THE EMO SITE (OAC), GULF PROVINCE, PAPUA NEW GUINEA:
Resolving Long-Standing Questions of Antiquity and Implications for the History of the Ancestral Hiri Maritime Trade

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Abstract
Since the 1970s the site of Emo (aka ‘Samoa’, ‘OAC’) in the Gulf Province of Papua New Guinea has been cited as one of the earliest-known ceramic sites from the southern Papuan lowlands. This site has long been seen as holding c.2000 year old evidence of post-Lapita long-distance maritime trade from (Austronesian-speaking) Motu homelands in the Central Province, where pottery was manufactured, to the (non-Austronesian) Gulf Province some 400km to the west where pottery was received and for which large quantities of sago were exchanged (the ancestral hiri trade). However, until now the only three radiocarbon dates available for Emo were out of chronostratigraphic sequence, and few details on the site had been published. This paper presents the results of new excavations and the first detailed series of AMS radiocarbon determinations from Emo, thereby resolving long-standing uncertainties about the age of the site and its implications for the antiquity of the long-distance Motuan hiri maritime trade.

Introduction
Emo, previously known to archaeologists as the ‘Samoa site’ and to the Papua New Guinea (PNG) National Museum and Art Gallery as site ‘OAC’, has been cited in the archaeological literature as one of the oldest known pottery-bearing sites of the southern (Papuan) lowlands of PNG since it was first excavated in the early 1970s (e.g. McNiven et al. 2006:69; Rhoads 1983). Yet its antiquity has remained largely speculative, for until now the only three radiocarbon dates obtained from the site have been out of sequence. Despite these uncertainties, Emo is referenced as a site of ‘the first millennium A.D.’ by Bulmer (1975:48); ‘which dates from 1800 years ago’ by Rhoads (1982:133); probably dating to ‘within the first 800 years of the Papuan pottery sequence’ by Rhoads (1983:99); potentially containing pre-2000 BP ceramics by McNiven et al. (2006:69-70); as being associated with the ‘Early Period’; within which the ‘allocation of sherds to any particular time within the period is problematic’ by Bickler (1997:158); as dating to the ‘earliest pottery occupational levels of the south Papuan coast’, sometime between 1850±295 BP and 2430±370 BP and ‘likely occurring somewhere short of 2,000 years ago’, by Summerhayes and Allen (2007:102); and supporting ‘occupation back to 2500 yr BP’ by Barham (1999:100).

Here we present results of new excavations undertaken at Emo in February 2008. Our primary aim was to redate the site using fine-grained excavation methods, with a detailed understanding of the site’s depositional and cultural chrono-stratigraphy in mind. It represents the first of a series of new excavations in the Gulf Province of PNG aimed at better understanding the history and inter-regional dynamics of ancestral hiri trade relations across some 500km from the pottery-producing centres of Port Moresby in the east to the recipient villages of the Gulf Province in the west.

The Hiri Trade
The peoples of the Port Moresby area – in particular the Motu but also, to a lesser degree, the Koita – were renowned makers of ceramic vessels during the early ethnohistoric period from the 1870s to the 1960s (Figure 1). ‘All of the Motu villages made pots, with the exception of two, Vabukori and Tatana, that specialized in the manufacture of shell ornaments … Thus there were manufacturing specialties even among the villages participating in the same trade system’ (Bulmer 1978:42, following Oram 1875). During early ethnographic times the pottery-making villages included Porebada, Boera, Lea Lea, Manumanu, Pari, Hanuabada, Eleuara and Tanabada (Lampert 1968:77, after Barton 1910; Chalmers 1887; Haddon 1894:2). Pottery was manufactured by women both for domestic use and for local, regional and distant (hiri) trade. The regional trade involved women carrying pots by canoe or on foot to kin or trade partners in nearby inland Gabadi, Doura and Koita villages (in particular villages along the Aroa River), in exchange for garden and meat produce, in particular yams and bananas. In time the Gabadi, Doura and Koita villagers themselves would exchange some of these pots further afield, resulting in a widespread spatial patterning of ceramic pots amenable to archaeological investigation (Groves 1960:8).

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The more far-reaching *hiri* trade is an ethnographically reported trade system involving Austronesian-speaking (principally Western Motu) ceramic pot manufacturers and traders sailing annually to villages in the Gulf of Papua (Dutton 1980). The *hiri* trade journeys are well-documented in the late nineteenth and early twentieth century literature (e.g. Barton 1910; Chalmers 1895; Chester 1878; see Oram 1982 for a review). Trade voyagers set-off in fleets of (typically around 20) multihulled sailing ships (*lagatoi*) from the Port Moresby area of Bootless Bay and Caution Bay when the southeast trade winds blew, typically in October or November, and returned with the monsoons around January. These trading expeditions brought ceramic pots and shell valuables to the western Gulf Province villages, in return for sago and canoe hulls that would be strapped to the ships for the return voyage. Fort (1886:15) reported that annually ‘20,000 pots were taken, for which they would bring back in exchange about 150 tons of sago’; other estimates indicate around 30,000 pots and up to 600 tons of sago per annum (see Allen 1977; Allen and Rye 1982 for reviews). Motu traders regularly travelled to the Gulf Province coastal villages as far west as Vaimuru along the Purari River delta, and there are suggestions in local oral traditions that the Motu trade expeditions sometimes went further west (Figure 2). These villages then served as redistribution centres for inland villages and villages further to the west (e.g. those of the Kikori River and nearby river systems) (e.g. Chester 1878:9; Oram 1982). Groves (1960:3) writes that in the 1950s ‘Motu pottery traditionally found its way, and still finds its way, into almost every village along the shores of the Papuan Gulf and in the immediate hinterland’. The ubiquity of this cultural product gives it great archaeological potential, allowing archaeologists to investigate cultural change, including past inter-regional relations and interactions across close and distant communities. The finding of a rock painting of a large, *lagatoi*-like crab-claw canoe on Dauan in northern Torres Strait (McNiven et al. 2004:244) suggests that on rare occasions *hiri* traders may have ventured even further west to northern Torres Strait. As Groves (1960:8) concludes from the ethnography, the Motu *hiri* trading network was ‘more extensive than any other yet reported from Papua and New Guinea’, and in this, *hiri* holds a special place in PNG’s cultural history.

Professional archaeological research since the late 1960s indicates that the ethnographically recognisable *hiri* trade system and its associated ceramic traditions probably began around 500 years ago (see David 2008). Older ceramic traditions across the Gulf and Central Provinces also suggest that the historical *hiri* descended from a further 1500 years or more of formalised long-distance maritime trade relations across the region (e.g. Allen 1972, 1977; Bulmer 1978, 1982; Rhoads 1982; for a review and significantly expanded radiocarbon chronology see David 2008). At the other end of the chronological spectrum, *hiri* expeditions were severely disrupted during World War II when Motu villages were evacuated and also as a result of increasing involvement in the wage economy since the mid-1900s (Ryan 1970; see also May and Tuckson 2000:59). Formal *hiri* trade expeditions continued sporadically into the 1960s.

Motuan oral tradition has it that the *hiri* trading voyages were begun by the legendary Edai Siabo near present-day Boera village, a short distance to the west of Port Moresby (e.g. Barton 1910; Lewis 1994:134-135). According to genealogical reckoning, this would date the origin of the *hiri* to around 350 years ago by most calculations.

**Hiri Pottery and the Significance of Emo**

The late nineteenth and early twentieth century ethnographic records from Motuan pottery manufacturing villages identify a number of formal pottery shapes and decorative designs within a single general ceramic style. Pottery was made in most Motu-speaking villages.

Numerically predominant among ceramic vessels during the 1870s to 1960s were *uro* cooking pots (Figure 3), *hodu* water jars (typically larger and deeper than the *uro*) and *nau* dishes (Arifin 1990:31; Barton 1910:114; Bulmer 1971; Chalmers 1887:122; Finsch 1914:270). More recent, mid-twentieth century commentators have documented up to 12 Motu pottery types. Not all of these pottery types are said to have been traded by the Motu. A number of pot shapes were further subdivided into size classes by the Motu to create a broader range of distinctive and formalised vessel types (Arifin 1990:35).

Motu pottery was made with paddle and anvil technique (rather than coil technique as practiced in some other parts of Melanesia), the paddles commonly being ridged, although *This* ridging is normally erased by the potter in the final paddling with
a smooth paddle’ (Bulmer 1978:57). Ceramic manufacturers made both plain (undecorated) and decorated wares, the latter representing makers’ marks enabling the male traders to keep track of whose (female kin) products they were exchanging (see Groves 1960 for details of such staisiai services). However unuro, in ethnographic times the principal trade item, was usually undecorated. More generally, pottery made for domestic use was undecorated (Bulmer 1978:61).

Previous archaeological research both within the Central Province (where the pots were made) and Gulf Province (to where the pots were traded) has revealed the existence of a range of ancient ceramic conventions that were not practiced during the late nineteenth and early twentieth centuries: vessel shapes and decorative designs have changed significantly through time. Emo has long been heralded as a key site by which the ancestral hiri trade’s antiquity can be better worked out, because since the 1970s it has remained the oldest reported location of imported ceramics into the Gulf Province; Bickler (1997) has shown that the earliest analysed pottery sherds from archaeological sites in the Gulf Province came from Motuan pottery-producing homelands. Yet a detailed and reliable chrono-stratigraphic study of Emo has not until now been produced; therefore, until we know precisely how old Emo is, we cannot know with any certainty how old the (direct or indirect) hiri trade to the Aird Hills is. This paper addresses this question of the antiquity of Emo and its pottery sherds.

Emo
The archaeological site of Emo is located on flat ground 30m west of the Komo River, on elevated land 15m above the river’s high tide mark (Figure 4). The site is located along the northeastern edge of the twentieth century missionary village of Samoa (Figures 5-6), but, as we were told at Samoa and Ero villages, within Porome customary lands; this is consistent with Rhoads’ (1983:97) observation that ‘The peoples inhabiting the area near Aird Hills were Porome language speakers’.

Archaeological research in Emo began in 1971 when Bowdler undertook five small excavations totaling 4.5m² (Rhoads 1983). This was followed by another excavation programme in 1976, when Rhoads excavated a further 1m². Rhoads (1983) published a short report on both of these excavations, noting that:

the site’s stratigraphy … consists of shell midden within a darkly stained soil matrix, overlying dense red mud. The shell remains vary in consistency with smaller fragments normally associated with near surface, intrusive features (i.e. pits and post holes). Although the stratigraphy is complex, its depositional integrity is secure outside the physical limits of these disturbances. In most places the cultural deposits reach a depth of 60cm below present ground surface’ (Rhoads 1983:98).

Eight stratigraphic units were reported, including the culturally sterile basal ‘red mud’. Three conventional radiocarbon determinations were obtained ‘from the same level’ (Rhoads 1983:98), one of 1850±95 BP (I-6153), submitted by Bowdler on charcoal from 55–60cm below the surface; the other two (2430±370 BP [ANU-2061A] and 1220±180 BP [ANU-2061B]) submitted by Rhoads on paired charcoal and shell respectively, also from 55–60cm below the surface. The youngest of these
determinations was on *Batissa violacea* shell, which incorporates a reservoir effect correction factor of 2900±150 years based on a single radiocarbon determination on a recent shell from nearby limestone-rich waters (Polach 1980:A.68). However, the Aird Hills themselves are of volcanic origins, and the Emo shells are likely to have come from nearby volcanic rather than limestone environments. As Polach (1980:A.68) noted, at the time that the Emo shell date was obtained it was already known that shell ‘Environmental Correction Factors’ (ECF) could range from 450±35 to 5700±200 years. Therefore, while Rhoads’ (1980) radiocarbon date on archaeological shell used an ECF of 2900±150 years, this was more or less a ‘stab in the dark’ and potentially contained a significant dating error of up to 2800 years. The Emo shell date was thus understood at the time to be highly problematic due to doubts about which reservoir effect to use. Consequently, that date was rejected by Rhoads (1983:99) as too young, leaving the original 1850±95 BP and subsequent 2430±370 BP charcoal dates as alternative indicators of the site’s antiquity. Yet the 2430±370 BP date contains a very large standard deviation and is thus of limited precision and usefulness. These three conventional radiocarbon dates obtained by Bowdler and Rhoads have remained until now the sole basis for the oft-cited
but uneasy claims of Emo as dating to the commencement of southern PNG’s ceramic sequence around 2000 BP, although Rhoads (1983:99) was cautious in interpretation, suggesting that, taking the uncertainty of the shell correction factor and the large standard deviation of the 2430±370 BP date into account, ‘an age of 1900 BP best approximates the earliest date for site occupation’. This was essentially deferring to Bowdler’s original single radiocarbon date as indicative of the site’s antiquity. To this day, because these radiocarbon dates are problematic, archaeologists do not know precisely what to do with the Emo results, although they are clearly of interest to archaeologists tracking the origins and subsequent history of ceramic production and specialised, long-distance maritime trade, including the ethnographically-known hiri and the presence of apparently ‘early’ ceramic types at Emo (in particular, red-slipped pottery, despite the antiquity and longevity of red-slipped pottery being poorly understood across southern PNG).

The Excavation
Two juxtaposed 50cm x 50cm squares (A and B) were excavated in February 2008 by BD, J-MG, and NA. The squares were positioned along the NNE, exposed edge and topographically most elevated surviving portion of the site. Here the stratigraphy is exposed in a vertical cutting made for the construction of a house in 2001, located 2m to the south of the site. Archaeological deposits here are at their thickest. The ground surface is covered by a thick growth of low grass that holds surface sediments together; apart from the anthropogenic cuttings for house construction, there are no signs of erosion.

Squares A and B were located approximately 7m to the northeast of Bowdler’s original excavations. Excavation of Squares A and B proceeded in Excavation Units (XUs) averaging 2.4cm thick, following the stratigraphy where evident, although individual Stratigraphic Units (SUs) could not easily be differentiated because of the apparent similarities in colour, texture and contents of the various strata. It was only after the excavations were completed that the complex stratigraphy was exposed. Tables S1 and S2 (supplementary information) list the excavation details for Squares A and B.

Stratigraphy
The Emo excavations revealed 12 major layers or SUs (SU1-12, starting with SU1 at the surface) subdivided into 24 major and sub-SUs. SU1 is subdivided into SU1A-1G; SU2 into SU2A-2E;
SU4 into SU4A-4B; and SU6 into SU6A-6B. SU3, SU5 and SU7-12 are not further subdivided. All SUs except for the basal SU12 are cultural layers, each containing very dense shell and other cultural remains with minor amounts of non-cultural sediments (Figures 7-9). Indeed, by weight only 0.5% of the total excavated sediments >2.8mm in size from Square A, and 1.3% from Square B, consist of non-cultural materials. Tables S3 and S4 list details of the sediments from each SU.

**Radiocarbon Dates**

Ten AMS radiocarbon ages have been obtained, four from Square A and six from Square B (Table 1). All radiocarbon ages are on charcoal collected in situ in three dimensions. These are all in good stratigraphic order and can be used to resolve the chronological uncertainties raised by Rhoads (1983).

The radiocarbon determinations show four clear occupational phases. Based on the midpoints of the highest probability ranges at a single standard deviation, the four phases are:

- **Phase 1**: 1780 cal BP (= approximately 1840 years ago).
- **Phase 2**: 1560 cal BP (= approximately 1620 years ago).
- **Phase 3**: 1470 cal BP (= approximately 1530 years ago).
- **Phase 4**: 660 cal BP (= approximately 720 years ago).

Generally, XU1-6 date to Phase 4; XU7-22 to Phase 3; XU23-32 to Phase 2; and XU33-34 to Phase 1. However, XUs tend to cut across SUs or sub-SUs, and therefore some XUs contain a combination of cultural sediments from more than one phase, especially in levels close to the edges of phases. The basal XU35-36 date to before the arrival of people at Emo. Within this context, some significant trends are evident and explored below.

The radiocarbon ages do not give clear indications as to how long each phase lasted, but the great similarity of the dates within each phase suggests that occupation during each phase was not prolonged; that is, each phase appears to have lasted two or three decades at the most (and probably less) and was followed by a period of regional abandonment or a shift in site location. Further research into this question is in progress (using shell sizes as an indication of predation pressure on regional resources) to shed more light on the temporal pattern of occupation in the regional landscape.

**Archaeological Site Contents**

The contents of Squares A and B are similar to each other, and thus support the general patterns outlined below (Tables S5 and S6).

### Stone Artefacts

A total of 50 stone artefacts were recovered from Squares A and B – 24 from Square A and 26 from Square B (Table S7). The assemblage mostly comprises flakes (N=32, 62%) and flaked pieces (N=13, 26%). A retouched flaked piece or core, a ground fragment, two retouched flakes and a heat-affected fragment make up the only other artefacts recovered.
Artefacts range in length from 4.7mm to 77.8mm; weights range from <0.1g to 184.9g (Figure 10) (the latter being for a fragment of possibly ground volcanic stone). The size distribution for artefacts shows a major peak at around 10mm, with most artefacts less than 40mm in length.

Chert is the most common raw material type in the assemblage, making up 60% of the artefacts, followed by volcanic stone at 26%. Quartz (6%) and weathered stone of unidentifiable type (8%) are the only other raw materials represented. Cherts were found in a range of colours including white, yellow, red-orange and grey and could be uniform or speckled in colour.

Approximately 66% of the artefacts are incomplete, with marginal fragments most common, followed by heat fragments, distal, medial and proximal fragments and a single right-side cone split. Seven artefacts show signs of heat damage, and six artefacts were heated enough to create spalling and breakage.

Cortex is rare, and while found on seven artefacts only three chert artefacts exhibit cortex. Together with the small size of chert flakes, this probably reflects extensive reduction of chert materials, all of which derive from distant sources (see below).

Flakes are on average quite squat (mean length/width = 1.07±0.41) with typically small platforms (ventral area is on average 6.5 times larger than the platform). Macroscopic edge damage is present on six chert flakes (see Table S8), all of which show signs of use (see below). All but one are broken, and were most likely once much larger.

The volcanic and weathered stone artefacts are typically much larger and heavier than the chert and quartz flakes; all are grey in colour. Volcanic and weathered stone flakes have much smaller ventral relative to platform areas than is the case with the chert flakes (Figure S1). All quartz platforms are crushed. The larger size and relatively larger platforms suggest less pressure on the use of volcanic stone, or at least different reduction behaviours. This may reflect greater availability of volcanic stone or different uses of raw materials.

Stone artefacts are most common in Phase 3, with a peak in artefact discard in XU6 (N=6). Artefact discard is lowest in Phase 1 (N=7), rises slightly in Phase 2 (N=8), rising to the Phase 3 peak (N=20) before dropping slightly in Phase 4 (N=15) (Figure S2).

Retouching and heating are only found in Phases 3 and 4. Volcanic artefacts are absent in Phase 1, peak in Phase 2, then drop to low proportions in Phase 3, then increase again slightly in Phase 4. Artefacts are almost all very small throughout the occupation of the site, but one large chert flake is present in Phase 2, and larger chert and volcanic flakes are found in XU7, XU6 and XU3 (Phase 4). Despite the small sample size, stone artefacts become noticeably more abundant around the time pottery also becomes more abundant and shell valuables make their first appearance at the site. This period of innovation and intensification of flaked stone artefact, ceramic and shell deposition coincides with a relative peak in chert artefact abundance. Hence hiri trade for pots may have brought the inhabitants of Emo into more frequent contact with their stone-producing neighbours, in particular those controlling the chert sources located upstream.

Overall, the assemblage reflects the discard of predominantly small flakes and broken pieces, with rare larger flakes. Chert and volcanic artefacts clearly have different life histories, with chert artefacts showing more extensive signs of reduction, including two retouched flakes. Several of the small chert flakes in the assemblage could derive from the retouching of larger flakes that have not been recovered in the excavated sample. Raw material change is present at Emo with a change from chert and quartz at the base of the deposit to the inclusion of volcanic stone and weathered stone in the last three phases of occupation beginning around 1620 years ago (Figure 11). The peak in stone artefact discard in Phase 2 coincides with increased use of volcanic stone and chert, and probably represents strengthened connections between neighbouring groups reflected in transfers of raw materials and other goods.

Stone Artefact Residue and Use-Wear Analysis

A combined residue and use-wear analysis was carried out on a total of 25 stone artefacts from Emo (Table S8, Figures S3-S4). Despite the small size and fragmentary nature of the majority of the sample, 14 were identified as used, with specific functional interpretations made for 10. Of the remaining 11 artefacts, six show no evidence of having been used, and it was not clear whether the remaining five were used or not.
A range of task associations are represented at the site, including skin-working, bone-working and plant processing. Seven instances of plant processing were identified, ranging from cutting plants to scraping resinous wood; three instances of bone-working were identified; and skin-working and ochre grinding were identified once each. It is likely that one artefact was a multifunction tool, possibly used for more than one task.

**Pottery**

A total of 704 pottery sherds were excavated. Fifty-two (7.4%) of these are decorated. Almost all of these sherds are tiny pieces weighing less than 5g (and most weigh less than 1g). The average weight of all sherds is 0.9g, indicative of the very small and weathered state of the ceramic assemblage. Only seven of these are rim sherds, three of which conjoin. The Emo ceramics include seven neck sherds from everted indirect vessels (typical of uro ethnographic forms; see above); six of these are near-surface finds from the uppermost seven XUs of both squares, the other sherd from XU18 of Square A. None of the sherds from everted indirect vessels was recovered from the lowermost levels of the Emo sequence. No sherds from obvious carinated vessels were identified in the entire sequence (Table S9).

Of the 52 decorated sherds, 12 are red-slipped, one is red painted, 31 are either red-slipped or red painted (the sherds are too small to determine which is the correct option), one is red-slipped externally and red painted internally, two are incised, three are either incised or fingernail or shell-impressed, one is red-slipped and incised, and one is red-slipped or red painted and incised or impressed. The red-slipped and red-slipped or red painted sherds occur throughout much of the sequence, with no apparent levels of absence. No shell-impressed decorations were identified, unlike many of the decorated sherds previously recovered from archaeological sites along the southern PNG coastline (e.g. Bulmer 1978; David et al. 2009; Vanderwal 1973). The tiny size of the vast majority of sherds does not allow for a detailed investigation of vessel forms and decoration at Emo; we also note that while decorative conventions are reported here, many of the sherds of vessel forms and decoration at Emo; we also note that while incision/impression depths).

**Bone Artefacts**

Drilled mammal teeth were recovered from Square B XU5 and XU15. Two other bone artefacts found in Square A XU31C and XU26 are a small long bone fragment that has an irregular point fashioned on one end and might have served as a casual engraving or boring implement, and a larger long bone shaft fragment that has been carved internally, perhaps to improve its functionality as a scoop, and also has some cut marks externally. Judging from its size, this bone is probably from a cassowary, human or pig; extraction of ancient DNA may resolve the question of its derivation (Figure S5).

**Shells**

A total of 165,214 Minimum Number of Individual (MNI) non-land snail shells weighing 148.46kg were excavated from Squares A and B. The vast majority of these – 99.9% by MNI as well as by weight – represent discarded food remains, in particular *B. violacea*, *Neritina* spp., *Pythia scarabaeus* and *Melanoides* sp. However, a small number of shell valuables were also found, consisting of seven drilled shell beads, and eight *Cypraea annulus* fragments representing an MNI of five. Three broken pieces of clam, *Tridacna* sp., were also found in XU18 of Square A and XU24 of Square B; one of these has been drilled (see Tables S10 and S11). These finds are further discussed below.

The four major shell species used as a food resource signal focused exploitation of the mangroves that are typical of the Kilori River delta. *Melanoides* sp., *Neritina* spp. and the bivalve *B. violacea* live both in freshwater and estuarine environments that interface in mangrove ecosystems, while *P. scarabaeus* is a mangrove species that can also exist in adjacent terrestrial woodland environments (Smith 1992). Poraituk and Ulijaszek (1981:13) have noted for the Purari River delta shortly to the east that *Neritina* was the taxon 'most frequently collected' by local peoples, 'and was found regularly at all localities investigated'. In some areas it 'appeared in colonies of hundreds or more. Larger snails were found crawling on tree trunks and nypa fronds. Due to its abundance villagers often collect it for food'. Poraituk and Ulijaszek (1981:14) also note that a species of *Pythia* is the most commonly found on rotten leaves and branches … the species is found out of the water'.

A MNI of 49 land snail shells were also excavated. With one exception these are native forest species that inhabit the litter zone, and their incorporation in the deposits is merely indicative of the local forest environment in the area of the site. They comprise *Camalenidae* spp., *Assiminiidae* spp., *Papinidae* sp. and *Lamprocystis* sp. (F. Helicarionidae). *Subulina octona* (F. Subulinidae) is a small, soil- and litter-inhabiting introduced species originating in the West Indies (Solem 1989). Today this species is almost circum-tropical, having been spread synanthropically by European commerce (Cowie 1998). On a more local scale, it may also have been spread by village-to-village trade. The only specimen excavated at Emo came from the surface XU1 of Square A.

MNI for shellfish for the two excavated squares (0.42m$^3$ excavated) total 21,898 *B. violacea*, 118,462 *Melanoides* sp., 12,911 *P. scarabaeus* and 11,941 *Neritina* spp. While *B. violacea* has elsewhere been measured to contain on average 21g of flesh (Meehan 1982:142) and the latter three taxa are small gastropods each estimated to contain approximately 1g of flesh per individual (based on gastropod flesh:shell ratios presented in Meehan 1982:142), the very large numbers of shellfish represented in the Emo excavations indicate consistent and reliable if not voluminous contributions to the diet. Based on surface clues and recent interviews with residents of Samoa village, we estimate that the site was originally approximately 50m x 30m in size, and that it averaged around 50cm in depth. By volume, the Square A and Square B excavations would thus represent approximately 0.056% of the original c.750m$^3$ of the site. As today we can see that the general range of species on the exposed edges of the site are the same as those represented in Square A and Square B, we can extrapolate for the site as a whole to estimate that some
B. violacea, 211,539,286 Melanoïdes sp., 23,055,357 P. scarabaeus and 21,323,214 Neritina spp. – that is, close to 300 million shellfish were eaten and discarded at Emo during the combined few decades of its occupational history. While such quantities are of themselves inordinately large, Melanoïdes, Pythia and Neritina in particular each contain very small amounts of flesh, the total extrapolated Emo shellfish amounting to some 1,077,092kg of flesh (or, at an indicative average of 500 kilojoules/100g of flesh [see Brand Miller et al, 1993], totalling 5,385,464kJ; see also Poraituk and Ulijaszek 1981:22-25 for nutritional values of shellfish in the broader region), consumable in 449 person-days (or 1.2 person-years) assuming an estimated total daily energy requirement of 12,000 kJ/person/day. Even if we assume that shellfish contributed only one-tenth of the Emo population’s complete energy intake, the total kilojoules represented by the shellfish remains in the entire site represent only 12.3 years of food for a single person (or 7 months for 20 people) spread over the entire period of the site’s occupation beginning some 1840 years ago.

It is clear that the Emo shell midden does not indicate a large population residing and depositing food remains over any extended period of time, but rather represents the site as representing a series of short-lived occupational pulses. It is of interest to note that one of the few studies of shellfish exploitation to have been undertaken in the Gulf Province, in this case in the Purari River delta some 50km to the east of the Aird Hills, notes that B. violacea is ‘highly favoured for eating by the local people’ (Poraituk and Ulijaszek 1981:12). They continue: ‘The normal way the local people collect these … species is to gather from one location until the population is depleted and then to move collection elsewhere. There is some oral evidence that this practice might be depleting the total population of these molluscs in the region since the people informed us that their numbers were decreasing with recent intensive collection’ (Poraituk and Ulijaszek 1981:13). It is clear from the Emo evidence presented here that, firstly, intensive exploitation of shellfish resources has a long antiquity in this part of the Gulf Province, dating back to at least 1800 years ago, and that the pulsating nature of site occupation holds potential for archaeologically investigating regional resource use through an examination of archaeological shell sizes with implications for past predation pressures on shell populations. Such a study is now in progress and will be reported elsewhere.

Hearth Stones and Charcoal

The uppermost SU1A and SU1B contain large numbers of hearth stones totalling more than 40kg, consistent with the presence of relatively large amounts of charcoal in those layers. The stratigraphic evidence also indicates the presence of earth ovens in these uppermost SUs.

Plant Remains

Seed and fruit macrofossils were recovered from Emo. Preliminary analysis shows the presence of nutshell and fruitstones in Square B. These include charred Cocos nucifera (coconut) nutshell (XUs 7-9, 12, 15 and 16) and Pandanus key (XU7) fragments, as well as a few Celtis fruitstones (XU10). All of these come from Phase 3, dated to around 1350 years ago, indicating that coconut, Pandanus and Celtis were managed and exploited at or near Emo at that time. Other specimens remain unidentified. From Square A only uncharred husk fragments of Areca catechu (betelnut) were present in XU1, probably from very recent activity. The presence of coconut and Pandanus at depth in the strata shows the use of plant foods at the site. Forthcoming analyses of the full charred plant remain assemblage may add to this picture.

Non-Shell Fauna

A total of 280g of bone were recovered from Square A and 274g from Square B (Tables S12-S15). Avian eggshell from the two squares weighed 4.44g and 0.94g, respectively. A very small quantity of crustacean exoskeleton (0.04g in Square A, probably all crab) completes the faunal assemblage. All of the material appears to be cultural in origin, although some of the smaller rodents may conceivably have died naturally within the context of the midden heap.

The taxonomic composition of the assemblage is summarised for each phase in Tables S12 and S14. Because the quantity of remains from individual XUs is typically quite small, for analysis the assemblages are pooled according to the four main occupation phases. For this analysis, the main domesticates (pig and dog) are separated from the remaining mammals which represent the proceeds of hunting in the forest environments of the Aird Hills.

Most of the bone in all taxonomic categories is unburnt, unweathered and often relatively unfragmented, allowing for allocation of almost all pieces at least to a major taxonomic category. Five major taxa are represented among the vertebrate remains (in descending order of total quantity): fish, mammals, squamates, turtles, birds and frogs. The excellent preservation of the bone and other faunal remains reflects the protective midden environment. Broad taxonomic composition of the assemblage is generally consistent across all four occupation phases.

The fish bone is dominated by the remains of catfish of the family Ariidae – these are most readily identified from their distinctive lenticular otoliths and finely tuberculate head plates. At least six other major groups of fish are represented, including members of the families Plesiosteidae (Catfish), Serranidae (Coral-cod, Coral Trout etc), Scaridae (Parrotfish), Lethrinidae (Emperors), Platyccephalidae (Flatheads) and Lutjanidae (Wrass). The composition of the fish assemblage is consistent with the modern fish community that inhabits the lower reaches of the larger rivers of the Papuan Gulf (Aplin and Rhoads 1980). A wide variety of sizes of fish are represented, suggestive of varied procurement techniques, probably including trapping and spearing.

Pig and dog remains are found throughout Phases 2-4 (Tables S13 and S15) and some larger fragments of bone from within Phase 1 might yet be identified as pig using ancient DNA. Although direct dating of selected bones and teeth has yet to be completed, the fairly even distribution of pig remains in particular through the stratigraphy speaks against all of the specimens from lower levels being intrusive. This pattern contrasts sharply with that described recently by O’Connor et al. (in press) for sites in north coastal New Guinea where the bulk of the pig remains comes from surficial contexts, and where pig bones and teeth from deeper levels yielded essentially modern radiocarbon dates when subject to direct determinations. From the very
fragmentary Emo remains it is difficult to form any opinion as to whether the pig remains are likely to derive from culling of a domestic population, maintained around dwellings and in sago swamps (Hughes 1970), or are the result of the hunting of wild pigs. Rhoads (1980) reported a difference in age profiles of pig remains between open village sites and rockshelters in the Waira region of the middle Kikori River. Pig remains from rockshelters were more often derived from younger pigs, perhaps reflecting easier hunting of young wild pigs or a selective transport of larger captures back to villages. The small sample of pig teeth from the Emo site includes both young and old individuals but there are too few specimens to warrant further analysis.

Wild mammal remains (Tables S13 and S15) include two species of bandicoot (*Echymipera* spp.), two cuscuses (*Phalanger* sp. and *Spilocuscus maculatus*), a wallaby (*Thylogale* sp.) and a variety of rats ranging from the medium-sized white-tailed rat (*Uromys* sp. cf. *U. caudimaculatus*) and water rat (*Hydromys chrysogaster*) to various smaller species (*Melomys* sp., *Rattus* sp.). All of these species can be obtained in lowland rainforest habitats in the Aird Hills, with bandicoots and cuscus predominating over the other groups. The relative paucity of wild mammal remains compared with fish in particular suggests either that relatively little effort was made to obtain wild mammals through hunting or snaring, or that the proceeds of hunting expeditions were consumed and discarded elsewhere.

The modest quantity of reptile bone is dominated by the remains of small- to medium-sized pythons (*Boidae*), with lesser amounts of fanged colubroid snakes (probably including file snakes, *Family Acrochordidae*) and very occasional fragments of monitor (*Varanus* spp.) and other lizards (Tables S13 and S15). The scarcity of larger snakes and monitors in this assemblage contrasts with other lowland Melanesian assemblages reported by Pasveer (2004) and O’Connor *et al.* (2005a, 2005b) and is not readily explicable in terms of local habitat. One possibility is that it reflects a somewhat more residential community at Emo that depleted local populations of larger snakes and monitors, and shifted the demographic profile towards younger and smaller individuals. This hypothesis can be further explored through more precise taxonomic identification of the python remains, a task requiring access to more specialised reference collections and osteological knowledge than presently available.

Turtles are surprisingly scarce throughout the deposit (Tables S13 and S15). All diagnostic remains seem to be derived from freshwater chelid turtles but some chunkier fragments might be from pig-nosed turtles, *Carettochelys* sp.

Bird and frog bones are both very poorly represented (Tables S13 and S15). This is somewhat surprising in the case of birds, especially in view of the fact that eggshell from two different kinds of birds indicates at least some occasional exploitation of this group.

Avian eggshell is derived almost equally from cassowary eggs (thick-walled and with characteristic flattened nodules) and a second type that is thin-walled and externally smooth (Tables S13 and S15). This second group is consistent in morphology and curvature with eggs of a mound-builder of the family *Megapodidae*, several species of which occur in the hinterland of the Papuan Gulf.

Overall, the character of the faunal assemblage varies little through the sequence and suggests a long-term reliance on occasional fishing and hunting to supplement the consumption of shellfish and whatever vegetable matter was gathered or produced.

### Pollen

The pollen and spore concentration throughout the Emo Square B profile is very low, suggesting that the site has been exposed to oxidation and surface disturbance resulting in abrasion and loss of palynomorphs from the record. One exception is the top sample (Square B XU1) which contains the most pollen, with *Poaceae* (dominant), *Cyperaceae*, *Amaranthaceae* (minor) and some fern spores (*Cyathea*) present, suggesting an open grassy environment. This is clearly associated with contemporary conditions. Fungal spores including dung fungi (*Sporomiella* and *Podospora*), perhaps indicative of pigs, are also found in this sample. Micro-charcoal (5-125 micron) shows much better preservation and is at a very high concentration throughout the site.
Summary

Starting with the lowermost deposits, people first came to Emo during Phase 1, some 1840 years ago, at which time the ground surface was clayey. Four major species of shellfish – *B. violacea*, *Neritina* sp., *P. scarabaeus* and *Melanoides* sp. – were each gathered and eaten. Some fish and wild mammals were obtained, and it is possible that pig was either maintained as domestic stock or hunted in nearby lowland rainforest (Tables 1S and 1S5). The thickness of Phase 1 deposits indicates that people did not stay in this part of Emo for very long; indeed, the presence of a single SU (SU11) in this phase indicates that Phase 1 was a single-episode occupational event lasting less than a few decades, and probably only a few weeks, months or years at the most. Undecorated pottery sherds are found in low numbers (N=14), indicating that (ancestral hiri) trade relations between Central Province (Port Moresby area) pottery manufacturers and sailors and Gulf Province trade partners has an antiquity dating back to at least 1840 years ago, given that Bickler (1997) had previously found that the earliest ceramics found in the Gulf Province came from the Port Moresby area.

Phase 2 (dating to about 1620 years ago) is the period when SUs 5-10 were deposited. These layers are generally subhorizontally stratified, but include also the relatively shallow, inverted cone-shaped pit of SU2B whose function is uncertain. Phase 2 sediments are again dominated by the four major shellfish taxa seen in Phase 1 while animal bones (predominantly fish, wild mammals and pig) again form a secondary component. One curious find dating to Phase 2 is the presence of a complete and closed *B. violacea* bivalve enclosing a slightly smaller closed *B. violacea* bivalve shell which in turn encloses the bones of a very small fish (Figure 12). The purpose of this complex construction is unknown, but could relate to either play or to some form of magic/ritual activity. An isolated human tooth was also found in XU25 of Square A. Pottery sherds are again found in low numbers, and consist of 62 undecorated and two decorated sherds (1 red-slipped and 1 red-slipped or red painted). However, 19 of these undecorated sherds come from XU2-4A in Square B, at the interface of Phases 3 and 4. The implication is that it is only around 720 years ago that the predominant ethno graphic vessel form (*uro*) relating to hiri trade begins to be clearly identified in the Emo sequence, although sample sizes are very small and this conclusion should thus be treated with caution. One human tooth fragment occurs in Square B. European objects (glass, metal, plastic) only occur in the top 3cm of the deposit (XU1-2), indicating that except for the uppermost two XUs Phase 4 deposits ceased well before the 1900s; the radiocarbon ages indicate that Phase 4 ended around 700 years ago. However, the presence of small amounts of glass, metal and plastic in XU1-2 indicate very recent, late nineteenth to twentieth century occupation at Emo, consistent with ethnographic records and with the presence of the twentieth-century Samoan village. We here divide this most recent period of Emo’s occupation into Phases 5 and 6; represented archaeologically by the uppermost 3cm of Squares A and B which contain all of the European-contact objects. Phase 5 relates to late nineteenth century to early twentieth century occupation as evidenced by ethnographic records (e.g. Butcher 1963). Phase 6 relates to the missionary village of Samoa, established by missionaries in the mid-1900s and continuing to this day.
Figure 13 Relative frequencies of the four common shell taxa, *B. violacea*, *Melanoïdes* sp., *Neritina* sp. and *P. scarabaeus* at Emo by excavation square and XU. A: Square A; B: Square B. For the presentation of data, TILIA spreadsheet and TGVIEW (v. 2.0.2). Constrained Incremental Sum of Squares (CONISS) cluster analysis was performed and the results displayed as dendrograms on the diagram. The analysis was carried out on percentage data, stratigraphically constrained and with a square-root transformation (Edwards and Cavalli Sforza’s chord distance). For further information see Grimm (1987).

Figure 14 Excavated pottery sherds from Emo, Squares A and B. A: Square A XU3; B: Square A XU15a; C: Square A XU2; D: Square A XU3; E, F: recovered from eroded sediments in front of Squares A and B; G: Square B XU5; H: Square A XU8; I: Square B XU14.
Conclusion

The results of the recent excavations at Emo indicate the following:

1. People first arrived and lived at Emo about 1840 years ago.

2. Since then, there is archaeological and ethnographic evidence of five subsequent phases of occupation, dating to 1620, 1530, 720 years ago (based entirely on archaeological evidence), to the early twentieth century AD (based largely on ethnographic evidence) and to the mid-twentieth century (the missionary village of Samoa). Each of these phases was of relatively short duration (none shows evidence of hundreds of years of use, but rather of periods of time measured in decades or less).

3. The village of Samoa is a very recent, mid-twentieth century colonial-period missionary village.

4. During each of the first four occupational phases, the residents of Emo exploited and ate the abundant local shellfish, with a secondary focus on vertebrate fauna in particular fish, pig and wild mammals.

5. Dogs also seem to be present from early times, at least of five subsequent phases of occupation, dating to 1620, 1530, 720 years ago pottery begins to appear in noticeably higher evidence) and to the mid-twentieth century (the missionary village of Samoa). Each of these phases was of relatively short duration (none shows evidence of hundreds of years of use, but rather of periods of time measured in decades or less).

6. During each of the first four occupational phases, the residents of Emo exploited and ate the abundant local shellfish, with a secondary focus on vertebrate fauna in particular fish, pig and wild mammals.

7. Coconuts were being consumed, and probably grown at or near Emo, during Phase 3 dated to around 1530 years ago. Coconuts are not native to the mangrove-rich river deltas of the Gulf Province, and must therefore have been introduced from further afield, possibly with the ancestral \textit{hiri} voyages documented in this paper.

8. At the same time that imported ceramic sherds increase significantly in numbers and shell valuables make their first appearance at Emo – both suggesting more regular trade partnerships with incoming (ancestral \textit{hiri}) seafaring traders from the east after 1530 years ago – the incidence of imported, curated chert artefacts also begins to increase noticeably, suggesting heightened levels of trade with stone tool manufacturers in the highlands foothills to the north. Chert sago pounders have not been found in the Emo excavations, but tiny flakes resulting from various uses (retouch flakes, use-impact flakes) indicate that around 1530 years regular trade relations with highlands foothills chert tool manufacturers became established across much of the lowlands. We suggest that the establishment of ongoing trade relations with peoples with chert sources was the result of increased need for access to stone sago pounders resulting from the increased demands caused by the large-scale production of sago for the ancestral \textit{hiri} trade closer to the coast. The establishment of large coastal trading centres following the onset of regular \textit{hiri} trade also led to an increased need for stone tools for the manufacture of a broad range of wooden items (including sacred boards, implements and weapons, structures) (see point 7). Kakare (1976:69), a local Motumotu man whose homeland was 180km west of Port Moresby, recounted in 1976 how his ancestral village was drawn from the hinterland to the coast by the \textit{hiri} trade:

According to my grandfather Suve Lari some Vabukori men came in a \textit{lakatoi} (Motu trading canoe) to the mouth of the Lakekamu river about 200 years ago. This date was worked out by the author by counting back the generations using twenty year intervals from the time of Tamate’s (James Chalmers) arrival in MotuMotu in 1879. The Motu met some Toaripi people who lived at Karikara Murumuru (village of darkness) up the Karova creek off the Lakekamu river. Their \textit{lakatoi}, however, could not get up the narrow creek to Karikara Murumuru village. It was then decided to shift the Toaripi people and their possessions to a more accessible position at the mouth of the Lakekamu river. A change in the course of the Lakekamu river has since made the sandspit where they built the new village into an island. The Vabukori men called the new village MotuMotu.

Motumotu village has continued its existence ever since. It is such a process of establishment of coastal trading centres that the \textit{hiri} trade encouraged.

9. There is little evidence in this part of Emo of the early twentieth century village of Phase 5, indicating that this ethnographic village had not been in this area for very long prior to the arrival of missionaries in the Aird Hills and the
establishment of a nearby government station at Kikori in 1912. The predominant archaeological expression is of the pulsating sequence of ancestral villages that date back from 1840 to 720 years ago.

10. As previously argued by David (2008), occupation along the Kikori River, including its delta, is best understood as a series of pulses characterised by shifting residential locations rather than long duration village histories in set locations. These pulses relate to the dynamics of long-distance hiri (and ancestral hiri) exchange partnerships and how the importation and redistribution of ceramic vessels and shell valuables brought by Motu seafarers articulate with regional systems of alliance and enmity. While the establishment of long-distance trade between Gulf Province and Central Province partners led to the establishment and growth of relatively stable and large coastal village locations as regional trade centres (see point 7), further inland the smaller villages were vulnerable to changing relations of alliance and redistribution on the one hand, and raiding on the other, with the powerful coastal groups who largely controlled the hiri trade and whose populations quickly grew. Among these upstream groups ethnographic records document high rates of head-hunting by raiding parties from the large coastal villages such as found among the Kerewo of Goaribari and Aidio and Paia of the Omati River mouth, leading upstream tribes such as the Rumu to relocate villages away from major waterways and at times on hilltops for reasons of protection. Local oral traditions recount ongoing enmity between the Porome of the Aird Hills and the Kerewo during ethnographic times. It comes as no surprise, therefore, to find that, archaeologically, Emo witnessed pulses of occupation which we suggest represent the coming and going of relatively exposed villages on the edge of the Komo River on the one hand, and more protected inland village locations (such as Kumukumu on the nearby mountain-top) on the other. It is in this pulsating movement of villages and dynamics of intertribal relations that the Emo occupational phases and Porome spatial history are readily understood, a process of shifting site location that largely reflects the growth of coastal trade centres and the powerful regional polities that they engendered.

During the early ethnographic period of the late 1800s into the 1900s, Indigenous peoples of the Gulf Province were subject to two largely opposing demographic-settlement forces: headhunting and long-distance maritime trade partnerships and their redistribution networks. The pervasiveness of headhunting, driven by cosmologies focused on the appropriation of embodied spiritual powers (as well-illustrated in the Kerewo ‘agibe cult’ for example – see Haddon [1918], which involved appropriate lineage members consulting ‘skull shrines’ where kiai ‘imumu spirits reside prior to battle [Austen 1935:342]) affected all of the coastal regions of the western Gulf Province, the Western Province and the eastern regions of West Papua. At times headhunting raiding parties involved fleets of large war canoes carrying many hundreds of heavily armed warriors travelling along the southern Papuan coastline, Torres Strait and major river systems of southwestern Papua New Guinea in search of human heads. For example, Haddon (1918:180) writes of the Kerewo headhunting raids I was informed at Dopima [on Goaribari island, 38.4km SSW of Emo] that when a new war canoe (obi) is made the warriors go in it to a strange village on the mainland and kill a man … the body is eaten and the skull attached to an agiba [sacred board and ‘skull shrine’]. In Ubua, an off-shoot from Kerewa [aka Otoia village] in the Kikori estuary, the beheaded corpse is held over the bow of the new canoe, so that the latter is covered with blood … In all cases the body of the victim was eaten and the skull kept in the dubu daima [men’s longhouse where sacred objects were also kept]. The Kerewo folk were in the habit of raiding the bush tribes of the Omati and those of neighbouring rivers, but most raids appear to have been made right up to the hills on the Sirebi River, which flows from the east into the Kikori some thirty miles from its mouth.

The arrival of such incoming enemy forces spread fear among local populations who adapted (where possible) by locating settlements in hidden settings away from the coast and major river systems. This was the situation in the middle Kikori River, where settlements tended to be small (typically dozens of inhabitants) and located along small creeks and on hilltops with good rainforest cover. In the region of the Aird Hills, the largest and most feared headhunting tribe was the Kerewo, a coastal group whose villagers typically numbered between one and two thousand per village (e.g. Otoia, Dopima on the island of Goaribari). Among these large villages, intertribal headhunting often led to revenge raids, as exemplified by an early nineteenth century patrol report:

Last May, the natives of Morigio Island [58km SW of Emo], Turama River, came across to the east bank of the Turama River, and murdered eleven natives belonging to the village of Yawobi, on the Paibuna River [c.46km SW of Emo]. On word reaching the station, the Assistant Resident Magistrate proceeded to the scene of the massacre, and from thence to Morigio Island. This island is a huge swamp, with hardly an acre of dry ground on it. Before leaving for Morigio, 22 canoes from Goari-Bari, with fighting men all painted and well armed with a large supply of bows and arrows, appeared on the scene. They were most anxious to go to Morigio and avenge the deaths of the eleven murdered men, which meant they would kill men, women, and children. [T]he Assistant Resident Magistrate, knowing full well what would happen if he allowed those people to accompany him, sent them back, much to their disgust. On the approach of the officer and his party the murderers deserted their villages, and took to the swamps (Ryan 1913, cited in Goldman and Tauka 1998:60).

The net effect of such raids on coastal and small inland villages by large coastal warring parties was the dispersal of the small inland settlements into camouflaged villages that were effectively also refuges, and the consolidation of large coastal villages into powerful village-based tribal polities. Largely countering these headhunting processes of inland village dispersal and population culling were forces of agglomeration and population growth caused by the establishment of centrifugal trading stations operationalised in the hiri. The coming of Motu hiri long-distance maritime traders called for recognised trading centres along the coast, to which incoming lagatoi could yearly berth and establish trading
relations, attracting residents into centralising settlements in the process. This process of settlement growth consolidated local groups into aggrandising village-based tribal polities who quickly achieved military superiority over neighbouring inland groups, and thereby the power to control and maintain headhunting practices and cosmologies. The raiding success of these large villages enabled them to grow rapidly into powerful tribes feared by neighbouring and distant riverine groups along the Kikori and other neighbouring rivers and their tributaries.

The interplay of these opposing forces of centralisation and village growth caused by the establishment of (ancestral hiri) trading centres on the one hand, and population culling and refugial village dispersal on the other, led to pulsating settlement trends in non-coastal regions, with villages being drawn to resource-rich river frontage during times of alliance and peace expressed by lulls in headhunting raids, and dispersal into camouflaged locations away from the major rivers during times of heightened headhunting activity. We argue that it is in such a setting of ongoing headhunting flux and rhythms of hiri trade partnerships that the Emo archaeological pulses should be seen.

Ongoing archaeological research in the sequence of Porome villages as recorded from oral traditions, and in ancestral Kerewo villages on the island of Goaribari and neighbouring Omati villages as recorded from oral traditions, and in ancestral Kerewo villages on the island of Goaribari and neighbouring Omati River mouth, are aimed at further investigating these processes of social change and settlement growth in the Gulf Province far recipient end of the ancestral hiri trade network of Papua New Guinea.

Supplementary Information
Supplementary information for this article is available online at www.australianarchaeologicalassociation.com.au.

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