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Part V

Pre-Lapita Horizons in the Admiralty Islands: Flaked Stone Technology from GAC and GFJ

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Abstract. Pioneering archaeological research in the Admiralty Islands by Kennedy (1979, 1981, 1982, 1983, 2002) and others (Ambrose, 1976, 1988, 1991; Ambrose *et al*., 1981; Ambrose & Duerden, 1982; Fredericksen *et al*., 1993; Fredericksen, 1994) revealed early on the central position and importance of these northernmost islands of the Bismarck Archipelago. Distinguished by abundant obsidian sources that were utilized and distributed by the local inhabitants for at least 12,000 years, and chert resources that were exploited for well over 20,000 years, these islands are part of the long-standing tradition of early exploration and colonization now recognized for greater Melanesia. This paper presents new technological data for the flaked stone assemblage from the sites of Peli Louson (GFJ) and Father's Water (GAC), which have cultural contexts dated to the mid and late Holocene. The technological data provide evidence about the occupation and management of the region and its resources and join an expanding dataset describing pre-Lapita settlement in island Melanesia.

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The Admiralty Islands were first settled before 21,000 BP (Spriggs, 2001: 367; cf. Fredericksen *et al*., 1993). Early occupation of these westernmost islands of the Bismarck Archipelago is consistent with the discovery and settlement of both New Ireland and New Britain in the late Pleistocene (Gosden & Robertson, 1991; Leavesley & Chappell, 2004; Pavlides & Gosden, 1994; Pavlides, 2004; Torrence *et al*., 2004). However, the minimum straight-line distance to reach Manus from New Guinea was more than 200 km over open ocean, far greater than the distances to New Ireland or

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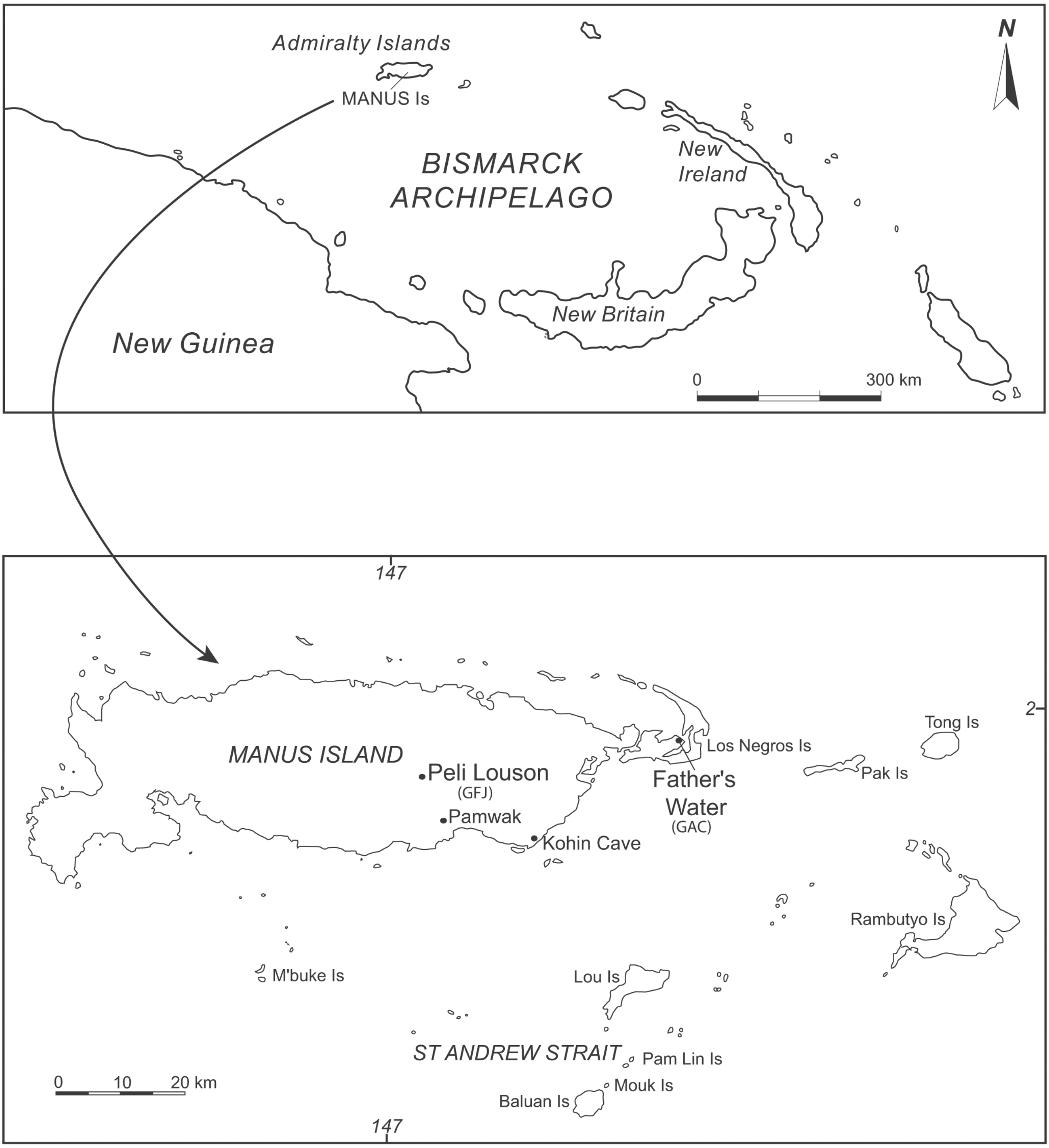

Fig. 1. The Bismarck Archipelago—location of archaeological sites and obsidian sources referred to in text.

New Britain (Fig. 1). How the early colonists of this island group adapted to and coped with their new surroundings remains to be explored. Although the sites discussed here date within the later part of the full Admiralties sequence, they can be used to explore several interesting features of Manus life during the Holocene. For example, several other Melanesian sites with Holocene chronologies indicate evidence of changing settlement organization between the early, mid and late Holocene. These changes are reflected in the organization of flaked stone technology (Pavlides, 1999, 2006; Torrence, *et al*., 2000). Questions relevant to the Manus assemblages therefore relate to understanding changing settlement patterns and site types during the mid to late Holocene. Can we see a similar set of organizational changes during this critical period in Melanesian prehistory and what might these be telling us about social and economic behaviour during the Holocene in the Admiralty Islands? Previously Pavlides (2006; also Torrence, 1992) has argued that in West New Britain society was radically transformed between 10,000 and 3,600 years ago, and that the main elements of social and economic organization more usually associated with later Lapita settlements were already in place by about 4,000 years ago. Based on changes in flaked stone technology new patterns of economy are envisioned

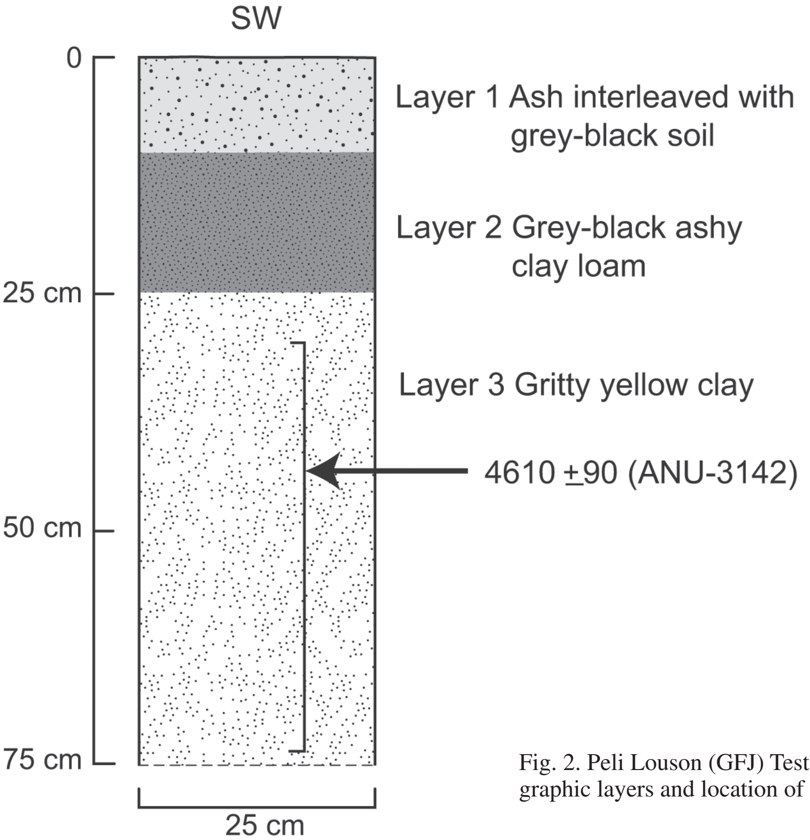

Fig. 2. Peli Louson (GFJ) Test Pit 1 southwest section—stratigraphic layers and location of radiocarbon ages.

for the mid Holocene in New Britain, including a shift to more organized and intensive plant-management (Pavlides, 1999). How the flaked stone assemblages from Manus fit into this model of Holocene change, if at all, is explored in this analysis.

The Admiralty Islands lie between 1° and 3° south of the equator and form the eastern part of Manus Province, Papua New Guinea. The Admiralties group consists of some 70 islands, the largest of which is Manus itself at about 80 km by 30 km. Temperature, rainfall and humidity are high throughout the year. The larger islands are characterized by dense rainforests, interspersed with fallow and gardens on the hill slopes, with patches of sago, nipa and mangrove swamps on flat and low-lying areas, especially along the lower reaches of the larger rivers (Freyne & Bell, 1982; Mitton, 1979; Ryan, 1972). Indigenous fauna includes mammals (mostly bats), reptiles and a variety of bird species (Kisokau, 1980). Pigs were introduced in the past, and probably also cuscus, bandicoot and rats (Flannery, 1995: 416). Hunting may have been a fairly laborious and low return venture by comparison with marine resources, which were utilized from the Pleistocene onwards and continue to be important (Schmidt, 1996: 16).

Table 1. Test pit contents by layer at sites GAC and GFJ.

site and layer	sherds	obsidian	other volcanic	chert	shell	bone
GAC						
Layer 1	●	●	—	—	—	●
Layer 2	●	●	●	●	—	●
Layer 3	—	●	●	—	—	●
Layer 4	—	—	—	—	—	●
Layer 5	—	●	—	—	●	●
GFJ						
Layer 1	●	—	—	—	●	—
Layer 2	●	●	—	—	●	—
Layer 3	—	●	●	—	●	●

The excavated sites

The two archaeological sites discussed here are Peli Louson (PNG site code GFJ), a small rock shelter in a large karst basin in the centre of Manus Island, and Father's Water (PNG site code GAC), an open coastal site on the grounds of Papitalai High School, on the north coast of the lower, geologically older arm of Los Negros, the crescent-shaped island separated from the eastern end of Manus by a very narrow channel. Both sites were recorded and excavated in 1981 (Kennedy, 1983).

GFJ—Peli Louson. Peli Louson is a narrow curving shelf overhung by limestone, above a broad stream terrace in the Upper Warei River. A 25 cm by 25 cm square was excavated against the limestone face at the rear of the rock shelter. There were three layers (Fig. 2), the upper two comprised ash lenses and ashy clay loam to a depth of 25 cm, overlying 50 cm of undifferentiated gritty yellow clay (layer 3). Bedrock was not reached. Marine shells (including gastropods and *Anadara* and *Polymesoda [Geloina]* spp.) were present throughout the deposits and obsidian was present in layers 2 and 3. There was no chert. A spherical (2.5 cm diameter) heavy volcanic pebble with a pecked surface from layer 3 was associated by informants with divination magic and retained by them.

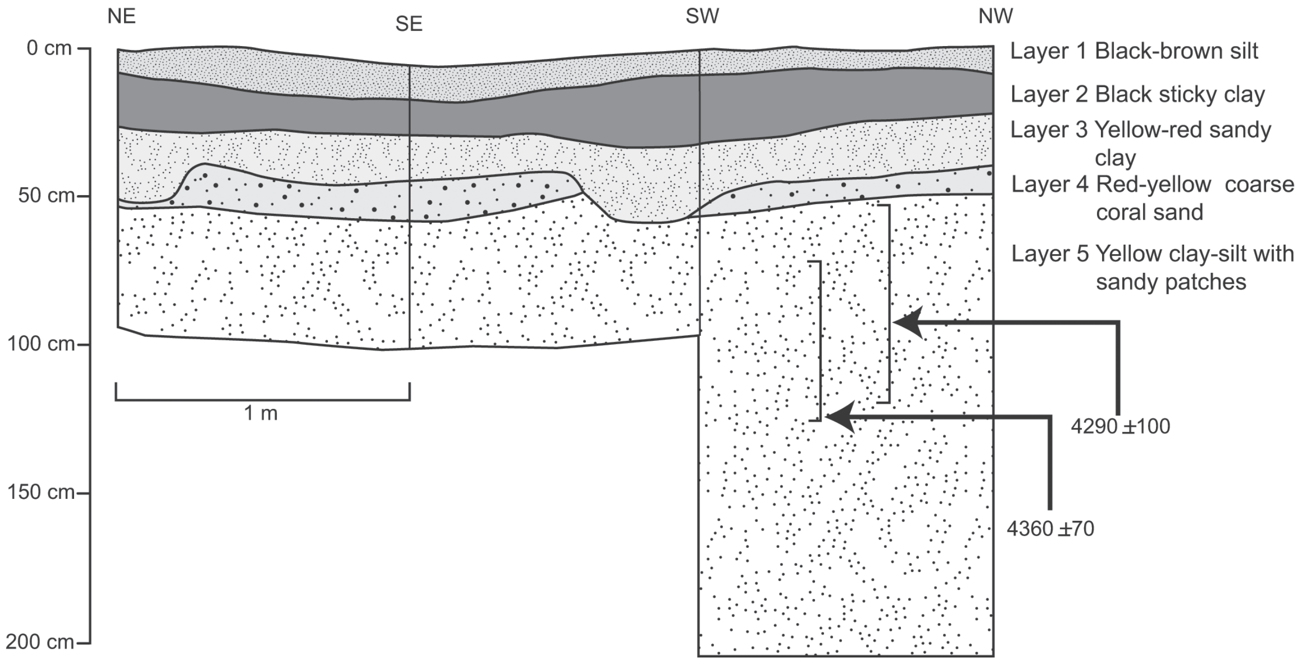

Fig. 3. Father's Water (GAC) Test Pit D1—stratigraphic layers and location of radiocarbon ages.

Sherds (one notched rim, one incised body and seven plain body) were confined to the upper two layers. One small bat or bird bone was present in layer 3 (Table 1) (Kennedy, 1983: 116).

GAC—Father's Water. The site is on a narrow stream terrace at the boundary between geologically older deposits (calcareous sandstone and basalt flows) and a more recent coral platform. The terrace is a remnant, eroding at the front into a sluggish tidal creek (Father's Water), and cut off at the back by a scarp altered by a WW II road along its top. A 1 m test square was placed near the front of the terrace; the full square was excavated to a depth of 1 m below which a further 1 m was excavated over half the square. The five layers distinguished are shown in Fig. 3. Layers 1–4 were excavated stratigraphically, and layer 5 in 20 cm spits from its surface. Layer 1 was disturbed by gardening. In the creek section, it could be seen that Layer 5 extended to a depth of about 4 m and that its base rested on a tongue of basalt just above water level.

Obsidian artefacts, abundant on the terrace surface and in the upper two layers, were also found in layers 3 and 5. A few artefacts of flaked chert and other volcanic materials (n = 6) were found in layers 2 and 3. Two volcanic stone pounders or hammer stones with pecked and ground surfaces derived from layers 2 and 3. Pottery sherds (n = 14) were confined to the upper two layers, only one of them distinctive. This and one surface-collected sherd had applied decoration (Kennedy, 1983: 116).

Bone, present throughout, was more common in the upper than the lower layers. Reef and estuarine fish dominate, with turtle and crocodile present in the upper layers. There was one murid femur in layer 4 (Kennedy, 1983: 118). Shell, including two species of *Tridacna, Anadara* and *Polymesoda [Geloina]*, and two or three gastropod species, was found only in layer 5 from 0.7 m to 1.3 m below the surface (Table 1) (Kennedy, 1983: 118).

Chronology. Radiocarbon ages obtained for GAC and GFJ are shown in Table 2. At GFJ, charcoal was not collected from layers 1 and 2, and in layer 3 a combined sample of the sparse charcoal was too small to date. The dated marine shell sample of mainly small bivalves was collected from between 0.3 m to 0.75 m in layer 3. At GAC, charcoal was abundant in layers 1 and 2, but was not collected because of the probability of gardening disturbance and root penetration. In layer 3 and below, charcoal was much sparser. To obtain the age of layer 5, two separate samples were submitted, one of charcoal collected from 0.5 m to 1.3 m below surface and the other of shells (excluding *Tridacna*) from 0.7 m to 1.3 m below surface. In both cases material from more than one spit had to be combined to provide datable samples.

Table 2. Radiocarbon ages for GAC and GFJ.

site	lab. no.	conventional age	age corrected for marine reservoir effect	calibrated 2σ	layer	depth of sample below surface (m)	sample material
GAC	ANU-3145	4290±100	*n.a.*	5260 [4847] 4535	5	0.5–1.3	charcoal
GAC	ANU-3146	4360±60	3910±70	4650 [4495] 4350	5	0.7–1.3	shell
GFJ	ANU-3142	4610±90	4160±90	5040 [4825] 4570	3	0.3–0.75	shell

450±30 years was deducted to correct for marine reservoir effect, and ages were calibrated using Calib 4.3 with ΔR set to 0 in the absence of local information.

In 1983 Kennedy used the conventional ages and applied the then-recommended ocean reservoir correction of 450±35 years to the two shell dates (Kennedy, 1983: 116–118). On the basis of the conventional radiocarbon age for the charcoal sample and the corrected shell age, Kennedy suggested that occupation represented by layer 5 at GAC occurred between 3800 BP and 4400 BP. The radiocarbon ages have now been calibrated and these results suggest the earliest cultural layers in GAC and GFJ were occupied during between 5300 and 4350 cal. BP (Table 2).

Subsequent occupations at both GAC and GFJ are undated. At GAC and GFJ decorated and plain sherds from the most recent occupations suggest, on stylistic grounds, a late Holocene age postdating Lapita (< 2500 BP) (Kennedy, 1983: 116).

This change in activity suggested by the divergent assemblages in the upper and lower layers is important, since it may reflect a shift to more organized and intensive plant-management away from cave sites. Technological changes in flaked stone assemblages before and after this time in West New Britain point to new approaches to problems of changing mobility and resource availability with a suggested concentration of land use in the mid Holocene associated with new forms of food production.

GFJ and GAC are the only two excavated sites in the Admiralty Islands with occupation beginning in the mid Holocene. Pamwak, in south-central Manus, the only site with earlier dates extending back to at least 20,000 years ago (Spriggs, 2001: 367), was also occupied in the mid Holocene (Fredericksen, 1994), but other excavated Admiralties sites are later—three belonging to the Lapita period (ca 3400–2700 cal. BP), and nine of post-Lapita age (post 2000 BP) (Kennedy, 2002: 18–24). Many more surface scatters containing late style pottery and distinctive obsidian points litter the landscape, especially in the southwest of Manus (Kennedy *et al*., 1991).

Obsidian and other stone sources. Obsidian occurs naturally in two Admiralty Islands locations, around Mt Hahie in the southwest of Manus Island (Kennedy, 1997; Kennedy *et al*., 1991), and the St Andrew Strait islands, about 30 km southeast of Manus Island. The Mt Hahie source group is geologically older, and obsidian from it may have been available before the St Andrew Strait sources (Ambrose, 2002). However, its archaeological occurrence is so far strictly localized to southwest Manus sites. The St Andrew Strait obsidian derives from Lou Island, which has several distinguishable sources, and the Pam Islands. Archaeological evidence of obsidian from either Lou Island or the Pam Islands dates from about 12,000 BP in Pamwak (Fredericksen, 1994, 1997). Obsidian assignable to Pam Island first appeared in Pamwak around 8000 years ago, followed by obsidian from the Wekwok and Baun sources on Lou Island at about 7000 BP (Fredericksen, 1994, 1997), indicating the availability and use of these three sources from the early Holocene.

Ambrose (pers. comm.), using PIXE/PIGME, assigned seven pieces from GFJ layer 3 to the Pam (n = 5) and Wekwok (n = 2) sources. In contrast, samples from GAC layers 2, 3 and 5 derive exclusively from the Wekwok source (n = 6). Fredericksen (1994: Appendix B), using less sensitive SEM energy-dispersive spectrometry, sourced GFJ layer 3 samples to Pam (n = 15) and Wekwok/Baun (n = 4). Samples from throughout the GAC site were assigned to undifferentiated Lou sources (n = 38), and three pieces from layer 2 to the Pam source. In these analyses, both tools and flake debitage were represented from both sources.

Since both Pam and Lou Island sources were utilized at GFJ in the pre-Lapita period, the absence of Pam material in GAC in the same period may indicate differences in the linkages between obsidian sources and sites where it was used.

The sources of other stone, including chert and miscellaneous volcanics, are unknown, but are probably more widespread than obsidian.

Analytical aims and methods

The aim of the analysis was to characterize the general structure and strategy of lithic procurement and production, and consider how these might have been organized in the study area. The attributes of unmodified flakes and tool blanks were examined in detail to generate inferences about the organization of technology over time. In this case the degree of reduction of raw materials and complexity of tool production and maintenance activities are critical, as are the tool types produced through time. Any chronological variations documented in the flaked stone technology may represent responses made by people facing risks associated with changing patterns of settlement mobility and economy as seen at other Melanesian sites during the Holocene (Pavlides, 2006; Torrence, 1992; Binford, 1977, 1979). The analyses presented here seek to identify whether similar changes occurred at GAC and GFJ on Manus.

The methodological framework rests on the understanding that stone technology is a reductive process. This is important to understanding the sequence from raw material acquisition and consumption, through manufacture or production, maintenance, use and finally discard (Pavlides, 1999: 192–195 for a fuller discussion). These activities represent the five general stages of reduction, which are used to make inferences about the way stone technologies are organised, and their relationship to changes in environmental circumstances, including access to raw material, and aspects of economic and social organization.

Artefact analyses

All available flaked stone artefacts excavated from GAC and GFJ were subject to a technological analysis as described in Holdaway and Stern (2004). While the sample from GFJ (n = 31) is too small for statistical tests, it nonetheless represents the complete lithic collection excavated from this site and is thus worthy of description.

Attributes. Each piece of flaked stone was described according to its raw material type, weight, technological type, form, cortex type and condition, and maximum dimension. The technological types used in this classification and the definitions of form are described below. Artefacts classified as cores, flakes or tools were further analysed by technological features (e.g., flakes by their platforms, dorsal surface characteristics, terminations, axial dimensions; cores by their platforms and flake scars; and tools by retouch variables) as outlined below.

Technological types and variables. Flaked artefacts are classified according to key technological variables, levels of completeness and form, defined as follows:

- *core*—has one or more platforms with evidence of negative flake scars initiated on the piece (Crabtree, 1972: 54). *Bipolar cores* are distinguished by a pattern of crushing and battering on at least two opposing ends with negative flake scars extending from these platforms;
- *complete flake*—displays a platform or point of percussion, single internal ventral surface, relatively intact margins and recognisable fracture termination (Crabtree, 1972: 11; Hiscock, 1984: 133);
- *complete tool*—similar to *complete flake*, though some complete tools can be made on a flake fragment (Holdaway & Stern, 2004: 168–169);
- *broken flake* or *broken tool*—is an incomplete flake or flake tool which still retains one or more flake characteristic, e.g., the proximal end with the platform, a recognisable termination, a marginal fragment or is a longitudinal split flake with part of the platform and/or termination (Holdaway & Stern, 2004: 111–112);
- *complete* or *split bipolar flake*—has a crushed platform, dorsal scars and ventral ripple marks radiating from the proximal and distal ends of the flake (White, 1968; Kobayashi, 1975; Patterson & Sollberger, 1976: 40; McCoy, 1982: 265; Magne, 1989: 17);
- *flaked piece*—has one or more ventral surfaces or part of a negative flake scar (Hiscock, 1988: 322), but cannot be classified as either a flake, tool or core, though it is probably the result of conchoidal fracture (Hiscock, 1984: 133). These artefacts also lack evidence of an impact point or platform;
- *angular fragment*—may have one or more concave flake-like surfaces but displays no clear flake or core attributes; generally irregular in form and lack evidence of an impact point or platform (Holdaway & Stern, 2004: 113);
- *tools*—have either macroscopic or microscopic edge modification, irrespective of form.
  All artefacts were examined under 7–40 × stereomicroscope. Continuous clusters of negative flake scars, crushing and edge rounding (Tringham *et al*., 1974: 185–191; Fullagar, 1986) were all considered evidence of retouch: no attempt was made to distinguish between purposeful retouch and use-damage on tools (cf. Holdaway & Stern, 2004: 154; Pavlides, 1999, 2004).

Form. All artefacts classified as either complete or broken flakes or tools are further subdivided on the basis of form. Three flake types are recognized: *normal, other* and *irregular. Normal* flakes are those with regular technological characteristics (e.g., platform, bulb of percussion and termination) and are neither the result of *other* special flaking activities such as core platform rejuvenation nor *irregular* in shape (thicker than they are wide). Core platform rejuvenation flakes (*other* flakes) have remnant platforms on their dorsal surface other than the platform surface associated with the removal of the flake. *Normal* flakes represent the majority of flake and tool blanks. These categories differentiate flakes with morphologies outside the expected range of normal variation from the majority of flakes. Only flakes and tools classified as *normal* are included in analyses of debitage, so as not to artificially increase variability in attributes such as size and shape.

Cores. Core variables describe aspects of reduction strategy, including raw material conservation and intensity of flaking as measured by the number of flakes removed from a core. The core type (single platform, multi-platform and bipolar), core blank type (block, flake, cobble or indeterminate), number of platforms, number of core scars, longest complete core scar and maximum platform height remaining on a core (the distance between any useable platform and the opposing core edge), are all useful in reconstructing elements of reduction strategies. The mode of flaking was recorded as uni-directional, bi-directional, multi-directional, bifacial or bipolar. Several cores displayed a combination of these flaking modes and were recorded accordingly (Table 7).

Flakes. *Platform characteristics*. Platform characteristics were recorded for all complete and proximal flakes and tools, and marginal flakes and tools with intact platforms. Platform surface types include flaked (single or multiple scars), facetted, focal, crushed, collapsed, or a combination of these. No cortical platforms were observed in these assemblages. The presence or absence of overhang removal was noted as one of four states: absent, one flake scar, many regular flake scars and many stacked step scars. These platform attributes are important because they describe the form of the core face from which the flake was detached.

Dorsal surface characteristics. The location of cortex on complete flakes and tools was recorded using the quadrant system (Baumler, 1988: 263), which divides the artefact into quadrants, numbered 1 to 4 beginning with the platform and moving clockwise around the flake. The same recording method is used to describe the direction of dorsal scars and the position of retouch (see below). The location of dorsal cortex was recorded for all complete cortical flakes and tools.

Dorsal scar count was recorded using staged intervals (0, 1, 2–3, ≥4), to organise the data into reference units from which artefacts can be divided into early and later stages in the reduction sequence. Both complete and incomplete scars were counted on all complete flakes and tools, and their orientation recorded using the quadrant system described above. Flake scars traversing quadrants were recorded with multiple quadrant numbers. The dorsal scar arrangement was recorded for all complete flakes and tools.

Metric data. The axial dimensions of all complete flakes and tools were measured with electronic callipers to the nearest tenth of a millimetre. Axial length was taken between the impact point and termination, and oriented in the direction of force application. Axial width and thickness were taken at right angles to the line of axial length, half way down the line of percussion between the left and right margins, and ventral and dorsal surfaces (Hiscock, 1988: 366; Hiscock & Hall, 1988: 85).

Table 3. The number and weight (g) of stone artefacts from GAC and GFJ.

site and layer	obsidian		chert		volcanic		total	
	n	(g)	n	(g)	n	(g)	n	(g)
GAC								
Layer 1	415	626.1	1	9.8	—	—	416	635.9
Layer 2	292	683.9	2	30.6	1	75.0	295	789.5
Layer 3	8	22.3	1	5.4	1	154.8	10	182.5
Layer 4	—	—	—	—	—	—	—	—
Layer 5	10	72.6	—	—	—	—	10	72.6
total	725	1404.9	4	45.8	2	229.8	731	1680.5
GFJ								
Layer 1	—	—	—	—	—	—	—	—
Layer 2	1	—	—	—	—	—	1	0.6
Layer 3	30	—	—	—	—	—	30	75.8
total	31	—	—	—	—	—	31	76.4

Tools. All artefacts classed as either complete or broken tools were further classified by morphological type, and the type, direction and orientation of retouch per edge. Four morphological types are recognized in the Manus assemblages: scrapers, end scrapers, notched pieces and flake tools. Flake tools are flakes characterized by the presence of light retouch or micro-damage which may equate to use-damage, whereas scrapers have invasive continuous overlapping retouch. End scrapers were distinguished on the basis of retouch location.

Retouch scars. The nature and positioning of retouch around the edges of all complete and broken tools, and some cores, was recorded using the quadrant system. For each of the four edges of a tool, the presence or absence of retouch was recorded in one of nine categories:

- ventral, dorsal and/or bifacial edge damage—small retouch scars on either surface;
- steep ventral, dorsal and/or bifacial scars—larger overlapping retouch scars on either surface;
- ventral and/or dorsal notch—concave areas of retouch on either surface;
- N/A—no retouch on any edge.

This level of detail describes both the type and orientation of retouch scars and allows analysis and quantification of the dominant direction of retouching and edge damage (Pavlides, 1999: 205–207).

Flaked stone assemblages from GFJ and GAC

The GFJ test pit produced 31 pieces of flaked obsidian from layers 2 and 3, whereas the larger test pit at GAC produced 729 flaked obsidian and chert artefacts and two artefacts of pecked volcanic stone (Table 3). Fredericksen (1994: table 5.4) lists ten additional obsidian pieces from GAC, including two from layer 4 and one from layer 5. The original site description and catalogue record no artefacts in layer 4. These disparities have little effect on the overall appearance of the assemblage.

Procurement strategies, raw material selection and reduction stages. The earliest stage of flaked stone reduction involves initial decisions regarding raw material selection and procurement. This stage is important because decisions made regarding raw material procurement influence not only the general structure and strategy of reduction, but also the creation of various site types around the landscape, for example quarry and associated initial flaking sites versus manufacture and discard locations. These aspects of flaked stone reduction are therefore relevant to questions about the varying nature of settlement patterns through time.

Artefact attributes, such as raw material type, the type and condition of cortex, the overall proportion of cortex, the overall frequency of artefactual and non-artefactual material throughout each site's deposits, and the distribution of fracture class frequencies within assemblages, may reflect the initial steps associated with early stage reduction strategies, and are therefore relevant variables to analyse in the context of changing settlement patterns and economic behaviour.

Cortex. The low incidence of dorsal cortex on obsidian flakes points to the flaking of decortified material, that is, material other than rolled cobbles or weathered rock from ancient flows (Table 4). Three artefacts (a core, a tool and a broken flake from GAC layer 2) have a rough rolled cortex distinctive of water-worn cobbles. The other 10 examples display flat weathered surfaces. While there are proportionally more cortical artefacts in layer 3 at GAC than in more recent layers, the small sample is problematic. The presence of remnant cortex on only one of the cores mirrors the general flake population.

Table 4. The number and percentage of cortical obsidian artefacts from GAC and GFJ.

	GAC				GFJ
	Layer 1	Layer 2	Layer 3	Layer 5	Layer 3
n	2	8	1	—	2
%	0.5	2.7	12.5	—	6.7

Table 5. Fracture classes for obsidian artefacts in GAC and GFJ.

fracture class	GAC								GFJ					
	Layer 1		Layer 2		Layer 3		Layer 5		Layer 1		Layer 2		Layer 3	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
core—freehand	9	2.2	7	2.4	—	—	—	—	—	—	—	—	1	3.3
core fragment	2	0.5	1	0.3	—	—	—	—	—	—	—	—	—	—
bipolar core	1	0.2	—	—	—	—	—	—	—	—	—	—	—	—
tool complete	6	1.4	7	2.4	1	13	3	30	—	—	—	—	2	6.7
tool broken	7	1.7	14	4.8	—	—	2	20	—	—	—	—	1	3.3
tool other form	1	0.2	1	0.3	—	—	—	—	—	—	—	—	—	—
flake complete	97	23.4	71	24.3	2	25	1	10	—	—	—	—	10	33.3
flake broken	271	65.3	164	56.2	4	50	2	20	—	—	1	100	14	46.7
flake broken bipolar	—	—	1	0.3	—	—	—	—	—	—	—	—	—	—
flake other form	17	4.1	19	6.5	1	13	2	20	—	—	—	—	1	3.3
flake irregular form	—	—	1	0.3	—	—	—	—	—	—	—	—	—	—
flaked piece	2	0.5	3	1.0	—	—	—	—	—	—	—	—	1	3.3
angular fragment	2	0.5	3	1.0	—	—	—	—	—	—	—	—	—	—
total	415	—	292	—	8	—	10	—	—	—	1	—	30	—

The extremely small sample of chert artefacts (n = 4) from GAC lacks cortex and also primarily represents late-stage artefacts (Table 6).

Table 6. Fracture classes for chert artefacts in GAC.

fracture class	Layer 1		Layer 2		Layer 3	
	n	wt (g)	n	wt (g)	n	wt (g)
flake complete	1	9.8	1	8.2	—	—
flake broken	—	—	—	—	1	5.4
flaked piece	—	—	1	22.4	—	—
total	1	9.8	2	30.6	1	5.4

Fracture class frequencies. There is no evidence of material testing or activities indicative of early reduction stages (such as flaked pieces, irregular flakes or angular fragments) in the lower layers at GAC (Table 5). Although low proportions of these artefact types are present in layers 1 and 2, the general pattern of production through time at GAC indicates high proportions of flaking debitage that is consistent with late stage production and use activities (i.e., complete and broken flakes and tools).

Other indications of late-stage flaking activities are the presence of core platform rejuvenation flakes (“flake other form” and “tool other form”), distinguished by the presence of old platforms on their dorsal surface. The latter form is represented in higher proportions in layers 3 and 5 at GAC, although sample sizes are small (Table 5). In the more recent layers at GAC they represent a moderate portion of the assemblages.

In GFJ, late-stage flakes also make up the majority of the assemblage, although one artefact in layer 3 is a platform removal flake (“flake other form”) (Table 5).

The steady decrease in the relative proportion of obsidian tools to unmodified flakes suggests a higher proportion of use-related activities at GAC in earlier layers (3 and 5), although the sample in these layers is small (Table 5). In contrast, GFJ layer 3, chronologically equivalent to layer 5 at GAC, has a considerably lower proportion of tools to unmodified flakes (10%, n = 3).

In summary, and combining the evidence from both sites, the composition of the later assemblages can be characterized as mixed stone technologies representing production, use and maintenance activities rather than the mostly use-related activities in the earliest layers. There is no evidence of early-stage reduction at either site.

Reduction strategies. Secondary reduction activities account for the bulk of the flaked stone material. The changing state of technological attributes such as flake and tool dimensions, platform type, overhang removal type, dorsal scar count, the proportion of dorsal cortex on artefacts and the termination type can be indicative of later stage reduction. Here simple flaking, indicative of early stage reduction, and complex multi-step flaking, indicative of later reduction, are contrasted in order to separate and then compare assemblage proportions. It is the changing state of various attributes as they pass through different stages of the reduction continuum that renders them useful in the analysis of manufacturing activities. This information is then used to reconstruct the generalized reduction sequences represented in the study area and to investigate changing patterns of resource use, settlement and economy.

Table 7. Obsidian core types and flaking modes at GAC and GFJ.

	GAC		GFJ
	Layer 1	Layer 2	Layer 3
core types			
single platform	1	2	1
multi-platform	10	6	—
bipolar	1	—	—
flaking mode			
unidirectional	2	3	—
bidirectional	1	—	—
multi-directional	7	5	—
bifacial	3	2	1
bipolar	1	—	—
total cores	12	8	1

Table 8. Number of flake scars on GAC obsidian cores

site and layer	core types	no. of flake scars 3	4	5	6	7	8	9	10	11	14
GAC											
1	single platform	1	—	—	—	—	—	—	—	—	—
	multi-platform	2	2	2	—	—	—	1	1	1	1
	bipolar	—	—	—	1	—	—	—	—	—	—
	total (12)	3	2	2	1	—	—	1	1	1	1
2	single platform	—	1	1	—	—	—	—	—	—	—
	multi-platform	—	1	2	—	1	—	2	—	—	—
	total (8)	—	2	3	—	1	—	2	—	—	—
GFJ											
3	single platform	—	—	—	—	—	1	—	—	—	—
	total (1)	—	—	—	—	—	1	—	—	—	—

Flaking mode. The dominant flaking mode at both sites is freehand flaking of blocks and flakes. Of the 21 cores and core fragments (Tables 5 and 7), only one is from GFJ, a small (maximum length 24.4 mm), bifacially flaked core, discoidal in shape, in layer 3. The 20 cores from GAC are from layers 1 and 2 only (see Fig. 4). The single bipolar core in layer 1 at GAC reflects the very low incidence of bipolar flaking at this site (Table 5). There is only one bipolar flake in the entire assemblage and this is from layer 2.

Evidence of bifacial flaking was proportionally higher in layer 1 than 2 at GAC. Multi-directional flaking dominated in layer 1 (Table 7).

Table 9. Number of platforms on obsidian cores from GAC.

no. of platforms	1	2	3	4	6
GAC layer 1	1	2	5	3	1
GAC layer 2	2	3	3	—	—
total (20)	3	5	8	3	1

Scar count on cores. A count of the number of scars on cores suggests that GAC multi-platform cores are reduced to a greater extent than both the single platform cores and the bipolar cores in layers 1 and 2 (Table 8). Also, cores displaying the highest numbers of scars (greater than ten negative flake scars in layer 1 and nine negative flake scars in Layer 2) have all been flaked bifacially. The bifacially flaked core from layer 3 at GFJ has eight flake scars.

Platform to core ratio. The platform to core ratio in layer 2 at GAC is 2.1:1 (total number of platforms 17), confirming a pattern of low intensity flaking. This is only slightly increased in layer 1 (platform to core ratio 3.2:1, total number of platforms 38) (Table 9). When the number of scars on cores is compared to the number of dorsal scars on complete flakes, the generally low levels of core reduction are confirmed. Based on the platform to core ratios and the number of scars on cores, the material from layer 1 at GAC appears to have been more intensively reduced than that in other layers.

The GFJ core has one continuous bifacial platform around its circumference. Despite the relatively low number of platforms on this small core, it has a large number of negative flake scars (n = 8). However, this is in line with data from flakes; 50% (n = 5) of the layer 3 flake assemblage has four or more dorsal scars, indicating intensive reduction (Table 10). In the chronologically equivalent layer 5 from GAC, the pattern appears to be one of less intensive flaking of obsidian (Table 10).

Each of the two chert flakes from GAC layers 1 and 2 has more than three dorsal scars.

Flake length versus core scar length. A comparison of flake length with core scar length provides a further test of flaking intensity and/or raw material economy (Table 11). At GAC layer 2, only 29.3% (n = 69) of the complete and broken obsidian flakes have a maximum dimension greater than the overall mean core scar length (23.2 mm). In layer 1, almost half the flakes (49.2%, n = 181) are longer than the mean core scar length (17.1 mm). This result suggests

Table 10. Number of dorsal scars on complete obsidian flakes from GAC and GFJ.

no. of dorsal scars site and layer	1 n	 %	2–3 n	 %	≥4 n	 %	 total
GAC							
Layer 1	7	7.2	40	41.2	50	51.5	97
Layer 2	6	8.5	40	56.3	25	35.2	71
Layer 3	—	—	2	100	—	—	2
Layer 5	1	100	—	—	—	—	1
GFJ							
Layer 3	1	10	4	40	5	50	11

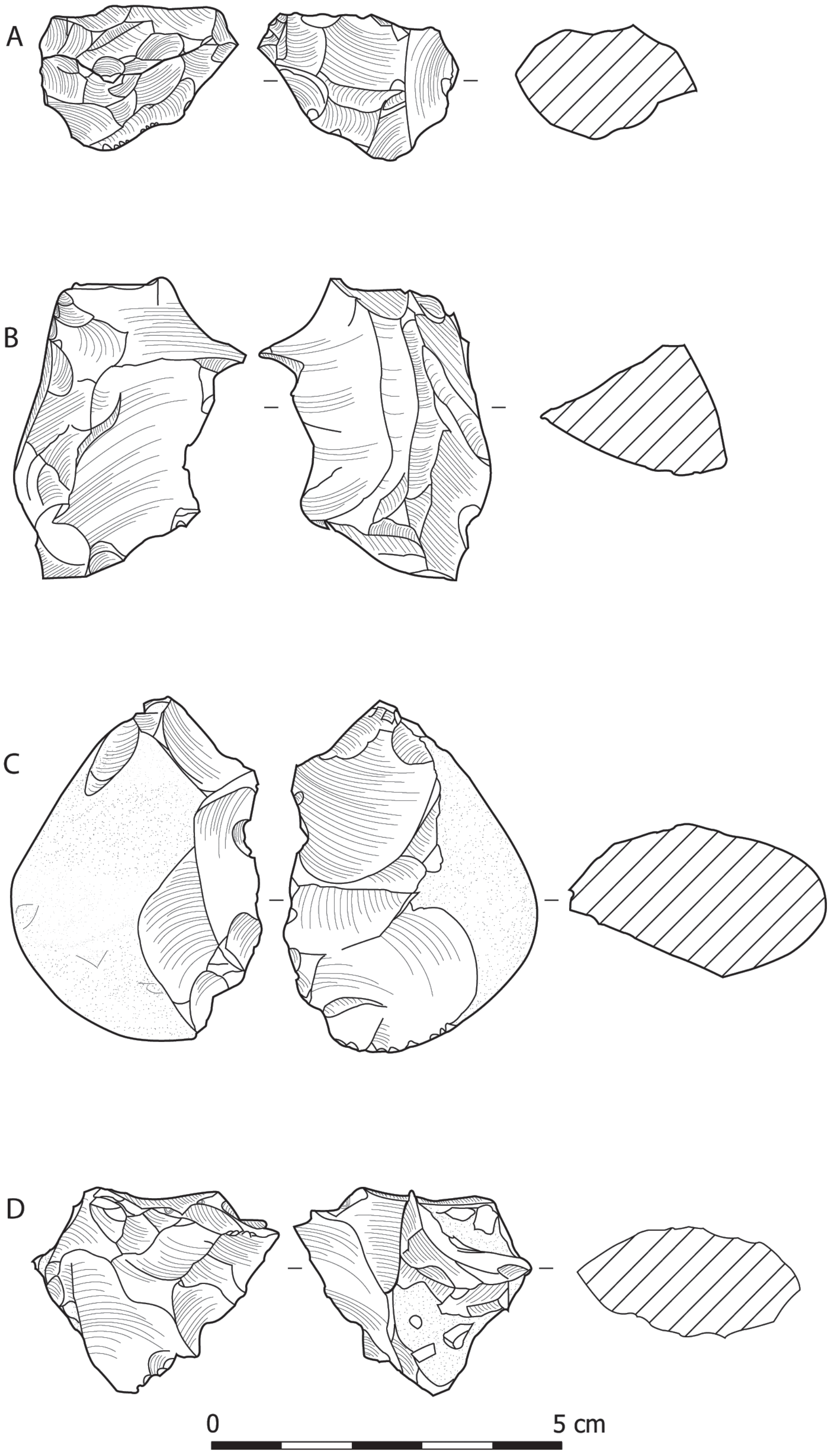

Fig. 4. Cores from GAC: *A*: Layer 1, multi-platform core with multi-directional and bifacial flaking; *B*: Layer 1, multi-platform core with multi-directional flaking; *C*: Layer 2, multi-platform core on an obsidian pebble with bifacial and multi-directional flaking; *D*: Layer 2, multi-platform core with multi-directional and bifacial flaking.

Table 11. Mean core scar length (mm) and maximum potential platform height (mm) on cores from GAC and GFJ.

core type		GAC Layer 1					GAC Layer 2					GFJ Layer 3	
		n	mean	min.	max.	s.d.	n	mean	min.	max.	s.d.	n	mm
single platform	core scar length	1	10.6	—	—	—	2	19.7	16.6	22.7	4.3	1	14.2
	platform height	1	10.9	—	—	—	2	24.8	24	25.5	1.1	1	16.3
multi-platform	core scar length	10	17.9	8.3	32.8	7.3	6	24.4	15.6	31.9	6.9	—	—
	platform height	8	27.6	18.3	41.5	6.8	6	33.8	21.6	46.5	8.8	—	—
bipolar	core scar length	1	15.4	—	—	—	—	—	—	—	—	—	—
	platform height	1	24.1	—	—	—	—	—	—	—	—	—	—

Table 12. Platform surfaces on complete and broken flakes GAC and GFJ.

flake platform surface	GAC Layer 1		Layer 2		Layer 3		Layer 5		GFJ Layer 3	
	n	%	n	%	n	%	n	%	n	%
one flake	80	53.7	58	56.3	—	—	—	—	8	61.5
several flakes	32	21.5	22	21.4	1	50	1	100	—	—
one flake + facetting	2	1.3	3	2.9	—	—	—	—	—	—
several facets	10	6.7	7	6.8	1	50	—	—	2	15.4
focal	4	2.7	—	—	—	—	—	—	1	7.7
crushed	2	1.3	2	1.9	—	—	—	—	2	15.4
collapsed	19	12.8	11	10.7	—	—	—	—	—	—
total	149	—	103	—	2	—	1	—	13	—

that obsidian cores in layer 1 were discarded at a later stage in their reduction than those in layer 2.

At GFJ, 62.5% (n = 15) of complete and broken obsidian flakes from layer 3 have a maximum dimension greater than the core scar length (14.2 mm), suggesting intensive reduction of cores at that time.

Core size. At GAC, the average maximum length of cores in layer 1 is 29.6 mm (n = 12) compared to 36.7 mm (n = 8) in layer 2, and 24.4 mm in layer 3 at GFJ (n = 1). The difference in the mean maximum length of cores in layers 1 and 2 at GAC is statistically significant ($t = 1.934$, $df = 18$, $p = 0.069$), but small sample sizes preclude further statistical analysis of size differences between sites and dated layers.

Flaking direction. The predominant flaking direction indicated by the location of dorsal scars on flakes is from a single platform (quadrant 1), that is, uni-directional. At GAC this pattern is consistent through time, with the exception of the single complete flake from the earliest layer, which was removed from a rotated core and flaked in the direction of quadrant 2. At GFJ the ten complete flakes have all been flaked from a single platform, with only one artefact showing rotation of the core in two directions. These patterns of minimal core rotation are consistent with generally non-intensive flaking practices through time, however they do not match the pattern described for the small sample of cores, many of which display multi-directional flaking.

The two complete chert flakes from GAC show the same pattern.

Platform preparation. The proportion of obsidian flakes with intensive platform preparation, such as a series of flake scars or facetting, is relatively equal in the later layers at GAC (layer 1: 29.5%, n = 44; layer 2, 31.1% n = 32) but the small number of flakes in layers 3 and 5 preclude comparison with the later layers (Table 12). At GFJ, simple platform treatments such as single flake scars dominate the layer 3 assemblage (Table 12).

This pattern of more intensive platform treatment early on in the sequence at GAC is not borne out by the attribute of overhang removal. At GAC the two early flakes lack dorsal trimming, and relatively high proportions of obsidian flakes display little or no dorsal trimming in layers 1 and 2 (Table 13). There are almost equal proportions of simple and intensive treatments applied to core faces in layer 3 at GFJ (Table 13).

Table 13. Overhang removal types on complete and broken flakes GAC and GFJ.

overhang removal	GAC Layer 1		Layer 2		Layer 3		Layer 5		GFJ Layer 3	
	n	%	n	%	n	%	n	%	n	%
absent	67	48.2	49	50.5	—	—	1	100	5	38.5
1 flake	10	7.2	10	10.3	—	—	—	—	1	7.7
many regular scars	44	31.7	19	19.6	2	100	—	—	3	23.1
many step scars	18	12.9	19	19.6	—	—	—	—	4	30.8
total	139	—	97	—	2	—	1	—	13	—

The chert flakes from GAC layers 1 and 2 each have simple platform treatments. Only the flake from layer 2 has been trimmed to remove overhang.

Size change through time: metrical data

The difference in the nature of flaking activities is indicated by size variation of flakes. Decreasing artefact size can be used both to deduce reduction order and to compare different categories of flaking debris. For these reasons differences in artefact size between these sites provide information about the selection of workable cores and the organization of production through time. Regularities in flaking within and between successive chronological units can also be investigated through analyses of maximum and axial flake and tool sizes.

Table 14. The mean maximum length (mm) of non-cortical flakes from GAC and GFJ.

site and layer	obsidian mean length n	(mm)	s.d.	chert max. length n	(mm)
GAC					
Layer 1	97	19.9	8	1	35.2
Layer 2	70	23.6	11.1	1	44.9
Layer 3	2	29.5	7.4	—	—
Layer 5	1	42.7	—	—	—
GFJ					
Layer 3	9	19.7	9.3	—	—

Flake size—maximum dimensions. There is a significant difference between the maximum dimensions of flakes from layers 1 and 2 ($t = 2.368$, $df = 118.5$, $p = 0.02$) (Table 14). However, the sample sizes from GAC layers 3 and 5 are too small to test the significance of differences in the mean maximum lengths of flakes. This result indicates that flake production was not standardised, at least in the more recent period, with flake lengths decreasing though time. These data are consistent with that presented above for decreasing core size in layers 1 and 2 at GAC (see Table 14).

The single cortical flake from GAC layer 2 is quite large (38.9 mm) compared with the mean length of non-cortical flakes from this layer, a result expected from the general principles of reduction. The two chert flakes from GAC are also comparatively long (Table 14).

The obsidian flakes from layer 3 at GFJ (Table 14) are smaller than the single flake from the chronologically equivalent layer 5 at GAC. This result may indicate more intensive reduction of cores at GFJ compared to GAC at this time, consistent with data for core size, flake scars and discard thresholds at GFJ. However, the sample size in GFJ layer 3 is only one artefact.

Table 16. The mean axial dimensions of cortical flakes >10 mm in axial length from GAC.

raw material and GAC layer	n	axial length mm	axial width mm	axial thickness mm
obsidian				
Layer 2	1	32.3	22.4	7.1
chert				
Layer 1	1	20.8	23.7	11.6
Layer 2	1	37.9	29.8	8.1

Flake size—axial dimensions. Of the axial dimensions of non-cortical obsidian flakes from layers 1 and 2 at GAC, only the difference in width is significant: greater in layer 2 ($t = 2.143$, $df = 116.6$ $p = 0.034$) (Table 15). Axial length and thickness are comparable in layers 1 and 2 (length $t = 1.812$, $df = 133.7$, $p = 0.072$; thickness $t = 0.975$, $df = 118$, $p = 0.331$). The mean axial dimensions of the seven flakes from layer 3 at GFJ vary only slightly from those of layer 2 at GAC (Table 15).

The single cortical flake from layer 2 at GAC is again larger than its non-cortical counterparts in all mean axial dimensions, as are the chert flakes from layers 1 and 2 (Table 16).

In summary, the obsidian flake dimensions indicate the production of slightly smaller artefacts in the most recent period (layer 1) at GAC. Axial lengths and thicknesses vary less over time than axial widths. Cortical artefacts appear to be larger than non-cortical artefacts, however sample sizes are extremely small. Artefacts from layer 3 at GFJ appear to be smaller than artefacts from layer 5 at GAC. Thus, it is possible that in the mid Holocene, the large flakes produced at GAC were made from nodules of raw material that were larger than those available to the inhabitants of GFJ.

Table 15. The mean axial dimensions of non-cortical flakes >10 mm in axial length from GAC and GFJ.

site and layer	axial length (mm) n	mean	s.d.	axial width (mm) n	mean	s.d.	axial thickness (mm) n	mean	s.d.
GAC									
Layer 1	118	14.0	6.5	97	14.0	6.2	97	3.8	2.2
Layer 2	81	16.1	9.2	70	16.6	8.7	70	4.3	3.1
Layer 3	2	25.0	9.5	2	14.4	3	2	4.6	1.8
Layer 5	1	36.3	—	1	38.3	—	1	5.9	—
GFJ									
Layer 3	7	17.9	5.3	7	13.8	5.9	6	4.3	3.0

Procurement strategies and reduction sequences through time

On geological grounds (see above discussion), the obsidian used at GFJ and GAC has been identified as coming from St Andrew Strait sources. Procurement strategies and the consumption of stone material used by the inhabitants of these sites appear to have involved small amounts of stone probably being moved around the landscape as decortified blocks or flake blanks. This movement could have involved either direct access or some form of down the line exchange.

The technological types represented within the assemblages indicate a pattern of primarily late-stage reduction and use activities rather than early stage production-based activities. The layer 1 and 2 assemblages at GAC have a more mixed technological composition, indicative perhaps of base camp occupation, with most production taking place on site, rather than transient use locations or stopping points within a wider settlement pattern. The higher incidence of tools and late-stage artefacts to unmodified flakes in the earlier layers at GAC may support the latter pattern of transient occupation at GAC possibly associated with broad ranging mobility patterns. This is similar to one aspect of the technological pattern revealed for the early Holocene at Yombon in West New Britain (Pavlides, 1999, 2006).

Core reduction strategies involve the flaking of single or multi-platform cores, with negligible evidence of bipolar flaking restricted to layers 1 and 2 at GAC. Low levels of core rotation were noted at GAC, with cores from layer 1 appearing to have been more intensively reduced than those of earlier periods. This is also reflected in the decrease in mean maximum length of flakes from layer 2 to layer 1. This is interesting because it may suggest restricted access to material later in the sequence. Another possible explanation for this pattern is a reduction in settlement mobility leading to changes in raw material access. At GFJ the intensive reduction of the single core with bifacial flaking from layer 3, combined with the high proportion of flakes within the assemblage that are longer than the mean core scar length on this core, and the small mean maximum dimensions of flakes, all suggest maximising behaviour in relation to the use of raw material.

Table 17. Dorsal scar counts on complete tools from GAC.

no. of dorsal scars	1		2–3		≥4		total
	n	%	n	%	n	%	
Layer 1	1	16.7	2	33.3	3	50	6
Layer 2			3	42.9	4	57.1	7
Layer 3					1	100	1
Layer 5					3	100	3

However, neither platform preparation and trimming nor the numbers of dorsal scars on flakes support intensive treatments. At best, the assemblages from layer 1 at GAC and layer 3 at GFJ have equal proportions of flakes with high and low numbers of remnant dorsal scars, reflecting an even mix of early and late-stage reduction. Platform surface treatments at GAC suggest more intensive treatments in the early period, although overhang removal treatments were non-intensive at this time.

Both mean maximum and axial dimensions suggest a steady decrease in flake size through time at GAC. Where statistical tests could be performed, only mean maximum length and axial width decreased significantly between layers 2 and 1. Nevertheless there is a trend towards reduced artefact size through time in the unmodified flake assemblage.

Table 18. Platform surface types on complete and broken obsidian tools from GAC.

platform surface	Layer 1		Layer 2		Layer 3		Layer 5	
	n	%	n	%	n	%	n	%
one flake	2	22.2	9	81.8	1	100	2	50
several flakes	2	22.2	—	—	—	—	—	—
one flake + facetting	—	—	—	—	—	—	1	25
collapsed	—	—	1	9.1	—	—	—	—
N/A	5	55.6	3	—	—	—	1	25
total	9		11		1		4	

Table 19. Overhang removal types on complete and broken obsidian tools from GAC.

overhang removal	Layer 1		Layer 2		Layer 3		Layer 5	
	n	%	n	%	n	%	n	%
absent	2	22.2	5	38.5	1	100	1	25
one flake	—	—	1	7.7	—	—	1	25
many regular scars	1	11.1	3	23.1	—	—	1	25
many step scars	1	11.1	2	15.4	—	—	—	—
N/A	5	55.6	2	15.4	—	—	1	25
total	9		13		1		4	

Table 20. The mean maximum dimension (mm) of non-cortical and cortical obsidian tools from GAC and GFJ.

site and layer	non-cortical mean length n	mm	s.d.	cortical max. length n	mm
GAC					
Layer 1	6	34.1	16.3	—	—
Layer 2	7	32.9	8.1	—	—
Layer 3	—	—	—	1	22.1
Layer 5	3	42.6	3.8	—	—
GFJ	—	—	—	—	—
Layer 3	2	23.8	7.5	—	—

Table 21. The mean axial dimensions (mm) of cortical and non-cortical obsidian tools >10 mm in axial length from GAC and GFJ.

site and layer	axial length			axial width			axial thickness		
	n	mean	s.d.	n	mean	s.d.	n	mean	s.d.
GAC									
non-cortical									
Layer 1	5	30.2	7.0	4	25.3	18.4	4	6.0	1.7
Layer 2	8	26.7	9.1	7	23.3	5.9	7	7.1	3.4
Layer 5	3	36.3	6.6	3	27.2	11.3	3	8.0	3.6
cortical									
Layer 3	1	20.9	—	1	12.1	—	1	3.7	—
GFJ non-cortical									
Layer 3	2	28.3	12.8	1	17.8	—	1	3.8	—

Table 22. The frequency of obsidian tool types from GAC and GFJ.

tool types	GAC Layer 1	Layer 2	Layer 3	Layer 5	GFJ Layer 3
flake tool	3	5	1	3	—
notched tool	3	4	—	—	1
scraper	8	11	—	2	2
end scraper	—	2	—	—	—
total	14	22	1	5	3

Tool blank technology and reduction

There are 42 complete and broken tools from GAC and three from GFJ (regardless of form), all obsidian. As described above, the proportion of tools to flakes at both sites decreases slightly through time (Table 6).

The technology of tool blank production at GAC and GFJ indicates the selection of primarily late-stage tool blanks. Decortified flakes (tool blanks) were routinely selected for modification and use. Only two tools from GAC have cortex. The one from layer 3 has a flat weathered surface, whilst that from layer 2 has a rough water-rolled cortex. The number of dorsal scars on tools also indicates that later rather than early stage flake blanks were chosen more frequently for use and retouching at both sites through time. In layers 2, 3 and 5 at GAC the proportion of tools with three or less dorsal scars is slightly lower than that for the assemblage of unmodified complete flakes (Tables 17 and 10). These data confirm a pattern of selection involving late-stage blanks. The two complete tools from GFJ both have more than three dorsal scars.

The direction of dorsal scars indicates flaking predominantly from a single platform (quadrant 1) with minimal core rotation towards quadrant 4 on tools from layers 2 and 5. At GFJ, the single tool where this attribute could be determined has also been flaked in the direction of quadrant 1.

Platforms amongst the small group of tools indicate generally low incidences of intensive working (less than 30% in all layers) at both sites through time. This is generally also true when the attribute of overhang removal is considered (Tables 18 and 19).

Table 23. The number of modified edges on obsidian tools from GAC and GFJ.

obsidian tool type	GAC Layer 1				GAC Layer 2				GAC Layer 3				GAC Layer 5				GFJ Layer 3			
	no. of edges				no. of edges				no. of edges				no. of edges				no. of edges			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
flake tool	2	1	—	—	3	2	—	—	1	—	—	—	—	2	1	—	—	—	—	—
notched tool	3	—	—	—	2	1	1	—	—	—	—	—	—	—	—	—	1	—	—	—
scraper	3	2	1	2	5	5	1	—	—	—	—	—	—	—	2	—	1	—	—	1
end scraper	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
total	8	3	1	2	12	8	2	—	1	—	—	—	—	2	3	—	2	—	—	1
%	57.1	21.4	7.1	14.3	54.5	36.4	9.1		100					40	60		66.7			33.3

Size change through time: metrical data

At GAC, it appears that the tools from the earliest layer are the largest. Small sample size does not allow statistical confirmation of this trend. The tools from layer 3 at GFJ are considerably smaller than those from layer 5 at GAC (Table 20). Also, the single cortical tool from GAC layer 3 is quite small compared to non-cortical tools from this site (Table 20).

A comparison of the mean lengths of obsidian tools and unmodified obsidian flakes at GAC and GFJ shows that in all cases, except GAC layer 5, larger blanks were chosen from the general flake population for retouching and use purposes (Tables 14 and 20).

When axial dimensions are considered, the tools from layer 5 at GAC are larger than unmodified flakes only in layers 1, 2 and 3 but equivalent in layer 5. Generally however larger flake blanks were selected for modification at both sites in earlier layers (Tables 15, 16 and 21).

Tool types and the morphology of retouch

Typologically, four obsidian tool types are represented in the GAC and GFJ assemblages: flake tools, notched tools, scrapers and end scrapers (as defined above). GAC layers 1 and 2 have the greatest variety of tool types. However, if the GAC layer 5 assemblage is combined with that from GFJ layer 3, all but end scrapers are present in earlier as well as later assemblages (Table 22).

Analysis of the number of tool edges that were modified and the pattern and location of retouch on each tool indicates low intensity tool retouching and utilization. The 45 tools from GAC and GFJ have a total of 80 modified edges. Except for GAC layer 5, over 50% of the tools from each layer's assemblage have only one or two modified edges (Table 23), and the combined assemblages from both sites show this pattern is consistent through time. Although layer 5 at GAC has a higher incidence of tools with three modified edges, the small number of tools in this layer (n = 5) does not warrant further conclusions.

The pattern of retouch applied to obsidian tools involves modification of the ventral and dorsal surfaces almost equally (ventral 42.5%, n = 34, dorsal 40%, n = 32), with a low proportion of bifacial retouch. When the pattern of retouching is considered through time the distribution appears to be quite random and mixed between chronological units (Table 24).

The location of retouch is most frequently along the lateral margins (quadrant 4, 31.3%, n = 25, quadrant 2, 27.5%, n = 22), followed by distal retouch (quadrant 3, 23.8%, n = 19) and retouch over the platform (quadrant 1, 17.5%, n = 14). This pattern of retouch location is consistent through time at both sites. The scraper forms are generally characterized by steep invasive retouch whilst the majority of other tools display less invasive small retouch.

Tools from both sites lack heavy retouch and there is little evidence to suggest the repeated retouching or rotation of tools involving more than two edges. This pattern is consistent through time with the exception of the earliest tools from GAC, which may be more intensively used. There are no formal morphological types in either assemblage, such as the stemmed tools found in West New Britain (Pavlides, 1993, 1999, 2006; Rath & Torrence, 2003; Torrence, 2004).

Table 24. The quadrant location, type and direction of retouch on obsidian tools from GAC and GFJ.

site and layer	obsidian tool type		Quadrant			
			Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
GAC Layer 1	flake tool		steep ventral scars = 1	ventral edge damage = 1 bifacial edge damage = 1		dorsal edge damage = 1
		edges (n)	1	2		1
	notched tool			ventral notch = 1	dorsal notch = 1	dorsal notch = 1
		edges (n)		1	1	1
	scraper		dorsal edge damage = 1 bifacial edge damage = 1 steep dorsal scars = 1 steep ventral scars = 1 steep bifacial scars = 1	dorsal edge damage = 1 bifacial edge damage = 1 steep dorsal scars = 1 steep ventral scars = 1	ventral edge damage = 1 steep dorsal scars = 1 dorsal notch = 1	dorsal edge damage = 2 steep dorsal scars = 1 steep ventral scars = 1 steep bifacial scars = 2
		edges (n)	5	4	3	6
GAC Layer 2	flake tool		ventral edge damage = 1	ventral edge damage = 1		ventral edge damage = 4 bifacial edge damage = 1
		edges (n)	1	1		5
	notched tool		ventral edge damage = 2	ventral edge damage = 1 ventral notch = 1	dorsal notch = 1	dorsal notch = 1 ventral notch = 1
		edges (n)	2	2	1	2
	scraper		steep dorsal scars = 1 steep ventral scars = 1	ventral edge damage = 3 dorsal edge damage = 2 steep dorsal scars = 1 steep bifacial scars = 1	ventral edge damage = 2 dorsal edge damage = 3 steep dorsal scars = 1	ventral edge damage = 1 steep dorsal scars = 1 steep ventral scars = 1
		edges (n)	2	7	6	3
	end scraper				dorsal edge damage = 1 ventral edge damage = 1	
		edges (n)			2	
GAC Layer 3	flake tool					ventral edge damage = 1
		edges (n)				1
GAC Layer 5	flake tool		ventral edge damage = 1	ventral edge damage = 1	bifacial edge damage = 1 steep ventral scars = 1	ventral edge damage = 2 bifacial edge damage = 1
		edges (n)	1	1	2	3
	scraper			steep ventral scars = 1 steep bifacial scars = 1	steep dorsal scars = 1 steep bifacial scars = 1	dorsal edge damage = 1 bifacial edge damage = 1
		edges (n)		2	2	2
GFJ Layer 3	notched tool				dorsal notch = 1	
		edges (n)			1	
	scraper		steep dorsal scars = 2	steep dorsal scars = 1	bifacial edge damage = 1	dorsal edge damage = 1
		edges (n)	2	1	1	1

The largest tool blanks were more commonly selected for modification and these were primarily late-stage flakes lacking cortex. As with the unmodified flake component of these assemblages there is a steady reduction in the size of tools through time with the largest tools appearing in layer 5 at GAC. The early tools from GFJ are smaller than their contemporaries at GAC.

Discussion

The small assemblage of flaked stone material from GFJ and the larger assemblage from GAC date from the mid-Holocene period. There is nothing to suggest that the procurement of obsidian was systematically organized at any period in either site. The reasons for selecting particular sources and the mechanisms of raw material acquisition cannot easily be described. Generally the flaking intensity of obsidian material is low at all times in the past, though it may increase in the most recent period at GAC. The early assemblage from GFJ, however, does appear to be more intensively reduced than the contemporary assemblage at GAC. There is some variation in size over time, and artefacts tend to be larger in the mid-Holocene than they are later.

The early assemblages at both sites, whilst admittedly small samples, share few of the technological characteristics identified for pre-Lapita sites elsewhere in the Bismarcks region. For example, source targeting and the production of specific morphological types such as stemmed tools are known characteristics of other early to mid Holocene sites in West New Britain (Pavlides, 1993, 1999, 2006; Rath & Torrence, 2003; Torrence, 2004). The highly distinctive scrapers from the Manus Island site of Pamwak date to the terminal Pleistocene and early Holocene (Ambrose 2002; Fredericksen *et al*., 1993). The characteristic debitage associated with producing and retouching large bifacially and unifacially flaked tools is largely missing from the early assemblages at GAC and GFJ, suggesting that these tool forms were not present. There are, however, more tools and later stage artefacts to unmodified flakes in the earlier layers at GAC, a pattern similar to other mid Holocene assemblages from West New Britain.

The assemblage from layer 1 at GAC contains nothing comparable to the presumed contemporary assemblages [c. 2000 cal. BP] on Lou Island and southwest Manus, which are dominated by triangular points (Kennedy, 1997; Kennedy *et al*., 1991). Although the Pamwak scrapers and the point industries may lead one to suspect the continuity of similar technological strategies, including the production of formally shaped tools, from the early to mid and late Holocene, there is no evidence for this at GFJ or GAC.

Once settlements were established in the Admiralties, procurement strategies on Manus Island involved firstly the exploitation of chert followed by obsidian exploitation. At Pamwak rockshelter, small stream pebbles of chert may have been the targeted tool stone for Pleistocene knappers (Fredericksen, 1994). Despite the probable Pleistocene availability of Mt Hahie obsidian (Ambrose, 2002: 67–8), it is not present in sites outside southwest Manus. By the mid Holocene, chert had all but been abandoned as a major resource in favour of obsidian. Large obsidian quarry sites such as that reported at Umleang on Lou Island date to this later Holocene period (Fullagar & Torrence, 1991).

Pavlides (1999) and Torrence *et al*. (2000) have argued that the production of formal tool types in West New Britain point to long-term changes in settlement patterns and economy between the early to mid Holocene. No such technological evidence was identified in the two assemblages examined here. Although the mid Holocene assemblages from the Manus sites are very small samples, the debitage does not suggest formal tool production or tool retouching on a scale comparable to Yombon in West New Britain during this period (Pavlides, 1999, 2006). While it is possible that the longer Pleistocene and Holocene sequence from Pamwak rockshelter will reveal a pattern of changing settlement and site organization, especially between the early and mid Holocene, the smaller assemblages from GAC and GFJ only hint at such changes. If however there is little or no change in technological organization during these critical times, then it may be possible to argue for alternative social and economic behaviours during the Holocene in the Admiralty Islands. Certainly more work is needed to test such theories in the Admiralty Islands.

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