and up to 34 km distant from it provides support for her original hypothesis (Symons 2001).

Predicting lithic outcomes for mobility

I begin by developing a model of the characteristics of stone reduction that result both from mobile and sedentary patterns of land-use. Mobility is defined here as land-use that involves moving through the landscape between temporary bases to acquire and use resources. In contrast, sedentism involves permanent or semi-permanent settlements, with staple food resources often acquired from a closely positioned source, and with raw materials and some rarer food supplies acquired from further afield. However, there are various possible forms of mobility and sedentism, rendering a definition difficult (Kelly 1992: 43). Whilst this variation makes it difficult to identify mobility and sedentism, it also reveals the range of activities and the distribution of these across mobile and sedentary landscapes. Here I use variation in the archaeological record between and within sites to provide a basis for recognising mobility and sedentism.

Binford (1979, 1980) discussed the nature and archaeological traces of mobile communities. In particular, he asked 'what, if anything, renders differences in man’s mobility patterning, and in turn the archaeological “traces” of this behavior in the form of spatial patterning in archaeological sites, both “understandable” and “predictable”’ (Binford 1980:4). Binford (1979) discussed the incorporation of stone procurement and use within a mobile land-use pattern. Once stone has been procured, there are several ways that it could be utilized, including the manufacture, use and discard of tools at the source (e.g. Gould 1977, 1980), and transport of raw material away from the source area for manufacture and/or use of tools elsewhere, known as curation (Binford 1979).

Curation is one of the main characteristics of mobile stone use, because in many cases involving mobile groups the only stone available at a particular site is what has been carried there (for an exception see Gould 1977, 1980). Curation can be seen to ‘mitigate’ the spatial gap between the location of a lithic raw material source and that where the raw material is used (Nelson 1991). In curated assemblages different stages of reduction are differentiated in space (Binford 1979; Parry and Kelly 1987; Nelson 1991; Kelly 1992). ’Curation has the effect of separating temporally, and by implication, spatially the location of a tool’s disposal or loss from the location of its manufacture’ (Keeley 1982:799). Following from this, ‘one consequence of high levels of mobility is extensive reliance on the limited battery of artefacts that people can carry along with them as they move about the landscape’ (Kuhn 1994:426).

Depending on the availability of raw material, the conservative use of raw material – including the preparation of cores and multi-purpose implements in the source area – is an important aspect of mobility (Parry and Kelly 1987:300). Consequently, we can begin to make predictions about whether a group was or was not mobile from the nature of the lithic remains at a site, and through inter-site comparisons.

Inter-site variability

Procurement of raw material took place at a quarry, where the material was either mined or collected from surface deposits. The amount of activity that occurred at the quarry site will vary depending on the scale and type of reduction that took place there (Gould 1980; Nelson 1991:80). I predict that the largest reduction assemblage will be located where preparation of cores and production of formal tools took place. This is because these activities were costly in time and skill, resulting in waste flakes of various kinds as well as accidental breakages before completion of the formal tools (Parry and Kelly 1987:288;
Nelson 1991:80). The source area is also where exhausted cores and implements were discarded.

In a mobile settlement pattern, stone use away from the source area should be characterised by several distinctive features. Sites would not necessarily have been occupied for the same periods of time or for the same activities (Binford 1980; Kelly 1992; Shott 1986). There should be differing assemblage size and flake variability at each site, though not a recognisable decline in the artefact numbers and size with distance from the source. This follows because the closest sites would not necessarily have been visited first, and material carried around the landscape had to support their users until they could return to the source area. A possible exception to my prediction is where the material was traded or exchanged into areas where it was not otherwise available.

The key element of a mobile land-use pattern is that all sites should differ from each other as a result of the location of the sites relative to the raw material source, the need to transport and conserve raw material, and the differing activities and time spent at each location.

**Intra-site variability at the sources**

The largest degree of intra-site variability within a mobile economy should occur within the source area because of the differing activities that occurred there. Intra-site variability within the source area is based on the notion that these activities were spatially differentiated to some extent. Torrence (1992) suggested spatial distribution of reduction within the source area based on her investigation of two sites at Bitokara Mission on Willaumez Peninsula. Outcropping obsidian occurs on a hill slope at site FDQ, whilst site FRL is located at the base of this slope. Analysis showed that artefacts from FDQ have more cortex, and flakes were generally larger with a wider range of area and thickness, than those from FRL (Torrence 1992:116). Intra-site variability in the source area is based on the spatial distribution of different activities across the landscape as part of mobile land-use.

**Predicting lithic outcomes for sedentism**

Definitions of sedentism vary widely. This problem relates back to traditional concepts of hunter-gatherers, for whom mobility has 'long been considered a defining characteristic…This is not entirely accurate, for many hunter-gatherers move infrequently – some less than “sedentary” horticultural societies’ (Kelly 1992:4). For the present paper, sedentism requires that residences remained fixed on a year-round basis.

The main characteristic of sedentary stone use is that it principally occurred at a single location. Once acquired, stone was used and discarded in an expedient manner at the same location, with 'minimised technological effort under conditions where time and place are highly predictable’ (Nelson 1991:64). Once raw material had been supplied to a particular sedentary community, expediency would most likely occur even at sites outside the source area. Parry and Kelly’s (1987) study led them to suggest that expedient stone use and sedentism were linked. 'In each area, the most significant decrease in the use of formal tools occurred at about the same time as the first occupation of large, nucleated permanent villages’ (Parry and Kelly 1987:297).

**Inter- and intra-site variability**

The main contrast between mobility and sedentism is that the range of variation within the stone artefact assemblage at each sedentary site should be the same because the activities are concentrated at the one location. Inter-site variability would be limited to ‘distance-decay,’ following Renfrew’s (1975) ‘down the line’ exchange model. Raw material might be utilised as it was passed from one community to the next, resulting in a decrease in assemblage and artefact sizes as distance from the source area increased.

Intra-site variability within sedentary communities should relate to different concentrations of stone artefacts and not in relation to spatial variation of reduction stages. Particular areas within these sedentary communities might have been used more intensively for flaking than other.

![Figure 1](image-url) Location of Willaumez Peninsula, West New Britain, Papua New Guinea.
areas, but the expedient nature of the tools produced (Parry
and Kelly 1987:288) suggests that there would not be
spatial variation in reduction.

Case study
The ideas presented above can now be applied to
assemblages from Willaumez Peninsula during the period
between 5900 and 3600 BP. This period ‘remains scarcely
evidenced in the archaeological record thus far recovered
from Near Oceania’ (Kirch 1997:38), largely due to the
apparent shift away from rockshelter occupation in the
middle Holocene and the difficulty of locating detectable
surface assemblages (Kirch 1997; Spriggs 1997). Open area
excavations on Willaumez Peninsula (Torrence 1992, 1993,
2000) and in central New Britain at Yombon (Pavlides
1999; Pavlides and Gosden 1994) have revealed new
archaeological evidence for this period. To test Torrence’s
hypothesis for mobility, I examined the presence or absence
of inter-site variability between ten sites (Fig. 2) in terms of
the presence or absence of different reduction stages. All
sampling units are 1m².

A number of these sites are located in oil palm
plantations, the names and boundaries of which are shown
in Figure 2. To test for the spatial distribution of activities
within the Katau/Bao obsidian source area, as identified in
Torrence’s (1992) study, three obsidian assemblages from
FAO were included. One of these, from pit 1000/1010, has
an assemblage count of 8,259, from which a sample of
1,515 was used for this study (Table 1).

The ten sites are located at varying distances from the
Kutau/Bao obsidian source, shown as FDQ on Figure 2. Sites
FAO on Garua Island and FRL at Bitokara Mission are
located in this obsidian source area, but for consistency the
distances of all sites were measured from FDQ. Robin
Torrence supplied the FRL data whereas I recorded other
assemblages for this study.

Reduction stages
Debitage produced at different stages of production has
distinctive characteristics. Observation of reduction
sequences is based on the principle that flake manufacture ‘is
basically a reductive or subtractive technology’ (Ahler 1989:
89). Based on stone artefact characteristics and following
previous research (Andrefsky 1998; Nelson 1991; Parry
and Kelly 1987; Shott 1994; Whittaker 1994), obsidian artefact
production was divided into the three stages: Initial, Further
and Late. These reduction stages and their features are listed
in Table 2. These reduction stages represent the different
states that occurred from procurement to discard. At
sedentary residences, most stages of stone production would
have been focussed at one location. In contrast, mobile stone
use would result in reduction stages being spatially
differentiated around the landscape.

Analyses
The following sections present the analyses of attributes
listed in Table 2 to investigate whether the reduction stages
are spatially differentiated.

Cortex
Cortex, the naturally weathered surface of a piece of
stone, would be removed by flaking at an early stage of
reduction. ‘As tool reduction progresses, cortex is gradually
removed from the outer surface of the core/tool and cortex
should become less frequently represented on the dorsal

The distribution of cortex on flakes is shown on Figure 3.
The amount on each flake was divided into three categories:
tertiary, secondary and primary. Tertiary was recorded where a flake had no cortex and secondary where some cortex was present; and primary where the dorsal surface of a flake was completely cortical.

There is a clear distinction between sites at different distances from the source area. Most cortex was removed within the source area, but some secondary material is present at FABK and FABO just outside the source area. These sites are only slightly further from the source area than FRI, which has a smaller assemblage and lacks primary or secondary flakes. This distribution pattern of cortex presence or absence supports the prediction that the majority of the initial reduction took place within the source area. Fairly substantial reduction must have taken place within the source area at FAO and FRL for the cortex to have such a small presence away from the source. Spatial differentiation is present in the source area, as illustrated by the lack of primary cortex and Initial reduction at FAO 1000/999.

The extensive reduction within the source area, the general lack of cortex elsewhere around the landscape and the lack of primary flakes at FAO 1000/999 support the prediction of gearing up at the source followed by curation. Large amounts of manufacture and stone use occurred within the source area, whereas latter stage working took place outside the source area (cf. Nelson 1991).

**Measurements**

One of my predictions for mobility was the presence of different stages of stone reduction at various places. Differences in the distribution of Initial, Further and Late reduction stages should be detectable between sites. Because stone use is a subtractive process, the mean size of flakes should get smaller with each reduction stage (Ahler 1989:89; Henry 1989:140).

Flake axial length, axial width and thickness data were chosen with respect to increasing distance as shown in Figures 4 to 6. For weight, data from all artefact types were grouped. The mean and standard deviation of axial length and axial width fluctuate between sites, and there is no significant decrease at sites located outside the source area.

**Table 2** Attributes and reduction stages used in the analyses.

<table>
<thead>
<tr>
<th>Reduction Stage</th>
<th>Cortex Description</th>
<th>Dimensions and Weight</th>
<th>Platform Type</th>
<th>Dorsal Scar Count</th>
<th>Cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial reduction</td>
<td>Much cortex, primary flakes</td>
<td>High</td>
<td>Plain, flaked</td>
<td>Low</td>
<td>Present</td>
</tr>
<tr>
<td>Further reduction</td>
<td>Less cortex, more secondary than primary flakes</td>
<td>Low to high</td>
<td>Plain, flaked</td>
<td>Low to high</td>
<td>Present</td>
</tr>
<tr>
<td>Late reduction</td>
<td>Rare/absent</td>
<td>Low</td>
<td>Flaked</td>
<td>High</td>
<td>Rare</td>
</tr>
</tbody>
</table>

**Figures**

- **Figure 3** Distribution (%) of primary, secondary and tertiary cortex in the sample assemblages.
- **Figure 4** Means and standard deviations of flake axial length (mm) in the sample assemblages.
- **Figure 5** Means and standard deviations of flake axial width (mm) in the sample assemblages.
- **Figure 6** Means and standard deviations of flake thickness (mm) in the sample assemblages.
With the exception of FABN, mean weight provides an interesting contrast, as flakes from sites beyond the source area are noticeably smaller. Secondly, there is also a decrease in the standard deviations of thickness and weight outside the source area (Fig. 7). This may indicate a more conservative use of material outside the source area which can be explained by more controlled flaking that resulted in less variation in flake thickness and weight. These data confirm the prediction for mobility that Further and Late reduction outside the source area would be characterised by more conservative/controlled flaking activity.

Intra-site variation is illustrated by the differences between the trenches at FAO. Trench 1000/999 is characterised by large standard deviations of flake thickness. This suggests that within the source area Initial and Further reduction were more varied and less controlled than at locations away from the source. FRL has similar mean dimensions to the other trenches within the source area, but has much larger standard deviations.

Platforms

Flake platforms can also reveal information about reduction stages. Three categories of platform - cortical, plain and flaked - represent the degree of previous flaking activity, whereas faceted platforms indicate preparation of the platform to achieve certain aims, such as greater flake length (Andrefsky 1998; Whittaker 1994:101). Crushed platforms are small platforms crushed during flaking and intensive reduction prior to flake removal. The distribution of platform types is shown in Table 3.

Cortical platforms are present at FRL and in two pits at FAO. These platforms are an unmodified surface on the core and represent Initial reduction (Andrefsky 1998:93). Flaked platforms are the most frequent platform type at FRL and 1000/1010 at FAO. Facetted platforms occur in every assemblage in the source area, but occur at only at two sites outside the source area. This presence of facetted platforms within the source area supports the idea of tool manufacture and preparation there. In contrast, plain platforms are the most frequent platform type in the remaining two assemblages from FAO and at the sites outside the source area (>50%), except at FACP. Crushed platforms occur in varying proportions in all assemblages except at FRL. This wide distribution suggests that such platforms indicate various flaking activities including damage to small platforms during intensive reduction.

Flaked platforms provide an indication that reduction occurred prior to flake removal. In a mobile economy platforms outside the source area should indicate previous flaking and Further or Late reduction. A test was conducted to observe whether the dominance of plain platforms outside the source area was due to decreasing platform size and subsequent loss of evidence of previous flaking, or an indication of reduction stage. The correlation coefficient was calculated from the average platform size and the percentage of plain platforms at each site (Table 4).

The Correlation Coefficient of these two rows of data is –0.44, suggesting a negative correlation between platform size and the occurrence of plain platforms. In other words as average platform size decreases, the occurrence of plain platforms increase. The frequent occurrence of plain platforms outside the source area is largely due to smaller platform size rather than reduction stage.

Dorsal scars

Dorsal scars provide an idea of the amount of flaking that took place before a particular flake was removed. This is linked to the identification of reduction stages because a low dorsal scar count should represent an early stage of reduction, and a high dorsal scar count should represent more extensive flaking and hence Late reduction (Andrefsky 1998:106). Andrefsky (1998:106) and Shott (1994:80) consider dorsal scar counts vary with the size of a flake, so that a large flake taken from the same reduction stage as a small flake should carry more dorsal scars.

Only complete artefacts from the flake categories were used in this analysis. FRL was not used in this analysis because the individual flake scars were not recorded at this site in the original analysis. The axial width and axial length were multiplied together to provide the area (mm²) of each flake.

To test whether the dorsal scar count is linked to size of the flake, the correlation coefficient of dorsal scar count versus weight was calculated. The result (0.06) shows almost no correlation between these data sets, indicating that an increase in flake size does not necessarily mean a high dorsal scar count among the flakes studied. This result counters the argument put forward by Andrefsky (1998:106) and Shott (1994:80) that ‘smaller flakes have fewer scars ceteris paribus.’

To investigate the presence of Late stage flaking, the percentage of flakes with more than three dorsal scars was calculated (Fig. 8). Using this calculation, Late stage reduction makes up less than 50% of the samples within the source area, and more than 50% outside it, with the exception of FACP. This confirms generally the spatial difference in reduction and presence of inter-site variability as predicted for mobile communities.
Cores
My model predicts that the most conservative use of stone would be outside the source area, so that cores taken outside the source area should only be discarded when their use became untenable. As a result, there would be fewer cores in assemblages away from the source area. To test this I analysed the distribution of cores.

Cores are present in all samples from the source area, but only one core is present at a site outside the source area, at FABO (Table 5). The activities of gearing up and obsidian use within the source area would result in cores being discarded there before being exhausted. Outside the source area where conservation of material was important, cores would be discarded when they could no longer be used.

Discussion
Table 6 summarises the results of the analyses, and lists a stage of reduction for each analysed attribute and corresponding site.

It is evident that there is a contrast in reduction stage between sites inside and outside the source area. All sites within the source area represent either Further reduction or a combination of Initial and Further. This is in contrast to sites outside the source area where Late or mixed Further and Late reduction are represented. In a mobile economy, the source area is where Initial and Further reduction should be predominant because this is where finished tools are prepared (Cowan 1999:600-01).

In my model I predicted that there would be conservation of material and inter-site variability outside the source area due to differences between sites in activities and duration of occupation. There is a noticeable trend in the variability of reduction stages outside the source area. One site (FACC) has only Late stage reduction in all but one variable; some (e.g. FABT) are mixed Further and Late, and one (FABN) has mostly Further reduction stages. The predominance of Late and a combination of Further and Late suggests more extensive reduction and conservation of obsidian.

There is variability in assemblage size between the three pits at FAO (Table 1) with an enormous amount of flaking at 1000/1010. In contrast, 1000/999 has a much smaller assemblage size, less controlled flaking, no primary cortex and the lowest average count of dorsal scars of the samples from FAO. The large amount of flaking activity at 1000/1010 represents a broad range of reduction activity, including discarded cores, primary flakes, and a high average dorsal scar count for the source area. Pit 970/1000 demonstrates similar characteristics to 1000/1010, but in a smaller assemblage.

Conclusion
These analyses of obsidian production support the prediction of variability in the stages of stone artefact production.

Table 4 Mean platform area and percentage of plain platforms.

<table>
<thead>
<tr>
<th>Site</th>
<th>Mean platform area (mm²)</th>
<th>Mean platform (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRL</td>
<td>55.2</td>
<td>36.6</td>
</tr>
<tr>
<td>FAO</td>
<td>60.5</td>
<td>29.3</td>
</tr>
<tr>
<td>FRI</td>
<td>38.4</td>
<td>71.4</td>
</tr>
<tr>
<td>FABO</td>
<td>27.9</td>
<td>51.4</td>
</tr>
<tr>
<td>FABK</td>
<td>43.2</td>
<td>52.4</td>
</tr>
<tr>
<td>FABN</td>
<td>73.7</td>
<td>62.5</td>
</tr>
<tr>
<td>FAAY</td>
<td>25.5</td>
<td>75.0</td>
</tr>
<tr>
<td>FACC</td>
<td>15.9</td>
<td>57.0</td>
</tr>
<tr>
<td>FABT</td>
<td>27.1</td>
<td>66.7</td>
</tr>
<tr>
<td>FACP</td>
<td>39.6</td>
<td>45.2</td>
</tr>
</tbody>
</table>

Table 5 Distribution of cores by sites.

<table>
<thead>
<tr>
<th>Site</th>
<th>No. of cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRL</td>
<td>3</td>
</tr>
<tr>
<td>FAO - 1000/1010</td>
<td>9</td>
</tr>
<tr>
<td>FAO - 970/1000</td>
<td>4</td>
</tr>
<tr>
<td>FAO - 1000/999</td>
<td>3</td>
</tr>
<tr>
<td>FABO</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 6 Summary of reduction stages by attributes. I = Initial reduction; F = Further reduction; L = Late reduction; – = no cores.

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production across Willaumez Peninsula during the period from 5900 to 3600 BP, and support a model of mobile land-use. The variation between sites, used here as the key to identifying mobile stone use, is due to the spatial differentiation of activities and differing lengths of stay at each site. Inter-site variation is also based on the idea that mobility does not necessarily mean moving outwards in a linear fashion from the source of important resources, such as stone. The distance of sites from the obsidian source area does not necessarily bear relation to the order in which they were visited.

These ten archaeological sites provide evidence for intra- and inter-site variability, and for greater manufacture and preparation within the source area. FRL and FAO have substantial assemblage counts and contain cores and faceted platforms, all indicators of further reduction and production of formal implements. Intra-site variability is evident between the three assemblages from FAO. Flaking activity was centered at one location (1000/1010), with similar activities but on a smaller scale at 970/1000. Pit 1000/999 is an interesting contrast, as it demonstrates more variable flake production and no primary cortex. Thus, obsidian reduction was not uniform across FAO, where there is evidence for some degree of spatial variability in flaking activities.

Outside the source area, cortex at FABO and FABK is important in relation to ideas about the role of individuals in mobility (Binford 1979; Kelly 1992). It is possible that some occupants at FABO and FABK went back to the source area and procured stone while collecting food resources – an example of embedded procurement. FRL, closer to the source area than these two sites, shows minimal occupation and more late stage working. This demonstrates the different activities and duration of occupation characteristic of sites outside the source area.

Some of the evidence from this project is not clear, and it is possible that as more trenches are excavated in this region, other trends may emerge (Symons 2001). The available data, however, support spatially differentiated reduction stages based on both distance from the source area and the nature and length of site occupation.

The major aim of this study was to test Torrence's (1992) model of mobile land-use between 5900 and 3600 BP through an analysis of lithic reduction sequences in relation to spatial patterns. In both this and Torrence's study, variation within metric attributes was linked to different relation to spatial patterns. In both this and Torrence's study, variation within metric attributes was linked to different reduction stages. Future work should expand to include evidence for occupation of Willaumez Peninsula both before and after the period of this study.

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References