– ARTICLE –

Late Pleistocene Colonisation of the Eastern New Guinea Islands? The Potential Implications of Robust Waisted Stone Tool Finds from Rossel Island on the Long Term Settlement Dynamics in the Massim Region

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ABSTRACT

Robust waisted stone tools were recently discovered on Rossel Island, the easternmost island in the Massim region of eastern Papua New Guinea. These are the first waisted tools to have been found in the Massim, but they are otherwise known from Late Pleistocene-Early Holocene contexts in New Guinea and Australia, two of the major landmasses which comprised the Sahul supercontinent. The Rossel tools are described and compared to other waisted assemblages from across Sahul, the Bismarck Archipelago and the Solomon Islands, with the morphological and technological attributes of the Rossel assemblage similar to some of the earliest comparative examples. Although undated, it is suggested that the waisted tools from Rossel Island belong to a previously undocumented Late Pleistocene stone tool tradition in the Massim, at a time when many of the islands were much larger or formed a continuation of the New Guinea mainland. The implications of a potential Late Pleistocene time depth for the colonisation of the Massim islands are discussed.

Keywords: Massim, Papua New Guinea, Late Pleistocene, Rossel Island, Waisted tools

INTRODUCTION

The Massim islands, situated off the eastern tip of New Guinea (Figure 1), are in relatively close proximity to the mainland and have the potential to provide insight into the adaptive strategies employed by people to survive in an environment that fluctuated in both size and ecological diversity following colonisation. Currently, the earliest evidence for human settlement in the region dates to the Late Holocene, from 2800–2600 cal BP (Negishi and Ono 2009). However, it is likely that the Massim islands were colonised considerably earlier than this. Archaeological evidence indicates the Bismarck Archipelago was colonised by 44–43 cal kBP (Summerhayes *et al.* in press), and the Solomon Islands chain by 34–32 cal kBP (Wickler and Spriggs 1988). The Huon Peninsula, where a coastal Late Pleistocene human settlement site (>40 kBP) has been identified (Groube *et al.* 1986), is situated just to the north of the Massim. Surface collected stone mortars, pestles and a stemmed obsidian tool have been found on several Massim islands. These tools are otherwise known from Mid Holocene contexts on the New Guinea mainland and in the Bismarck Archipelago, leading Swadling (2016) to suggest a similar settlement date in the Massim. Unfortunately, excavated cultural deposits of this antiquity are lacking in the region as archaeological research programs have largely focused, out of necessity, on the characterisation of the complex Late Holocene cultural systems (Shaw 2016).

This paper presents a case for the possible Late Pleistocene colonisation of the Massim islands by analysing six surface collected waisted stone tools found on Rossel Island in 2012 (Figure 1). Several lines of archaeological and paleogeographical data are drawn together to demonstrate the feasibility of settlement in the region at this time. These are the first waisted tools to have been found in the Massim so their wider distribution in the region is unknown. However, it is evident from waisted tools found in excavated deposits elsewhere in Papua New Guinea and Australia that their manufacture and use has a wide chronological and geographic range, with the earliest examples securely dating to the Late Pleistocene (Golson 2001). Despite a lack of stratigraphic context for these finds, their discovery presents an opportunity to consider the implications Late Pleistocene colonisation might have for understanding long term settlement dynamics in the Massim islands.

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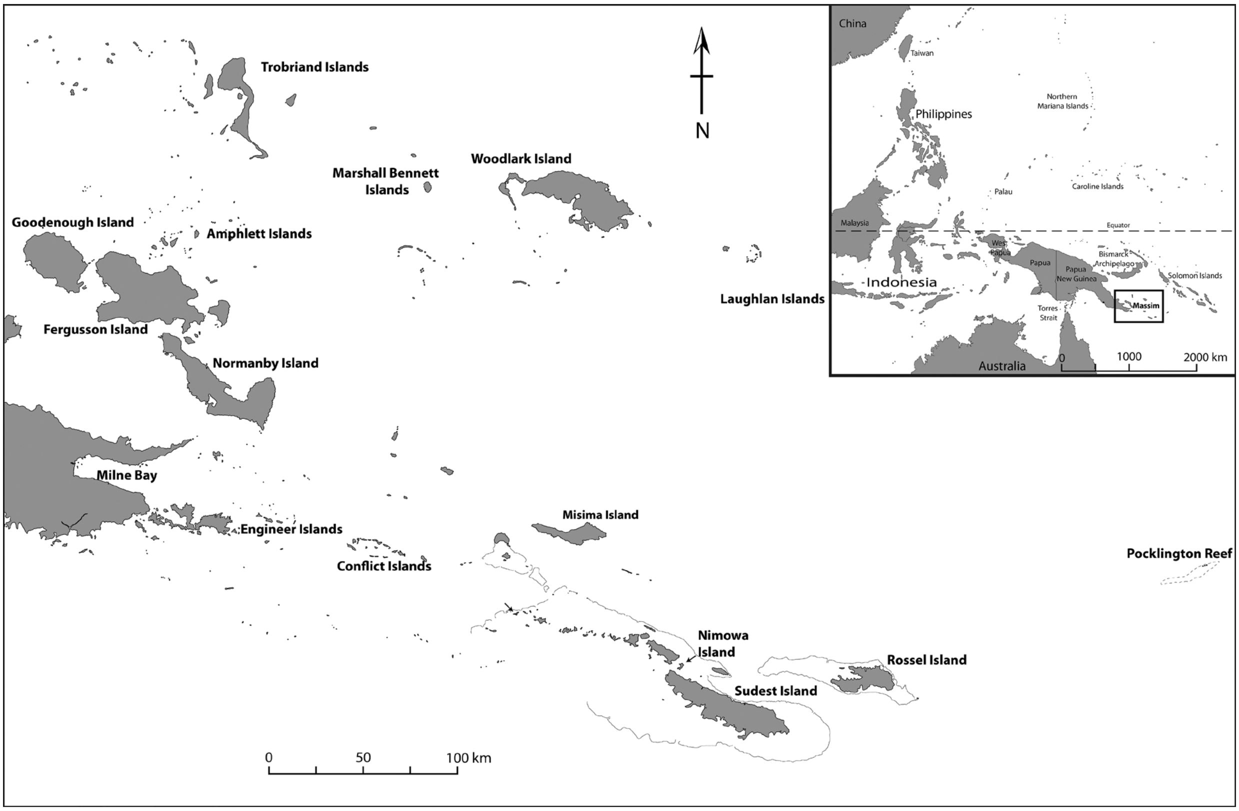

Figure 1. Map of the Massim region showing the location of Rossel Island, with an inset showing the location of the Massim in the Western Pacific.

THE LATE PLEISTOCENE CONTEXT

Archaeological and paleoecological evidence from a number of sites in Australia and New Guinea demonstrates that in the millennia following colonisation around 50 kBP, behaviourally modern humans moved relatively rapidly across Sahul and occupied a range of tropical, semi-arid and arid environments (Hamm *et al.* 2016; Smith 2013; Summerhayes and Ford, 2014; Summerhayes *et al.* in press; Veth *et al.* 2009). Throughout the Late Pleistocene people were also faced with coastal and island landscapes that changed due to fluctuating sea levels exposing or submerging the relatively shallow but expansive plateau that flanked the coastline. The most pronounced change occurred in the Early-Mid Holocene when sea levels rose relatively rapidly from their lowest point of 134m below modern levels during the Last Glacial Maximum (LGM; ~30–20 kBP) (Lambeck *et al.* 2014). It is also now well understood that the land bridge between Australia and New Guinea (Torres Strait) was submerged within the last 9000–8000 years (Barham *et al.* 2004:7; McNiven 2011:214). Consequently, the modern size and coastline of many islands in New Guinea and Australia are a relatively recent phenomenon (Lambeck and Chappell 2001).

Prior to the Holocene sea level change, people were largely unimpeded by major water boundaries as they travelled across the Sahul continent, with only biogeographical and presumably social factors limiting human mobility at this time. Previous investigations of human adaptation to increasingly insular landscapes during the Late Pleistocene and Early Holocene include locations in the Aru Islands in Eastern Indonesia (O'Connor *et al.* 2006; Veth *et al.* 1998), Tasmania (Cosgrove 1999), Kangaroo Island in southern Australia (Lampert 1981), and the Montebello/Barrow Islands in northwestern Australia (Veth *et al.* 2014; Veth *et al.* 2007). The documentation of Pleistocene settlement on these islands has allowed new suites of questions to be addressed concerning the changing nature of settlement and resource use, and the role of physical isolation in the development of divergent cultural systems. The same questions can potentially be addressed in the islands of the Massim.

THE SPATIAL AND TEMPORAL DISTRIBUTION OF WAISTED STONE TOOLS

Waisted tools made from a range of lithic materials, though predominantly from schist, quartzite and granite, have been found in archaeological contexts in parts of New Guinea (Bulmer 1977, 2005a) and Australia (Lampert 1975, 1983), as well as throughout Southeast and Northeast Asia (Anderson and Summerhayes 2008; Chard 1974; Te-

K'un 1957). Yet, these tools are not constrained to a defined chronological period, with cobble and/or pebble waisted tools having been found in Japan from around 30 kBP (Oda and Keally 1992), the Hoabinhian period in Malaysia from 10 kBP (Bellwood 1997), and ground, polished and stylised waisted tools produced in the Solomon Islands until the ethnographic present (Parkinson 1999). Neither are these tools constrained to a single environmental context as they have been found in highland, lowland and coastal sites (Golson 2001). In New Guinea and Australia, however, large unground waisted tools are clearly associated with the earliest known archaeological sites from the Late Pleistocene (Allen and O'Connell 2014; Muke 1984; White 2014) (Table 1 and Figure 2).

Excavated tools

The most notable areas where waisted tools have been found in a primary depositional context is the Ivane Valley, situated at ~2000 m a.s.l. in the Papuan Highlands. The earliest waisted tools in this area date to 46–42 cal kBP (Wk-23354: 40,298±956; Wk-23356: 39,836±909 BP), with several also found in deposits dating from 32–30 cal kBP (ANU-191: 26,870±590 BP). These tools were all produced from locally available schist and metagraywacke, and it has been suggested that they were used for *Pandanus* tree exploitation prior to the apparent abandonment of the valley during the LGM (Ford 2011; Summerhayes *et al.* 2010; White *et al.* 1970). The Bobongara site on the uplifted terraces of the Huon Peninsula in Papua New Guinea is also well known archaeologically for the discovery of a large number of robust andesite waisted tools. Over 100 were found on the surface of the terraces, with three recovered from excavated contexts dated by thermoluminescence techniques to 60–38 kBP (Allen & O'Connell 2014; Groube *et al.* 1986; Muke 1984). These tools were argued to have been associated with ringbarking, felling and management of naturally occurring soft trees such as Sago (*Metroxylon* sp.), *Pandanus* and cycads in areas where fire was not an effective method of rainforest clearance (Groube 1989).

Waisted tools have been found at the Highland sites of Yuku and Kiowa in Papua New Guinea from contexts dating to 15–13 cal kBP (GX-3112b: 12,100±350 BP) and <7.5–6.5 cal kBP (Y-1370: 6,100±160 BP) respectively (Bulmer 1964, 1966; Gaffney *et al.* 2015). Excavations at Nombe and Manim, also in the Highlands, have both produced waisted stone tools. Although the dating of the tools at these sites is far from secure, they are claimed to be older than 11 kBP at Nombe, with recently published AMS determinations placing one example between 25–15 cal kBP (Wk-22087: 11,845±60 BP; Wk-22091: 20,838±139) (Denham and Mountain 2016; Mountain 1991). At Manim they are dated between 11–7 cal kBP (ANU-1375: 9670±220; ANU-1373: 5860±130 BP) (Christensen 1975; Mountain 1991). The Kiowa tools were made of limestone, whereas the Yuku, Nombe and Manim tools had been manufactured from various metamorphic cobbles or slabs. In the Bismarck Archipelago, a lightly waisted volcanic cobble stone tool has been found in the Pamwak cave site on Manus Island, dating to 13–9 cal kBP (ANU-8253: 10,960±120; ANU-7763: 8730±130 BP) (Fredericksen *et al.* 1993; Spriggs 1997). A stemmed tool fragment was supposedly also recovered

Table 1. *Waisted tools excavated from archaeological contexts on Sahul. Note the listed tools have been defined as waisted tools, and may be further defined as stemmed or tanged tools.*

Site name	Location	Altitude (m asl.)	No. of waisted tools	Associated calibrated dates	Reference
Papua New Guinea					
Kosipe/Ivane Valley	Central Province	2000 m	17	46–30 kBP	White *et al*. (1970); Ford (2011)
Bobongara, Huon	Morobe Province	130 m	3 + >100 surface finds	60–38 kBP	Muke (1984); Groube *et al*. (1986)
Yuku	Western Highlands Province	1280 m	21 + 2 preforms	15–13 kBP	Bulmer (1964)
Kiowa	Simbu Province	1530 m	1 + 1 preform	7.5–6.5 kBP	Bulmer (1964)
Nombe	Simbu Province	1660 m	≤4	32–11kBP	Mountain (1991); White (1972); Bulmer (2005)
Manim 2	Western Highlands Province	1770 m	1	11–7 kBP	Mountain (1991)
Pamwak	Manus Province	30 m	1	13–9 kBP	Frederickson *et al*. (1993)
Yombon, Passismanua	West New Britain Province	500 m	1	4 kBP	Pavlides (1993); Pavlides & Gosden (1994)
Australia					
Sandy Creek Shelter 1	Cape York, Queensland	~200 m	1	38–34 kBP	Morwood & Trezise (1989)
Malangangerr	Western Arnhem Land	~10 m	3	30–25 kBP	Schrire (1982)
Nawamoyn	Western Arnhem Land	~20 m	2	30–25 kBP	Schrire (1982)

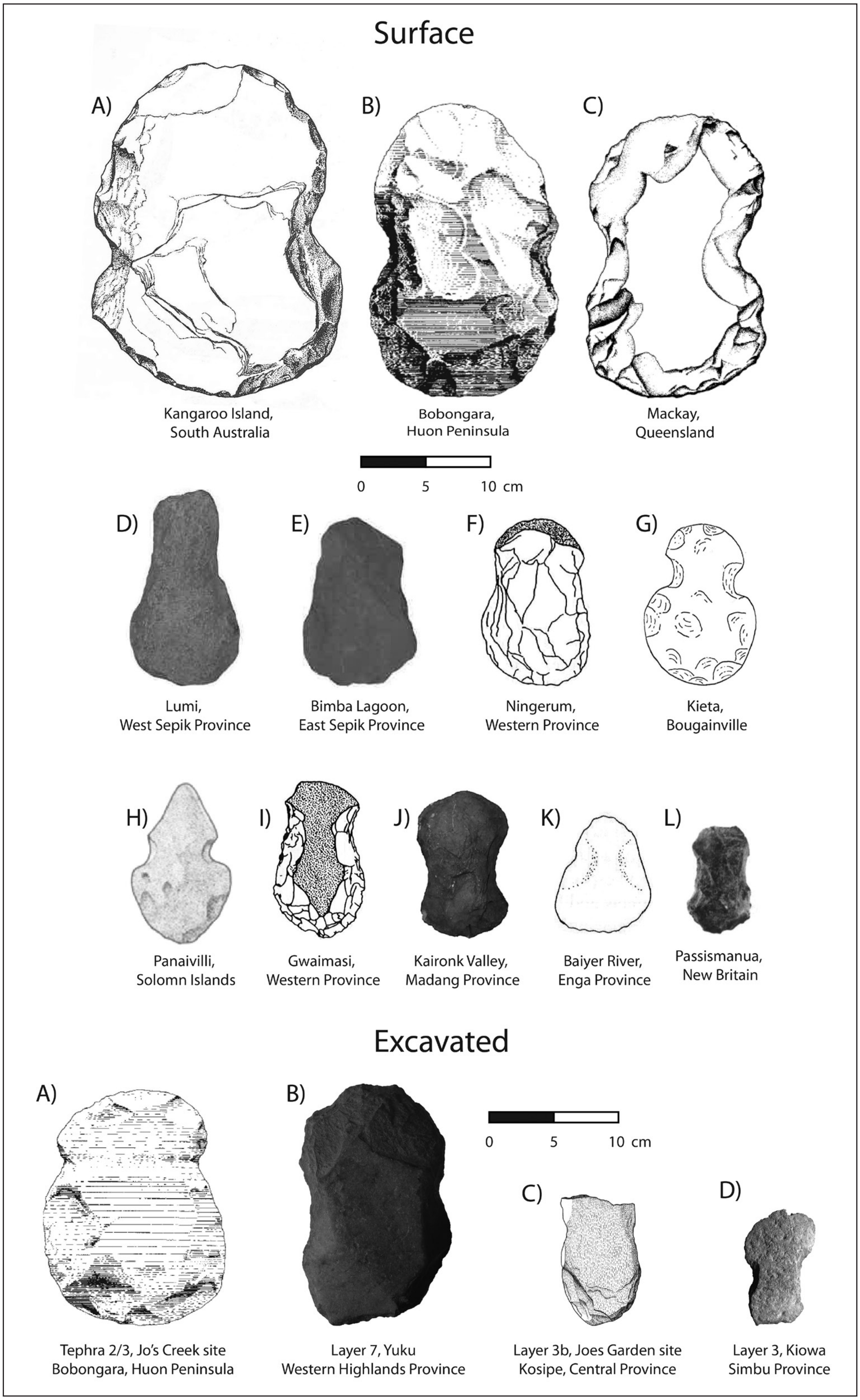

Figure 2. Comparative waisted stone tools found on the surface and in excavated contexts, ordered from largest to smallest in each category. Note: excavated waisted tool C is broken and does not represent the total length of the tool. Surface tool references: A) Lampert (1981); B) Groube *et al.* (1986); C) Lampert (1983); D-E) Swadling *et al.* (1988); F, I) Minnegal (1991); G) Specht (1969); H) Reeve (1989); J) Author, unpublished, K) Bulmer (2005a); L) Bulmer (2005b). Excavated tool references: A) Groube *et al.* (1986), B) Unpublished photograph, C) Summerhayes *et al.* (2010); D) Gaffney *et al.* (2015).

from a context at Kuk swamp dating to around 20 kBP, but the context for this find is dubious (Golson 2001: 192).

In Australia, a ground edge quartzite waisted/grooved tool was recovered from Sandy Creek 1 shelter in Northern Queensland dating to 38–34 cal kBP (SUA-2870: 31,900±700 BP) (Morwood and Trezise 1989). Five hornfels tools described as waisted or grooved were excavated from two sites, Malangangerr and Nawamoyn, in Western Arnhem Land dating between 30–25 cal kBP (ANU-77b: 22,900±1000; ANU-51: 21,450±380 BP) (Schrire 1982). With the exception of these sites, tools with clear waisting have not been found in secure contexts in Australian archaeological sites.

Surface collected tools

A greater number of waisted tools have been found in surface sites in Australia (Lampert 1975, 1981, 1983), the New Guinea mainland (Bulmer 2005a; Groube *et al.* 1986; Minnegal 1991; Swadling and Hope 1992; Swadling *et al.* 1988), the Bismarck Archipelago (Bulmer 2005b; Chowning and Goodale 1966; Pavlides and Gosden 1994; White 1982) and the Solomon Islands (Specht 1969). Although waisted stone tools found on the surface in the former three landscapes are likely to be of some antiquity, those from the Solomon Islands may be more recent in age as waisted tools were still produced until European contact (Parkinson 1999). Fortunately, the ethnographically known waisted tools are clearly distinguishable from their predecessors as they are ground and polished, and often with a highly stylised form, such as the example in Figure 2h (surface); see also Riesenfeld (1950) for a description and illustrations of other stylised examples.

On Kangaroo Island in southern Australia, waisted tools (N=24) have only been found in undated surface contexts and were all made from locally sourced quartzite slabs. A pre-LGM or LGM age for these robust tools has been inferred given their absence in excavated post-LGM and Early Holocene lithic industries from 20–19 cal kBP onwards (ANU-1221: 16,110±100 BP) where cobble tools made of quartzite from the same sources were otherwise present (Draper 1987; Lampert 1981). It is notable that prior to and during to the LGM a land bridge connected Kangaroo Island to mainland Australia, which would have facilitated colonisation at this time.

In the Mackay area of NE Australia, 80 waisted tools had been collected on the surface from farmed paddocks in several different areas. They were made from a widely available local volcanic rock, and were naturally shaped with squared ends making it relatively easy to manufacture the rocks/cobbles into effective tools. Many of the waisted surface finds had percussive evidence for use as hammerstones, but there was marked variation in their shape with the waist being the only common morphological feature between them (Lampert 1983).

The lack of any waisted tools in Island Melanesia further east beyond the Solomon Island chain, on the surface or in excavation, indicates that waisting had dropped out of the toolkit used by the Lapita people who colonised these islands from ~3000 cal BP (Kirch 1997; Spriggs 1997). Small waisted chert tools have been found in Mid Holocene contexts in New Britain (Passismanua region), as have stemmed obsidian blades, but these are markedly unlike the larger antecedent waisted tools found in Late Pleistocene and Early Holocene sites (Kononenko *et al.* 2010; Pavlides and Gosden 1994). The later appearance of lugged and tanged adzes in East Polynesia is also reminiscent of waisting. However, the positon of the lug/tang is typically at the distal end of the tool (Bellwood 1978) and is almost certainly a local innovation rather than a technological trait held over from earlier cultural milieus. As such, large cobble/slab waisted tools of varying morphologies have been found in excavated contexts from northern Sahul dating from 46–7 cal kBP, and are notably absent in late Holocene – that is Lapita and Post-Lapita – assemblages.

THE ARCHAEOLOGICAL PROBLEM RELATING TO WAISTED STONE TOOLS

Two major issues have surrounded discussions of waisted stone tools and their relative position in the archaeological record of Sahul. The first concerns the terminology used to describe waisted implements as a formal tool. There is no standardised definition for this tool type which has in turn resulted in a variety of artefacts described as 'waisted', making it difficult to identify temporal patterns and to infer function. Waisted tools are generally distinguished from stemmed and tanged variants, although there is overlap in their classification (Bulmer 1977; Groube 1986). To avoid ambiguity in tool classification, waisted tools are defined here as having proximal and distal ends which are wider than the mid-section of the tool with at least one end having a unifacial or bifacially prepared bevel (Bulmer 1977; Lampert 1983; Muke 1984). Late Pleistocene waisted tools are generally robust and produced from a large retouched oval cortex flake with two notches produced by a combination of flaking and pecking (hammer-dressing) (Bulmer 2005a: 399).

The second issue is the relationship between waisted tools found across Sahul. Having been found over such a large geographic area, debate has focused on whether they are technologically related and belong to a single tool tradition, or were independent innovations in the respective areas where they have been found (Golson 1972; Groube 1986; Lampert 1983). For example, a Southeast Asian Hoabinhian connection with some Australian-New Guinea stone tool traditions has long been argued, which includes light waisting on cobble tools (Bowdler 1996; Matthews 1966). In addition, no waisted tools have been found at Late Pleistocene-Early Holocene sites on the large islands of New Britain and New Ireland in the Bismarck Archipelago, nor have any robust tools been found on the surface that are comparable to those from the New Guinea mainland. It is feasible that the Late Pleistocene inhabitants of New Britain and New Ireland did not require waisted tools as part of their subsistence strategies or cultural practices, which were largely orientated towards maritime and coastal forest resources (Leavesley 2006).

From this summary it is clear that a more precise chronology and classification of waisted tool technology in the archaeological record is still confounded by the small number of examples having been found in securely excavated contexts. Most have been found on the surface with no associated chronological or stratigraphic information. Nonetheless, correlations of surface assemblages with excavated examples have contributed to the broader spatial and temporal understanding of their manufacture and use.

Rossel Island – a relatively remote Massim islandscape

Rossel Island, also known as Yela, is a moderate sized volcanic island surrounded by an expansive reef system. It is relatively isolated and is the easternmost island in the Milne Bay political province, situated 360 km from the eastern tip of the New Guinea mainland and 440 km southwest of the Solomon Islands. The island is 34 km in length (E-W) and 14 km in width (N-S) at its widest point, with a total land area of approximately 290 km². The interior of the island is mountainous, with the highest peak elevated 838 m above sea level.

Rossel Island is primarily made up of schist and a broadly defined metagabbro that is also found on Sudest Island and many of the other islands immediately to the west (Davies 1959; Smith and Pieters 1969; Smith *et al.* 1973) (Figure 1). The northern and eastern coasts are almost wholly metagabbro and basalt, as is a limited area of the south coast. Gabbro and dolerite are exposed across a limited area of the south coast, with pyroxenite and serpentinite exposed intrusively on the western end of the island. The schist is defined as a series of fine grained siltstones, sandstones, conglomerate and phyllites which have been pushed upward to form the central mountain range, as well as parts of the southern and western coasts (Smith 1973; Smith and Pieters 1969; Smith *et al.* 1973). There is therefore an abundance of rocks suitable for the manufacture of waisted tools available on Rossel Island and on many of the neighbouring islands.

The northeast coast of the island – the find location

The waisted tools were found along a 1.8 km stretch of coast on the northeast side of Rossel Island, between Cheme village and Bwapawe River (Figure 3). Five tools were found within 400m of each other at the base of the slope below Kimbekwap village. The sixth was found further to the east in a village above the Bwapawe River valley. All of the tools were found along a similar contour, 20–40 m above sea level and 400–600 m inland from the coast. There is a fringing reef that runs along this part of the island, some 600 m distant from the modern shoreline with a shallow lagoon that is exposed in some parts during low tide (Figure 4). The coast in this area is characterised by a relatively low-lying flat composed of a mixed sand and

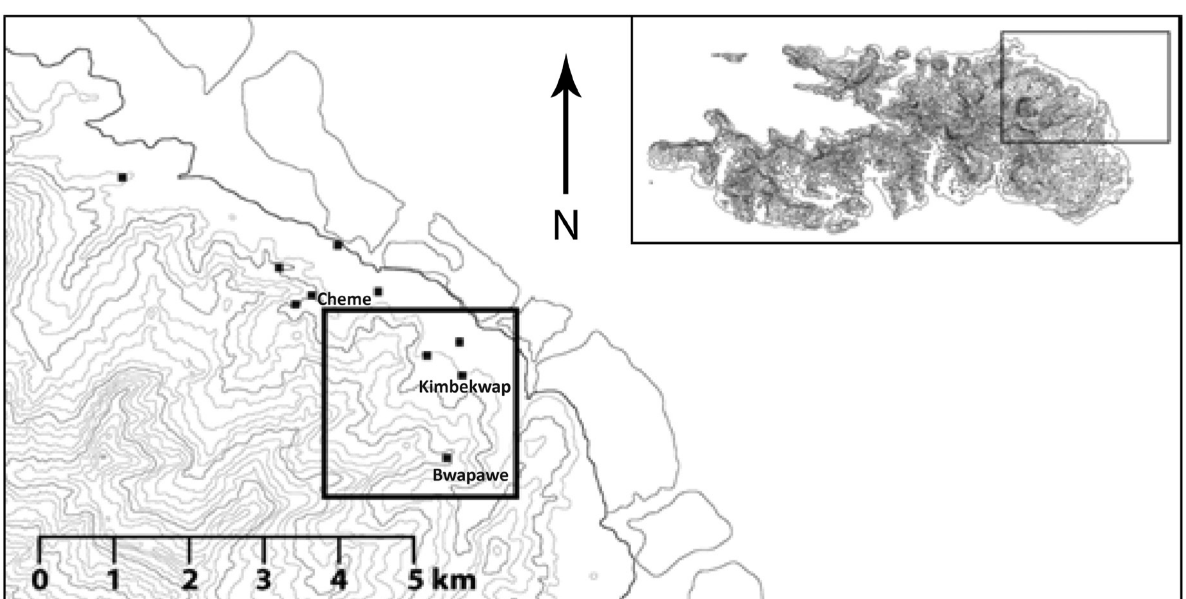

Figure 3. Topographic map (40m contours) of the NE coast of Rossel Island outlining area where the waisted stone tools were found. Black squares are villages.

Figure 4. View over the NE coast of Rossel Island from the coastal hills showing the lagoon at low tide and the extent of the exposed coastal flat. Arrow indicates the general area where the waisted tools were found.

clay substrate that extends 200–300 m inland. A prominent clay bank runs perpendicular to the coast at the back of this flat marking the base of foothills which rise up to an elevation of 80–100 m. These foothills separate the coastal flat from an interior mountain range that forms the northern side of Mt Rossel, the highest peak on the island.

A thick layer of colluvial clay is conspicuous along much of the northeastern coastline, having come from the unstable steep sided ridges of the adjacent foothills and mountains. These slopes are prone to landslides as a result of more extensive vegetation clearance for gardens and plantations within the last century (Liep 1983). Given the amount of sediment displaced along this coastline, even during recent seasonal cyclones and storms, it is likely that the waisted tools found at the base of the coastal foothills had been brought down from a higher elevation during an erosional event/s. Unfortunately, extensive erosion limits the potential for discovery of intact Late Pleistocene-Early Holocene cultural deposits on this part of the island.

The first waisted tool was found fortuitously by a local team member near the track down to the coast from his village (Kimbekwap). The area where the tool was found was subsequently surveyed intensively and resulted in five further tools being discovered. All possible tools were collected and examined in detail, with their location and elevation recorded using GPS. The waisted tools presented in this paper therefore represent all of those found during the initial survey.[1]

Along the northeast coast there is an abundance of raw lithic material, predominantly larger cobbles, from which most of the waisted stone tools were manufactured. The ridges above the find locations were surveyed and test pitted in the hope of determining where they originated from, but no significant sub-surface cultural deposits were encountered. A search of the rest of the coastline and hinterland around Rossel Island did not result in any other waisted stone tools being found. Cobbles of the raw lithic material were less abundant around the rest of the island and may have contributed to the restricted distribution of these tools along the northeast coast where metagabbro is more prevalent. Although it is not known whether the tools came from the same archaeological deposit, the spatial distribution of find spots suggests they at least originated from the same spur system.

THE WAISTED TOOLS FROM ROSSEL ISLAND

The waisted tools are illustrated in Figure 5, with the length, width and weight provided in Table 2. Tool B was not weighed and no Munsell colors were taken as it was recorded in the field and left with the owner who wished to hold on to it. The owner of this tool had found it while stripping the topsoil prior to building a house. It was kept because it had a peculiar shape, but was not recognised as a stone tool. It is therefore worth noting that if waisted tools had generally not been recognised as stone tools and therefore not collected on Rossel Island, it is possible that waisted tools in other parts of the Massim will also not have been readily identified by the local residents.

Waisted Tool A

This is a complete tool made from a foliated metagabbro rock (Figure 5a). It is the largest and heaviest of the collected waisted tools, weighing 1730 g and measuring 219 mm in length. Natural cortex is visible on both sides, with large flakes on the body of the tool having been removed predominantly from one side. However, no conchoidal fracturing was identified as it appears that the removed stone had broken along the foliations during manufacture. The flaked surface and natural cortex of the stone is of the same light olive brown (2.5Y 5/4) coloration from heavy weathering with a well-defined patina having developed, whereas the interior stone freshly exposed from recent damage is greenish grey (Gley 1 4/1) in colour. The tool had therefore been extensively weathered after it was made. The waisting is well-defined and, unlike the body, appears to have been initially prepared by rough bifacial flaking and subsequently shaped by hammer-dressing. Both ends of the tool were likely utilised as working edges, with no evidence that the tool has been recently used.

Waisted Tool B

This is a complete tool made from unfoliated slightly porous but dense basalt, brown in colouration but with a yellow tinge where the interior has been exposed from recent

1 Since the author left Rossel Island in 2012, local residents have collected more waisted tools in the area which have yet to be recorded.

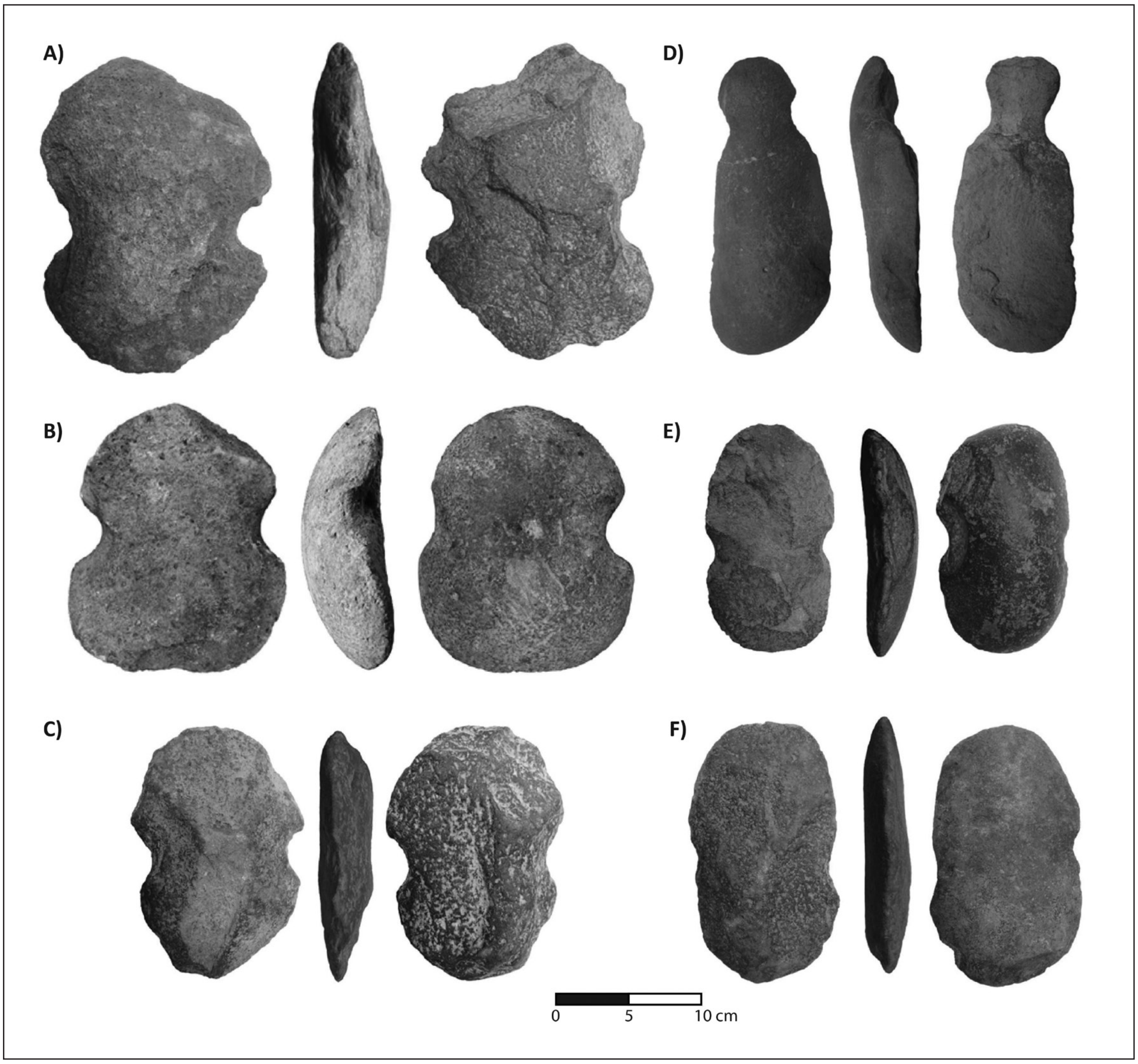

Figure 5. Waisted stone tools found on Rossel Island.

Table 2. *Dimensions of waisted tools found on Rossel Island.*

Waisted tool	Max. Length (mm)	Max. width (mm)	Waist width (mm)	Max. thickness (mm)	Weight (g)
A	219	144	104	46	1730
B	187	151	120	52	—
C	175	120	95	38	896
D	207	86	41	43	908
E	159	90	77	36	697
F	182	105	93	31	842

damage (Figure 5b). It measures 187 mm in length, 151 mm in width, and has a unifacially prepared bevel. The waists have been formed primarily from hammer dressing. The tool has clearly been made from a split cobble, and except for the initial fracture to create the split there is no clear evidence for flaking or grinding around the edges of the tool. One side is comprised entirely of natural cortex, while the other side is the interior surface of the rock. The tool has a well-defined flat butt end and a somewhat pointed end which forms a more defined asymmetrical bevel. The surface is weathered with a slight patination developing, with evidence for modern scraping damage and hammer-pitting on the cortex side.

Waisted Tool C

This is a complete tool made from an unfoliated red (5R 3/3) metamorphic rock (Figure 5c). It is somewhat smaller than tools B and C, 175 mm in length and weighs 896 g. Both ends of this tool have been bifacially modified, although one edge clearly has a more defined bevel. The considerable weathering and well-developed patina on the surface have obscured most flake scars and arrises. The waist scars are relatively worn but are nonetheless defined in shape.

Waisted Tool D

This is a complete tool with a unique morphology made from an unfoliated metamorphic cobble, which has been cleaved in half and modified to form a waist at one end (Figure 5d). The waist is situated further to the back of the tool to form a poll or butt that is distinct from the blade. The surface is olive (5Y 4/4) in colour, with a greenish grey (Gley 1 4/1) interior. It measures 207 mm in length and weighs 908 g. There is possible evidence of hammer dressing on the waist, but with no clear modification observed on the blade itself. It is long and thin with probable use wear on the lateral edges of the tool rather than on the terminal edge which suggests that it was used in a different orientation than the other Rossel tools. Almost all of the tool's weight is in front of the hafting location. The waisted end is not only thinner but is also angled. When the tool is laid flat, the waist and poll are displaced upwards on a ~20° angle.

The surface is clearly weathered as the edges are rounded, with a heavier patina having developed on the natural cortex than on the exposed interior. The stone is fragile as the tool broke along the waist during transport back to Australia. The cross section of the break revealed that the outer 20% of the stone has a defined colouration change resulting from prolonged weathering. The thickness of the internal weathering closely follows the shape of the waist modification, suggesting that colouration change from weathering must have occurred after the tool was made.

Waisted Tool E

This is a complete tool made from an unfoliated metamorphic stone of a dark brown (7.5YR 2.5/3) colour (Figure 5e). It is the smallest of the recovered tools and measures 159 mm in length and weighs 697 g. One side is comprised entirely of the heavily patinated cortex of a moderately sized split cobble, with the tool having a unifacially prepared bevel. Both sides of the tool are heavily weathered, with even the ventral surface having a patinated surface. The waist appears to have been simply knocked out with a hammerstone or similar tool, rather than hammer dressed as was likely the case with many of the others. There is a large conchoidal flake scar large above one waist notch, indicative of percussion flaking. Both ends of the tool would have served as viable working edges. Pitting across the cortical surface of the tool, which occurred after it had become patinated, suggests that it has either been used recently as a hammerstone and/or had sustained extensive natural taphonomic damage.

Waisted Tool F

This is a complete tool, although with less defined waists, made from a split unfoliated metamorphic stone. The surface is olive brown (2.5Y 4/4) in colour, with a greenish grey (Gley 1 6/1) interior. One side of the tool exhibits cortex (Figure 5f right), and the other side the exposed interior of the stone. Both surfaces are heavily weathered, with a well-developed patina. The area around the waist is heavily worn, perhaps from being hafted, with some possible evidence of pecking. Both edges of this tool may have originally been working edges. However, the lower edge in Figure 5f had been broken either during the manufacture of the tool, or while it was in use.

REGIONAL COMPARISONS OF WAISTED STONE TOOLS

The majority of previously recorded waisted tools from known Late Pleistocene contexts are made from cobbles of locally sourced metamorphic rock widely available in the area where they were found. They are shaped by bifacial or unifacial flaking, and with some instances of hammer-dressing (Bulmer 1977; Lampert 1981). Bulmer (1977, 2005a) undertook a thorough investigation of the morphology (size, shape, working edges and treatment of butt) of several waisted tool assemblages from Papua New Guinea to determine their functional qualities. She concluded that while there was a wide continuum of tool shapes, there was no apparent correlation between specific tool morphologies and the location (highland, lowland or coastal) or inferred function of the sites (permanent village, hunting camp or refuge shelter) from which excavated waisted tools are known. Bulmer therefore argued that waisted tools were a relatively generalised tool form, and with the exception of side notching there were no standardised manufacturing conventions involved in their production.

The Rossel waisted tools share many of the same attributes as other Late Pleistocene examples. They are similarly made from a range of locally available metamorphic stone types. The local Rossel stone is relatively fragile but easily workable, and therefore requires little skill to shape. Hammer dressing/pecking was used along with crude unifacial or bifacial flaking to produce the waisted notches, which is similar to the methods used to manufacture many of the waisted tools of northern Sahul (Bulmer 1977). The exception to this pattern is Tool B which is almost certainly non-local to Rossel (Figure 5) since it is made from a dense, porous basalt that differs from the basalts and gabbro otherwise found on the island. Because Tool B was found in a different location to the others it likely also derived from a different cultural and chronological context, although the origin of the tool cannot be determined at present. Lastly, variation in the shape of the six tools suggests they do not belong to a single tool tradition produced with defined manufacturing conventions. Such a pattern is in stark contrast to the specialised Late Holocene ground and polished stone axes/adze traditions identified in the Massim (Shaw 2015).

Comparative size

Figure 6 provides a length-width comparison with known measurements of waisted tools from Kosipe (Ivane Valley), Yuku, Huon, Gwaimasi, Passismanua, Kangaroo Island and Mackay, provided by Bulmer (1977), Lampert (1981), Muke (1984) and Minnegal (1991). Although only mean data are available for the Kangaroo Island and Mackay waisted tools (southern Sahul), they are generally very robust with a mean weight of 1837 g for the Kangaroo Island examples, and 1900 g for those from Mackay (Lampert 1981, 1983). The Rossel tools overlap with the upper length-width range of the tools from Kosipe and Yuku, with their length and width falling within the distribution of the larger Mackay and Huon assemblages. The Kangaroo Island tools are exceptionally robust with a mean width that is slightly bigger than those from Rossel.

There is no overlap with the Passismanua or Gwaimasi waisted tools, which are smaller both in width and length. The Passismanua waisted assemblage differs from the others as the tools were made from chert, a fine grained stone with greater flaking qualities allowing tools of a smaller size to be manufactured. Indeed, it is likely that the Passismanua tools are derivative of a later technological style from Mid Holocene (4500–3900 cal BP; Beta-45380: 3790±90 BP) cultural contexts (Bulmer 2005b; Chowning and Goodale 1966; Pavlides and Gosden 1994; White 1982).

Muke (1984) has argued that the size and weight of waisted tools generally decreases over time in Papua New Guinea sites. The Rossel waisted tools have relatively large dimensions, with some being similar in size and shape to known robust Late Pleistocene waisted tools from Bobongara, Kosipe and Yuku. Close similarities to the waisted tools from Kangaroo Island and Mackay is intriguing, because the Kangaroo Island tools at least have been convincingly argued to be Late Pleistocene in age (Draper 1987; Lampert 1981, 1983). Although size cannot necessarily be assumed to correlate with age, the comparatively large size of the Rossel waisted tools, coupled with their technological traits, is at least consistent with Late Pleistocene or perhaps Early Holocene age, with the possible exception of Tool B.

THE POSSIBILITY OF LATE PLEISTOCENE COLONISATION OF THE MASSIM ISLANDS

The presence of waisted tools on Rossel Island provides the opportunity to consider the feasibility of Late Pleistocene colonisation of the Massim islands. It also raises the question of why robust waisted tools are found in the Massim islands and not on the larger islands of New Britain and New Ireland where Late Pleistocene occupation has been well demonstrated. Although this is an issue that requires more clarity from excavation and surface survey, it is possible that since many of the southern Massim islands were once part of the New Guinea mainland, the more expansive Massim landscape was colonised by inhabitants already adapted to the mainland environment where expansive forests were present. Waisted tools may

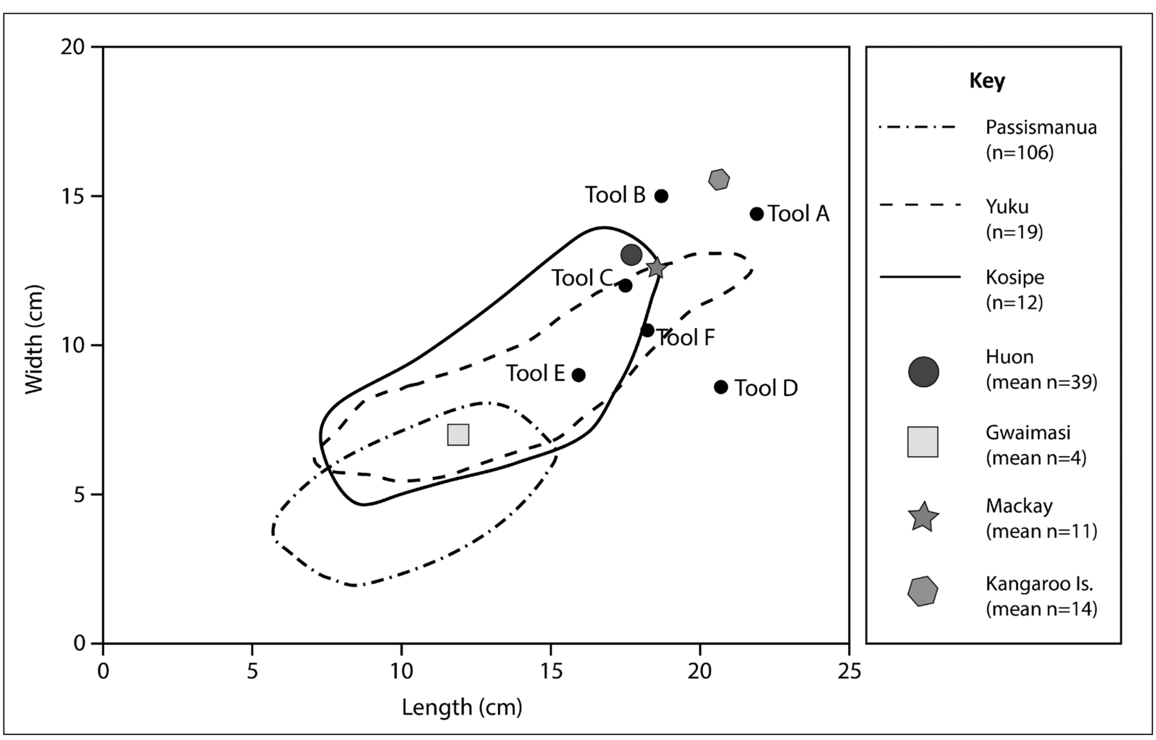

Figure 6: Length-width comparison of Rossel waisted tools with other waisted assemblages in New Guinea and Australia.

then have been part of an adaptive strategy for exploiting heavily forested hinterland environments (Groube 1989). In contrast, the sparse populations that settled the Bismarck Archipelago shortly after the initial colonisation of Sahul adapted to an ecosystem that has always been separated from the mainland. Archaeological evidence has indicated that subsistence strategies of these groups were orientated more towards coastal forest and shellfish exploitation, rather than the manipulation of the heavily forested hinterland and interior of New Guinea (Leavesley 2006). Interior settlement of Yombon in New Britain from 41–39 cal kBP (Beta-62319; 35,570±480 BP) is an exception to this coastal pattern, but no waisted tools were recovered from the Late Pleistocene deposits there (Pavlides and Gosden 1994). Waisted tools may therefore have been dropped from the material culture repertoire of the first colonists of New Britain and New Ireland.

Influence of sea levels, island size and climate on colonising population dynamics

Rossel is an isolated island landmass that can be difficult to reach today by dinghy or canoe. A Late Pleistocene age for colonisation would at first appear unfeasible. Therefore, to investigate further the possibility of Late Pleistocene settlement, a paleogeographical analysis was undertaken to reconstruct the Massim islands as they would have appeared during periods of lower sea levels using recorded water depths from hydrological maps and compiled sea level data (See Figure 7 for data used).

The majority of the lagoon systems in the Louisiade Archipelago and the southern Massim do not exceed 70 m in depth. When humans first colonised Sahul (~50–40kBP), the Massim landscape would have been significantly larger as sea levels fluctuated between 54 – 89 m below modern levels (Lambeck and Chappell 2001). During the LGM when sea levels were 115 – 134 m below modern levels, the New Guinea mainland, then comprising northeastern Sahul, was at its maximum size with many of the Massim islands forming the interior of an expansive plateau extending over 100 km further east. The plateau, which now forms the lagoon floors surrounding many of the Massim islands, would have only begun to flood from ~14 kBP onwards as sea levels rose significantly following the LGM (Figure 7 top). Further to this, the lagoons closer to the New Guinea mainland are deeper than those in the Louisiade Archipelago and would therefore have submerged first, effectively isolating the Louisiade islands, including Rossel, from the receding coast of the mainland. Significant reduction in the size of the remaining islands would subsequently have occurred around the same time that the Torres Strait land bridge was submerging (9–8 kBP), with the modern configurations of the islands reached shortly thereafter (Barham *et al.* 2004; McNiven 2011).

Although temperatures in the Highland regions of New Guinea varied substantially throughout the Late Pleistocene, the impact on coastal and island regions was much less pronounced. Prior to the LGM, temperatures close to sea level were not significantly different from modern times, and during the LGM they were perhaps only 0–3 degrees lower (Reeves *et al.* 2013). Fluctuations in sea level, however, would have produced unstable and less productive shorelines with no established lagoons (Specht 2005). It was only during the Holocene, when sea levels rose at a much slower rate, that the development of coral reefs in the shallow waters surrounding the islands was favoured (Chappell 1993) (Figure 7). There would undoubtedly have been a subsequent rise in the abundance and diversity of fish and shellfish resources at depths more accessible to inhabitants at this time. Indeed, it is evident that marine resources from the established lagoons formed a large part of Late Holocene subsistence practices in the Louisiade Archipelago (Shaw, 2015).

It therefore does not seem to be a coincidence that the waisted tools were found on the northeast coast of Rossel Island where a fringing reef rather than a barrier reef was present. The northeast coastline would have only extended 400–600 m further outward at most when sea levels were at their lowest during the LGM. Figure 4 shows the inferred Pleistocene coastline along this side of Rossel Island, as indicated by the extent of the exposed lagoon at low tide. Outside the reef system the water depth increases rapidly, effectively limiting the extent of past coastlines to the confines of the lagoon. In contrast, along parts of the island where there is a barrier reef the coast would have expanded outwards by several kilometres, with the modern coastline in these areas representing the hinterland of the island during the Late Pleistocene.

POSSIBLE IMPLICATIONS FOR THE PREHISTORY OF THE MASSIM AND SAHUL

Island proximity and sea faring

Rossel Island was never connected to the mainland during the Late Pleistocene, and has always been separated from the other island landmasses by a deep and swift sea gap. However, many of the islands were connected, and prior to 14 kBP a journey from the New Guinea mainland to Rossel Island would have involved sea crossings not exceeding 13–14 km in length (Figure 7 bottom). Throughout the Holocene when the Rossel lagoon had already flooded, the distance to the nearest island of Sudest increased to at least 32 km and the land area of Rossel reduced three and a half times in size. In contrast, as sea levels rose many of the other islands in the Louisiade Archipelago, although also hugely reduced in size, remained in close proximity to one another (1–4 km). Nonetheless, it is known that voyages of up to 90 km were needed to initially colonise Sahul from Sunda around 50 kBP, and once people reached the Bismarck Archipelago, voyages in excess of 200 km were made to reach Manus Island during or shortly after the

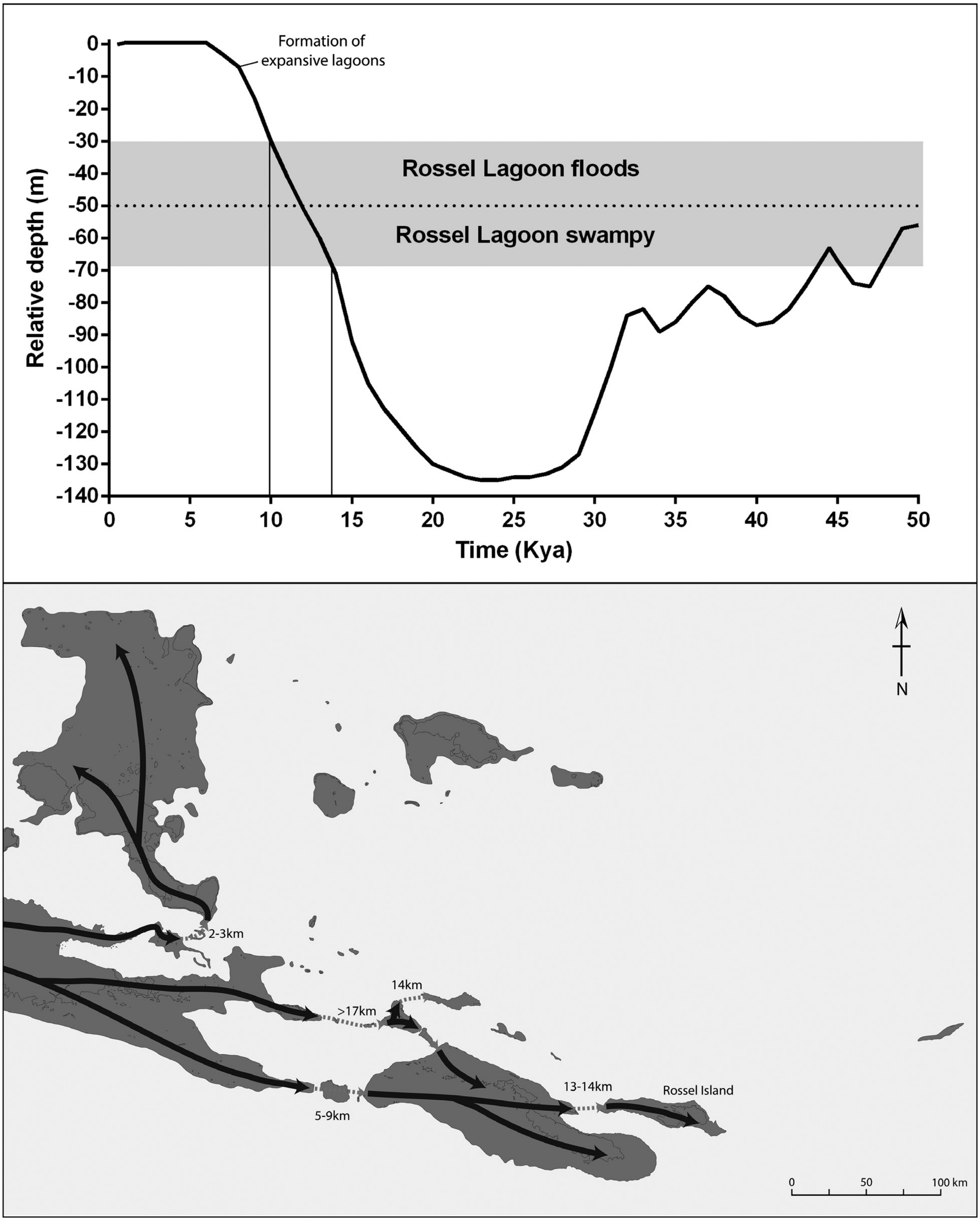

Figure 7: Top) Changes in sea level over the last 50kBP, indicating changes in Rossel lagoon based on its depth. Bottom) Late Pleistocene configuration of the Massim islands from ~14–30kBP showing two possible routes people could have taken to get to Rossel Island. Sea level data from www.sahultime.monash.edu.au (Lambeck and Chappell 2001), and land reconstruction based on water depths from the 1:150 000 AUS hydrological map series.

LGM (Fredericksen *et al.* 1993; Spriggs 2001). Crossing the short sea gaps to reach Rossel Island during the Late Pleistocene was therefore feasible, and well within the technical ability of early seafarers.

Changing island ecosystems

During the terminal Pleistocene and Early Holocene, the natural resources available to hunting and gathering or proto-agricultural populations living in the Massim would have decreased markedly as a result of diminished landmasses and unstable coastlines without established lagoons (Barham *et al.* 2004). Many of the smaller islands which formed during this process, such as those in the Calvados group, were likely abandoned and left to be recolonised at a later time when socioeconomic systems were in place to mitigate the effects of living in an impoverished island ecosystem. Rossel Island, on the other hand, with permanent flowing water and expansive forests would have remained large enough to sustain a population during this process and may have served as a population refuge. Archaeological evidence in the Massim has so far indicated that the subsistence-trading based social systems that enabled permanent settlement of the smaller islands were only established in the Late Holocene (Egloff 1978; Macintyre and Allen 1990; Shaw 2016).

THE UNIQUE POSITION OF ROSSEL ISLAND IN MASSIM PREHISTORY

The population on Rossel Island is renowned as being linguistically, genetically and culturally different from all of the other island populations in the Massim (Levinson and Majid 2013; Liep 2009; van Oven *et al.* 2014). Long-term isolation has been considered as a driver for the development of the idiosyncrasies of Rossel language and culture. However, until recently this model lacked archaeological data to support it, but it has now been demonstrated that regionally divergent cultural systems were established on the island in the Late Holocene (Shaw 2015). If people did reach Rossel Island in the Late Pleistocene when sea crossings were considerably smaller, the peripheral position of Rossel (within its own lagoon system at the end of an island chain) would almost certainly have contributed greatly to prolonged cultural and geographic isolation throughout the Holocene.

CONCLUSIONS

The discovery of waisted tools on Rossel, the easternmost and one of the most isolated islands in the Massim region of Papua New Guinea, has prompted the timing for the colonisation and settlement in the region to be reconsidered. It is posited that it was possible for people to have travelled as far east as Rossel during the Late Pleistocene when landmasses were considerably larger, closer together, and had more diverse ecosystems. In the Holocene, sea levels rose significantly, reducing the land area and presenting new ecological challenges for any inhabitants. However, the possibility of a greater time depth for human settlement in the Massim can only be further investigated as part of ongoing archaeological fieldwork that targets landscapes where Early Holocene and Late Pleistocene archaeological sites are likely to be preserved. It is to be hoped that this will result in a better understanding of the long-term processes that led to the eventual development of complex social systems in the Massim.

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