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Mid–late Holocene diversification of cultural identities in the Massim islands and the formative development of *Kula*: Excavations at the Mumwa site, Panaeati Island

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Abstract

Anthropological, linguistic and genetic research has suggested that the Massim islands of south-east New Guinea have a complex human history. Archaeological research has gone some way to model the long-term trajectories of island settlement in this region. However, the role of inter-island interaction and connections with mainland populations in shaping cultural diversity remains poorly understood, particularly as it relates to the formative development of the ethnographically described *Kula* network within which Panaeati Island (Louisiade Archipelago) was once a central node. Excavations at the Mumwa site on Panaeati Island have revealed a mid-Holocene cultural deposit (4350 cal. BP), with overlying pottery-bearing layers (750–500 cal. BP) spanning a period of profound social change across the Massim and south Papuan coast, during which time *Kula* is thought to have commenced in earnest. Our data suggests that more regular human habitation of the Massim islands from the end of the mid-Holocene coincided with similarly timed population expansions and changes in tool technologies in other parts of New Guinea that influenced subsequent population dispersals, and likely contributed to the diversification of regional cultural identities. Within the last millennium, inter-island connections had been established with population on Woodlark and perhaps along the south Papuan coast, facilitating the spread of shared cultural behaviours that overlaid established local practices. The gradual withdrawal of islands in the Louisiade Archipelago from regular involvement in regional maritime networks over the last 500 years contributed to deepening linguistic, genetic and cultural boundaries, and were thereafter on the periphery of the *Kula* network.

Introduction

The island of New Guinea is well recognised as a global hotspot of linguistic and cultural diversity, having more extant languages than the Eurasian continent, despite having only 0.5 per cent of the world's land area (Eberhard et al. 2022; Hua et al. 2019). In part, such remarkable diversity can be attributed to a long human history spanning more than 50,000 years that involved innovative behavioural adaptations to a wide range of landscapes and ecologies (Allen and O'Connell 2020; Nettle 1998; Summerhayes et al. 2017). Yet it has become increasingly apparent that the last few millennia have been profoundly influential in the diversification of unique but often interconnected cultural identities following the arrival of Lapita-affiliated groups (McNiven et al. 2011; Shaw et al. 2022; Spriggs 1997; Summerhayes and Allen 2007). The Massim region of south-east Papua New Guinea, in particular, has been the focus of ethnographic investigations attempting to understand the idiosyncratic social practices of island populations and the varying institutions that connected them (Haddon 1894; Seligman 1910). The best known is the *Kula* network that still operates and involves cross-cultural negotiations between trade partners from different islands (Kuehling 2021; Malinowski 1922; Uberoi 1962). Although *Kula* in its ethnographically recorded form is a relatively recent cultural institution that (re)intensified following colonial suppression of warfare, antecedent networks on which it developed have far greater time depths and varied both in function and geographic scope (Irwin et al. 2019). Identifying changes to inter-island connections and the underlying social drivers can therefore provide a robust heuristic framework within which to investigate the diversification of cultural identities in past populations (Allen 1985; Earle and Ericson 1977; Irwin and Holdaway 1996).

Here we present results of archaeological investigations at the newly discovered open site of Mumwa (site code: BAPF[1]) on Panaeati Island, located 170 km from the New Guinea mainland at the western end of the Louisiade Archipelago (Figure 13.1). Systematic excavations at Mumwa have demonstrated that cultural material accumulated rapidly between 720 and 490 years ago and included a more diverse range of pottery styles than previously reported in the archipelago. The predominant pottery style has characteristic 'Massim' art motifs still in use today, reflecting the development of regional cultural identities. Underlying sediments tentatively associated with a mid-Holocene radiocarbon date contained the first tanged blade and stone mortar fragment to be recovered from an excavated context in the Massim region. Our results expand on regional models by suggesting that closer social connections between Massim island populations within the last millennium reflects the formative development of the *Kula* network. A human presence from 4350 cal. BP coincides with population expansions and the development of formalised tool technologies in other parts of New Guinea (south Papuan coast, Bismarck Archipelago, Highlands) and on other Massim islands (Brooker) that likely influenced subsequent population dispersals, distributions and densities (Araho et al. 2002; David et al. 2022; Shaw 2021; Shaw, Field et al. 2020; Shaw et al. 2022; Swadling 2016). Although commonly defined as a singular cultural area (cf. Haddon 1894; Young 1983), this was a relatively recent phenomenon with the long-term history of the Massim islands best modelled as 'pulses' of habitation interspersed by periods of sporadic use or abandonment, particularly in the Louisiade Archipelago, that contributed to the development of diverse regional cultural identities.

1 National Museum and Art Gallery of Papua New Guinea site code register, with each site having a three or four-digit code. Codes provided in text for Massim sites.

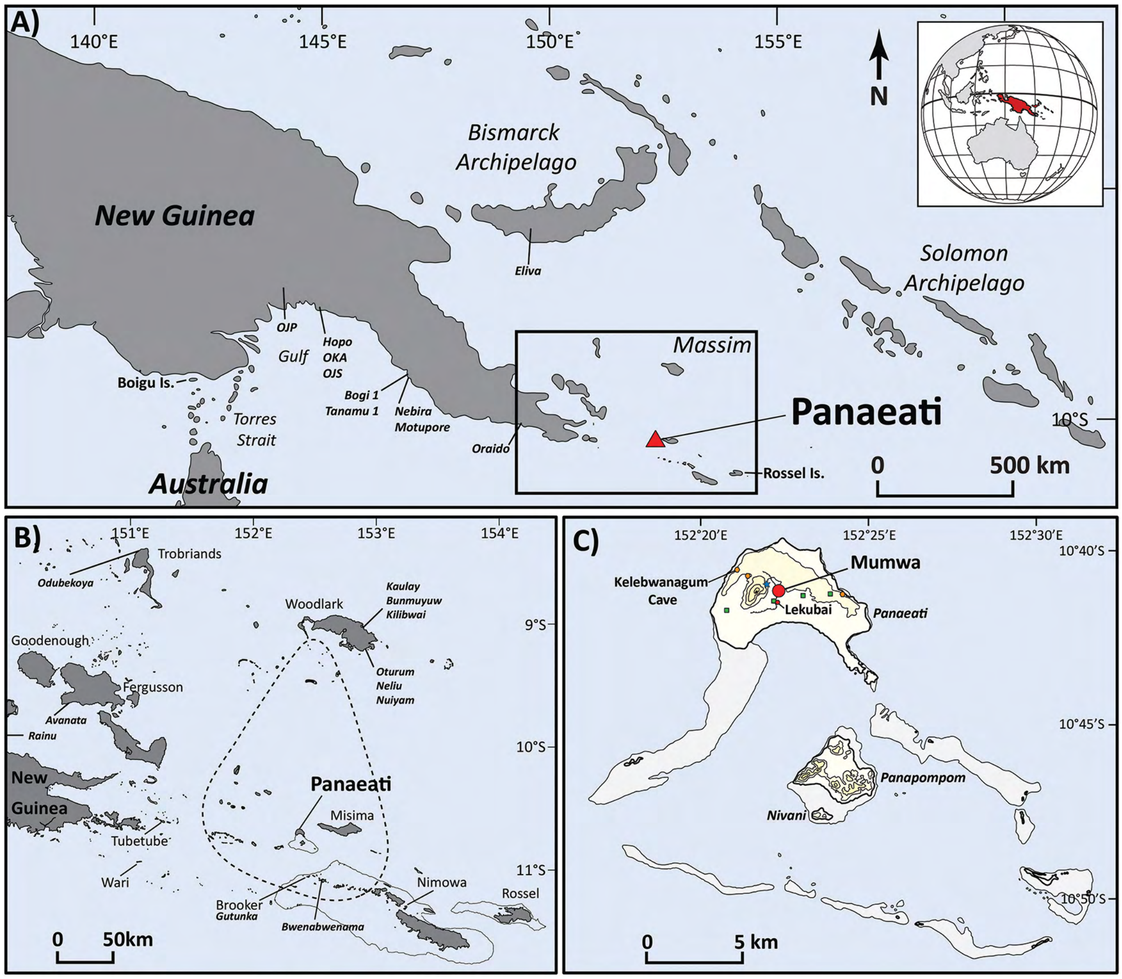

Figure 13.1: (A) Map of Island New Guinea; (B) Massim island region; (C) Panaeati Island.

Notes: (B) The dashed line marks the distribution of people speaking Misima language as their primary language; (C) recorded archaeological sites marked with 40 m contours drawn. Place names mentioned in the text are labelled. Inset: Global location of island New Guinea.

Source: Authors.

The Massim islands in a regional context

Pre-pottery settlement of the southern lowland and island New Guinea

The Massim islands and southern lowlands of Papua New Guinea, spanning 1500 km from Rossel Island in the east to Boigu Island in the west, have a long human history that is currently not well understood (Figure 13.1A). Of ~107 excavated and radiocarbon-dated sites, only eight have cultural chronologies older than 3000 cal. BP[2] (Shaw 2021). The earliest evidence for a human presence has been documented at Kelebwanagum cave (site code: BAPI) on Panaeati Island from 17 cal. ka (cal. kilo annum, thousands of years) (Shaw, Coxe, Haro et al. 2020). Except for OJP

2 Kelebwanagum, OJP, Wokoi Amoho, Ruisasi 2, Tanamu 1, Bogi 1, Kukuba and Gutunka. Excludes single dates from Nebira 4 and Popo, considered by the original authors as erroneous.

cave (13.5 cal. ka) in the riverine lowlands of the Papuan Gulf, all other sites are Holocene in age (David et al. 2007). On current evidence, modern coastal and island fringes were inhabited soon after they developed, between 5200–4880 cal. BP (Tanamu 1, Wk-32553) and 4410–4150 cal. BP (Gutunka, Beta-535172) (McNiven et al. 2011; Shaw et al. 2022; Thangavelu 2015; Vanderwal 1973). The reuse of Kelebwanagum cave from 4810–4440 cal. BP (OZX-905, Marine20 ΔR: –135±20) after an ~8 ka hiatus tentatively suggests population dispersals were more frequent and/or intensive at this time. Lowering sea levels from a mid-Holocene peak (+1.5–3 m, 7–4 ka) will have facilitated more regular human use of stabilising coastlines (cf. Lewis et al. 2013). Yet, the speed at which these developing coastal landscapes were inhabited suggests the lowlands were already well inhabited by this time.

Lapita—Ancestral maritime communities

It is now clear that the first pottery producing communities in southern New Guinea, from 2900–2800 cal. BP to 2500–2350 cal. BP, were affiliated with the Lapita Cultural Complex (Chynoweth et al. 2020; David et al. 2019; McNiven et al. 2011; Shaw et al. 2022). As many as 21 Lapita sites are now known, complementing the nearly 300 sites identified across the western Pacific (cf. Bedford et al. 2019), with the geographic scope of the Lapita diaspora through southern New Guinea consistent with the modern distribution of Papuan Tip Austronesian languages (Ross 1988). Lapita-affiliated sites include three on Massim islands (Gutunka, Kasasinabwana, Malakai), at least 16 in Caution Bay, one in the Gulf (Hopo), and perhaps one in the Torres Strait (Mask Cave) (David et al. 2019; McNiven et al. 2011; McNiven et al. 2006; Mialanes et al. 2016; Negishi and Ono 2009; Shaw, Coxe, Kewibu et al. 2020; Skelly et al. 2014). Interactions between populations, whether Lapita or indigenous, over subsequent millennia has evidently contributed significantly to modern cultural diversity.

Early Papuan Pottery and its relevance to the Massim

What was initially thought to have been the earliest pottery producing communities in southern Papua New Guinea are likely cultural descendants of both Lapita-affiliated and indigenous populations (Shaw et al. 2022; Summerhayes and Allen 2007). Defined as 'Early Papuan Pottery' (EPP), the term broadly describes a set of pottery traditions spanning a millennium or so from 2300–2100 cal. BP to 1300–1100 cal. BP documented at several archaeological sites along the south coast. The earliest pottery was predominantly made locally, with some having similar intricate shell-impressed motifs (Allen 2010). Such similarities suggest the populations were culturally related and, like the preceding Lapita diaspora, had migrated rapidly along the south coast (Allen 1972; Bulmer 1978; Irwin 1985; Vanderwal 1973). Although the initial development of EPP represents a second large-scale population migration, evidence now indicates that at least in some areas (Caution Bay) there was continuity in pottery production and use since its introduction with Lapita (David et al. 2012). From 1600–1500 cal. BP, pottery styles along the south Papuan coast had diversified but continued similarities of some styles is evident, namely the Papuan Gulf and Port Moresby areas, indicating pottery trade and use of some decorative motifs was maintained (Allen 2010; Rhoads 1980).

Whether EPP and the social influences that facilitated its widespread production and distribution also occurred in the Massim islands remains uncertain. Pottery dating from 2200–1600 cal. BP has now been recovered at the Kasasinabwana (BALU), Malakai (BYP) and Gutunka (BANA) sites. With the exception of lip incision on one sherd, all pottery has thus far been undecorated

(Shaw et al. 2022). Although there are similarities in vessel forms and the application of red slip, these assemblages bear no apparent resemblance to contemporary south coast EPP (Negishi and Ono 2009; Shaw, Coxe, Kewibu et al. 2020; Shaw et al. 2022). Currently, shell-impressed pottery from the excavated but undated Avanata site (BALZ) on Fergusson Island provides the only potential link between Late Lapita and initial EPP (Ford et al. 2021). Irwin (1991) included the southern Massim islands within the EPP distribution and argued that the Louisiade islands were on the periphery of core maritime dispersals, presumably inferring that the earliest EPP styles were not present in the region. Irwin et al. (2019) have since illustrated excavated pottery from the Bwenabwenama site (BADD/BADL) on Moturina Island associated with two dates that encompass the full EPP range (2330–1830 cal. BP and 1350–940 cal. BP, ANU-5131/5133) (Figure 13.2). The pottery has closest parallels in rim form and motif elements with Bulmer's thick-rimmed Style II (~1200–1000 cal. BP) that was initially thought to have represented pottery imported from the Massim to the Port Moresby area (Bulmer 1971; Swadling 1981). A lack of shell-impressed motifs and the presence of comparative stylistic attributes supports an association with the later of the two dates. As such, closer social connections between the Louisiade Archipelago and the south coast may have only been re-established around the last millennium, with earlier social connections evident, at least initially, during the rapid diaspora of Lapita cultural groups through these regions (Figure 13.2).

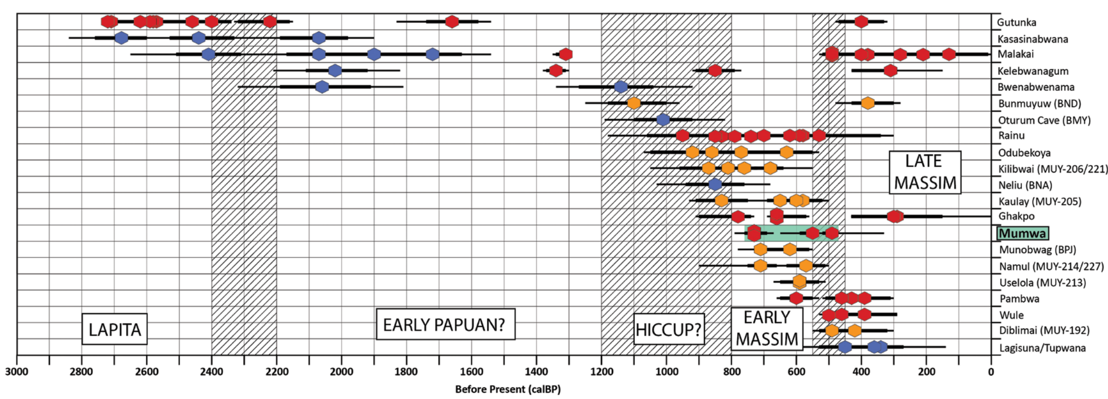

Figure 13.2: Calibrated radiocarbon dates from systematically excavated sites in the Massim region with heuristic chronological divisions based on south coast and Massim datasets.

Notes: Red dots = charcoal, blue dots = marine shell, orange dots = human bone. Site names are listed on the right margin. Note the good chronological coverage across the Hiccup–Early Massim boundary but limited coverage of the preceding Early Papuan (EPP). Hashed areas indicate broadly defined periods of change in archaeological assemblages.

Source: Authors.

Last millennium social change in the Massim

There are now nine Massim sites with median dates between 1200 and 800 cal. BP,[3] contemporary with the so-called 'hiccup'. The hiccup heuristically defines the end of EPP on the south coast when a myriad of localised pottery styles had emerged (Summerhayes and Allen 2007; Vilgalys and Summerhayes 2016) (Figures 13.1 and 13.2). In the Massim during this time, pottery import from the mainland (Rainu) was gradually replaced by inter-island connections, and by 600–500 cal. BP communal burial grounds associated with megalithic arrangements had been superseded by an apparent preference for secondary pot burials (Bickler 1998; Burenhult 2002; Egloff 1979).

3 Kelebwanagum, Bwenabwenama, Oturum cave (BMY), Neliu (BNA), Bunmuyuw (BND), Rainu, Odubekoya, Kilibwai (MUY-206) and Kaulay (MUY-205).

Elaborately carved *Conus* shell valuables recovered from Rainu and several northern Massim islands have characteristic spiral motifs still in use today, with four directly dated to between 910–640 cal. BP (Wk-25781) and 650–380 cal. BP (Wk-31234) (Ambrose et al. 2012). It has been convincingly argued that the *Conus* objects reflect the earliest known representation of 'Massim' art, and together with regional evidence demonstrate the expansion of social networks at this time through which the cultural significance of these motifs was shared and reinforced.

Site setting, survey and excavations

Panaeati Island (30 km^2, 206 m above sea level) is located in the Louisiade Archipelago of the Massim region. It comprises a central metavolcanic hill surrounded by an uplifted coral limestone platform (Smith and Pieters 1973) (Figure 13.1B). Uplift of the plateau has created a basin into which rainwater draining off the mountain accumulates that would have been the only regular water source on the island before the introduction of modern water storage tanks. Archaeological investigations were initiated on Panaeati because it forms a natural 'bottleneck' island through which people would often travel to reach the Louisiade Archipelago. A barrier reef and shallow lagoon encloses the southern side of Panaeati and encompasses two smaller islands—Panapompom and Nivani (Figure 13.1C). Despite the relative isolation of Panaeati from New Guinea, it is near the larger island of Misima and the Calvados Island chain where more regular maritime connections have been documented historically and archaeologically (Berde 1974; Shaw et al. 2016). The Panaeati population speak Misima language, which is also spoken on the small offshore islands near Woodlark, suggesting regular social connections had been maintained with these northern islands in the past (Figure 13.1B). Close ancestral ties are also attested through oral histories with populations on Misima and Brooker in the Louisiade Archipelago, Woodlark in the north, and Tubetube and Wari in the west (Damon 1990; Kinch 2020; Macintyre 1983; Lincoln Wesley, pers. comm, 2021).

A foot survey of Panaeati in 2017–18 resulted in 11 sites being recorded, including four secondary pot burial niches, four caves, two surface artefact scatters and a clay quarry used historically for pot production (Figure 13.1C). One excavated cave—Kelebwanagum—has yielded Late Pleistocene evidence for human use. Two other caves contained secondary burials associated with pots typologically attributed to Southern Massim Pottery (SMP) and antecedent Southern Massim Combed Pottery (SMCP), tentatively suggesting the pots were intermittently deposited over the last 1000–500 years. The two dense surface scatters—Mumwa and Lekubai—are located 600 m apart on the edge of the limestone plateau near the base of the hill where pottery, obsidian and lithics were collected, with Mumwa 1.7 km from the southern coast (Figures 13.1B and 13.3A). Lekubai (BAPC) predominately contained SMP that has been dated in secure excavated contexts elsewhere in the region to within the last 550–500 cal. BP (Irwin et al. 2019; Shaw, Coxe, Kewibu et al. 2020). Mumwa yielded SMCP and several other styles that have not been widely documented in the Louisiade Archipelago, tentatively suggesting it was inhabited earlier than Lekubai. Nine spade test pits were subsequently dug across Mumwa to determine the nature and depth of cultural material relative to surface concentrations (Figure 13.3B). A total of 2731 g (n = 624 sherds) of pottery was excavated, one third of which was recovered from SP3 where the deepest sedimentary deposits were also identified.

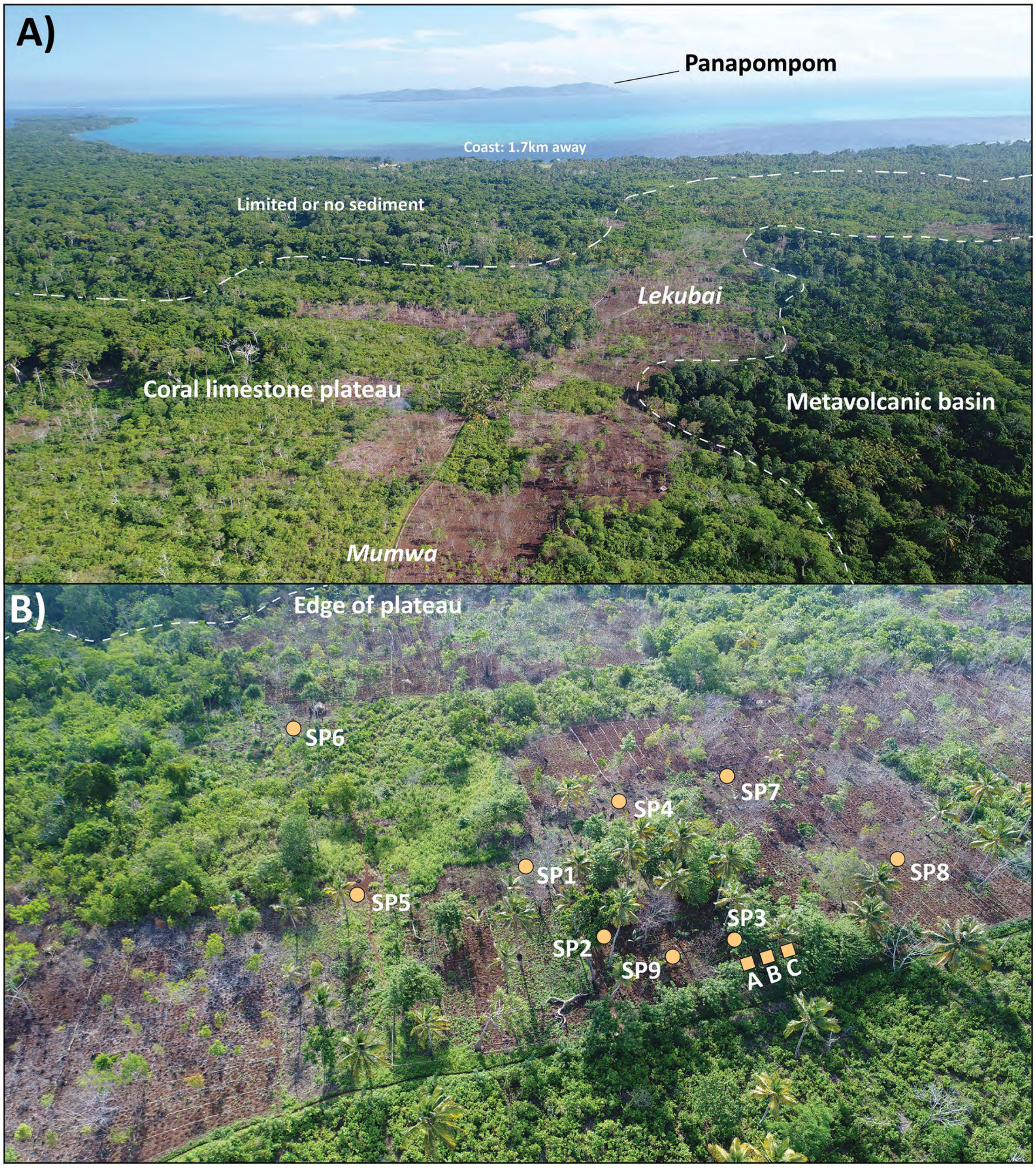

Figure 13.3: Aerial drone images of Mumwa and the surrounding landscape.

Notes: (A) Looking south across the limestone plateau and Deboyne lagoon from Mumwa, showing the site's location relative to geological and geomorphological boundaries. The Lekubai site is 600 m from Mumwa and mainly contains Southern Massim Pottery (SMP); (B) cleared garden plots at Mumwa close to the edge of the limestone plateau showing the distribution of spade pits and the Square A–C excavations.

Source: Authors.

Table 13.1: Stratigraphic layers identified in Squares A–C at the Mumwa site.

Layer	Approx. depth below surface (cm)	Spits			m³ excavated	% organic	pH	Munsell	Description
		Sq. A	Sq. B	Sq. C					
1	0–14	1–3	1–3	1–2	0.457	19	8–7	5YR 3/3 (Dark reddish brown)	Poorly sorted lightly compacted sediment of silt (60%), clay (23%) and fine sand (17%) sized particles, with friable nodules, dense root matter and moderately dense angular metavolcanic stone inclusions. Few limestone nodules. Ant bioturbation noted.
2	14–46	4–9	4–8	3–5	0.751	17	8–7	5YR 4/4 (Reddish brown)	Poorly sorted, moderately compacted friable sediment predominantly silt (73%) and fine sand (19%) sized particles, with 8% clay. Root matter and natural stone inclusions decreasing with depth, and limestone nodules increasing. Ant bioturbation still evident.
3	46–99	10–18	–	6–7	0.301	16	7–6.5	2.5YR 4/4 (Reddish brown)	Poorly sorted sandy silt sediment with moderate limestone nodule inclusions, increasing with depth. Only few fibrous roots present. Moisture content increases near baserock with sediment increasingly compact. Limited bioturbation present. Pockets of sediment with higher clay content in some basal limestone crevices.

Notes: % organic obtained by loss on ignition analysis, and clay–silt–sand proportions from particle size analysis. Sediment colour obtained using Munsell (2000) colour charts.
Source: Authors' summary of site.

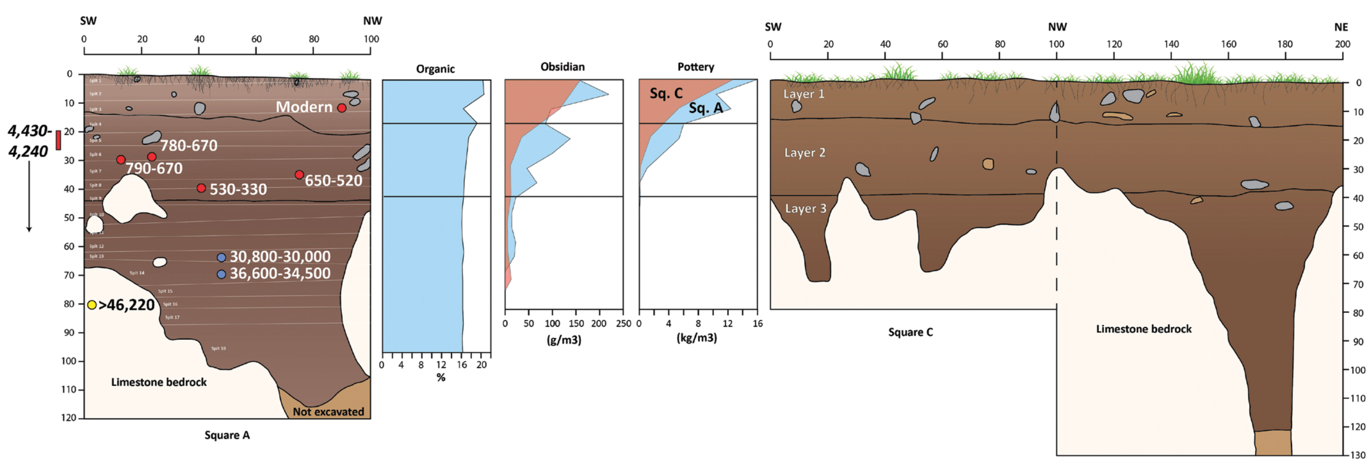

Figure 13.4: Stratigraphic profile of the Mumwa site, Squares A and C.

Notes: The organic component of the sediment is shown, as well as the corrected volume (g/m³) of excavated obsidian and pottery. The 95.4 per cent confidence index range of calibrated radiocarbon dates are indicated. Red circle: charcoal. Blue: *Tridacna* sp. shell. Yellow: coral.

Source: Authors.

In 2018–19 three 1 m^2 squares were systematically excavated near SP3 within apparent stratigraphic layers in 5 cm spits for Squares A–B and 10 cm spits for Square C. All excavated sediment was sieved through 5 mm mesh onsite, with remaining sediment wet sieved through 3 mm mesh. Neutral (pH 8–6.5) sediments provided good conditions for the preservation of organic materials. The notably high organic component (19–16 per cent) suggests sediment formation was primarily a result of in situ decomposition of plants. A lack of reaction of sediments in hydrogen peroxide suggests the underlying limestone did not contribute to soil formation (Figure 13.4). Three stratigraphic layers were identified based on colour and particle size analysis, with two major cultural horizons (Layers 1–2 and Layer 3) defined based on the distribution of cultural material and radiocarbon dating (Table 13.1, Figure 13.4).

The depth of the sediment deposit varied due to undulating basal reef limestone exposed in places 25–30 cm below the surface, with Layer 3 largely defined by infilled sediment within pockets of reef limestone. Squares A and C were excavated to basal limestone, whereas Square B ceased within Layer 2 (~40 cm) due to a landowner dispute temporarily halting work.

Radiocarbon chronology

Nine AMS (accelerator mass spectrometry) radiocarbon determinations established a chronology at Mumwa (Table 13.2). Three additional samples did not survive pretreatment. Seven in situ charcoal samples from Square A indicate that Layer 2 was deposited between 790–670 cal. BP and 530–330 cal. BP (2σ ranges), possibly reflecting two separate pulses of occupation within this timeframe (Figure 13.2). A modern charcoal date (1956 AD) from Layer 1 suggests mid-twentieth-century garden plot preparation had disturbed the topsoil, with some degree of post-depositional disturbance in Layer 2 indicated by inversion of the radiocarbon dates within a 10 cm depth range. However, pottery from both layers was similar, suggesting it was deposited relatively quickly. A charcoal date from SP3 of 4430–4240 cal. BP at a depth (23 cm) equivalent to Layer 2 was clearly out of context. It is considerably earlier than the other determinations and predates the introduction of pottery in Oceania by a millennium (Kirch 2021; Summerhayes 2007). The charcoal was collected from an exposed section and may have been dragged up by the spade, or the enclosing sediment had been disturbed during past land use. In any case, a mid-Holocene age for the aceramic Layer 3 is likely.

Table 13.2: Radiocarbon accelerator mass spectrometer determinations from the Mumwa site.

Lab code	Context	Spit	Depth	Sample	Date	Error	68.3% range	95.4% range	Median
Beta-515727	Sq. A	3	11 cm	Charcoal	Modern	–	–	–	–
Beta-502623		6	29 cm	Charcoal	820	30	740–680	780–670	720
UNSW-1204		6	30 cm	Charcoal	821	36	740–680	790–670	720
UNSW-1205		7	34 cm	Charcoal	586	36	640–540	650–520	600
Beta-515728		8	39 cm	Charcoal	420	30	520–470	530–330	490
UNSW-1202		13	60–64 cm	*Tridacna* shell	27,016	170	30,600–30,100	30,800–30,000	30,400
UNSW-1203		14	64–73 cm	*Tridacna* shell	31,904	480	36,100–35,000	36,600–34,500	35,500
Beta-482842	SP3	–	23 cm	Charcoal	3,920	30	4,420–4,290	4,430–4,240	4,350
Beta-502624			110 cm	Coral	>43,500	–	>46,220		–

Notes: Calibrated ranges rounded to 10 years for Holocene dates and 100 years for Pleistocene dates. Radiocarbon dates are noted as before present (BP), with BP being AD 1950. Error is noted to 1 sigma. Calibrations were undertaken using OxCal 4.4 and the IntCal20 curve for terrestrial samples, and Marine20 with a ΔR of 0 for marine shell samples (Heaton et al, 2020; Reimer et al. 2020). The modern determination was calibrated using CALIbomb and the SHZ3 post-bomb dataset.

Source: Authors' summary.

Pre-Last Glacial Maximum human use or complex uplift history?

Two fragments of *Tridacna* sp. shell from Layer 3 (Spits 13–14) returned pre-Last Glacial Maximum ages of 30,800–30,000 cal. BP and 36,100–34,500 cal. BP. Although it is possible the dates reflect early human landscape use at Mumwa, the shell more likely derived from a relic shellfish bed on the underlying coral limestone. The dates therefore provide a tentative indication of when the Mumwa area was still submerged underwater prior to substantive uplift. If correct, it demonstrates that much of the limestone plateau of Panaeati Island was a lagoon even when sea levels were ~80–60m below modern levels at 36–30 ka. Branch coral from basal reef deposits in SP3 returned an age beyond the limits of detection (<46,220 cal. BP), indicating that the relic shellfish bed had formed on top of a well-established coral reef system.

Relatively recent uplift may explain the relatively dense concentrations of metavolcanic rock fragments on the limestone plateau that would have eroded off the adjacent hillside before uplift subsequently created a basin around its base. Sediment formation on limestone is generally slow, and at Mumwa the uplift history and human use has evidently influenced the sedimentation rate. It is possible that sediment had accumulated very slowly within the last 30 ka when the reef uplifted above sea level, but had probably increased in the mid-Holocene during more regular human landscape use that may have resulted in relict shell being dislodged from the fossil reef or having been used for some purpose.

Excavated material

Pottery, obsidian and lithics were the most abundant excavated cultural material recovered (Tables 13.S1 to 13.S3: see Appendix). A total of 1787 potsherds weighing 5144 g were recorded. Except for two fragments with fresh breaks in Layer 3 (Square C) that had almost certainly fallen from the exposed section, all sherds were attributed to Layer 1 (74 per cent by weight) and Layer 2 (26 per cent). Obsidian was found in all layers with a total of 342 pieces weighing 103.4 g recorded, of which 3.7 g (n = 22) came from Layer 3 in low but consistent quantities in both Squares A and C where Layer 3 was exposed, suggesting its presence in this context was cultural rather than a result of downward post-depositional movement. Considerable quantities of obsidian were present on the surface, with 683 g collected by five people over a 10-minute period, of which the largest piece weighed 10 g. A small amount of pumice (9.3 g), marine shell (7 g) and faunal bone (6.4 g) was identified, including 2.2 g of shell and 0.2 g of fishbone in Layer 3. Pig and fish remains were present in Layers 1–2.

A total of 27 lithic artefacts of hornfels, tuff, limestone, siltstone and schist were also recovered from systematic excavation (Table 13.S4: see Appendix). Of these, 11 were flakes or flaking debris (e.g. Figure 13.5C–D), nine were ground/polished fragments likely broken from an adze-axe blade during use (e.g. Figure 13.5A–B), two were unmodified manuports (e.g. Figure 13.5J) and one was a core (Figure 13.5F). The remaining four were from formally manufactured tools, including a tanged blade and a mortar/stone bowl rim (Figure 13.6A, B), as well as an axe-adze fragment or possibly a grindstone with cut marks, and a retouched axe-adze blade (Figure 13.5G–H). The latter blade had a weathered surface with fresh stone revealed in the retouch scars, indicating the tool had been recycled and may therefore be older than its in situ depositional context. A hornfels axe-adze preform found on the surface of the nearby Lekubai site had also been recycled in the same manner (Figure 13.5I).

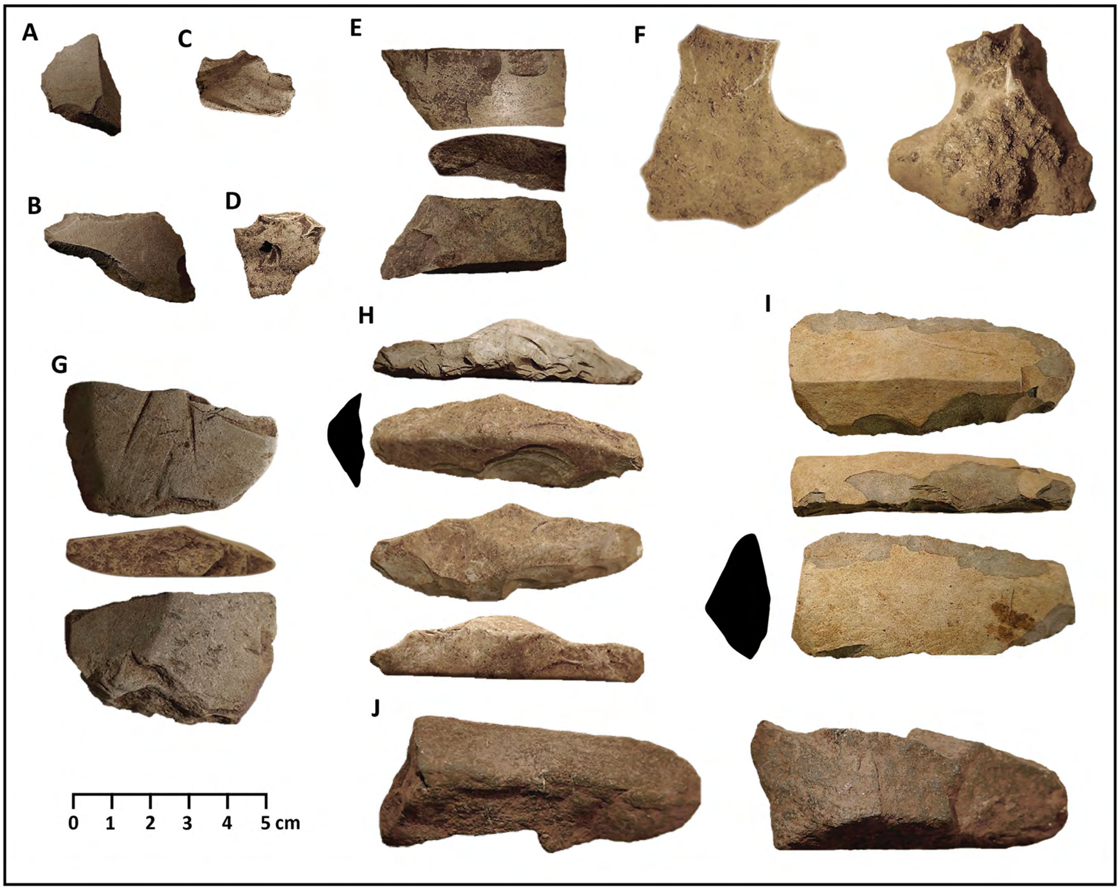

Figure 13.5: Lithic artefacts from Mumwa.

Notes: (A) C.1.1, layer 1, hornfels, ground fragment; (B) C.3.1, layer 1, hornfels, ground fragment; (C) A.4.2, layer 1, limestone, flake; (D) A.14.1, layer 3, limestone, flake; (E) C.4.1, layer 2, hornfels, ground fragment with partial bevel; (F) A.13.1, layer 3, limestone, possible core with flaked edge; (G) A.5.1, layer 2, quartz siltstone, axe-adze preform fragment or grindstone with incisions; (H) B.6.1, layer 2, fine-grained tuff, axe-adze preform with retouch; (I) Lekubai, surface, hornfels, axe-adze preform; (J) C.2.2, metavolcanic, layer 1, manuport.

Source: Authors.

A mid-Holocene human presence at Mumwa

The radiocarbon evidence for burning at 4430–4240 cal. BP cannot on its own be unequivocally associated with human activity, not least because it is out of stratigraphic order. However, the heavily weathered tanged blade and mortar rim are consistent with those recorded in mid-Holocene sites elsewhere in New Guinea, and are the first to be recorded in an excavated Massim context (Figure 13.6A, B) (Bulmer 2005; Swadling 2016; Torrence et al. 2013). Both tool forms are absent from Australasian archaeological contexts spanning the last three millennia and are unknown in Massim ethnographic records and to modern populations.

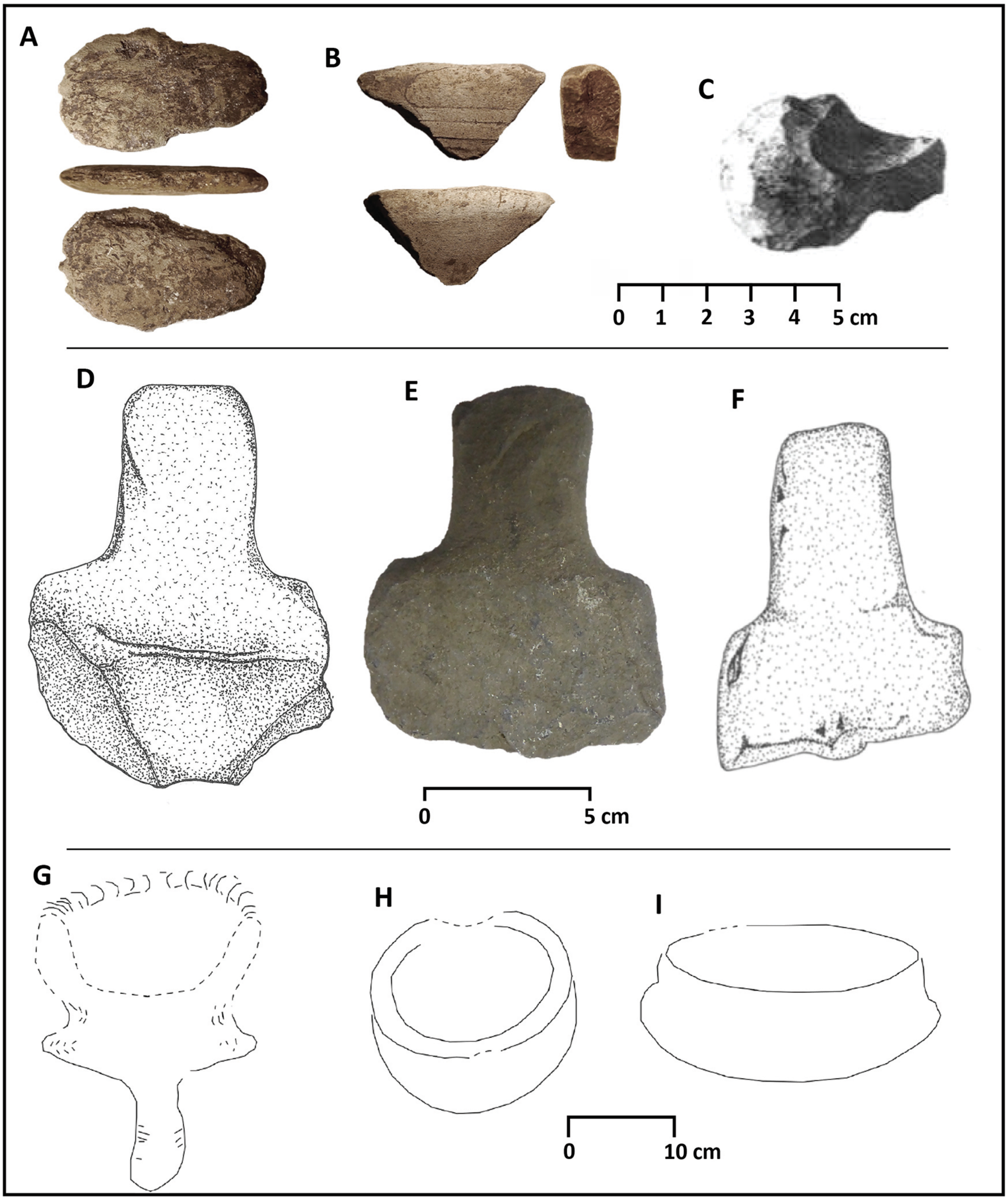

Figure 13.6: Tanged blade (A) and mortar rim (B) from Mumwa compared with other examples from the Massim and island New Guinea.

Notes: (A) Tanged schist blade, Mumwa, Layer 3, spit 14 (64–73 cm below surface, or bs); (B) quartz siltstone mortar rim with four horizontal incised lines, Mumwa, Unit C, Layers 1–2, Spit 2 (92–197 cm bs), possibly out of stratigraphic context; (C) tanged blade from Yombon-Eliva-Asiu, Chronological unit 3 dated to Mid-Holocene; (D) and (F) tanged blades from Okaiboma village, Kiriwina Island recorded by Fernstal et al. (2002); (E) tanged blade (E3054, BOI) from Okabulula, Kitava Island, Trobriand Group collected by G. Gerritz and held by the National Museum and Art Gallery of Papua New Guinea; (G) Pedastalled and bossed mortar, surface, Misima Island; (H) flat rim mortar, surface, Goodenough Island; (I) bowl mortar, surface, South coast.

Source: (A–B, E): Author supplied; (C) from Pavlides 1999; (D, F) from Fernstal et al. (2002); (G–I) adapted from Swadling (2016: Fig. 3).

Tanged blades

The tanged blade from Mumwa was recovered in situ within Layer 3, 689 mm below the ground surface (bs) (Square A, Spit 14). It is made from a grey-green lightly foliated chlorite schist, and could have been obtained locally on the island (Smith and Pieters 1973). A limestone flake and a larger limestone piece with a flaked edge of local origin were also found in Layer 3, the latter recorded in situ 636 mm bs (Square A, Spit 13) (Figure 13.5D, F), suggesting low-intensity utilisation of locally available material for tool production during the mid-Holocene.

Several tanged stone blades have previously been found in undated surface contexts in the Massim, all larger and all recorded on the limestone Trobriand archipelago, about which nothing is known of their use by local residents (Fernstal et al. 2002; Norick 1976). On the northern boundary of the Massim at Eliva in the interior of New Britain, tanged chert tools of a broadly similar size and morphology as the Mumwa tool were found in excavations dated to between 4860–4090 cal. BP and 4410–3900 cal. BP (Pavlides 1999:Unit 3). Obsidian tanged/stemmed blades with similar profiles but larger in size have been found elsewhere in the Bismarck Archipelago, with the few recovered from secure contexts mainly constrained between 6160–5740 and 3480–3160 cal. BP (Araho et al. 2002; Torrence 2016). A stemmed obsidian blade was found under 4 m of sediment on Misima Island, only 14 km from Panaeati, tentatively suggesting the Louisiade Archipelago was within the ambit of mid-Holocene social networks spanning island and mainland New Guinea (Seligman and Joyce 1907; Swadling 2016). Larger tanged and waisted tools on mainland New Guinea date to at least 45 ka, with similar undated examples also known on the Massim island of Rossel (Bulmer 1977; Groube et al. 1986; Shaw 2017).

Mortar rim

Whereas the tanged blade can be tentatively attributed to a mid-Holocene context on both morphological and stratigraphic grounds, the mortar rim was recovered from Layer 2 (92–197 mm bs, Spit 2, Square C) and is either out of stratigraphic context or is a later tool form. Later manufacture of mortars in the Massim can be parsimoniously discounted as they have not been recorded in archaeological sites spanning the last millennium, and are similarly not known in ethnographic collections or to modern communities (Swadling 2013). The quartz rich siltstone from which it was made likely came from the larger island of Misima (Gulewa formation) (de Keyser 1961). Hundreds of mortars and pestles have been recovered in undated surface contexts across highland and lowland New Guinea and adjacent islands, including the Massim (Swadling 2016; Swadling et al. 2008). The most securely dated excavated example has been documented in the Ivane Valley at 4410–4150 cal. BP, with two pestles probably used with mortars dated at the Waim site to 4850–4640 cal. BP and 4300–4080 cal. BP, respectively (Field et al. 2020; Shaw, Field et al. 2020). It is, therefore, probable that the mortar had been displaced from an underlying context and is mid-Holocene in age. Certainly, if the charcoal date of 4430–4240 cal. BP from Mumwa is associated with the tanged blade and mortar it would be chronologically consistent with what is currently known about the age and distribution of these stone technologies in island New Guinea (Shaw 2017). However, a later age for the Mumwa mortar cannot be presently ruled out.

Figure 13.7: Excavated pottery from Squares A–C and spade pits.

Notes: The majority of the pottery was Southern Massim Combed Pottery (SMCP) but contained pottery styles identified by Bickler (1998:98–131) that were likely manufactured on Woodlark Island (Muyuw). Some were likely also manufactured in the D'Entrecasteaux Islands. Except SMCP, names are those defined by Bickler (1998).

Source: Author supplied.

Pottery reveals connections with Woodlark Island and south Papuan coast

The identification of several distinct pottery styles at Mumwa indicates that from 720–490 cal. BP the population had been socially connected with the northern Massim island of Woodlark—still a major *Kula* hub (Damon 1990). Sites elsewhere in the Louisiade Archipelago dating after 500 cal. BP have notably less diversity in pottery styles and are dominated by SMP (Shaw, Coxe, Kewibu et al. 2020). The majority of sherds large enough to determine morphological characteristics and motif elements could be attributed to SMCP (Figure 13.7A–P).

Smaller quantities were attributed to 'Early Period' styles defined by Bickler (1998) on Woodlark Island broadly dated to 1050–500 cal. BP (Figures 13.S1–13.S2: see Appendix). The age range overlaps with the Mumwa chronology and suggests either that (1) pottery deposition at Mumwa may have commenced slightly earlier than the radiocarbon dates currently indicate, (2) production and use of the same pottery styles occurred earlier on Woodlark, or (3) the earliest dates on Woodlark are not securely associated with the pottery. As most radiocarbon dates on Woodlark are on marine shell and human bone that are not associated with a local ΔR marine correction it is possible that the pottery on both islands has a core date range of 720–490 cal. BP, with antecedent forms made earlier.

The complete lack of SMP on the surface or in excavation at Mumwa indicates settlement ceased before its widespread production and trade from 550–450 cal. BP. The presence of SMP at Lekubai only 600 m away implies that the focus of settlement may have shifted further along the plateau towards the coast. As such, stylistic change in pottery at Mumwa and Lekubai may be associated with broader social changes that influenced settlement location as well as pottery production.

Southern Massim Combed Pottery

Mumwa is the only excavated site where SMCP is the predominant style, providing the first chronological constraints for its production and trade. SMCP vessels are made by coiling, often with only the exterior having a smoothed finish. Rim courses are generally straight or have a slight concavity between shoulder and lip, with the lip typically shaped from folded clay to form an interior or exterior swelling (see also Irwin et al. 2019). Elders on Panaeati Island recall that their great-grandparents were told by their own grandparents that pottery was once made with folded clay rims (Aliti Luyana, pers. comm, 16 October 2017). Comb incision motifs are geometric and limited to the upper half of the vessel above a carination or shoulder with notching, appliqué strips or applied nubbins occasionally demarcating the lower motif boundary (see Figure 13.7).

Trace quantities of SMCP have been recovered at the Wule (BAOT), Ghakpo (BAOP) and Pambwa (BAMY) sites on Rossel Island associated with larger amounts of SMP and dated from 540–470 cal. BP (Shaw 2015). Earlier dates at Ghakpo and Pambwa (910–530 cal. BP) overlap with the Mumwa chronology but are not associated with pottery, suggesting SMCP was not imported as far as Rossel at this time and that its production and trade volume had declined by the time pottery was introduced *en masse* to the island (Shaw 2016). SMCP has otherwise been found in surface contexts on several southern Massim islands and in trace qualities on the northern island of Woodlark—defined by Bickler (1998:107–108) as 'incised fineware'. It was not recovered from the contemporary Rainu deposits, indicating that the distribution of SMCP was primarily limited to the southern Massim islands. Chemical sourcing analyses by Irwin et al. (2019) identified Tubetube Island as one probable production centre. The high concentration of SMCP at Mumwa suggests Panaeati was probably another.

Northern Massim pottery

Bickler (1998:98–131) defined pottery styles on Woodlark by combining decorative elements and vessel morphology; those identified at Mumwa included geometric grooved and incised, fingernail impressed, geometric incised, linear vertical incised, incised redware, punctate geometric, linear incised and notched, and geometric incised (Figures 13.7, 13.8 and 13.S1).

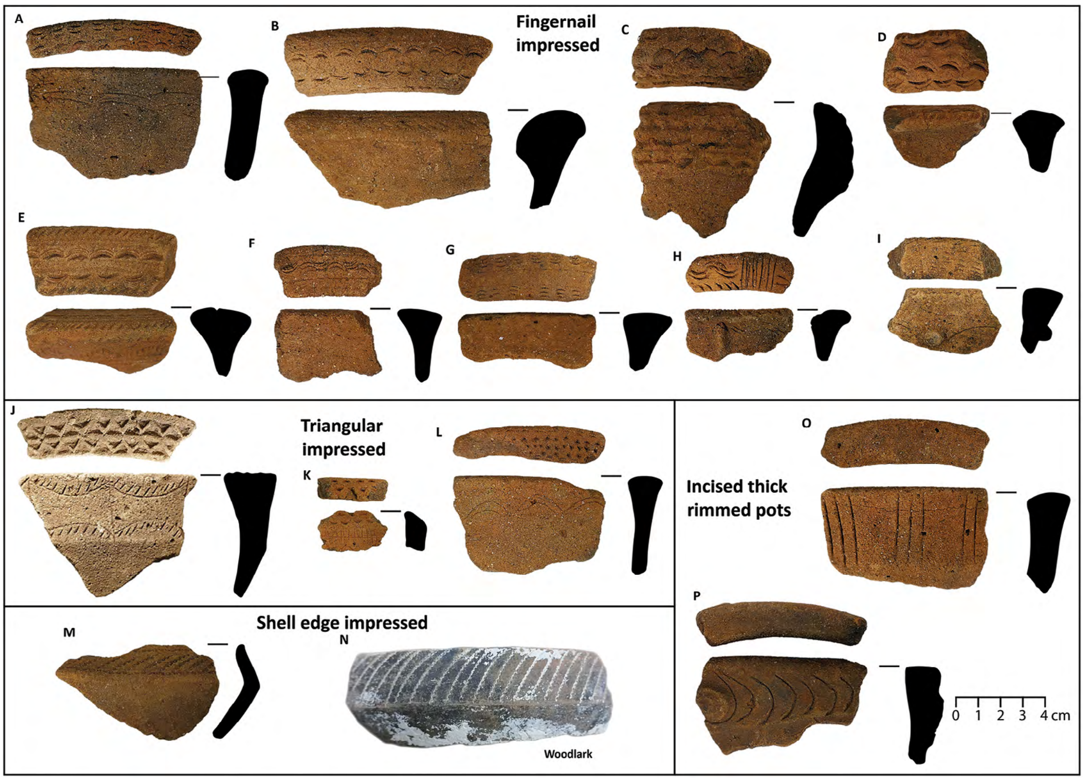

Figure 13.8: Surface pottery from Mumwa not well represented in excavation.

Notes: A range of thick-rimmed fingernail-impressed pottery, suggesting multiple wares with similar decorative conventions. Triangular-impressed sherds were not found in excavation but are known from the Rainu excavations. Shell-impressed pottery has thus far only been reported on Fergusson Island. The right-hand shell-impressed sherd was collected on Woodlark by Ollier and Pain (1978) and photographed in the National Museum and Art Gallery of Papua New Guinea.

Source: Author supplied, except where cited.

Although some of these styles likely belong to the same tradition, their presence together at Mumwa confirms they are broadly contemporary. Allocation of Mumwa pottery to Bickler's Woodlark styles was clear when motifs were preserved, although sherds with eroded surfaces could generally be distinguished from SMCP by rim form and a thicker wall profile (Figure 13.9). Of the Woodlark styles, fingernail-impressed pottery, well represented at Mumwa, was determined by Bickler (1998) through radiocarbon and seriation analyses to have been manufactured from 1050 cal. BP (median age). However, it was more likely produced later as it had also been found more securely associated with secondary pot burials dating to 800–500 cal. BP. Fingernail-impressed pottery has so far not been found to be associated with secondary cave or niche burials on Panaeati. Chemical and petrographic sourcing analyses of the Woodlark 'Early Period' pottery has been interpreted as evidence for local production. However, the geometric grooved and incised pottery is strikingly similar to historically recorded pottery made on Goodenough Island, so a D'Entrecasteaux Archipelago origin remains a possibility (Lauer 1973).

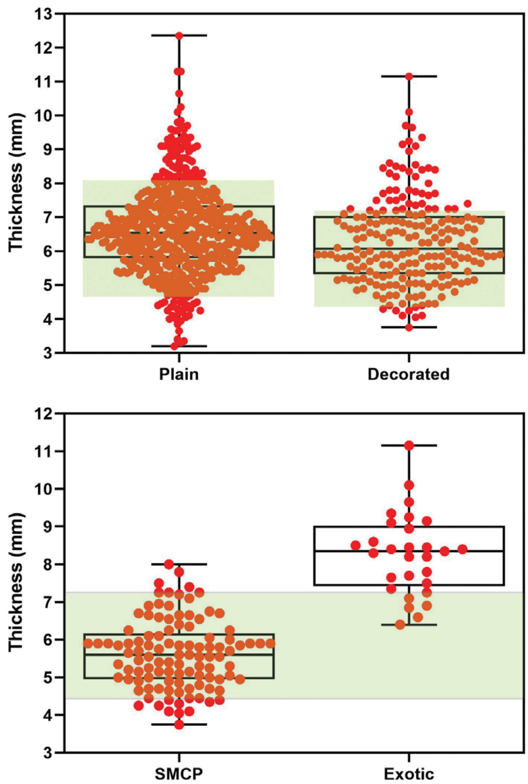

Figure 13.9: Box and whisker plot of decorated sherd thickness recovered from Square A, Mumwa, attributed to SMCP or styles defined by Bickler (1998) for Woodlark Island.

Notes: Although there is overlap, the SMCP is thinner than contemporary pottery manufactured elsewhere in the Massim. The green band marks the 1-standard deviation range of SMP recorded on Rossel Island, showing consistency with antecedent SMCP vessels.

Source: Author supplied.

Shell-impressed pottery

Two shell-impressed sherds were recovered from excavation that do not fit into any known regional Massim style and may belong to an as-yet undefined style, or was imported into the region from elsewhere. Shell-impressed pottery is rare in Massim island archaeological contexts but is common in the Rainu mounds on the adjacent mainland. There is, however, no clear correlation between the Mumwa and Rainu shell-impressed sherds (Egloff 1979). On Woodlark Island, shell impression is combined with incision on a northern variant of SMP dated to within the last ~600 years. On Fergusson, sherds from the Avanata site are probably associated with terminal Lapita or EPP (Ford et al. 2021).

The first excavated shell-impressed Mumwa sherd (Figure 13.7SS) is a rim and carination of a shallow vessel with bivalve edge impression, consistent with an *Anadara* sp. shell. A rim sherd found on the surface at Mumwa and a rim recorded in association with secondary burials in Nuiyam Cave (BMW) on Woodlark recorded by Ollier and Pain (1978) also have similar vessel forms and edge impressions (Figure 13.8M–N). An association with secondary burials is consistent with regional models for changing attitudes to interment. This excavated sherd is also similar to shell-impressed bowls at the contemporary Motupore site on the south coast dated to 800–300 cal. BP (Allen 2017:Fig. 8.12).

The second excavated sherd (Figure 13.7TT) is stamped with individual impressions consistent with the umbo of a bivalve shell. The impressions may have been made by a similarly shaped end of a stick but this is less likely based on comparisons with other shell-impressed sherds. It is broadly similar to EPP pottery dating from ~2200–1600 cal. BP at OKA and OJS in the Gulf, and Nebira 4 and Bogi 1 in the Central Province (Allen 1972; David et al. 2012; Skelly 2014). Two other shell-impressed surface sherds at Mumwa have small triangle umbo impressions on thickened rims (Figure 13.8K–L) and are identical to pottery from Rainu (Mound C, Group P, 1000–600 cal. BP) and the Oraido site (Layer C,1600–1300 cal. BP) in Amazon Bay (Egloff 1979; Irwin 1977). Production of shell-impressed pottery in the Massin islands may therefore have commenced as early as 1600–1300 cal. BP, but given the relatively small number of shell-impressed potsherds at Mumwa, they were likely imported to Panaeati at the later end of its production lifespan as has also been suggested for Rainu. Petrographic and elemental analyses are also underway to confirm regional connections.

Stone tools suggest multiple island connections

The Suloga peninsula on the south coast of Woodlark has the highest quality fine-grained stone in the region for the manufacture of axe/adze blades, with most islands in the Louisiade Archipelago having smaller outcrops or foliated base rock not well suited for tool manufacture (Bickler and Turner 2002). The surface collected axe-adze preform from Lekubai (Figure 13.5I) is consistent with the metamorphosed hornfels (*Kaitalamai*) from Suloga and its triangular cross-section is consistent with the predominant tool form produced on Woodlark. The presence of similar ground fragments of the same lithology at Mumwa suggests Suloga stone may have been imported to Panaeati from at least 790–670 cal. BP (Figure 13.5A–B, C). The tuff blade preform at Mumwa, clearly imported to Panaeati, also had a triangular cross-section and may indicate the use of other lithic materials from Woodlark, where tuff occurs, to manufacture tools using similar conventions (Trail 1967) (Figure 13.5H). Again, elemental and petrographic analyses also underway to confirm the source.

Obsidian implies direction and extent of inter-island trade

Obsidian does not occur naturally in the Louisiade Archipelago and its presence on Panaeati indicates that it was imported to the island through maritime networks. Known obsidian source regions are geochemically distinct from each other and include three in the Bismarck Archipelago (Willaumez Peninsula, Mopir and Admiralties) and one (Fergusson Island) in the Massim. Multiple outcrops occur within each of these regions (Bird et al. 1981; Smith 1974). Portable X-ray fluorescence (pXRF) analysis of 91 Mumwa obsidian pieces demonstrate it was all sourced from western (n = 87) and eastern (n = 4) Fergusson Island sub-sources, 190–240 km west of Panaeati. Sampled Layer 3 obsidian (n = 12) was imported exclusively from western sub-sources. Obsidian volume in Layers 1–2 at Mumwa (Squares A and C) is similar to the lowest pottery-bearing Lapita layer at the Gutunka site on nearby Brooker island (87 g/m^3), with volumes considerably lower in Mumwa, Layer 3 (10.2 g/m^3). The obsidian volume data suggests import to Panaeati occurred regularly from 720–490 cal. BP but less frequently in earlier contexts. The size of obsidian pieces on the surface further suggests obsidian import to Panaeati occurred in relatively large pieces. Flakes comprise 70 per cent (n = 241) of the excavated assemblage, angular fragments 20 per cent (n = 67) and cores 10 per cent (n = 32). The obsidian pieces are relatively small in length (5–28 mm, $\bar{x}$ = 12 mm) and weight (0.02–2.65 g, $\bar{x}$ = 0.30 g), with cores smaller than the largest flakes. No formal tools were present. The metric data collectively indicates that reduction occurred onsite and was relatively intensive, with all cores exhausted to the smallest practical size prior to discard. More detailed analyses of the Mumwa obsidian will be presented in forthcoming publications by one of the authors (LS).

Maritime pathways to Panaeati

Potential maritime import pathways to Panaeati can be inferred when the Mumwa obsidian data is considered against contemporary sites elsewhere in the region. The obsidian density at Rainu (950–530 cal. BP) on the mainland, 140 km west of Fergusson Island, was considerably higher than at Mumwa (203–282 g/m^3) (Egloff 1979). However, at Kasasinabwana on Wari Island, 170 km south of Fergusson, only 63 pieces were recovered from a 2 m^2 trench spanning the last 2680 cal. years, of which 59 came from layer one that likely dates to the last 500 years or so (Negishi and Ono 2009). In the Trobriand group, 130 km from Fergusson, densities at Odubekoya (BALP) were surprisingly much lower than at Mumwa, as only 787 pieces were recovered from 66 m^2 of excavated sediment,

with most collected on the surface (Fernstal et al. 2002). Finally, on Woodlark, although Bickler (1998) did not provide any site-specific obsidian data, he noted it was plentiful on the surface in association with pottery styles identified at Mumwa. Sites on the island's northern side contained larger flakes than those in the south, with the implication that obsidian may have been imported through northern communities and redistributed across the island and to other islands. In later contexts within the Louisiade Archipelago (<550 cal. BP), obsidian densities decrease significantly (<20–5 g/m^3) indicating that these communities were not as regularly connected to social networks through which obsidian was imported (Shaw, Coxe, Kewibu et al. 2020). Given the low densities of obsidian at the contemporary sites on Wari and Kiriwina, obsidian may have been transported to Panaeati through Woodlark, perhaps via smaller 'stepping stone' islands such as Gawa and Iwa that are connected through *Kula* exchange routes (Munn 1992).

Discussion

Archaeological investigations at Mumwa have filled a conspicuous gap in cultural chronologies of the Louisiade Archipelago and the southern Massim, with analyses indicating the site was occupied during a period of marked social change in the region when inter-island maritime networks were augmenting and cultural identifies diversifying. The results suggest that connections that had been maintained with Woodlark and other islands nearer to the New Guinea mainland were closer between 720 and 490 years ago than in later centuries. Potential links with south coast pottery production centres also suggest the Louisiade Archipelago was integrated into overlapping regional social networks, including those antecedent to *Kula*, and appear to have excluded some contemporary maritime-focused Massim and south coast communities where similar pottery has not been found. Prior to *Kula* and the establishment of other historically recorded networks there was a fluidity of interactions throughout the Massim islands and with the New Guinea mainland that included the production of more diverse pottery than is known within the last 500 years. Such fluidity was likely to have been foundational to the development of the *Kula* network and was driven by intergenerational social linkages.

EPP and the 'hiccup'

The pottery recovered from Mumwa is consistent with the pottery from Moturina Island defined by Irwin et al. (2019) as EPP, and on Woodlark Island defined by Bickler (1998) as 'early style pottery'. Although this pottery, or antecedent forms of it, may have been produced regionally from 1300–1050 cal. BP or slightly earlier, it was evidently more widespread from 720–490 cal. BP, and broadly overlaps with the 'ceramic hiccup' when local styles had proliferated. There is currently no substantive evidence for an EPP sequence in the Massim islands like that of the south Papuan coast beyond the broad similarities in vessel form that probably derived from a shared history of Lapita-affiliated pottery production. Bulmer (1971) and Swadling (1981) considered that pottery from the Eriama and Boera sites (Style II) was reminiscent of historic Massim styles. The pottery from Mumwa confirms contemporary Massim pottery does have close similarities, and the potential presence of south coast pottery at Mumwa implies some maritime connections, albethey irregular.

There is a notable absence of deposition between 1300 and 550 cal. BP on small Massim islands, including Nimowa (3.5 km^2), Brooker (1.4 km^2), Wari (2.2 km^2) and perhaps also Tubetube (2.5 km^2). Reduced annual rainfall and shortages in available fresh water have been suggested as a reason for the abandonment of small islands in favour of larger islands during this time. It may also be a driver of the identified 'ceramic hiccup' on the south coast, where changes in settlement patterns

also occurred (Allen 2010; Shaw, Coxe, Kewibu et al. 2020; Sutton et al. 2015). The Mumwa site, near a natural watershed on Panaeati Island, was one such settlement maintained over this time of apparent social disruption. A shift in settlement from Mumwa to locations nearer the coast from or after 550 cal. BP coincided with a large-scale influx of pottery import to Rossel Island (290 km^2) and reoccupation of Nimowa and Brooker Islands, all associated with the deposition of SMP. The Mumwa sequence, therefore, demonstrates that SMCP is ancestral to SMP, and stylistic change was associated with changes in settlement location and social organisation that involved cross-cultural maritime networking.

Pulses of population movements since the mid-Holocene

The tentative correlation of a tanged blade and mortar rim with a radiocarbon date of 4420–4320 cal. BP at Mumwa suggests that the overlapping mid-Holocene social networks spanning the Bismarck Archipelago and the New Guinea mainland also included the Massim islands, as suggested by Swadling (2016). A later age for the mortar is possible, but evidence is mounting for the more regular habitation of Massim islands from 5–4 ka, although populations were relatively mobile because as yet there is no evidence for continuous use of any one island since this time (Shaw, Coxe, Haro et al. 2020; Shaw et al. 2022). It is likely that until the last millennium many small islands were mostly used as short-term fishing and bird hunting camps, or refuges during longer sea voyages between larger islands. 'Pulses' of population expansion would likely have been supported by a network of culturally related groups occupying surrounding islands, such as was likely the case during Lapita expansion, that contributed to the maintenance of ancestral connections within archipelagos as inferred by genetic analyses (Shaw et al. 2022; van Oven et al. 2014). Innovations occurring within these interconnected maritime-focused social systems led to the deepening diversification of cultural identities. The greater number and smaller geographic range of languages in the D'Entrecasteaux might suggest that different social processes influenced diversity in this island group. We must now look to increase the resolution of existing sequences and to fill the many blanks in archaeological coverage so more nuanced models can be developed.

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Appendix: Supplementary tables and figures

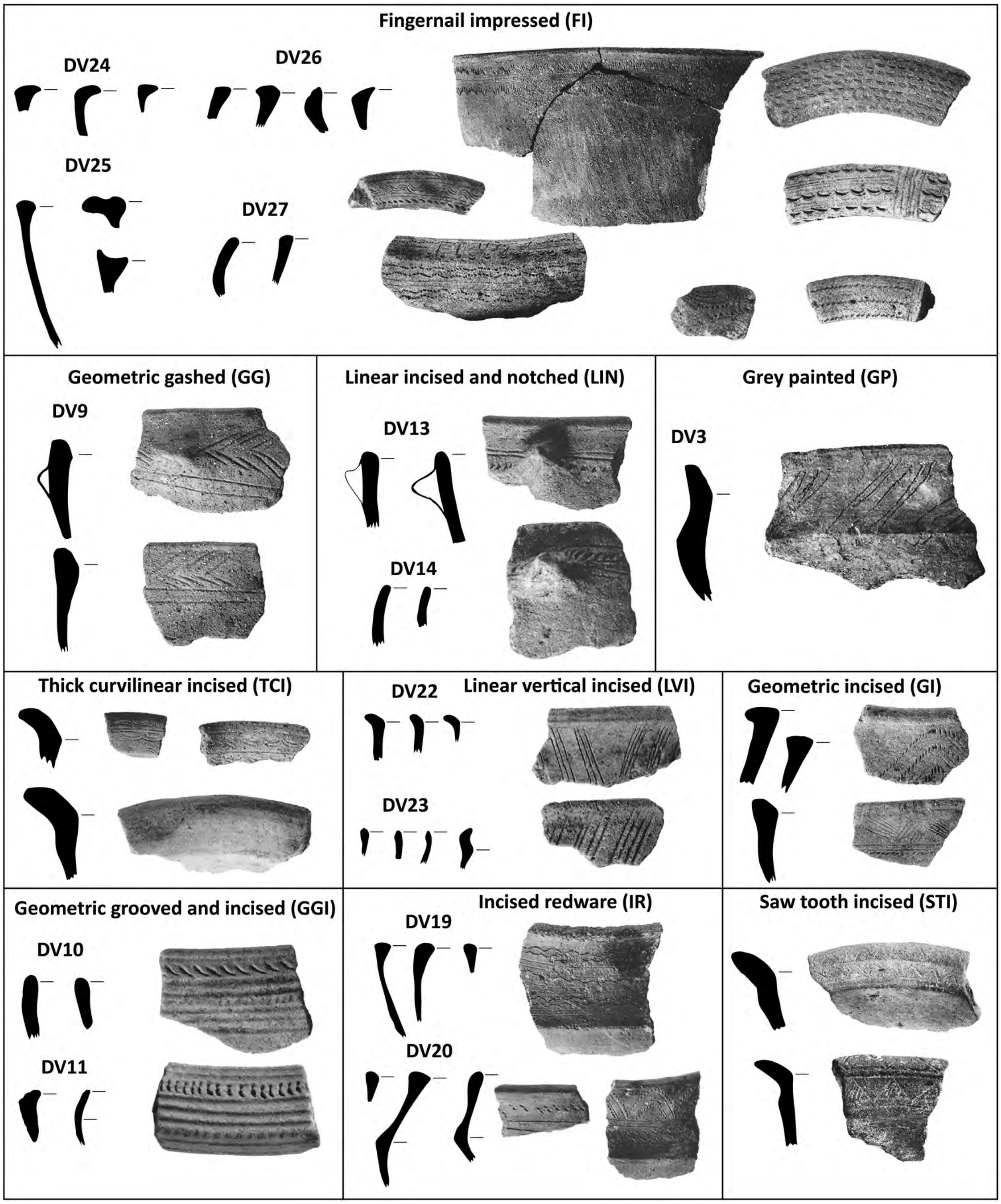

Figure 13.S1: Early Period pottery (~1050–500 cal. BP) recorded on Woodlark Island.

Note: DV = Decorated vessel as defined by Bickler (1998).

Source: Recorded by Simon Bickler (1998).

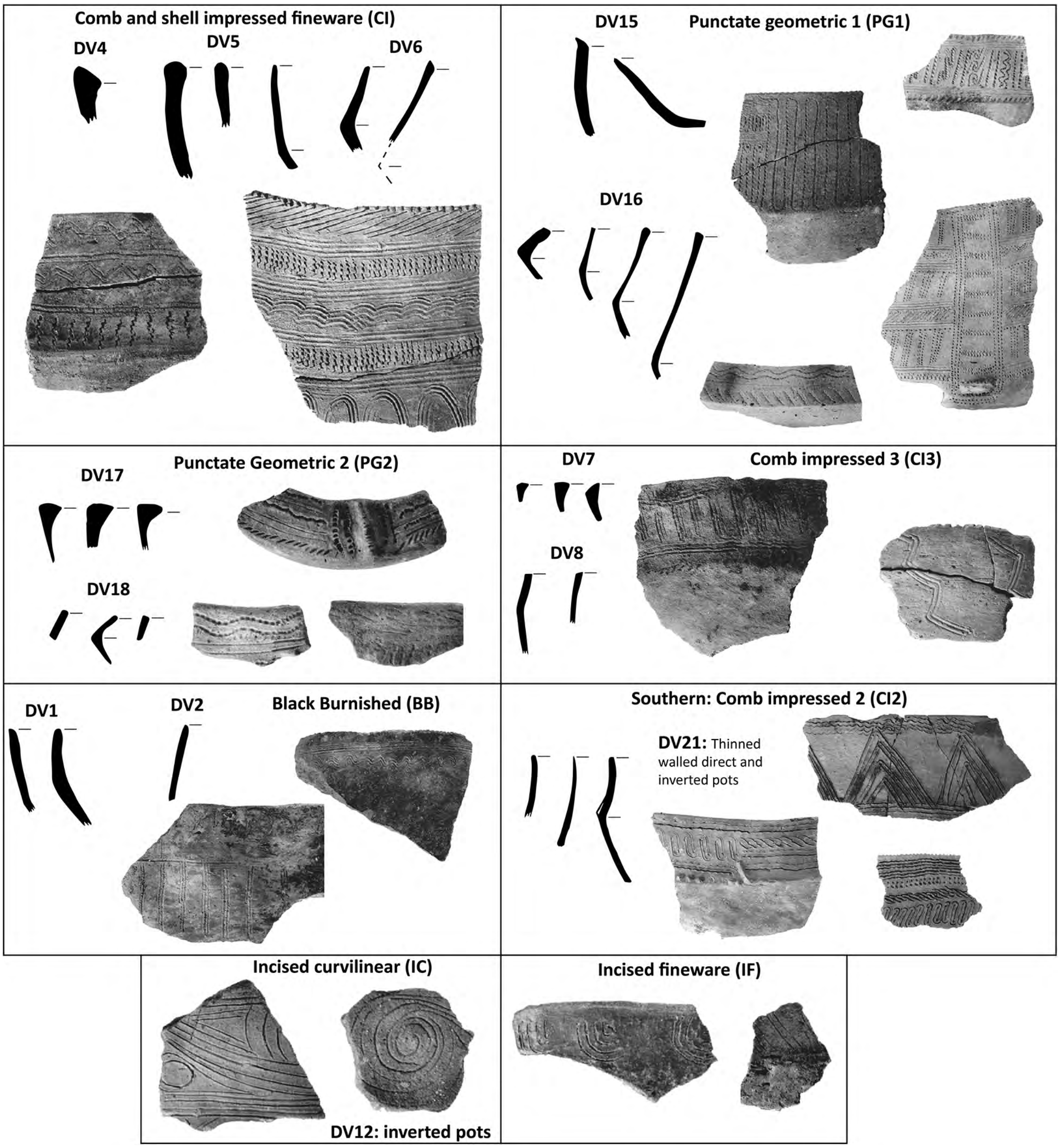

Figure 13.S2: Late Period pottery (<500 cal. BP) recorded on Woodlark Island.

Note: DV = Decorated vessel as defined by Bickler (1998).

Source: Recorded by Simon Bickler (1998).

Table 13.S1: Excavation data from Square A, Mumwa.

Spit	Layer	Area (m^2)	Depth range (mm)	Average spit depth (mm)	Spit volume (m^3)	Sediment weight (kg)	Sediment volume (L)	Kg/L	Obsidian (no.)	Obsidian (g)	Obsidian (g/m^3)	Pottery (no.)	Pottery (g)	Pottery (g/m^3)	Lithic (no.)	Lithic (g)	Shell (g)	Bone (g)
1	1	1.0	0–34	34	0.0340	44.8	35.5	1.26	15	5.262	155	219	543.4	15,982	3	1.14	0.86	0.28
2			34–88	54	0.0540	65.4	55.5	1.18	25	11.84	219	216	562.8	10,422	3	2.94	–	2.54
3			88–135	47	0.0470	67	54	1.24	16	4.584	98	202	583.4	12,413	2	0.37	0.12	–
4	2	1.0	135–203	68	0.0680	93.4	81	1.15	22	5.815	86	140	408.9	6013	2	3.14	–	–
5			203–254	51	0.0510	66.4	59.5	1.12	22	7.042	138	69	274.6	5384	1	31.32	–	0.28
6			254–299	45	0.0450	57.8	58	1.00	13	4.490	100	36	140.1	3113	–	–	–	–
7			299–354	55	0.0550	74.4	72	1.03	7	2.568	47	14	60.6	1102	–	–	–	–
8		0.9	354–397	43	0.0387	49	45	1.09	7	2.615	68	1	1.2	31	–	–	–	–
9		0.8	397–458	61	0.0488	75.6	71.5	1.06	4	1.133	23	4	9	184	–	–	0.27	–
10	3	0.7	458–503	45	0.0450	54.8	51.5	1.06	3	0.666	15	–	–	–	–	–	–	–
11		0.6	503–561	58	0.0348	53.6	46	1.17	4	0.516	15	–	–	–	–	–	0.1	0.08
12		0.4	561–606	45	0.0450	61.7	51	1.21	6	1.026	23	–	–	–	–	–	0.15	–
13		0.3	606–643	37	0.0111	68.2	55	1.24	1	0.224	20	–	–	–	1	25.75	1.31	–
14			643–725	82	0.0246	46.8	36.5	1.28	–	–	–	–	–	–	2	10.22	0.68	–
15		0.2	725–771	46	0.0092	7	6	1.17	–	–	–	–	–	–	–	–	–	–
16			771–811	40	0.0080	6.5	6	1.08	–	–	–	–	–	–	–	–	–	–
17			811–868	57	0.0114	7.2	7	1.03	–	–	–	–	–	–	–	–	–	–
18			868–990	122	0.0244	9.2	8	1.15	–	–	–	–	–	–	–	–	–	–
Total					**0.6550**	**908.8**	**799**	**1.14**	**145**	**47.781**	**83**	**901**	**2584**	**5853**	**14**	**74.88**	**3.49**	**3.18**

Source: Author supplied.

Table 13.S2: Excavation data from Square B, Mumwa.

Spit	Layer	Area (m^2)	Depth range (mm)	Average spit depth (mm)	Spit volume (m^3)	Sediment weight (kg)	Sediment volume (L)	Kg/L	Obsidian (no.)	Obsidian (g)	Obsidian (g/m^3)	Pottery (no.)	Pottery (g)	Pottery (g/m^3)	Lithic (no.)	Lithic (g)	Shell (g)	Bone (g)
1	1	1	0–46	46	0.046	46.2	38	1.22	0	0	0	37	144.5	3141	–	–	–	0.60
2			46–76	30	0.030	40.6	36	1.13	4	1.516	51	34	82.5	2750	–	–	–	–
3			76–125	49	0.049	67.1	57	1.18	9	3.995	82	48	191.7	3912	–	–	–	–
4	2	1	125–186	61	0.061	71.7	61	1.18	15	6.229	102	36	98.3	1611	–	–	–	–
5		0.9	186–232	46	0.041	54	48	1.13	14	7.592	183	27	96.7	2336	–	–	–	–
6		0.8	232–287	55	0.044	50.7	53	0.96	16	3.257	74	24	68.9	1566	1	26.75	–	0.17
7		0.7	287–338	51	0.036	46.1	44	1.05	3	1.156	32	3	3.0	84	–	–	–	–
8		0.6	338–398	60	0.036	–	–	–	1	0.021	1	1	0.7	19	–	–	–	–
Total					**0.343**	**376.4**	**337.0**	**1.12**	**62**	**23.766**	**69**	**210**	**686.3**	**2000**	**1**	**26.75**	**0**	**0.77**

Source: Author supplied.

Table 13.S3: Excavation data from Square C, Mumwa.

Spit	Layer	Area (m^2)	Depth range (mm)	Average spit depth (mm)	Spit volume (m^3)	Sediment weight (kg)	Sediment volume (L)	Kg/L	Obsidian (no.)	Obsidian (g)	Obsidian (g/m^3)	Pottery (no.)	Pottery (g)	Pottery (g/m^3)	Lithic (no.)	Lithic (g)	Shell (g)	Bone (g)	Pumice (g)
1	1	1.0	0–92	92	0.0920	113.2	109	1.04	52	14.519	158	432	1165	12,663	8	8.46	3.15	1.7	6.3
2	1/2	1.0	92–197	105	0.1050	139.2	124	1.12	52	12.07	115	194	549.4	5232	2	92.93	0.28	–	2.98
3	2	1.0	197–295	98	0.0980	118	110	1.07	21	3.35	34	44	145	1480	1	7.73	0.09	0.62	–
4		0.7	295–384	89	0.0630	89.4	89	1.00	2	0.657	10	4	11.7	186	1	25.53	–	–	–
5	2/3	0.7	384–478	94	0.0658	83.6	74	1.13	3	0.78	12	1	1.6	24	–	–	–	–	–
6	3	0.5	478–588	110	0.0550	96.8	79.5	1.22	3	0.214	4	1	0.9	16	–	–	–	0.14	–
7		0.2	588–649	61	0.0122	46.2	47.5	0.97	1	0.064	5	–	–	–	–	–	–	–	–
Feature		0.04	–	–	0.0200	54.2	56	0.97	1	0.247	12	–	–	–	–	–	–	–	–
Total					**0.5110**	**740.6**	**689**	**1.07**	**135**	**31.654**	**62**	**676**	**1873.6**	**3913**	**12**	**134.65**	**3.52**	**2.46**	**9.28**

Source: Author supplied.

Table 13.S4: Excavated lithic artefacts from Mumwa.

Square	Spit	Layer	Depth (mm)	Context	Artefact no.	Mass (g)	Lithic	Artefact	Length (mm)	Width (mm)	Weathering	Notes
A	1	1	0–34	Sieve	A.1.1	0.37	Hornfels	Ground axe-adze fragment	14	13	No	–
					A.1.2	0.6	Hornfels	Flake	17	10	No	–
					A.1.3	0.17	Hornfels	Angular fragment	11	8	No	–
	2		34–88	Sieve	A.2.1	0.73	Hornfels	Flake	19	13	No	Fragment
					A.2.2	0.44	Hornfels	Ground axe-adze fragment	13	11	No	–
					A.2.3	1.77	Tuff	Manuport	19	16	Yes	Possible bowl carination
	3		88–135	Sieve	A.3.1	0.31	Hornfels	Ground axe-adze fragment	11	10	No	–
					A.3.2	0.06	Hornfels	Ground axe-adze fragment	9	8	No	–
	4	2	135–203	Sieve	A.4.1	0.58	Hornfels	Flake	16	13	No	–
					A.4.2	2.56	Limestone	Flake	26	16	Yes	–
	5		232	In situ	A.5.1	31.32	Quartz siltstone	Axe-adze preform or grindstone	53	32	Yes	Bevelled edge with 3 cut marks on body surface and 3 on bevel
	13	3	636	In situ	A.13.1	25.75	Limestone	Possible core	52	51	Yes	flaked edge
	14		643–725	Sieve	A.14.1	2.12	Limestone	Flake	26	22	Yes	–
			689	In situ	A.14.2	8.1	Chlorite schist	Tanged blade	47	29	Yes	–
B	6	2	279	In situ	B.6.1	26.75	Fine-grained tuff	Axe-adze blade	71	25	Yes	Retouched edge
C	1	1	0–92	Sieve	C.1.1	2.42	Hornfels	Ground axe-adze fragment	26	17	No	–
					C.1.2	1.83	Hornfels	Flake	21	16	No	Distal notch
					C.1.3	1.75	Hornfels	Flake	23	17	No	–
					C.1.4	1.01	Hornfels	Flake	21	16	No	–
					C.1.5	0.68	Hornfels	Ground axe-adze fragment	18	13	No	–
					C.1.6	0.28	Hornfels	Flake	14	13	No	Fragment
					C.1.7	0.37	Hornfels	Ground axe-adze fragment	13	11	No	–
					C.1.8	0.12	Hornfels	Flake	10	8	No	–
	2		92–197	Sieve	C.2.1	12.17	Quartz siltstone	stone bowl fragment	40	21	Yes	4 x incised lines
			209	In situ	C.2.2	80.76	Metavolcanic	Manuport	82	31	Yes	–
	3	2	197–295	Sieve	C.3.1	7.73	Hornfels	Ground axe-adze fragment	39	20	No	Retouched edge, reused as core.
	4		335	In situ	C.4.1	25.53	Hornfels	Ground axe-adze fragment	45	22	No	Partial bevel

Source: Author supplied.

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