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From Misisil Cave to Eliva Hamlet: Rediscovering the Pleistocene in Interior West New Britain

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ABSTRACT. The potential for archaeological evidence of Pleistocene activity to exist in West New Britain was first realized by Jim Specht. More recent work in Specht's research region of Yombon reveals intriguing archaeological data which demonstrate the organized utilization of rainforest resources as early as 35,500 years ago. The early colonists of the Bismarck Archipelago were versatile hunter-gatherers able to move beyond the coastal island fringes of Melanesia and harness important economic and lithic resources deep within the lowland rainforests.

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Twenty years ago Jim Specht published two short and modestly titled papers listing the then oldest archaeological site in the Bismarck Archipelago (Specht *et al*., 1981: 14, 1983: 92). The first paper relayed the facts that Misisil Cave, a site set deep in the lowland tropical rainforest of West New Britain, had evidence of terminal Pleistocene occupation. The realization that the Bismarck Archipelago might have been colonized during the Pleistocene was just dawning on scholars of Melanesian prehistory and this find in West New Britain put Jim Specht firmly in the middle of the most hotly pursued set of archaeological data. Since then many archaeological sites in the Bismarck Archipelago and the Solomon Islands have demonstrated the remarkable colonizing feats of Melanesia's first occupants. Several of these very early sites are from another area visited by Jim Specht in the early 1980s—the Yombon village area in the shadow of Misisil Cave. The Yombon sites are extremely important as they indicate that the rainforests of West New Britain were entered and occupied in excess of 35,500 years ago. In addition they indicate that the early colonists of the Bismarck Archipelago were not trapped along coastal island fringes, but rather were able to harness and utilize important inland resources and locales. This paper will evaluate current models of early habitation in Melanesia by examining the organization of flaked stone technologies found at Yombon and comparing this new information with data from other contemporary Melanesian sites.

"Strandlooper" models of sporadic, low intensity use of new environments by highly mobile coastal foragers are not consistent with new data from the Yombon area. For example, there is evidence to suggest that West New Britain's Pleistocene occupants were more structured in their approach to lithic resource acquisition and artefact production. In this case the targeting of specific high quality geological sources has organizational implications for technological planning and mobility strategies, as has the production of formal tools which could be maintained for extended periods of time. Models which argue for patterns of high mobility during the Pleistocene are therefore consistent with the pattern of technology observed at the

Yombon sites. A review of the available technological data from other sites of similar antiquity in Melanesia does not suggest this pattern of mobility. Significant differences may therefore have existed between these earliest colonists and those of the West New Britain interior forest.

Pleistocene models of settlement and subsistence in Melanesia and the Pacific

A number of models have been presented to explain the earliest occupation of Melanesia. For mainland Papua New Guinea these include the seasonal use of special local resources in cold, Highlands landscapes at sites such as Kosipe (White *et al*., 1970) and Nombe (Gillieson & Mountain, 1983; Mountain, 1983); and possible evidence of more permanent occupation and structural remains beginning at about 18,000 years ago at the site of NFX in the central Highlands (Watson & Cole, 1977: 35–40, 130–132, 194–195); and later at Wañelek in the Bismarck-Schrader Range (Bulmer, 1977: 65).

For the Melanesian islands a "strandlooper" model was proposed on the basis of early data from the coastal cave sites on New Ireland (Gosden, 1991, 1993; Gosden & Robertson, 1991; Spriggs, 1997: 35–39). These earliest colonists were seen as rapid explorers, taking advantage of local resources, wherever possible, within a system of low intensity foraging. This is in contrast to a model which sees the settlement of island Melanesia as characterized by more specialized and intensive solutions to resource acquisition (Allen, 1993: 146; Gosden, 1995: 815), including the movement of various goods, animals and raw materials after 20,000 B.P. (Gosden, 1993: 133; Enright & Gosden, 1992: 174). Such organization suggests reduced settlement mobility and a changed economy because it had the effect of equalising the distribution of key but scarce resources between regions.

The concentration on marine resources at many coastal sites and the total distance traversed by the early colonists are evidence for strong maritime capabilities (Irwin, 1991); however a totally marine adapted economy (Gosden & Robertson, 1991) at this early stage is unlikely. Evidence of Pleistocene activities occurs at numerous locations indicating the exploitation of an extremely diverse range of habitats on immediate arrival to the region (Table 1). In particular the findings reported here from the Yombon area of West New Britain (Pavlides, 1999; Pavlides & Gosden, 1994) clearly indicate that the model of earliest Pleistocene settlement must now include both coastal and inland adaptations as part of an extremely mobile and rapid process of colonization. Furthermore, the management of this range of environmental niches required a number of different technological and social approaches to resource acquisition and exploitation.

Evidence for the utilization of lowland, tropical rainforest resources comes in the form of plant residues, raphides and starch grains present on the Pleistocene tools from Kilu Cave, Buka Island (Loy, *et al*., 1992; Wickler, 1990) dating to 28,000 years ago and the earliest levels at Yombon (Pavlides, 1999). Other evidence of early plant manipulation comes in the form of special artefact types. Groube (1989: 298–302) has argued that the large waisted axes found at Pleistocene sites on the Huon Peninsula represent forest clearance activities. Environmental evidence from some sites in Papua New Guinea and Irian Jaya also point to early clearance activities, consistent with disturbance of the canopy (Groube, 1989; Haberle, 1993: 119; Haberle *et al*., 1991; Hope, 1982, 1983).

Pleistocene flaked stone assemblages have rarely been used to formulate or support models of settlement and subsistence in Melanesia. A review of these data indicates that patterns of high mobility encompassing long distances are not borne out in the organization of technology at most sites. For example, resource selection routinely involved relatively low cost solutions to raw material acquisition. In particular, secondary geological stone sources such as river and streams beds, often in the immediate vicinity of sites, were targeted and a wide variety of lithic material types selected. This pattern is observed at the New Ireland, Manus and Buka Island sites—Matenkupkum (Freslov, 1989: 35), Buang Merabak (Leavesley & Allen, 1998: 70–71; Rosenfeld, 1997), Pamwak (Fredericksen, 1994: 76) and Kilu (Wickler & Spriggs, 1988)—which contain a variety of local raw materials, extracted primarily from riverbed sources. The same is true of many mainland New Guinea sites: Kosipe (White *et al*., 1970: 163), Nombe (Mountain, 1983: 94; White, 1972: 132), Fortification Point on the Huon Peninsula (Groube *et al*., 1986: 454), Wañelek (Bulmer, 1991: 473) and Batari (White, 1972: 27). Only the Pleistocene assemblages from the sites around Yombon (Pavlides, 1999) indicate the selection of high quality stone from primary geological contexts. Flakeable stone material is locally available in riverbeds as cobbles and from *in situ* sedimentary rock sources around the Yombon area. The specific targeting of primary geological source material represents a much more costly solution to resource acquisition with organizational implications for planning, landscape use and mobility strategies.

Generally, the patterns of artefact production observed at most Melanesian Pleistocene sites indicate little specialization or standardization, and technological features from Matenkupkum, Balof and Pamwak do not suggest intensive reduction strategies (Freslov, 1989; Fredericksen, 1994: 74; White *et al*., 1991). During the Pleistocene the only formal tool, the stemmed and waisted axe, comes from mainland Papua New Guinea where it is a component of several assemblages, for example, at Kosipe (White *et al*., 1970: 165), Nombe (Mountain, 1983: 9) and the Huon Peninsula (Groube *et al*., 1986: 454). If highly mobile settlement patterns are to be predicted for the Pleistocene in Melanesia, then the production of formal tools which could be used and maintained for long stretches of time whilst on the move should be more prevalent. Within island Melanesia only the unifacial ovoid scraper from one of the Pleistocene sites at Yombon (Pavlides, 1999) and the ovoid tools from Pamwak, dating to the terminal Pleistocene (Fredericksen, 1994: 76; Fredericksen *et al*., 1993: 148), could indicate the production of formal tools.

On the surface, these Pleistocene data do not suggest a pattern of high residential mobility as part of either a rapid colonizing process or simple broad-based foraging, as there is little evidence to suggest a pattern of highly planned technological organization. Instead the organization of flaked stone technology at most Melanesian sites is primarily unspecialized and characterized by high variability in raw material selection and low levels of planning in terms of stone resource exploitation, tool design and use. In

Table 1. The earliest Pleistocene sites in mainland Papua New Guinea and island Melanesia and their geographic distribution.

geographic zone	site location	site name	reference
coastal	cave	Matenkupkum	Gosden, 1995; Gosden & Robertson, 1991
		Matenbek	Gosden, 1995; Gosden & Robertson, 1991
		Buang Merabak	Leavesley & Allen, 1998; Rosenfeld, 1997
		Kilu	Wickler, 1990; Wickler & Spriggs, 1988
		Lachitu	Gorecki, pers. comm., 1996; Gorecki *et al*., 1991
	open	Fortification Point	Groube, 1986; Groube *et al*., 1986
inland	cave	Panakiwuk	Marshall & Allen, 1991
		Pamwak	Fredericksen, 1994; Fredericksen *et al*., 1993: 149
		Nombe	Gillieson & Mountain, 1983; Mountain, 1983, 1991*a,b*
		Batari	White, 1972: 27
	open	Yombon	Pavlides & Gosden, 1994
		Kosipe	White, 1965, 1972; White *et al*., 1970
		Kuk Swamp	Golson & Hughes, 1977
		NFX	Watson & Cole, 1977: 35–40
		Wañelek	Bulmer, 1977: 62–65, 1991: 471

particular, lithic procurement activities appear to be non-intensive involving a least effort and largely unsystematic strategy of collection. Reduction activities are also generally non-intensive, as are tool production and use. These organizational and technological features suggest either low residential settlement mobility or extremely high stone resource availability (Andrefsky, 1994*a,b*; Bamforth, 1990, 1991; Nelson, 1991; Parry & Kelly, 1987).

The Pleistocene flaked stone assemblages from Yombon stand out from other Melanesian assemblages in several key respects regarding the organization of procurement activities, the effort involved in raw material extraction and the production, use and discard of flake stone artefacts. The pattern indicates a different picture of technological planning more consistent with the model of rapid colonization and high mobility proposed generally for the region.

The Pleistocene sites from Yombon

The Yombon area (which includes the historically documented Yombon village) is located approximately 35 km inland from Kandrian, the old administrative head-quarters of West New Britain's south coast (Fig. 1). The five trenches with evidence of Pleistocene occupation levels are in two areas of Yombon village itself, Eliva hamlet (PNG site code FYV) and the Yombon airstrip (PNG site code FIF). One further trench excavated at Asiu village (PNG site code FYW), 1 km southeast of Auwa hamlet, has evidence of a terminal Pleistocene occupation level dating to approximately 12,400 cal. B.P. above an as yet unidentified tephra layer. It is uncertain whether the unidentified tephra layer that forms the base of this 12,400 year old layer is the same as the material which seals the Pleistocene unit in the Eliva hamlet and Yombon airstrip trenches, although it is quite possible (Fig. 2). The poor preservation of the glass fraction within these Pleistocene volcanic deposits makes chemical characterization and comparison difficult. Further radiocarbon determinations may solve this problem. One flake tool was associated with this Pleistocene date at Asiu hamlet. This material is not, however, included in the analysis of Pleistocene technology presented here but rather has been grouped with assemblages deposited after the deposition of the unidentified Pleistocene tephra. A further nine trenches containing evidence of Holocene occupation levels were excavated in another three locations along a 4 km transect between the Yombon area and Dulago village (Pavlides, 1993, 1999). Discussion in this paper, however, confines itself to the site locations with evidence of Pleistocene activities prior to the deposition of the unidentified Pleistocene tephra (the Yombon airstrip and Eliva hamlet sites).

The local topography of the study area comprises flat, limestone ridge tops, lower rises, and valleys of varying depths and angles (Pain, 1981: 62). Coupled with high annual rainfall, the effects of swidden agriculture and the deposition of volcanic tephra material, these topographic features are most likely the main variables affecting the formation of archaeological sites (Pavlides, 1999). During Specht's, 1979 and 1981 field research around Auwa hamlet, he excavated trenches on only the high limestone ridge tops. Other features, such as the low rises below the highest ridge tops and the shallow valley bottoms, were excluded from Specht's sample. He did not find sites with well-preserved tephra layers or with deposits older than 4,200 years (Specht *et al*., 1981: 14). This is because the high ridges suffer more from erosion (due to human and natural processes) (Pain, 1981: 73; Specht, 1981: 57) than other parts of the landscape.

Site location and chronology

Eliva hamlet stands approximately 490 m above sea level on a low rise extending out of a shallow valley to the west below the main hamlet of Auwa. The Yombon airstrip is located 600 m west of Auwa hamlet. At its northern-most point the airstrip is 491 m a.s.l. The Pleistocene occupation levels were located within trenches FIF/2–3–4 in a shallow valley bottom on the airstrip's eastern side. This area is approximately 485 m a.s.l.

The two 1×1 m trenches excavated at Eliva hamlet, FYV/1 and FYV/2, were located approximately 15 m apart. Trenches FYV/1 and FYV/2 revealed a tephrostratigraphic sequence spanning the Holocene and Pleistocene and a

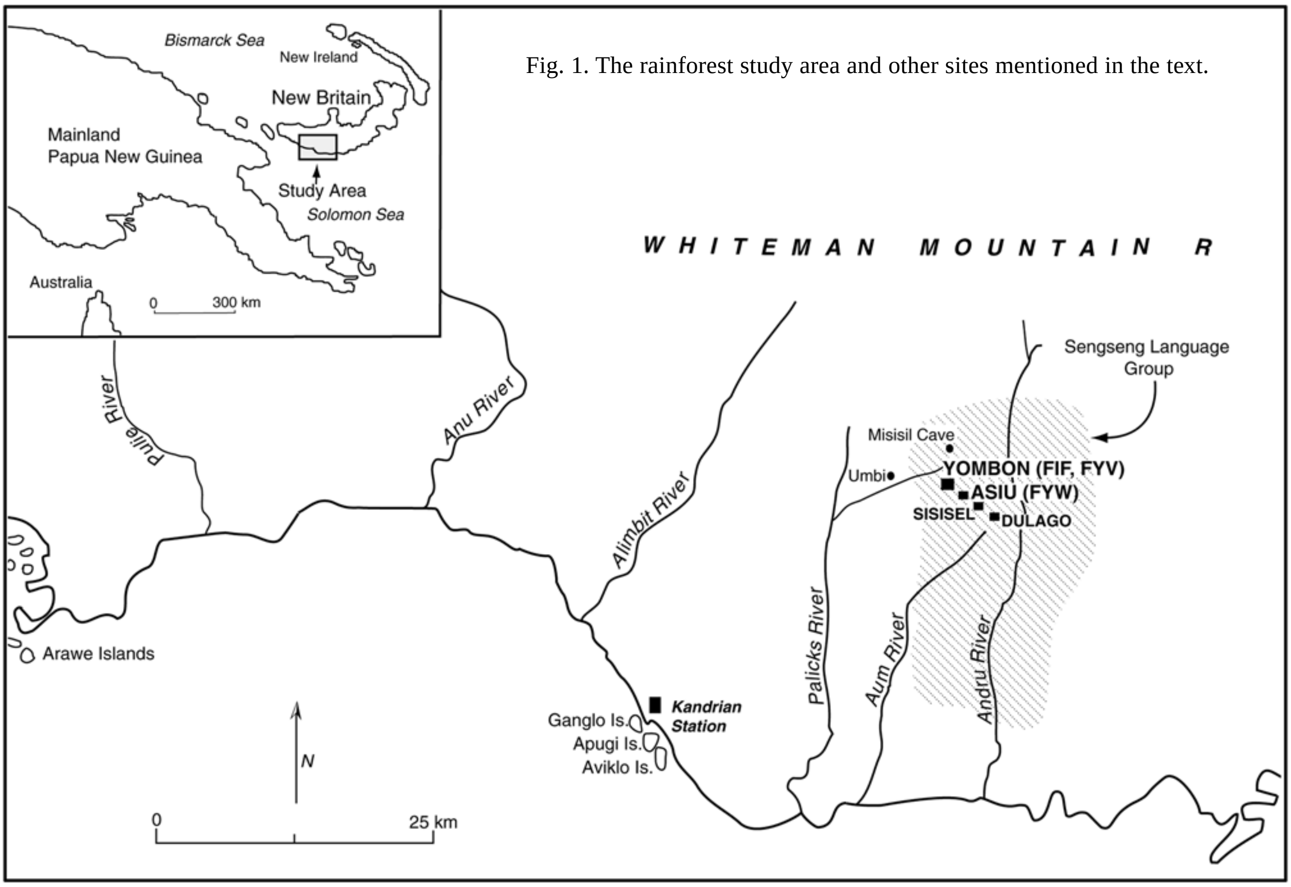


Fig. 1. The rainforest study area and other sites mentioned in the text.

chronology spanning over 35,500 years. The trenches have similar stratigraphies, and each contains three tephra beds. However, FYV/1 (Fig. 2 and Table 2) revealed the most complete stratigraphic sequence containing nine layers, while trench FYV/2 revealed a sequence of eight layers. The depth of FYV/1 is also greater than that of FYV/2 (2.2 m and 1.9 m respectively). Trench FIF/2–3–4 on the Yombon airstrip revealed a stratigraphic sequence comprising the maximum ten layers observed in the rainforest study area (see Pavlides, 1999 for details of the composite stratigraphic sequence). This 1×3 m trench revealed the full Pleistocene and Holocene tephrostratigraphic sequence. Like the trenches at Eliva hamlet, FIF/2–3–4 has a chronological span in excess of 34,000 years. The total depth of this trench is 2.76 m.

Flaked chert, limestone cortex, volcanic heat retainer cobbles and lumps of carbon were present within the Pleistocene levels. All sites were excavated until limestone bedrock was encountered.

Tephra layers and site formation processes

The preservation, structure and chronology of the rainforest sites of West New Britain are tied closely to the volcanic history of the island. In the past huge clouds of dense airfall tephras periodically showered this region. These ashes sealed entire landscapes and today act as stratigraphic marker beds which, through geochemical analyses, can be correlated directly with the volcanic sources from which they derive. Specht (1983: 4) suspected that Mt Witori, inland of Cape Hoskins, was the source of these volcanic ashes. Data collected as part of the current project (Pavlides, 1999) established this as fact and revealed that other later Holocene volcanoes have also showered the rainforest study area (see also Machida *et al*., 1996; Torrence *et al*., 2000).

All of the sediments in the study area are derived from either decomposing limestone, volcanic ash or soil development resulting from a combination of these two and

Table 2. Radiocarbon determinations from the Pleistocene layers at Yombon and Asiu Village.

chronological unit	trench locality	measured ^{14}C age	conventional age (^{13}C adjusted)	calibrated age b.p. (1σ)[a]	laboratory number
Unit 4	Asiu Village FYW/3	10,450±350	10,450±350	12,735 (12,360) 11,660	OZA179
Unit 5	Eliva Hamlet FYV/1	14,310±100	14,310±100	17,300 (17,155) 17,010	Beta 62318
	Yombon Airstrip FIF/4	29,100±750	29,100±750		OZA180
	Yombon Airstrip FIF/2	32,630±400	32,630±400		Beta 47046
	Yombon Airstrip FIF/3	33,600±670	33,570±670		Beta 62323
	Eliva Hamlet FYV/2	35,570±480	35,570±480		Beta 62319

[a] Radiocarbon dates calibrated using CALIB 3.0.3 (Stuiver & Reimer, 1993).

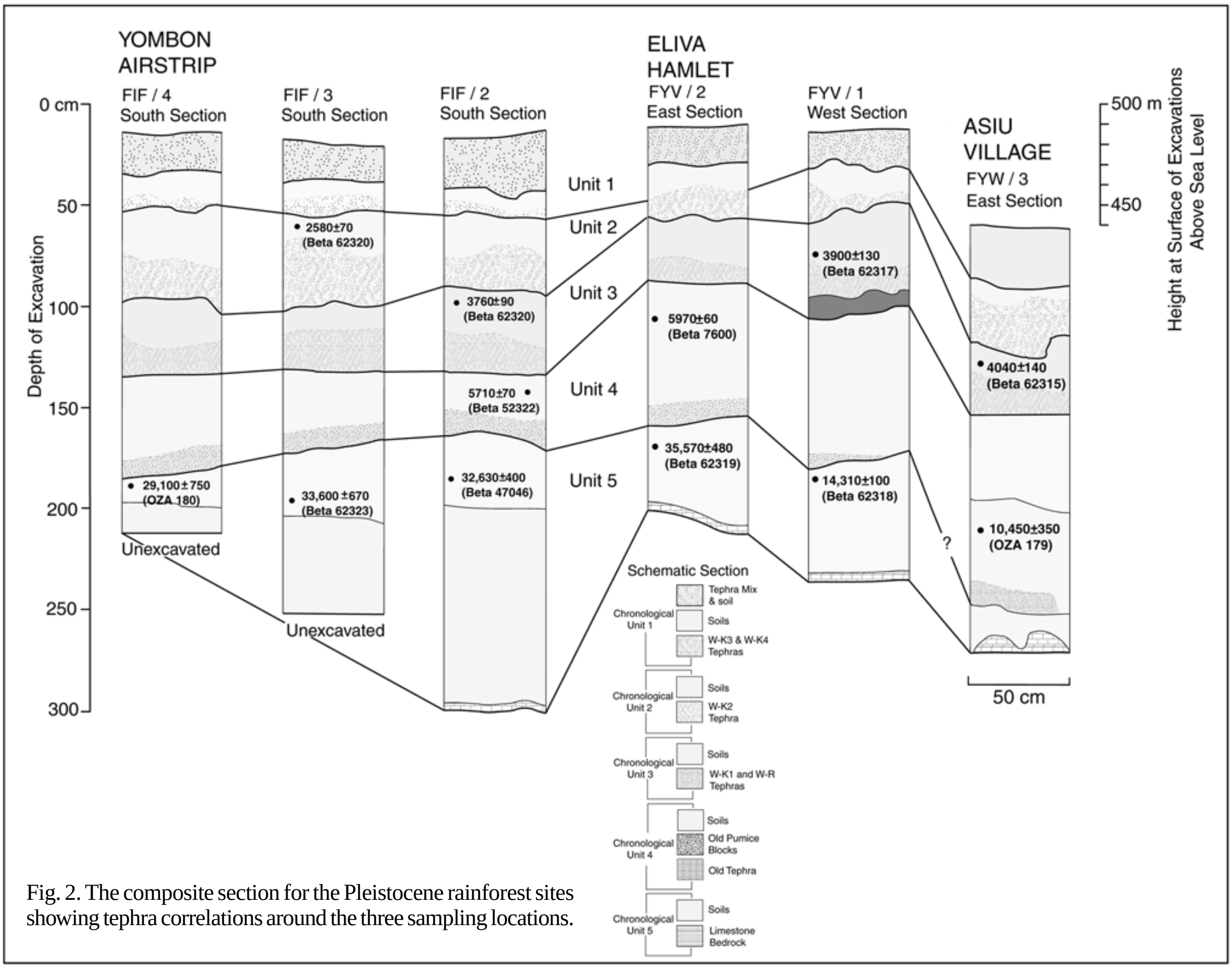


Fig. 2. The composite section for the Pleistocene rainforest sites showing tephra correlations around the three sampling locations.

organic matter (Pain, 1981: 70–74). The decomposition of the area's basal Miocene limestone and the deposition of airborne volcanic ash are thus the two primary sources and mode of sediment accumulation.

The Eliva hamlet and Yombon airstrip trenches contain Pleistocene deposits capped by a dense tephra which probably fell over southern West New Britain some time around 17,000 to 12,000 years ago.

The Pleistocene flaked stone assemblages from Yombon

The sample of flaked stone tools from the Pleistocene West New Britain sites is admittedly small, comprising only 29 artefacts. Nevertheless, several interesting points can be made regarding the structure and organization of technology during the Pleistocene in this region. As discussed above in relation to other Melanesian sites, stone material use during the Pleistocene suggests assemblages characterized by least effort procurement, reduction and tool use. This pattern of technological organization is not consistent with generally excepted views and models of highly mobile hunter-gatherers (Binford, 1979; Bleed, 1986; Kelly, 1992; Nelson, 1991; Shott, 1986; Torrence, 1989). At the Pleistocene rainforests sites around Yombon the pattern of stone resource procurement, production and use has some similarities with flaked stone assemblages from other Melanesian sites. However, several key elements in the organization of technologies suggest an alternative approach to lithic resource use.

Firstly, the pattern of raw material procurement at this time involved the location and quarrying of *in situ* primary geological source material. Secondly, the production of particular morphological types is indicated by the presence of one formal tool type, a unifacial ovoid scraper (Fig. 4). This artefact is the first of its kind to be discovered within the Bismarck Archipelago and is technologically and typologically unlike other contemporary Pleistocene tools found elsewhere in Melanesia in terms of its size, shape and production technology. This artefact may point to the development of a formal tool technology at this time. Finally, several of the retouched artefacts retain microscopic evidence of organic residues and usewear suggesting the utilization of local forest plant resources. All of these technological and organizational features suggest the development and use of a planned technological strategy functioning within a highly mobile settlement pattern.

Raw material procurement strategies

The only stone material selected for flaking during the Pleistocene phase was fine-grained chert. A total of 29 pieces, weighing 525.9 g, were recovered from the five excavated trenches at Eliva hamlet and the Yombon airstrip (Table 3).

Table 3. The frequency and weight of stone artefacts in Pleistocene layers at Eliva hamlet and Yombon airstrip.

locality	trench code	frequency number	%	weight g	%
Eliva Hamlet	FYV / 1	13	44.80	70.5	13.40
Eliva Hamlet	FYV / 2	4	13.80	372.2	70.80
Yombon Airstrip	FIF / 2	2	6.90	8.2	1.60
Yombon Airstrip	FIF / 3	9	31.00	74	14.10
Yombon Airstrip	FIF / 4	1	3.40	1	0.20
totals		29		525.9	

The exact quarry or source location of the Pleistocene chert material is unknown; however, chert is available as both nodules within *in situ* geological deposits of Miocene limestone, usually within deep sinkholes, and unconsolidated cobbles in secondary river gravel bed contexts within the immediate area. An inspection of the Eliva hamlet and the Yombon airstrip material indicates that only primary context material extracted from sedimentary bedrock contexts was utilized. The type of cortex and the unaltered condition of the flaked surfaces of the artefacts indicate the exclusive selection and quarrying of chert from *in situ* geological deposits. That is, the surface of the cortex and flaked surfaces are neither rolled nor stained with red oxides, two characteristics noted on material extracted from river bed and stream contexts. The cortex noted on the Pleistocene artefacts is chalky white limestone, indicative of primary source material.

Two artefacts from trench FYV/2 at Eliva hamlet reveal something of the type and size of quarried raw material at this time. One is a large angular fragment produced on a split limestone nodule with a centre of poor quality chert and another is a large *outrepassé* flake which is almost totally cortical on the dorsal surface (Fig. 3). These two artefacts may both indicate primary quarrying and nodule testing at the Eliva hamlet locality. The frequency of chert artefacts and limestone rubble discarded at Eliva hamlet is also greater than that present at the Yombon airstrip, suggesting a different set of activities at this location. This evidence from Eliva hamlet may represent production and discard activities close to a primary stone source during the Pleistocene.

While both *in situ* deposits of bedrock stone and river bed sources are locally available, the selection of primary source material from geological deposits of Miocene limestone has implications in terms of the development of extraction technologies (probably underground mining from sinkholes), extraction effort and processing technologies and effort. Clearly, the extraction of cobbles from river bed deposits would have been a less costly and more time efficient procurement strategy; however, this was not the choice made by the Pleistocene inhabitant of the West New Britain rainforest.

The composition of assemblages

The Pleistocene assemblages contain relatively little flaking debris (angular fragments or flaked pieces) compared to flakes and tools. The stone working debitage includes a single irregular flake (classed as *irregular* because of its cross section, size and general shape) and a core rejuvenation flake (*flake other form*) from Eliva hamlet as well as two angular fragments. The assemblages from the Eliva hamlet trenches also contain a range of fracture types (Table 4). Evidence suggesting *in situ* quarrying and flaking

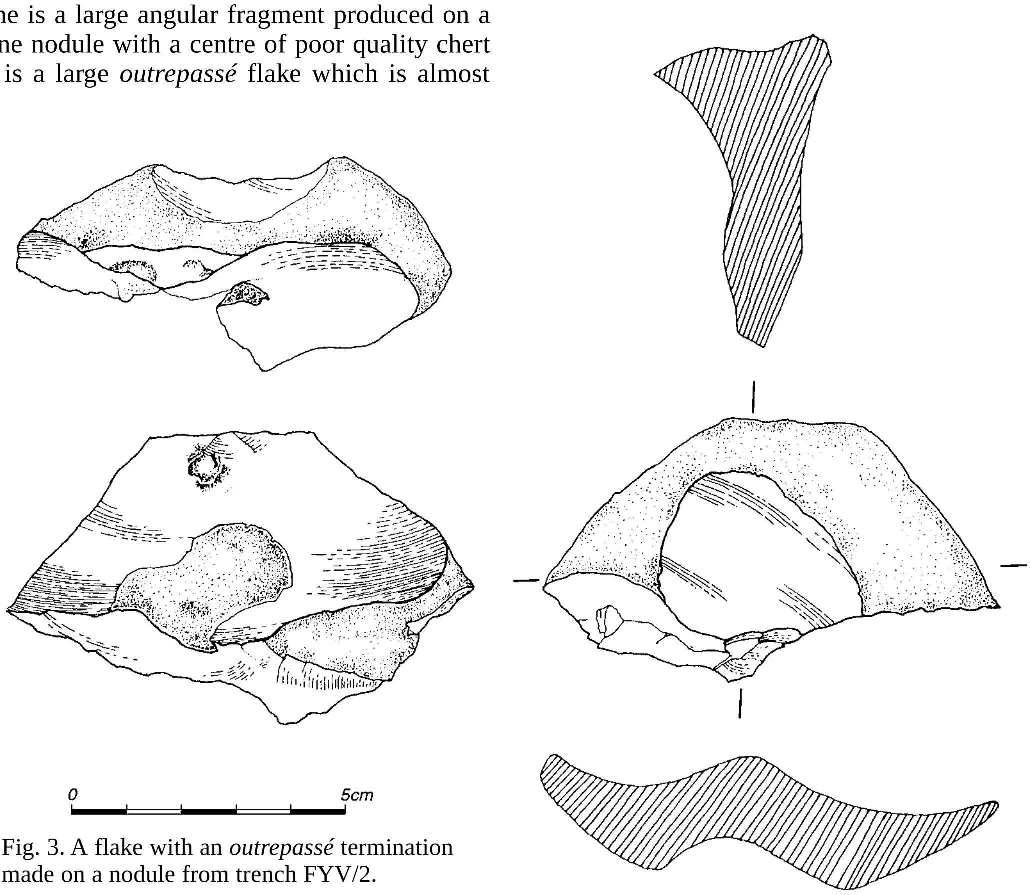


Fig. 3. A flake with an *outrepassé* termination made on a nodule from trench FYV/2.

Table 4. The frequency and weight (g) of artefact types in Pleistocene assemblages at Eliva hamlet and Yombon airstrip.

artefact type	**FIF/2**		**FIF/3**		**FIF/4**		**FYV/1**		**FYV/2**		**total**	**total**
	n	**(g)**	**n**	**(g)**	**n**	**(g)**	**n**	**(g)**	**n**	**(g)**	**n**	**(g)**
flake—complete	—	—	—	—	1	1.0	1	15.9	—	—	2	16.9
flake—broken	1	6.2	1	0.8	—	—	4	13.6	—	—	6	20.6
tool—complete	—	—	1	71.7	—	—	4	32.9	2	147.7	7	252.3
tool—broken	—	—	—	—	—	—	2	1.3	—	—	2	1.3
flake—other form	—	—	—	—	—	—	1	6.4	—	—	1	6.4
flake—irregular form	—	—	—	—	—	—	—	—	1	83.9	1	83.9
angular fragment	—	—	1	0.6	—	—	1	0.4	1	140.6	3	141.6
fire-cracked stone	1	2	6	0.9	—	—	—	—	—	—	7	2.9
total	2	8.2	9	74	1	1.0	13	70.5	4	372.2	29	525.9

is not found at the other Pleistocene trenches, although a few very small angular fragments were recovered from trenches FYV/1 and FIF/3.

The presence of tools, including the formally shaped unifacial ovoid scraper (Fig. 4) indicates activities at the West New Britain rainforest sites beyond simple stone procurement and primary flaking. Tools are present at both locations with the highest number in the Eliva hamlet trenches. Burnt and fire-cracked chert artefacts are also present in assemblages from FIF/2 and 3. Inadvertently or deliberately burnt artefacts may signify that activities other than stone procurement took place at the Yombon airstrip.

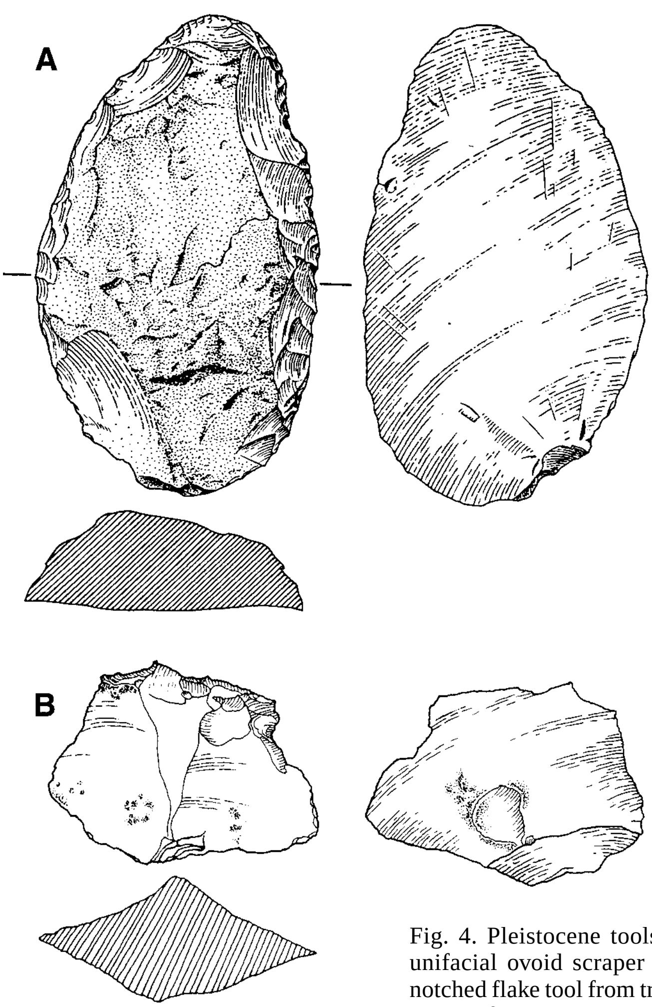
Reduction strategies

As indicated above, the type and density of artefacts at Eliva hamlet may indicate that a slightly different set of activities was undertaken at this location during the Pleistocene compared to the Yombon airstrip. Although the numbers are small, the relative frequency of cortical artefacts is greatest at Eliva hamlet FYV/2. Cortex is, however, also present on artefacts from all other assemblages except FIF/4 (Table 5).

There are only two complete and six broken flakes in the Pleistocene assemblages. All of these artefacts lack dorsal cortex. These non-cortical flakes are present in three assemblages from both Eliva hamlet (FYV/1) and the Yombon airstrip (FIF/2, FIF/4). The two complete flakes have been struck downwards from one platform, that is, the core was not rotated prior to their removal, and only one of these flakes has more than three dorsal scars.

The platform surface treatments indicate both simple and more specialized core preparation. One flake, from trench FYV/1, has a highly worked platform, displaying several facets, while two others, from trenches FYV/1 and FIF/4, have only a single flake scar, or cortex and one flake scar. The flake with the faceted platform is interesting because it has microscopic evidence of residues along the platform, consistent with the use of this edge while the flake was still part of a larger tool (Fullagar, pers. comm.). Similar damage is also present along the platform of one of the flake tools (see below). This may indicate the resharpening of larger tools.

Regular or stepped overhang removal is present on three flakes. The dorsal platform angles measured on two flakes (60° and 80°) are quite acute indicating attention to core face morphology. One of the flakes ends in a feather and the other in a hinge termination.



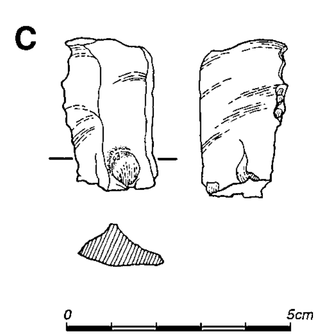


Fig. 4. Pleistocene tools from Eliva hamlet. 4a, unifacial ovoid scraper from trench FYV/2, 4b, notched flake tool from trench FYV/1 and 4c, flake scraper from trench FYV/2.

Table 5. The proportion of cortical to non-cortical chert artefacts within individual assemblages.

chert artefacts	FIF/2		FIF/3		FIF/4		FYV/1		FYV/2		total
	n	%	n	%	n	%	n	%	n	%	n
non-cortical	1	50	6	66.7	1	100	9	69.2	1	25	18
cortical	1	50	3	33.3	—	—	4	30.8	3	75	11
total number	2		9		1		13		4		29

While it is difficult to conclude much about either the organization of technology or the reduction strategies used during the Pleistocene, several patterns can be isolated. Firstly, chert extracted from *in situ* geological deposits was exclusively selected and quarried for flaking during the Pleistocene phase, and decortified material was reduced at both Eliva hamlet and the Yombon airstrip revealing a technological pattern of late and early stage reduction at the two locations. Some evidence of tool resharpening activities is indicated at Eliva hamlet, which also has the majority of discarded tools.

Tool blank technology and the spatial organization of reduction

Nine artefacts of the 29 flaked stones from the Pleistocene, are classified as tools (Table 4). These artefacts are all retouched flakes. The technology of tool blank production indicates evidence of both early and late stage flaking, and the type and intensity of retouch is consistent with low intensity tool modification and use.

Tools are present in assemblages from the two trenches at Eliva hamlet and trench FIF/3 at the Yombon airstrip (Table 6). The proportions of cortical (55.6%, n=5) and non-cortical (44.4%, n=4) retouched artefacts are similar, indicating almost equal early and late stage reduction and tool blank selection activities at both Eliva hamlet and the Yombon airstrip. Dorsal scars are directed predominantly from the platform down, indicating unidirectional flaking with little core rotation. Three of the six complete and proximal tools display complex platforms. One of these, from trench FYV/1, has a platform consisting of both multiple flake scars and faceting suggesting more intensive core platform preparation. Intensive overhang removal is present on two of the tools. Tools have more acute platform angles than the unmodified flakes with five of the six artefacts displaying platform angles less than 76°. The axial and maximum dimensions of the cortical and non-cortical tools indicate that cortical tools are generally larger (Table 6). The axial and maximum dimensions of the tools are larger than those of the cortical and non-cortical unmodified flakes, which is consistent with the selection of the largest blanks for further modification and use.

Tool types and the morphology of retouch

The Pleistocene retouched flakes were classified into three groups: flake tools, notched flake tool and the unifacial ovoid scraper (Table 7 and see Fig. 4). The flake tools and the notched flake tool are flakes with edge modification in the form of micro-flaking and larger retouch, while the large unifacial ovoid scraper is more formally shaped by intensive retouching and edge modification.

Microscopic usewear and residue analysis of the notched flake tool and one flake tool indicates generally non-invasive edge modification consistent with light woodworking and plant processing (Figs. 4B and 4C). The notched flake tool reveals heavy polishing around its notch with organic residues and unidentified cellular structures. A high density of starch grains is impacted into the notch and the surrounding step scars. Well-developed polishes, linear striations and dense concentrations of starch grains on the distal edge of this tool are also consistent with woodworking and the cutting of siliceous plant material (Fullagar, pers. comm.). A residue sample extracted from within the notch tested negative for different blood components using Ames Hemastix and immunoblot testing (Brass & Furby, 1999).

The flake tool displays light polish and edge rounding, in association with thick cracked residues along the right margin. Edge rounding, polish and residues are also noted on the platform indicating the use of this edge prior to the formation of the flake blank. Light plant processing is consistent with this pattern of edge modification (Barton, pers. comm.).

Table 6. The axial and maximum dimensions (mm) of cortical and non-cortical tools from Eliva hamlet and Yombon airstrip.

tool type	trench	axial dimensions (mm)			maximum dimensions (mm)		
		length	width	thickness	length	width	thickness
cortical tools							
unifacial ovoid scraper	FYV/2	100.8	60.9	21.6	105.8	63.1	23.3
flake tool	FIF/3	50.9	57.6	28.4	64	60.5	29.1
notched flake tool	FYV/1	38.3	47.6	18.2	49.2	36.3	20.8
flake tool	FYV/1	33.8	29.5	8	34.8	33.2	8.6
flake tool	FYV/1	—	—	—	28.4	11.9	4.1
non-cortical tools							
flake tool	FYV/2	32.8	18.9	8.1	36.7	21.3	7.9
flake tool	FYV/1	24.2	13.7	2.6	24.6	13.8	2.9
flake tool	FYV/1	16.4	9.2	1.6	17.4	11.9	1.7
flake tool	FYV/1	—	—	—	23.8	10.5	2.5

Table 7. The number of modified edges on Pleistocene tools from Eliva hamlet and Yombon airstrip.

tool type	1 edge	2 edges	3 edges	4 edges	number of tools	number of modified edges
flake tool	3	4	0	—	7	11
notched flake tool	—	1	0	—	1	2
unifacial ovoid scraper	—	—	0	1	1	4
total number	3	5	—	1	9	17
%	33.3	55.6	0.0	11.1		

The unifacial ovoid scraper (Fig. 4A) has been retouched around much of its circumference with the left margin more heavily retouched to produce a straight edge. Microscopic residues and edge damage on this tool indicate primarily soft plant processing and the linearity of striations present along the edges reveals use in a cutting action. A large quantity of starch grains is also present (Fullagar & Barton, pers. comm.).

In addition to the above data indicating the involvement of the unifacial ovoid scraper in plant processing, one residue sample taken from this tool gave a positive result to the Hemastix blood test. The Protein A Gold immunoblot produced a possible positive result and the Protein G Gold immunoblot produced a negative result, indicating a possible mammalian origin for this residue (Brass & Furby, 1999).

The number of modified edges (n=17) on the Pleistocene tools indicates a pattern of primarily low intensity retouching with a ratio of utilized edges per tool equalling 1.9 (Table 7). In this case, eight of the nine Pleistocene tools have one or two modified edges and only the unifacial ovoid scraper displays intensive retouch.

Retouch is most commonly present on the dorsal surface of tools (77%, n=13), followed by occasional instances of ventral (18%, n=3) and bifacial modification (6%, n=1) (Table 8). This pattern of retouch is consistent among the three Pleistocene tool types. The location of edge damage is most common in quadrant 4 (41%, n=7), 3 (29%, n=5) and 2 (24%, n=4), the left margin, termination and right margin, with only one instance of retouching along the platform edge, quadrant 1.

In summary, the data regarding tool types and the number, type and direction of edge modification reveals a pattern of relatively non-intensive retouching activities. What is striking about this small assemblage of Pleistocene tools is the presence of one highly worked formal tool, the unifacial ovoid scraper, unique to this region during the Pleistocene.

Discussion

During the Pleistocene phase in the West New Britain rainforests (approximately 35,500 to 17,000 cal. B.P.) stone material procurement involved the selection, extraction and use of local chert mined directly from *in situ* geological bedrock sources of Miocene limestone. No other stone material was utilized at this time, despite the importation and use of West New Britain obsidian at Matenbek (Allen, 1989: 151; Allen & Gosden, 1996: 188; Summerhayes & Allen, 1993) and Buang Merabak (Rosenfeld, 1997: 221) on New Ireland beginning approximately 20,000 years ago.

While the use of local stone is common in most Melanesian Pleistocene sites, the utilization and quarrying of local stone from *in situ* sedimentary deposits is not. Flaked stone assemblages from the New Ireland cave sites Matenkupkum, Matenbek (Freslov, 1989: 34), Panakiwuk (Marshall & Allen, 1991: 70) and Buang Merabak (Rosenfeld, 1997: 222; Leavesley & Allen, 1998: 73) all reveal a pattern of lithic source exploitation involving the collection of local river cobbles. This is also true for the more distant sites of Pamwak (Admiralty Islands) and Kilu (Solomon Islands), where water-rolled chert cobbles, along with other local stone, are used extensively in the early period of occupation (Fredericksen, 1994: 176; Fredericksen *et al*., 1993: 149; Loy *et al*., 1992: 901; Wickler, 1990: 140). Flaked stone assemblages from mainland New Guinea—Huon Peninsula (Groube *et al*., 1986: 454), Nombe (White, 1972; Mountain, 1983), Wañelek (Bulmer, 1991: 473) and Batari (White, 1972: 27)—also indicate the targeting of river cobbles along with very little material extracted from sedimentary contexts (see for example Kosipe, White *et al*., 1970: 167). This pattern of procurement is different to that witnessed at the Yombon airstrip and Eliva hamlet sites during the Pleistocene.

Table 8. The type and location of retouch on Pleistocene tools from Eliva Hamlet and Yombon Airstrip.

tool type	quadrant			
	1–platform edge	2–right margin	3–termination	4–left margin
flake tool	*n.a.*	1 dorsal edge damage 1 ventral edge damage 1 bifacial edge damage	3 dorsal edge damage	3 dorsal edge damage 2 ventral edge damage
number of edges	0	3	3	5
notched flake tool	*n.a.*	*n.a.*	1 steep dorsal scars	1 dorsal notch
number of edges	0	0	1	1
unifacial ovoid scraper	1 steep dorsal scar	1 steep dorsal scars	1 steep dorsal scars	1 steep dorsal scars
number of edges	1	1	1	1

The spatial distribution of reduction activities varies between the Eliva hamlet and Yombon airstrip localities, although cortical and non-cortical flake blanks were produced at both locations. The assemblage from trench FYV/2 at Eliva hamlet is the only exception in that it displays characteristics indicative of both extraction and the early stages of artefact production possibly taking place close to a raw material source in the vicinity of the Eliva hamlet trenches. Both cortical and non-cortical blanks were selected for further modification and use and these blanks are generally larger than the unmodified flakes.

Retouched artefacts are relatively frequent in the West New Britain Pleistocene assemblage and these exhibit a variety of residues and use-damage patterns. Obviously, other activities beyond stone procurement were undertaken at these sites. The presence of a formal tool may indicate a more organized technological strategy, incorporating the production and use of finished tools during this phase. A similar observation has been made regarding the assemblages of Pleistocene tools from Pamwak rockshelter (Fredericksen, 1994: 80).

Both the production technology and blank form of the unifacial ovoid scraper sets it apart from tools discovered in contemporary contexts around Melanesia and may signal a range of activities unlike those described for tools from mainland New Guinea (Groube, 1989). The tool is produced on a primary flake of locally quarried stone material rather than a river cobble. The discoid tools from Pamwak (Fredericksen, 1994: 80; Fredericksen *et al*., 1993: 148), and presumably the stemmed and waisted blades from Kosipe (White *et al*., 1970: 165) and Nombe (Mountain, 1983: 94; White, 1972: 132), are manufactured on large flake blanks; however, the form of the raw material and the reduction sequences involved remain sketchy. None of these Pleistocene tools appear to have been produced on primary (cortical) flakes, and all, except for the Pamwak discoids, have dimensions greater than the unifacial ovoid scraper from Yombon.

Conclusions

Based on the small data set presented here it is difficult to be definite about patterns of resource use and artefact production at the Pleistocene West New Britain rainforest sites. The behavioural model developed from other Melanesian sites occupied at this time indicates a picture of low density, sporadic occupation by small numbers of highly mobile people exploiting not only the locally available stone resources but also the available plant and animal resources of their habitats. Such a behavioural model of high residential mobility would suggest a pattern of highly planned technologies designed to be maintainable (Bleed, 1986), flexible (Nelson, 1991; Shott, 1986) and transportable (Binford, 1979). The organizational and technological features outlined above for most Pleistocene sites in Melanesia indicate an unsystematic, low intensity and spatially undifferentiated approach to procurement, production, tool maintenance and discard activities. This is coupled with high variability in raw material selection and use, and low levels of planning in terms of stone resource exploitation and tool design. In particular, lithic procurement activities appear to be non-intensive, involving a least effort and largely unsystematic strategy of collection.

On the surface, the small number of artefacts recovered from the Pleistocene deposits around Yombon appears consistent with assemblages from other Pleistocene sites. However, on closer inspection, the types of flaked stone artefacts recovered, the organization of procurement activities, the effort involved in raw material extraction and processing, and the associated residues and patterns of use-damage found on tools suggest an alternative picture of technological planning. For example, *in situ* sedimentary stone, probably from within deep sinkholes, was selected and exploited at all times despite the possibility of less costly extraction practices involving the collection of cobbles from loose river gravel deposits. The targeting of specific high quality geological sources in this way has organizational implications for technological planning and mobility strategies. Also, despite little evidence from other island Melanesian sites suggesting tool production and use beyond informal tools displaying little evidence of intensive retouch or distinctive morphology, there is some evidence for the production of more formally shaped and maintained tools in West New Britain. The unifacial ovoid scraper from Eliva hamlet indicates formal tool production during the Pleistocene and the microscopic use-damage on the platform of at least two other artefacts may indicate tool resharpening activities. The use of formal tools in the Papua New Guinea lowlands and islands during the Pleistocene is unknown.

Unlike the data outlined for other Melanesian sites, the evidence from Yombon is consistent with rapid colonization, high mobility, economic exploitation of important local resources and habitation of the rainforest niche during the Pleistocene, even if only for brief periods of time. A similar pattern of low artefact numbers is noted in the New Ireland cave sites and at Kilu Cave, where a model of high settlement mobility by small groups of people has been suggested (Gosden & Robertson, 1991: 43; Marshall & Allen, 1991: 89; Rosenfeld, 1997: 222; White *et al*., 1991: 56; Wickler, 1990: 139). Both short-term occupations, within a pattern of highly mobile settlement, or visits to the region for the purpose of raw material extraction and exploitation of local economic resources can explain the pattern of archaeological remains from the Yombon area of the West New Britain rainforest.

The pattern of stone procurement and tool production may also reflect the dispersed structure of resources within tropical forest environments. The new evidence from Yombon indicates that from the time of their earliest arrival in New Britain, people located and harnessed key rainforest resources. Contrary to current speculation (Bailey & Headland, 1991; Bailey *et al*., 1989; Hart & Hart, 1986; Headland, 1987; Headland & Reid, 1989), these new insights into the human utilization of the lowland rainforest zone challenge current theories about both the pre-agricultural utilization of this habitat, and the capability of Pleistocene humans to successfully harness and colonize the tropical rainforest zone (see also data presented by Endicott & Bellwood, 1991). In island Melanesia the lowland tropical rainforest zone has been one of the most important human habitats for at least 35,500 years.

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