From Field to Museum

Studies from Melanesia in Honour of Robin Torrence

edited by

Jim Specht, Val Attenbrow, and Jim Allen

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Front photo: Aerial view of Garua Island, one of Robin's research areas, with Mt Baki in the foreground and the location of the FAO Lapita pottery site on the ridge to the left. Malaiol Gully and the FAP site are in the foreground but are concealed by vegetation. The volcanoes of Hoskins Peninsula are visible in the distance, with Mt Witori lying behind the nearer twin peaks. West New Britain Province, Papua New Guinea. Photo: Jim Specht, 1989.

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From Field to Museum—Studies from Melanesia in Honour of Robin Torrence. Preface

Jim Specht[1,2], Val Attenbrow[1,2], and Jim Allen[3]

[1] Archaeology and Geosciences, Australian Museum,
1 William Street, Sydney NSW 2010, Australia

[2] Department of Archaeology, School of Philosophical and Historical Inquiry,
University of Sydney NSW 2006, Australia

[3] Department of Archaeology and History,
La Trobe University, Bundoora VIC 3086, Australia

This collection of 16 papers by 32 authors covers a diverse range of topics on archaeological materials and museum collections. The papers range in geographical coverage from Sarawak in Malaysia to Solomon Islands and Vanuatu, but their main focus is on Papua New Guinea (PNG). Their time frame covers 6000 or so years down to the present. These wide geographical and temporal spreads are held together by a common thread: the varied relationships of the authors to Dr Robin Torrence, who retired from the position of Senior Principle Research Scientist at the Australian Museum in 2020. Over the last 35 years in Australian studies Robin has taught, supervised, examined, mentored, conducted fieldwork and museum research, or been a co-author with all of the first authors and most of the others.

Robin's association with Australia began through encounters with Australian archaeologists at conferences while she was teaching Archaeology at Sheffield University in the United Kingdom in the late 1970s and early 1980s. Several visits to Australia resulted from these encounters, and Robin's European experience in the production and exchange of obsidian tools was quickly matched to Richard Fullagar's study of obsidian artefacts from Manus Province in Papua New Guinea recovered during the Lapita Homeland Project of 1985 (Fullagar and Torrence, 1991). In 1988 and 1989 she joined Specht's Australian Museum project in the Talasea area of West New Britain Province, PNG. By 1991 she had moved permanently to Australia and began her own project on the obsidian sources of West New Britain's Willaumez Peninsula and Garua Island. A flow of significant papers resulted dealing with the sources and their geochemical characterisation, the production, value and exchange of obsidian stemmed tools in Middle Holocene times (Torrence *et al*., 1996; Torrence and Summerhayes, 1997; Araho *et al*., 2002; Torrence, 2004; Torrence, Swadling *et al*., 2009) and the social and economic significance of obsidian in general (Torrence, 2005, 2011, 2016; Torrence, Kelloway and White, 2013; Torrence *et al.,* 2018).

Robin's focus on stemmed obsidian tools of the Middle Holocene involved the geochemical characterisation of New Britain obsidians to aid the plotting of past artefact movements that could cast light on social relationships and trade routes (Torrence and Swadling, 2008). She initially worked with Wallace Ambrose of the Australian National University and the late Roger Bird at the Australian Nuclear Science and Technology Organisation (ANSTO) using the PIXE-PIGME technique to analyse obsidian source materials and artefacts (Bird *et al*., 1997). With the development of portable XRF (pXRF) equipment, she rapidly adopted this new technique and with her partner Peter White visited museums in Australia, the United Kingdom and Europe to analyse obsidian collections from the Papua New Guinea region. This resulted in an extensive corpus of data indicating significant transport of obsidian artefacts from the Willaumez Peninsula sources to locations throughout the PNG islands and mainland during the Middle Holocene (Torrence, Kelloway, and White, 2013). This theme is taken up in this

Corresponding author: Jim Specht jspecht@bigpond.com
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volume by Christian Reepmeyer, who explores issues of social connections and cultural identity through the use and exchange of New Britain and Banks Islands' obsidian in Vanuatu and the SE Solomon Islands. Following the work of Attenbrow *et al*. (2017) in Australia, Robin encouraged the extension of the application of pXRF analysis in the Willaumez Peninsula-Hoskins area of northern New Britain to non-obsidian stone artefacts (Pengilley *et al*., 2019), and here Alana Pengilley extends this application to items from New Britain's south side. These two studies open new avenues for tracking the movement of stone tools over time and enhance our previous reliance on obsidian artefacts and pottery to understand past socio-economic networks.

Volcanic landscapes have held Robin's interest ever since her days as a doctoral candidate on the island of Melos in Greece (Torrence, 1986), and West New Britain provided many opportunities for her to take these interests further. They included being in the field during the eruption of Pago within the crater of Mount Witori in 2002 and co-authorship of a monograph on the volcanoes of the southern Willaumez Peninsula (McKee *et al*., 2005) that was followed a few months after publication by one of the volcanoes entering an eruptive phase. Robin's collaboration with a range of volcanologists, soil specialists and others in Australia, New Zealand, the USA, and the UK has yielded important advances in our knowledge and understanding of the histories, dating and impacts of the volcanoes of central New Britain. This has led to the refining of the stratigraphic records and chronologies of the eruptive histories of Witori and Dakataua volcanoes over the last 10,000 years (Neall *et al*., 2008; Petrie and Torrence, 2008; Torrence, Neall and Boyd, 2009; McKee *et al*., 2010). Here, Vince Neall and his colleagues present important new results on the geochemistry of tephras from these eruptions that greatly enhance our capacity to distinguish between volcanic events across thousands of square kilometres.

Much of the fieldwork for this archaeological and volcanological research was carried out within a broader framework of retrieving data from archaeological sites under threat of destruction by the development and expansion of oil palm plantations along the north coast of New Britain (Torrence, White and Kononenko, 2013; Specht and Torrence, 2007). Among the results of this research was the discovery of a partly-destroyed hillock on Numundo Plantation with obsidian artefacts exposed more than 4 metres below ground surface under series of volcanic ashes. Now named archaeological site Kupona-na-Dari, this archaeological site predates the Last Glacial Maximum and is among the oldest evidence for human occupation of the Bismarck Archipelago (Torrence *et al*., 1999, 2004). Numundo Plantation is preserving this remnant of the hillock, now known by some locals as 'Robin's grassy knoll.'

As well as these 'big picture' projects Robin has addressed the microscopic end of the scale by promoting studies of usewear and residues on stone and other artefacts and the identification of phytoliths and ancient starch granules to address aspects of past lifestyles that generally do not leave macroscopic evidence. The usewear studies have been greatly enhanced by Nina Kononenko choosing to make Australia, and Sydney in particular, her new home, a move that was strongly supported and encouraged by Robin. Their subsequent collaborations have produced significant results, including identification of Lapita age obsidian tools as probable tattooing implements (Kononenko and Torrence, 2009; Kononenko *et al*., 2016; Torrence *et al*., 2018). In this volume Nina combines with Pip Rath to explore some of Robin's ideas about the specialised production of stemmed obsidian tools, a topic also pursued by Paul Dickinson. These two papers neatly complement each other, suggesting the probable existence of a highly-structured workshop-style production system on Garua Island in which groups of specialists and novices produced a range of stemmed tools.

The phytolith and usewear studies have thrown light on the functions of stone tools from archaeological sites and in museum collections (e.g., Kealhofer *et al*., 1999; Barton, 2007), on human responses to landscape change (Parr *et al*., 2009; Torrence, 2016), and on the Lapita period settlement structure at site FAO on Garua Island, West New Britain (Parr *et al*., 2001; Lentfer and Torrence, 2007). The starch research resulted in a ground-breaking book titled *Ancient Starch Research* (Torrence and Barton, 2006) that received the somewhat dubious honour of receiving the 'Bookseller/Diagram Prize for the Oddest Title of the Year.' Be that as it may, reviewers of the book gave it unanimous high praise and strong recommendations. Four of the contributors to that volume are represented in the present one. Huw Barton uses usewear and residue analysis (phytoliths and starch) to identify the function of a collection of cylindrical stone tools in the Sarawak Museum, Malaysia, concluding that they were used for processing sago. Carol Lentfer and Alison Crowther, in combination with the late Roger Green, investigate the subsistence base at the Lapita pottery of Nenumbo (RF-2) in the Solomon Islands, concluding that evidence is consistent with the presence of domesticated crop plants and a significant shift from seeded to unseeded banana varieties through time.

Mention of Lapita pottery introduces two papers dealing specifically with Lapita sites in different parts of Papua New Guinea. Anne Ford, Vincent Kewibu and Kenneth Miamba describe recent discoveries on Fergusson Island in Milne Bay Province where they have recovered transitional pottery from the late-to-post-Lapita phase.

Nick Hogg, Glenn Summerhayes and Yi-lin Elaine Chen discuss Lapita sites in the islands of the Anir group in New Ireland Province. Through compositional analysis of the pottery they argue for a shift in mobility patterns between early and late Lapita times, and the probable movement of pottery to the islands of the Tanga group to the north of Anir.

The paper by Ben Shaw and Simon Coxe takes a completely different tack and examines evidence for cannibalism during the last 500–600 years at sites on Rossel Island in Milne Bay Province. This sensitive topic is generally avoided in the analysis of archaeological human remains. Many village people in Papua New Guinea, however, see the practice as part of their history and heritage.

The second half of the volume consists of papers relating to museum and collection studies not directly related to archaeological fieldwork. Peter Matthews, who contributed to the *Ancient Starch* volume, teams up with Rhys Richards to present an account of the blue-dyed barkcloths of Solomon Islands in the George Brown collection in the National Museum of Ethnology (Minpaku), Japan, raising issues about the identification of the raw materials employed in their production.

The remaining papers reflect a shift in Robin's interests in issues about indigenous agency in the production of museum collections, especially in response to western colonialism. She first expressed this interest in the early 1990s with her study of museum collections of obsidian spear points and daggers of Manus Province, PNG (Torrence, 1993). She returned to this topic in 2000 through an archaeological perspective on European—Manus islander exchange relations (Torrence, 2000). In more recent times she has been a driving force in the development of several projects on collaboration with the Queensland Museum and the Macleay Museum of the University of Sydney to investigate the composition, acquisition histories and related issues of 19th and 20th century museum collections in Australia and overseas. To date one edited volume has been published (Byrne *et al*., 2011) and another one is in preparation dealing with the major collection made by Sir William MacGregor during his time as Lieutenant-Governor of British New Guinea, now known as Papua, part of the independent state of Papua New Guinea. Initial results have been presented in Torrence *et al*. (2020; see also Chan, 2018).

The present volume includes five papers that reflect these interests. Bonshek writes about a time capsule of wooden bowls made expressly for the Australian Museum by the people of Nangali village on Guadalcanal Island, Solomon Islands to update an earlier collection from their area made by anthropologist Ian Hogbin in the 1930s now in the Australian Museum as part of the University of Sydney collection. Erna Lilje and Jude Philp illustrate the varied ways in which the meaning of objects in museum collections can change through time due to museum practices and the shifting views of curators, the public, and the descendants of the artists and artisans who produced them.

Peter Sheppard's contribution about a Solomon Islands 'war' canoe (*tomoko*) in the Australian Museum neatly fits this pattern. He traces the history of such canoes that were originally used in head-hunting raids and warfare, from the attempts by colonial officials to eliminate their construction to the present-day when they have become a powerful symbol of cultural identity for their producers and are frequently seen at major festivals. Cultural identity is also the theme of the paper by James Rhoads who presents the results of a stylistic analysis of 'spirit boards' produced by communities of the Gulf of Papua in an attempt to trace and define social boundaries.

Finally, Susan Davies and Michael Quinnell examine the visit to Australia in 1897 of James Edge-Partington, famous for his 3-part illustrated record of late 19th century museum collections. Davies and Quinnell look in detail at the production and content of the third part (Edge-Partington and Heape, 1898) that mostly covers items in Australian museums at the time of his visit.

This is a brief and incomplete review of Robin's Australian archaeological career but none-the-less it conveys a clear picture of the energy, imagination, inspiration and dedication that Robin has displayed over the last 30 and more years. In presenting this volume to her, the authors and editors express their thanks and appreciation for her friendship and collegiality, and wish her a successful and productive future.

References

Araho, N., R. Torrence, and J. P. White. 2002. Valuable and useful: Mid-Holocene Stemmed Obsidian Artefacts from West New Britain, Papua New Guinea. *Proceedings of the Prehistoric Society* 68: 61–81.
https://doi.org/10.1017/S0078497X00001444

Attenbrow, V., T. Corkill, R. Pogson, L. Sutherland, and P. Grave. 2017. Non-destructive provenancing of ground-edged mafic artefacts: a Holocene study from the Sydney Basin, Australia. *Journal of Field Archaeology* 42(3): 173–186.
https://doi.org/10.1080/00934690.2017.1324354

Barton, H. 2007. Starch residues on museum artefacts: implications for determining tool use. *Journal of Archaeological Science* 34(10): 1752–1762.
https://doi.org/10.1016/j.jas.2007.01.007

Bird, R., R. Torrence, G. R. Summerhayes, and G. Bailey. 1997. New Britain obsidian sources. *Archaeology in Oceania* 32(1): 61–67.
https://doi.org/10.1002/j.1834-4453.1997.tb00371.x

Byrne, S., A. Clarke, R. Harrison, and R. Torrence. 2011. *Unpacking the Collection, Networks of Material and Social Agency in the Museum*. New York, Heidelberg, Dordrecht and London: Springer Verlag.

Chan, K., ed. 2018. *Kambek. Reconnecting Collections*. Brisbane: Queensland Museum.

Edge-Partington, J., and C. Heape. 1898. *An Album of the Weapons, Tools, Ornaments, Articles of Dress etc., of the Natives of the Pacific Islands Drawn and Described from Examples in Public & Private Collections in Australasia by James Edge-Partington*. Third Series. Manchester: Palmer Howe and Co.

Fullagar, R., and R. Torrence. 1991. Obsidian exploitation at Umleang, Lou Island. In *Report of the Lapita Homeland Project*, pp. 113–143, ed. J. Allen and C. Gosden. Occasional Papers in Prehistory, 20. Canberra: Department of Prehistory, Research School of Pacific Studies, the Australian National University.

Kealhofer, L., R. Torrence, and R. Fullagar. 1999. Integrating phytoliths within use-wear/residue studies of stone tools. *Journal of Archaeological Science* 26(5): 527–546.
https://doi.org/10.1006/jasc.1998.0332

Kononenko, N., and R. Torrence. 2009. Tattooing in Melanesia: Local invention or Lapita introduction? *Antiquity* 83. Project Gallery, June 2009.
http://antiquity.ac.uk/projgall/kononenko/

Kononenko, N., R. Torrence, and P. Sheppard. 2016. Detecting early tattooing in the Pacific region through experimental usewear and residue analyses of obsidian tools. *Journal of Archaeological Science Reports* 8: 147–163.
https://doi.org/10.1016/j.jasrep.2016.05.041

Lentfer, C., and R. Torrence. 2007. Holocene volcanic activity, vegetation succession, and ancient human land use: Unraveling the interactions on Garua Island, Papua New Guinea. *Review of Palaeobotany and Palynology* 143(2): 83–105.
https://doi.org/10.1016/j.revpalbo.2006.06.007

McKee, C. O., V. E. Neall, and R. Torrence. 2010. A remarkable pulse of large-scale volcanism on New Britain Island, Papua New Guinea. *Bulletin of Volcanology* 73: 27–37.
https://doi.org/10.1007/s00445-010-0401-8

McKee, C. O., H. Patia, J. Kuduon, and R. Torrence. 2005. Volcanic Hazard Assessment of the Krummel-Garbuna-Welcker Volcanic Complex, Southern Willaumez Peninsula, W.N.B., Papua New Guinea. Geological Survey of Papua New Guinea Report 2005/4.

Neall, V. E., R. C. Wallace, and R. Torrence. 2008. The volcanic environment for 40,000 years of human occupation on the Willaumez Peninsula, West New Britain, Papua New Guinea. *Journal of Volcanology and Geothermal Research* 176: 330–343.
https://doi.org/10.1016/j.jvolgeores.2008.01.037

Parr, J. F., W. E. Boyd, V. Harriott, and R. Torrence. 2009. Human adaptive responses to catastrophic landscape disruptions during the Holocene at Numundo, PNG. *Geographical Research* 47(2): 155–174.
https://doi.org/10.1111/j.1745-5871.2008.00553.x

Parr, J., C. Lentfer, and W. Boyd. 2001. Spatial analysis of fossil phytolith assemblages at an archaeological site in West New Britain, Papua New Guinea. In *The Archaeology of Lapita Dispersal in Oceania*, ed. G. R. Clark, A. J. Anderson, and T. Vunidilo, pp. 125–134. Terra Australis 17. Canberra: Pandanus Books, Research School of Pacific and Asian Studies, Australian National University.

Pengilley, A., C. Brand, J. Flexner, J. Specht, and R. Torrence. 2019. Detecting exchange networks through geochemical analysis of axe/adze blades from West New Britain, Papua New Guinea. *Archaeology in Oceania* 54(3): 200–213.
https://doi.org/10.1002/arco.5188

Petrie, C. A., and R. Torrence. 2008. Assessing the effects of volcanic disasters on human settlement in the Willaumez Peninsula, Papua New Guinea: a Bayesian approach to radiocarbon calibration. *The Holocene* 18(5): 729–744.
https://doi.org/10.1177/0959683608091793

Specht, J., and R. Torrence. 2007. Lapita all over: Land-use on the Willaumez Peninsula, Papua New Guinea. In *Oceanic Explorations: Lapita and Western Pacific Settlement*, ed. S. Bedford, C. Sand, and S. P. Connaughton, pp. 71–96. Terra Australis 26. Canberra: ANU E Press.
https://doi.org/10.22459/TA26.2007.04

Torrence, R. 1986. *Production and Exchange of Stone Tools. Prehistoric obsidian in the Aegean*. Cambridge: Cambridge University Press.

Torrence, R. 1993. Ethnoarchaeology, museum collections and prehistoric exchange: obsidian-tipped artifacts from the Admiralty Islands. *World Archaeology* 24(3): 468–481.
https://doi.org/10.1080/00438243.1993.9980220

Torrence, R. 2000. Just another trader? An archaeological perspective on European barter with Admiralty Islanders, Papua New Guinea. In *The Archaeology of Difference: Negotiating cross cultural engagements in Oceania*, pp. 104–141, ed. R. Torrence and A. Clarke. One World Archaeology 33. London: Routledge.

Torrence, R. 2004. Pre-Lapita valuables in Island Melanesia. *Records of the Australian Museum, Supplement* 29: 163–172.
https://doi.org/10.3853/j.0812-7387.29.2004.1413

Torrence, R. 2005. Valued stone—how so? In *Many Exchanges: Archaeology, History, Community and the Work of Isabel McBryde*, pp. 357–372, ed. I. Macfarlane, M.-J. Mountain, and R. Paton. Monograph 11. Canberra: Aboriginal History Inc.

Torrence, R. 2011. Finding the right question: learning from stone tools on the Willaumez Peninsula, Papua New Guinea. *Archaeology in Oceania* 46(2): 29–41.
https://doi.org/10.1002/j.1834-4453.2011.tb00097.x

Torrence, R. 2016. Social resilience and long-term adaptation to volcanic disasters: the archaeology of continuity and innovation in the Willaumez Peninsula, Papua New Guinea. *Quaternary International* 394: 6–16.
https://doi.org/10.1016/j.quaint.2014.04.029

Torrence, R., and H. Barton, eds. 2006. *Ancient Starch Research*. Walnut Creek (CA): Left Coast Press, Inc.

Torrence, R., E. Bonshek, A. Clarke, S. Davies, J. Philp, and M. Quinnell. 2020. Regimes of value in museum practices: a networked biography of the MacGregor field collection from British New Guinea. *Museum History Journal* 13(2): 111–131.
https://doi.org/10.1080/19369816.2020.1807122

Torrence, R., S. Kelloway, and P. White. 2013. Stemmed tools, social interaction, and voyaging in early-mid Holocene Papua New Guinea. *Journal of Island and Coastal Archaeology* 8(2): 287–310.
https://doi.org/10.1080/15564894.2012.761300

Torrence, R., N. Kononenko, P. Sheppard, M. S. Allen, S. Bedford, P. V. Kirch, and M. Spriggs. 2018. Tattooing tools and the Lapita cultural complex. *Archaeology in Oceania* 53(1): 58–73.
https://doi.org/10.1002/arco.5139

Torrence, R., V. Neall, and W. E. Boyd. 2009. Volcanism and historical ecology on the Willaumez Peninsula, Papua New Guinea. *Pacific Science* 63(4): 507–535.
https://doi.org/10.2984/049.063.0404

Torrence, R., V. Neall, T. Doelman, E. Rhodes, C. McKee, H. Davies, R. Bonetti, A. Guglielmetti, A. Manzoni, M. Oddone, J. Parr, and C. Wallace. 2004. Pleistocene colonisation of the Bismarck Archipelago: new evidence from West New Britain. *Archaeology in Oceania* 39(3): 101–130.
https://doi.org/10.1002/j.1834-4453.2004.tb00568.x

Torrence, R., J. Specht, H. Davies, P. Ainge, and P. White. 1999. A Pleistocene landscape in West New Britain, Papua New Guinea. *Australian Archaeology* 49: 44–45.
https://doi.org/10.1080/03122417.1999.11681657

Torrence, R., and G. R. Summerhayes. 1997. Sociality and the short distance trader: intra-regional obsidian exchange in the Willaumez Peninsula region, Papua New Guinea. *Archaeology in Oceania* 32(1): 74–84.
https://doi.org/10.1002/j.1834-4453.1997.tb00373.x

Torrence, R., and P. Swadling. 2008. Social networks and the spread of Lapita. *Antiquity* 82: 600–616.
https://doi.org/10.1017/S0003598X00097258

Torrence, R., P. Swadling, N. Kononenko, W. Ambrose, P. Rath, and M. D. Glascock. 2009. Mid-Holocene social interaction in Melanesia: new evidence from hammer-dressed obsidian stemmed tools. *Asian Perspectives* 48: 119–148.
https://doi.org/10.1353/asi.0.0014

Torrence, R., P. White, and N. Kononenko. 2013. Meaningful stones: obsidian stemmed tools from Barema, New Britain, Papua New Guinea. *Australian Archaeology* 77: 1–8.
https://doi.org/10.1080/03122417.2013.11681974

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Geochemical Fingerprinting of Holocene Tephras in the Willaumez Isthmus District of West New Britain, Papua New Guinea

Vincent Neall[1], Lucy McGee[2], Michael Turner[1,3], Tanya O'Neill[1,4], Anke Zernack[1], and J. Stephen Athens[5]

[1] School of Agriculture and Environment, Massey University, Palmerston North, New Zealand

[2] The University of Adelaide, Adelaide SA 5005, Australia

[3] 22 Basedow Road, Tanunda SA 5352, Australia

[4] School of Science, The University of Waikato, Hamilton, New Zealand

[5] International Archaeological Research Institute Inc.,
2081 Young Street, Honolulu, Hawaii 96826, United States of America

Abstract. Electron microprobe analyses were conducted on volcanic glasses extracted from Holocene tephra marker beds on the Willaumez isthmus in West New Britain, Papua New Guinea. These tephra beds are pivotal in the dating of a wide range of human artefacts and manuports found in the intervening buried soils, extending back over the last 40,000 years. Three major groups can be easily separated: W-K1 and 2; W-K3 and 4; and the Dakataua tephra. Of the remaining post-W-K4 tephras, most show slightly higher FeO and CaO and lower SiO_2 contents than the W-K3 and 4 group, although there is some overlap. The combination of these geochemical data sets with the known stratigraphy and radiocarbon dates has helped resolve tephra correlation where these ashes become thin and less visually diagnostic or where pumice has been resorted and redeposited by the Kulu-Dulagi River.

Introduction

The volcanic alignment of the Willaumez Peninsula extends 60 km northwards from the main west-east axis of the island of New Britain in Papua New Guinea, near the provincial capital of Kimbe. Five km west-northwest of Kimbe, the Peninsula joins the main island by a narrow 18 km-wide strip of lowland hereafter referred to as the Willaumez isthmus (Fig. 1). Within this district, since the 1950s, oil palm plantation development has led to extensive deforestation, and the construction of roads has resulted in the cutting of many exposures into the dominantly tephra cover beds. Between these beds are numerous buried soils (palaeosols) in which abundant artefacts and manuports occur (Torrence *et al.*, 1990). Abundant obsidian flakes extend back over 40,000 years (Torrence *et al.*, 2004) as do less frequent oven (*mumu*) stones. The district is also renowned for being the site of some of the earliest Lapita pottery in the Pacific (Specht and Torrence, 2007; Torrence *et al.*, 2009). Hence the region has been the centre of much archaeological research, principally conducted by staff of the Australian Museum.

Most of the Holocene human settlement has been disturbed by four plinian eruptions (W-K 1 to W-K 4) from the Witori caldera and one from the Dakataua caldera (McKee *et al.*, 2011), with numerous subsequent sub-plinian and phreatomagmatic events from Witori (Table 1). Machida *et al.* (1996) published the reconnaissance tephrochronology of this sequence and Neall *et al.* (2008) have summarised the volcanological impacts on human settlement.

Keywords: Papua New Guinea; New Britain; Willaumez Peninsula; Holocene tephras; geochemical fingerprinting
Corresponding author: Vincent Neall vandaneall@inspire.net.nz
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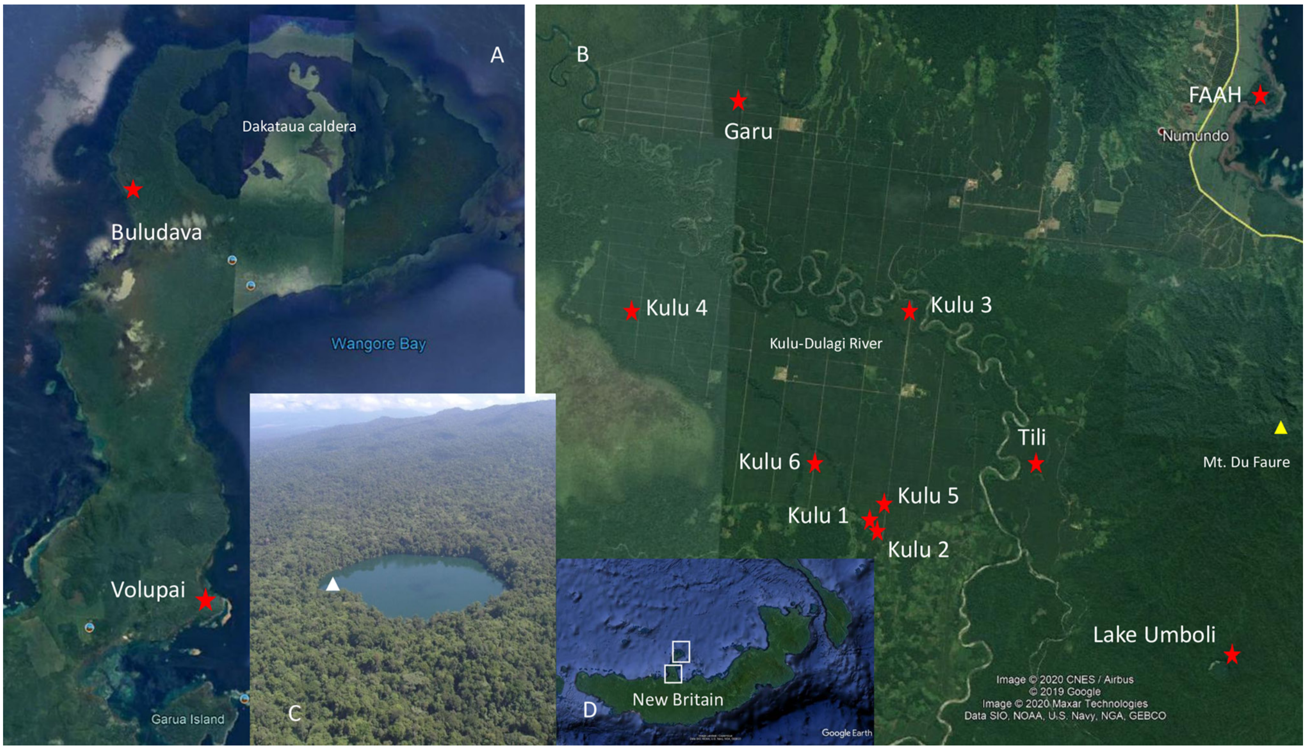

Figure 1. Location of sample sites in this study, West New Britain, Papua New Guinea. (*A*) northern Willaumez Peninsula; (*B*) Willaumez isthmus district.; (*C*) Aerial view of Lake Umboli from the south; white triangle marks location of core site; (*D*) Map of New Britain showing the Willaumez Peninsula; upper square is area covered by *A*, and lower square *B*. Images *A, B* and *C* with courtesy of Google Earth.

As the detailed record has emerged, the issue of distinguishing similar appearing plinian and sub-plinian tephras, particularly at distal localities, becomes a problem. In the current study we have applied geochemical fingerprinting of each major Holocene tephra on the Willaumez isthmus using electron microprobe analysis of volcanic glass. In particular, we have focussed on the post-W-K4 Witori tephras, comprising W-G, H1, H2 and five W-Hs, which are less distinguishable in macroscopic properties from the four major plinian eruptions.

Table 1. Tephra stratigraphy reported by Machida *et al*. (1996) compared with revised chronology used in this paper based on new radiocarbon dates and Petrie and Torrence (2008).

	Machida *et al*., 1996		this paper	
tephra name	tephra symbol	age	tephra symbol	age
Witori-Hoskins 7	W-H7	1914 AD?	W-H7	1914 AD ?
Witori-Hoskins 6	W-H6	< 0.5ka	W-H6	post-1426 cal. AD[a]
Witori-Hoskins 5	W-H5	< 0.5 ka	W-H5	1318–1636 cal. AD[a]
Witori-Hoskins 4	W-H4	< 0.5 ka	W-H4	1305–1450 cal. AD[a]
Witori-Hoskins 3	W-H3	0.5 ka	W-H3	1288–1450 cal. AD[a]
Hoskins 2	H2	1.0–0.5 ka	H2	1190–1395 cal. AD[a]
Hoskins 1	H1	1.0–0.5 ka	H1	783–993 cal. AD[a]
Dakataua tephra	Dk	1.15 ka	—	—
Witori-Galilo	W-G	1.2 ka	W-G	783–993 AD[a]
Witori-Kimbe 4	W-K4	1.3–1.5 ka	W-K4	1280 cal. BP[b]
	—	—	Dk	1300 cal. BP[b]
Witori-Kimbe 3	W-K2	1.8 ka	W-K3	1615 cal. BP[b]
Witori-Kimbe 2	W-K2	3.3 ka	W-K2	3315 cal. BP[b]
Witori-Kimbe 1	W-K1	5.6 ka	W-K1	5920 cal. BP[b]

[a] 95% confidence interval calibrated radiocarbon age range.
[b] Modal radiocarbon dates from Petrie and Torrence (2008).

Table 2. Specific details of sample sites shown in Fig. 1.

map reference (see Fig. 1)	archaeological reference site	geological reference site	latitude (S)	longitude (E)	altitude (m)
Buludava	—	Buludava village	05°04'46.5"	150°01'37.2"	1
FAAH	FAAH XVII	—	05°29'55.6"	150°05'47.4"	15
Garu	—	Garu peat	05°30'24.2"	149°58'48.3"	10
Kulu 1	—	Kulu-1	05°36'18.9"	150°00'56.7"	18
Kulu 2	FACR XXII	—	05°36'20.5"	150°00'58.9"	20
Kulu 3	—	Kulu-13	05°33'21.6"	150°01'17.2"	12
Kulu 4	—	Kulu-14	05°33'25.0"	149°57'28.6"	6
Kulu 5	350 m N of FACQ LXVII	Kulu-15	05°35'54.5"	150°01'04.7"	19
Kulu 6	—	Kulu-10	05°35'22.9"	150°00'02.2"	17
Lake Umboli	—	Lake Umboli-2004	05°38'05.4"	150°05'44.8"	230
Tili	—	Tili-3	05°35'46.8"	150°02'56.6"	20
Volupai	—	Pangalu Estate	05°14'42.7"	150°04'02.3"	28

Materials

Glass chemistry can provide a method to discriminate eruption deposits (in this study, all unidentified tephras) from one eruption to those associated with a different eruption from the same or a different volcanic source (Lowe *et al*., 2017), and has especially proven to be much more successful with rhyolitic eruptions compared to those of andesitic composition. In this study, we obtained glass shard compositional data from tephras preserved at ten sites on the Willaumez isthmus region, plus two samples from reference sites on the Willaumez Peninsula (Fig. 1A,B; see sites 9 and 11 in fig. 2 of McKee *et al*., 2011).

The first site is an archaeological site on Numundo Plantation (Fig. 1B) referenced FAAH XVII (Table 2). Its significance is that this site displays the complete sequence of four major Holocene plinian eruptions from the Witori (Pago) caldera with intervening buried soils (for further details see fig. 4 in Neall *et al*., 2008). The site is on a relatively flat-topped hill away from any downslope accumulation processes that might have led to redeposition. Thus, the primary tephra preservation is exquisite and tephra identification of W-K1, W-K2, W-K3 and W-K4 is unequivocal.

The second site is Lake Umboli, a circular 527 m-diameter water-filled depression located in hill country 10.5 km south-west of Kimbe (Fig. 1B, 1C, and Table 2). At an elevation of approximately 230 m, the lake was measured by us to have a maximum water depth of 32.9 m. Two bottom survey transects were conducted showing a broad ‘shallow’ concave profile suggestive that the lake is a phreatomagmatic maar. Being located away from any cultivation, the lake is surrounded by native forest to the water’s edge, minimising any human-induced erosion into the lake. A 3.6 m-long reference core was obtained from a water depth of 6.82 m, 10 m from the south-western shore of the lake. It provides a continuous record of many primary tephras erupted across the Willaumez isthmus in the last 1400 years. Here the tephras were unidentifiable by macroscopic features alone; hence a framework stratigraphy was established (Fig. 2) before geochemical fingerprinting could be applied.

The third site is on Tili Estate (Fig. 1B, Table 2), alongside a former oxbow of the Kulu-Dulagi River system. Here on a levee, floodwaters have entrapped three tephras within river silts and sands over the last 500 years (Fig. 3).

The fourth site is on Garu Estate (Fig. 1B, Table 2) where five tephras are preserved in peat above the water table (Fig. 4). The palynology of samples obtained from the peats was reported by Jago and Boyd (2005) with three of five tephras being identified as W-K3, W-K4, and W-G. Note that two further thin (1 cm thick), discontinuous tephras were identified in this study, above Tephra 1 in Jago and Boyd (2005).

Six further sites all located on Kulu Estate, to the west of the Kulu-Dulagi River (Fig. 1B, Table 2), were included in this study to clarify tephra identification. Kulu 1 is in a drain immediately north of the hills that border the Kulu Estate to the south. It is in a peaty, colluvial footslope position where all tephras are likely to be preserved but overthickening is identified due to colluvial redeposition. It was selected to try and resolve the latest W-H tephra sequence (Fig. 5).

Kulu 2 is an archaeological site (FACR XXII) on a hill overlooking the Kulu 1 site. It is a well-drained location with a tephra sequence extending down to the W-Ks, but only the W-H sequence was sampled for this study (Fig. 6).

Kulu 3 is on the northern border of Kulu Estate, close to the bridge across the Kulu-Dulagi River. The surrounding landscape is subdued, yet the tephra sequence extends back to pre-W-K3 time, suggesting this is a former hill almost buried by surrounding alluvium. A distinct tephra above W-K4 was sampled from this site for identification (Fig. 7).

Kulu 4 is a site near the western margin of Kulu Estate, 8 km south-east of the western coastline of the Willaumez isthmus. This location was sampled to identify the tephra beneath 0.9 m of alluvially resorted W-K 2 (Fig. 8).

Kulu 5 is from an auger hole cored to 6.4 m depth, 350 m north of archaeological site FACQ LXVII, near the southern margin of Kulu Estate. This sample was obtained to confirm the identity of the prominent pumiceous tephra between 5 and 6 m depth (Fig. 9).

Kulu 6 is another section near the southern margin of Kulu Estate in a drain at a small riser in the Kulu lowland landscape. Here deep incision into the pumice layers was causing severe erosion (with countermeasures in place). Nearly 50 cm of W-K 3 is preserved here, above redeposited W-K2 (Fig. 10). However, the section was sampled in this study for a post-W-K4 tephra identification at 25 cm depth.

Two reference sites were also sampled on the Willaumez Peninsula to obtain the volcanic glass composition of identified eruptives associated with the Dakataua eruption. One was pumice from pyroclastic-flow deposits of the Dakataua eruption, sampled from a coastal exposure at Buludava on the western flanks of the Dakataua caldera (site 11 in fig. 2 of McKee *et al*., 2011). The second sample was from a site half-way along the Willaumez Peninsula in the Volupai Plantation district near Pangalu village (site 9 in fig. 2 of McKee *et al*., 2011).

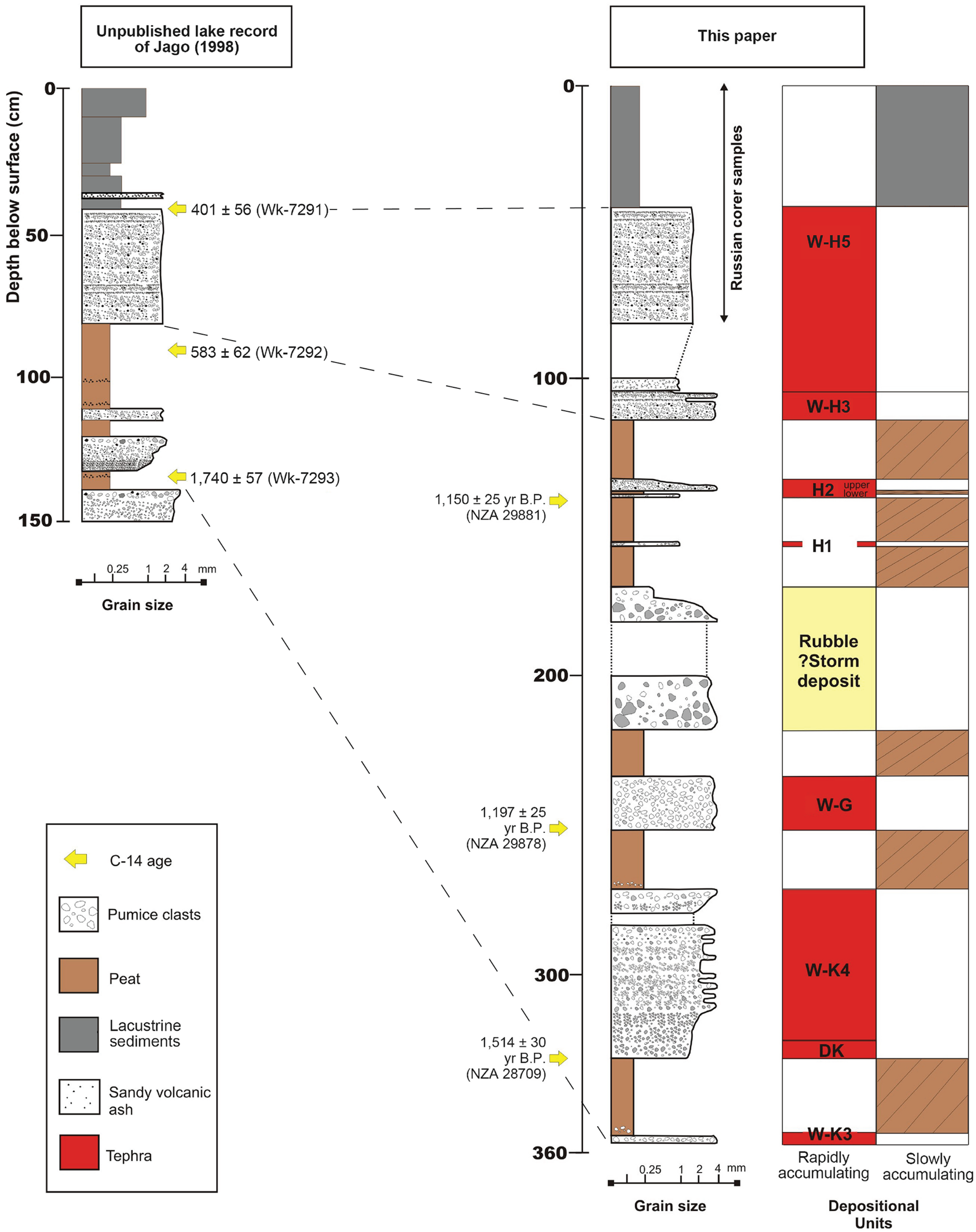

Figure 2. Stratigraphy of core obtained from Lake Umboli, West New Britain. Core beneath 1 m was sampled with a Geo-core piston sampler.

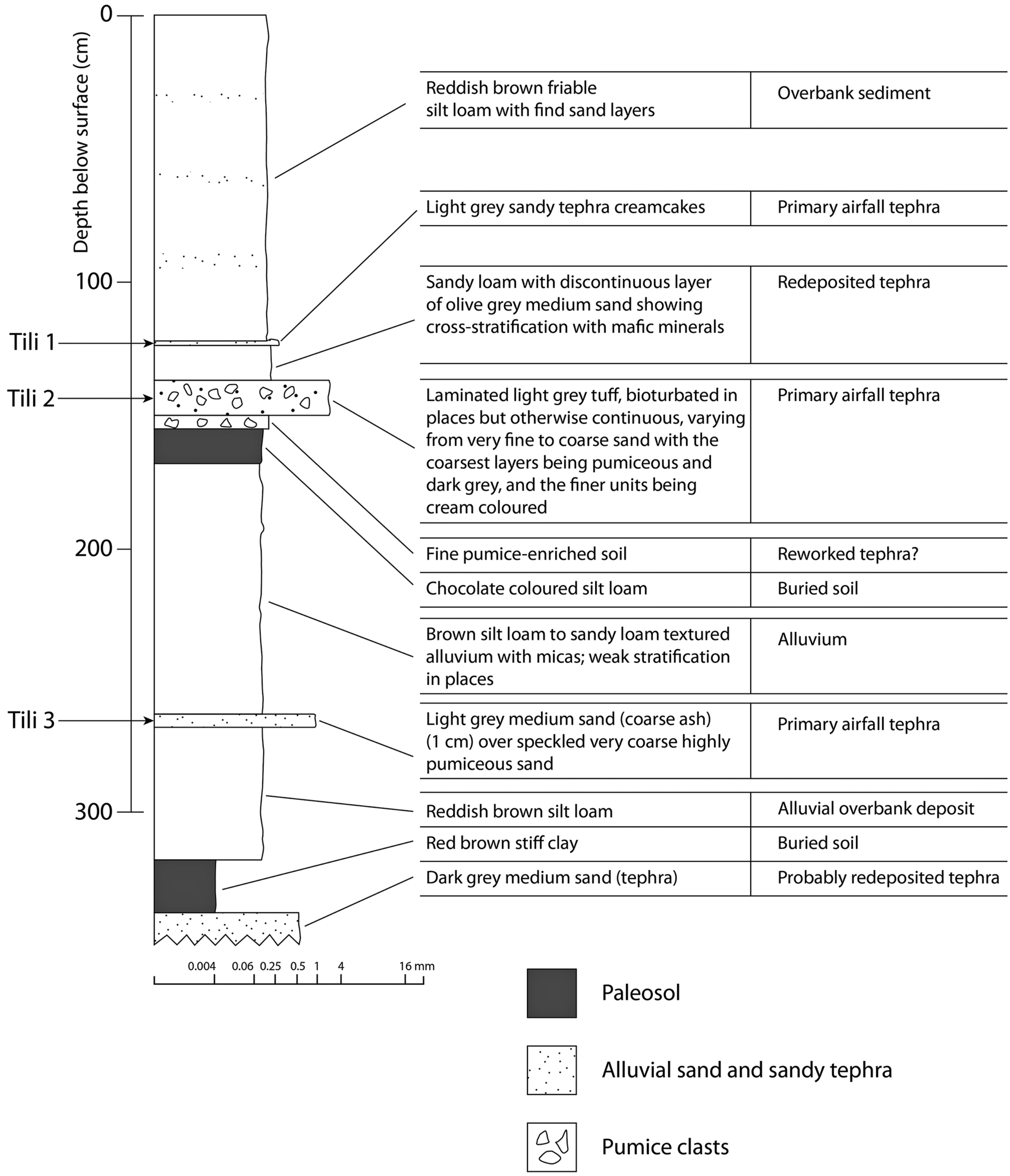

Figure 3. Stratigraphy of Tili site and stratigraphic positions of three tephra samples selected from the W-H sequence.

Figure 4. Stratigraphy of Garu site and stratigraphic positions of six tephra samples selected from the post-W-G sequence. Note samples 4 and 5 are from two beds forming a single tephra unit.

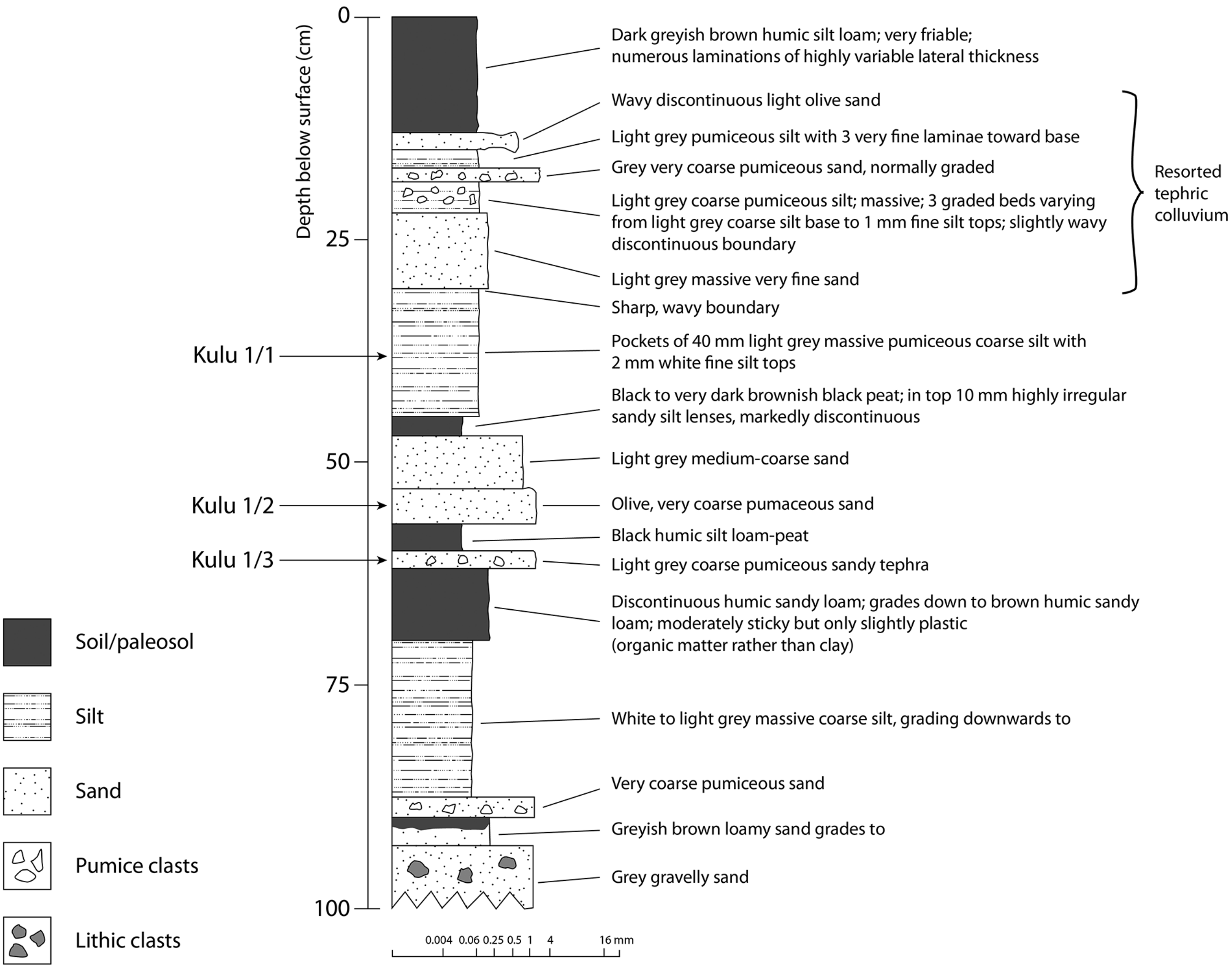

Figure 5. Stratigraphy of Kulu 1 site and stratigraphic positions of three tephra samples selected from the W-H sequence.

Methods

Sampling

The core from Lake Umboli was obtained as follows. First, the softer sediment at the top was sampled with a Russian corer to a depth of 70 cm. It was not possible to retain the loose pumice sand from 70–100 cm depth. Second, the core from 1 m to 3.6 m was obtained with a Geo-core piston sampler recovering sediment and tephra beds into capped aluminium collection tubes. All other samples were from vertical exposures where channel samples were scooped into plastic bags.

Sample preparation

Pumice clasts were washed, carefully crushed with a mortar and pestle, and then sieved. Loose grain samples were just sieved. Glass separates were isolated under a bi-focal microscope from the 125–250 μm fraction. Separates were then mounted in (EpoTek) resin and polished for electron microprobe analysis, using a Struers Planopol-3 and increasingly finer grades of diamond paste (6, 3, and 1 μm).

Electron microprobe

Glass compositions were determined by energy dispersive (EDS) electron microprobe (Jeol JXA-840) at the University of Auckland. The analytical data were collected using a Princeton GammaTech Prism 2000 Si (Li) EDS X-ray detector, a 20 μm de-focused beam accelerating voltage of 12.5 kV, beam current of 600 pA and 100 second live count time. Na_2O was recorded first, due to the volatile nature of Na in the probe beam. Detection limits (1σ in wt%) for this instrument were: SiO_2 0.11, TiO_2 0.08, Al_2O_3 0.06, FeO 0.07, MnO 0.07, MgO 0.07, CaO 0.04, Na_2O 0.11, K_2O 0.03, P_2O_5 0.07, SO_3 0.06, Cl 0.03, Cr_2O_3 0.06, NiO 0.1. An Astimex albite standard was used for calibration at the beginning of each analytical session and show good precision (see Table S1). Elements that were not present in the standard are denoted by italics in Table S1 and are not used in geochemical plots. This microprobe took part (along with 64 other participating laboratories) in the 'G-Probe-2 international proficiency test for microbeam laboratories'; the results of which were within the acceptable deviation from the NKT-1G basaltic glass standard (e.g., Potts *et al.*, 2005) and within the error of the median values for the standards tested. The deviation from the accepted values for the major elements is listed in Table S1.

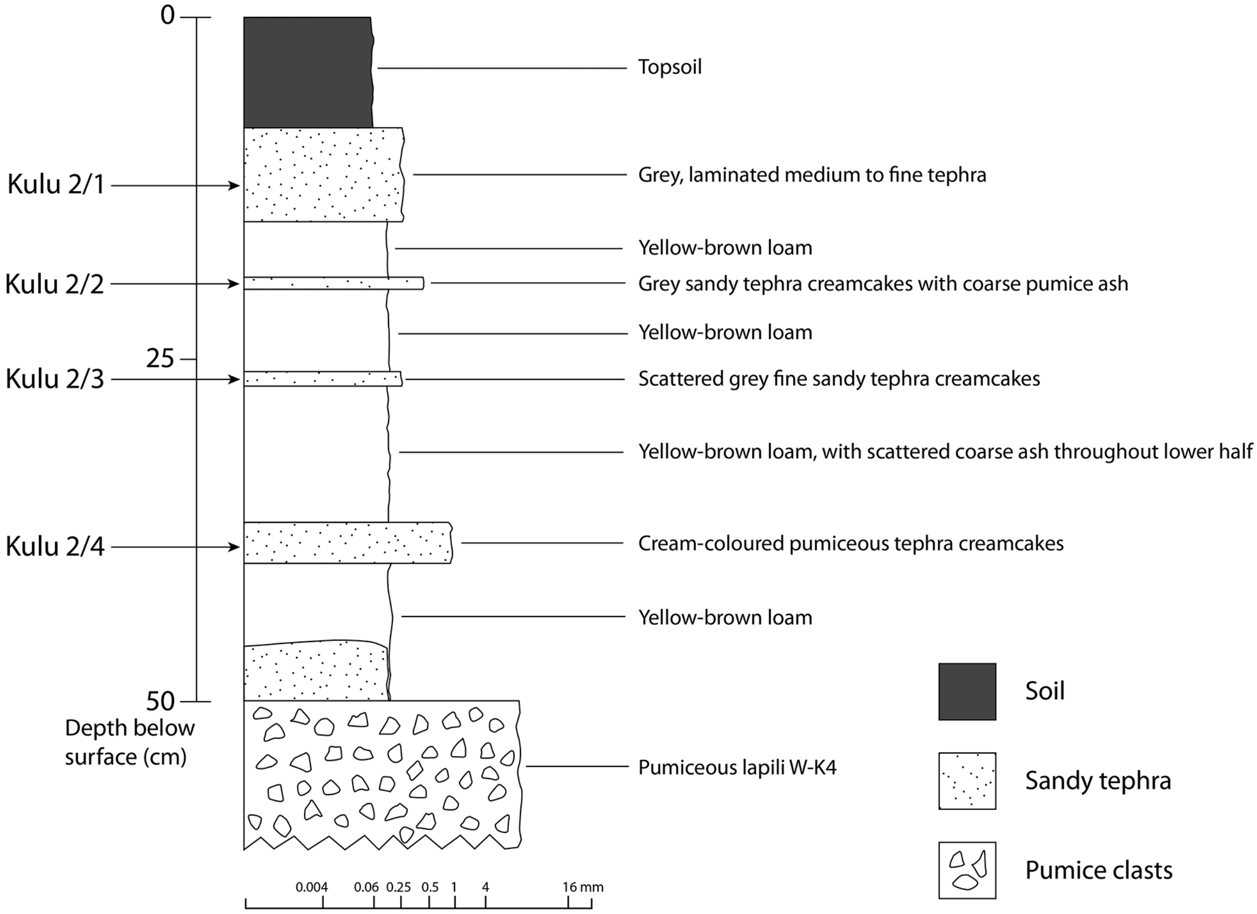

Figure 6. Stratigraphy of Kulu 2 (archaeological site FACR XXII) and stratigraphic positions of four post-W-K4 tephra samples selected.

Tephrochronology

The FAAH locality forms the reference locality for the W-K1 to W-K4 tephras (see Neall *et al*., 2008).

Three key localities form the basis for the post-W-K4 tephras in the district. The first is the core obtained from Lake Umboli (Fig. 2). Three AMS radiocarbon dates were obtained in this study (NZA 28709, NZA 29878 and NZA 29881). The lowest sample from 329–331 cm depth, immediately below a dark grey coarse ash, was dated on dark brown peaty sediment. The conventional radiocarbon age was 1514±30 BP (NZA 28709; BP = Before Present). This fits with the overlying coarse ash being the Dakataua tephra, which close to source contains charcoal logs within pyroclastic-flow deposits dated at 1370±37 BP (Wk-15505; McKee *et al*., 2011: table 3). It is notable that in this core there is no sediment preserved between the Dakataua tephra and the overlying W-K4 pumice. This date also demonstrates that the lowest pumice tephra sampled in the core is the W-K3 tephra.

The middle-dated sample was on pollen separated from black fibrous sandy peat at 252–254 cm depth, immediately beneath a prominent pumiceous coarse ash and fine lapilli and yielded a conventional radiocarbon age of 1197±25 BP (NZA 29878). This correlates well with a date of 1190±70 BP (Beta-29257) obtained from above the W-K4 tephra and below the W-G ('Galilo Pumice' of Blake, 1976) reported by Machida *et al.* (1996: fig. 4). Hence the pumiceous unit above can be confidently correlated with the Galilo Pumice.

The uppermost dated sample was on a pollen separate from black fibrous silty peat at 140–142 cm depth, immediately beneath a grey pumiceous coarse ash (with a 1 cm band of black peat within it, clearly separating an earlier and later closely time-spaced event). The resultant conventional radiocarbon age was 1150±25 BP (NZA 29881). Clearly the tephra above is not a W-H tephra based on the evidence that they are all younger than 519±68 BP (NZA 2011) (Machida *et al*., 1996: fig. 4). Hence, the only likely interpretation is that the tephra above NZA 29881 is Hoskins 2 (H2) of Machida *et al*. (1996), and the tephra 15 cm below it is Hoskins 1 (H1).

Previous unpublished radiocarbon dates obtained by Jago from a compressed core 1.475 m long (obtained from 2.82 m sediment depth) in shallower water (2 m from shore) at Lake Umboli can be directly correlated to this core. These dates (Fig. 2) constrain the youngest tephra sequence in the core to between 401±56 BP (Wk-7291) and 583±62 BP (Wk-7292). This information can be directly correlated to our core described here, demonstrating that the package of tephras between 40 and 114 cm depth in this core represents all or some of the W-H tephras.

The second key locality is located on the Tili oil palm plantation (Fig. 3). Here three post-W-K4 tephras are preserved within overbank silt deposits. No radiocarbon datable material was available at this section, but the clear tephra succession allows a geochemical comparison to be made.

The third key locality is located on the Garu oil palm plantation, 1.1 km west of Boku Hill (Table 1, Fig. 4). Here five tephras have now been identified above peat radiocarbon dated at 775±35 BP (OZF 371) (Jago and Boyd, 2005: table 1). Each was sampled for any distinguishing glass geochemistry of the W-H tephra sequence.

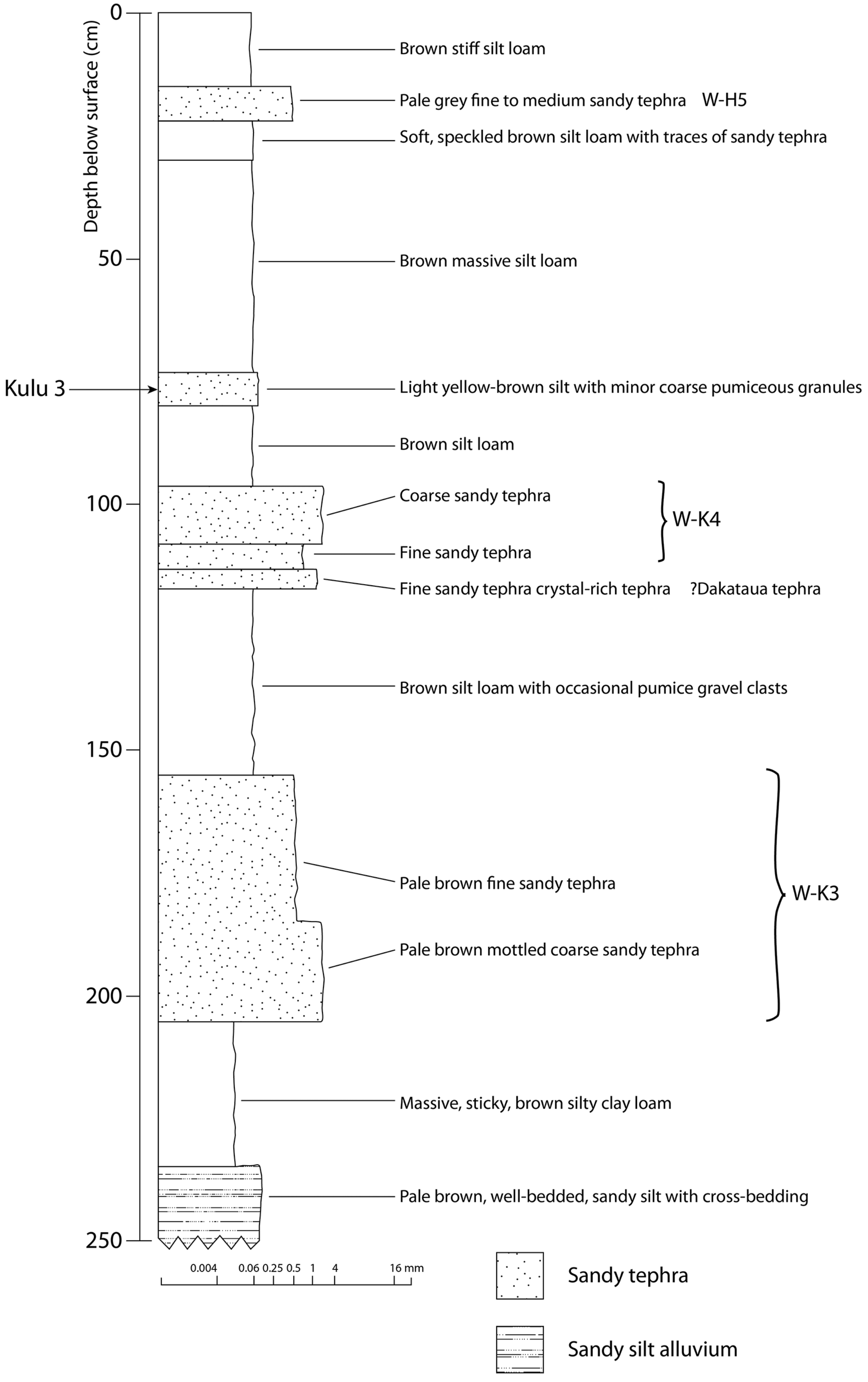

Figure 7. Stratigraphy of Kulu 3 site and stratigraphic position of one post-W-K4 tephra sample selected.

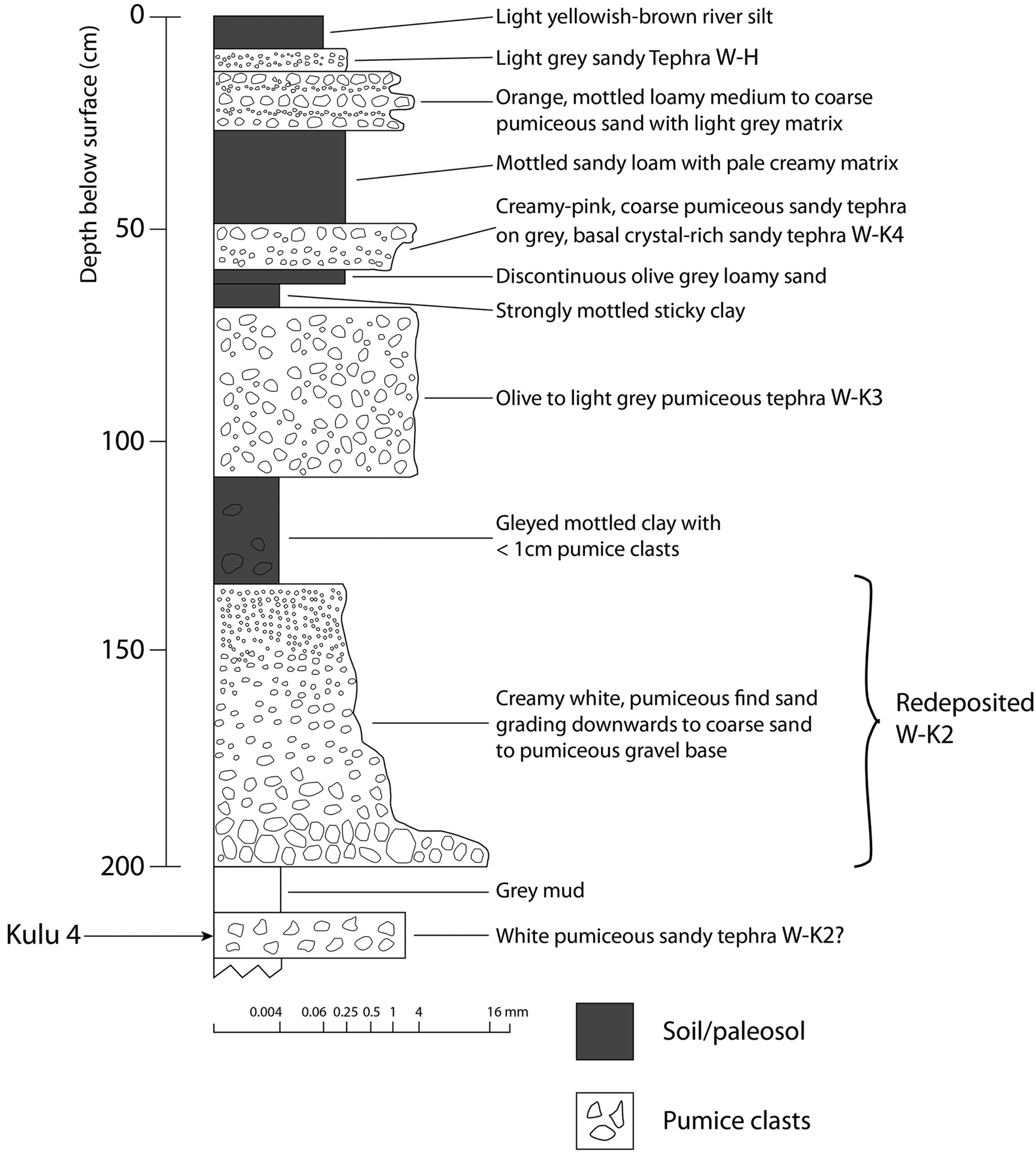

Figure 8. Stratigraphy of Kulu 4 site and stratigraphic position of one pre-W-K3 pumiceous tephra sample selected.

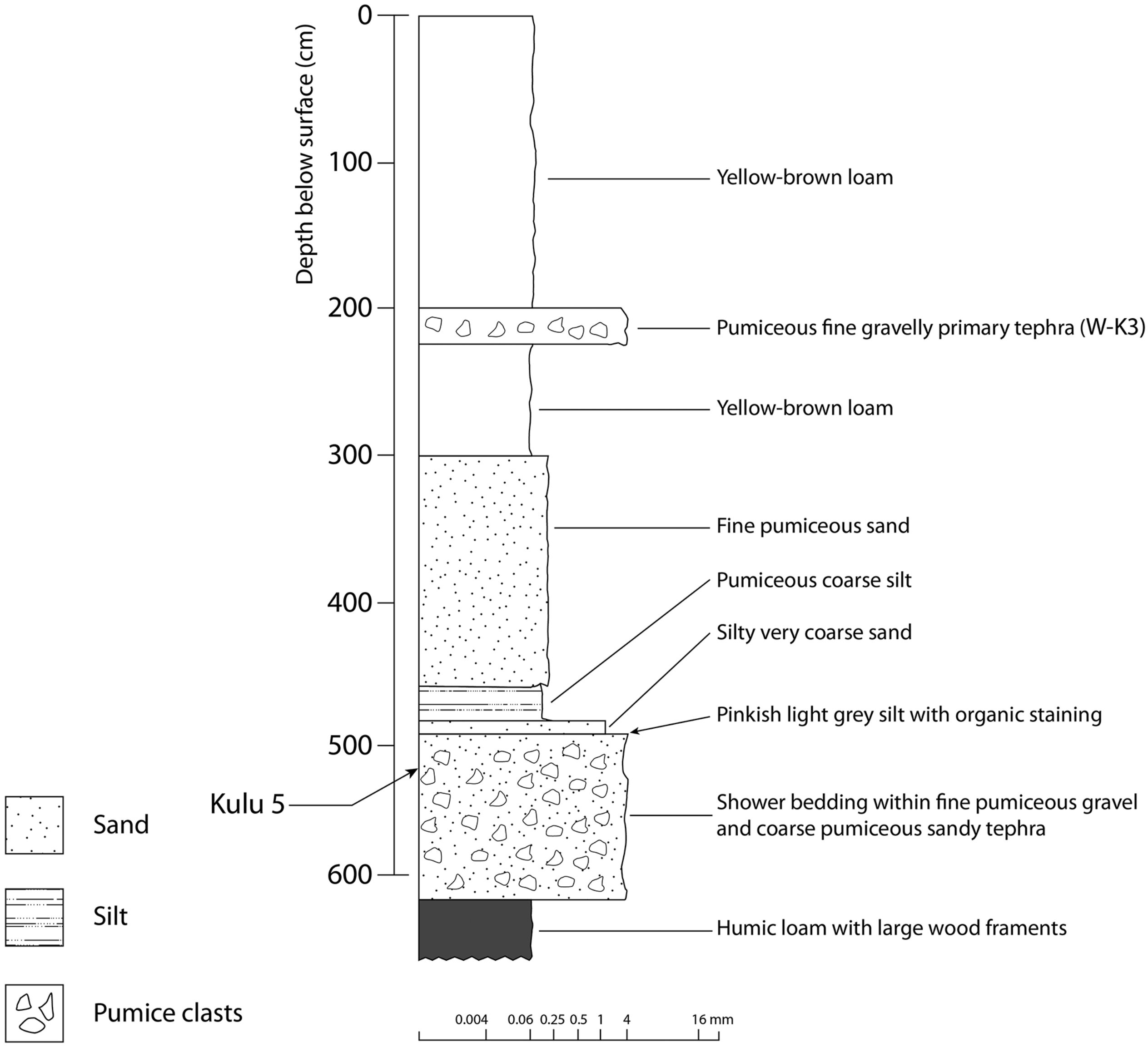

Figure 9. Stratigraphy of Kulu 5 site and stratigraphic position of one pre-W-K3 tephra sample selected from near base of augur hole.

Results

The composition of glass shards between and within the different samples obtained from all sites are presented in Table S1. The figures show data normalised to 100 wt%, and Table S1 presents both raw and normalised data.

Dakataua (DK) tephra from the Buludava and Volupai locations cluster at lower SiO_2 (66.5 wt%) but higher FeO, CaO and Al_2O_3 (5.1, 4.0 and 14.7 wt%, respectively, see Fig. 11) than other tephras in the Willaumez isthmus region, mostly sourced from the Witori caldera. The Dakataua tephra at these locations is identifiable due to the presence of charcoal fragments which are well-dated at 1370±37 BP (Wk-15505) and 1400±43 BP (Wk-11750) (McKee *et al*., 2011: table 3). Thus, the Dakataua tephra provides a reliable, recognisable marker bed for correlation with other sites in the region.

Tephra layers sampled from the FAAH site fall into two distinctive groups (Fig. 11). First is a high SiO_2 (76–79 wt%), low FeO (1.3–2.3 wt%), low CaO (1.6–1.9 wt%) group consisting of tephras from the plinian W-K1 and W-K2 Witori caldera-sourced eruptions. Second is a group comprising the W-K3 and W-K4 tephras, which have lower SiO_2 (72.5–74.8 wt%, not including outliers) and higher FeO (2.5–3.8 wt%), CaO (2.9–3.5 wt%) and Al_2O_3 (13.1–13.7 wt%) than the earlier Witori caldera eruptions (W–K1 and W-K2). Samples from Kulu 4 and Kulu 5 correlate to the W-K1 and W-K2 field.

When the geochemistry of tephras encountered in the Lake Umboli core are plotted with respect to the known Dakataua and Witori caldera eruptions (Fig. 12) some can be easily recognised. The lowermost Lake Umboli tephra (at 362–363 cm depth) has the middle SiO_2-middle FeO signature of the W-K3/4 group tephras. The low SiO_2-high FeO tephra above this (at 326–329 cm depth) clearly matches the composition of the Dakataua tephra. The tephra at 284–305 cm depth returns to a composition similar to W-K3/4 (although is somewhat bimodal in SiO_2 and CaO content), supporting the proposition that the Dakataua eruption occurred shortly before the W-K4 eruption (McKee *et al*., 2011) and unequivocally identifying the basal three tephras in the core (Fig. 12).

Trying to geochemically distinguish the post-W-K4 tephras in the Lake Umboli core is difficult due to substantial overlap in geochemical compositions (Fig. 13). However, the Galilo Pumice (W-G) is clearly identified by the radiocarbon date from immediately beneath it (Fig. 2). A further radiocarbon date from immediately beneath

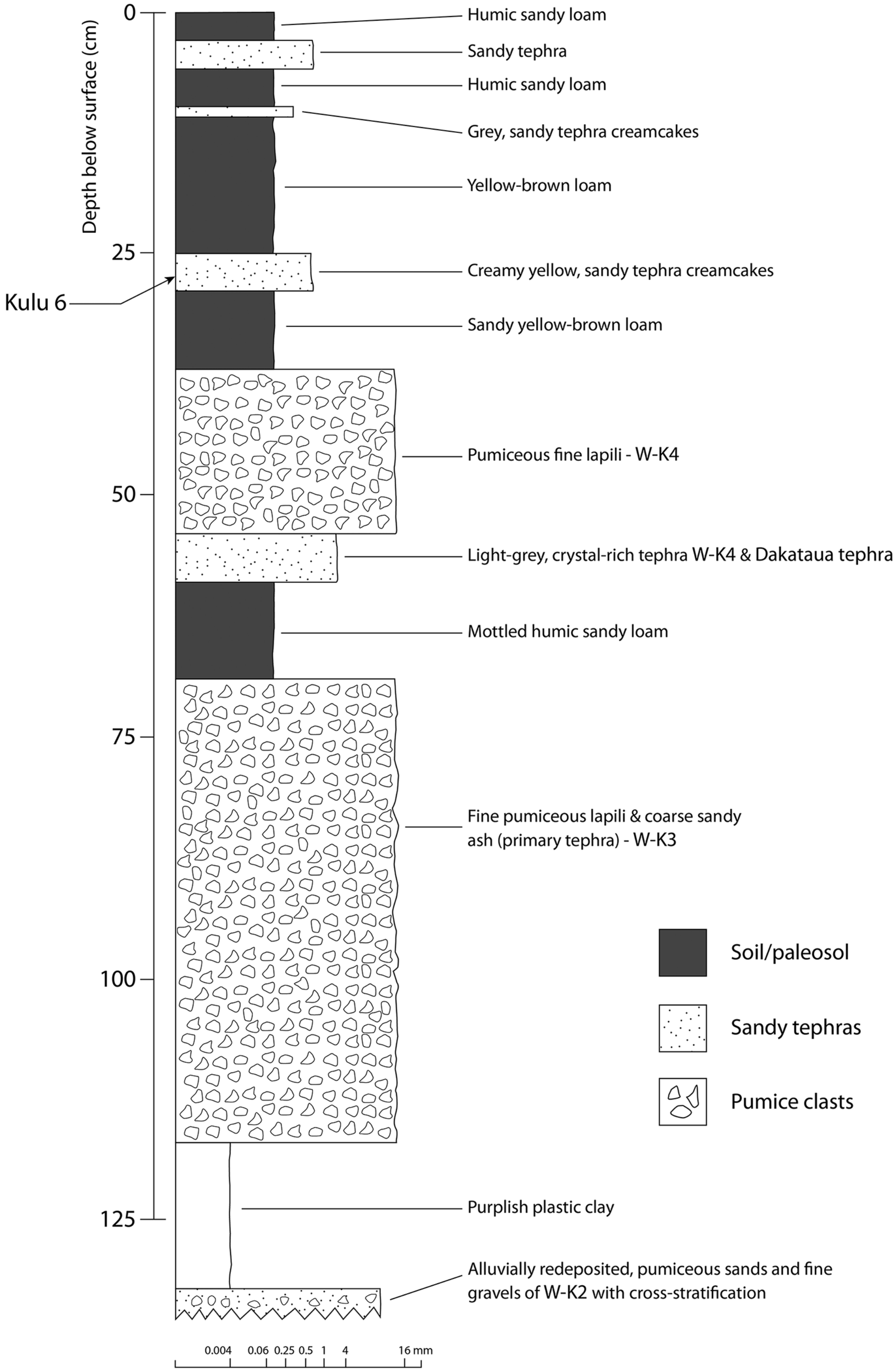

Figure 10. Stratigraphy of Kulu 6 site and stratigraphic position of one post-W-K4 tephra sample selected.

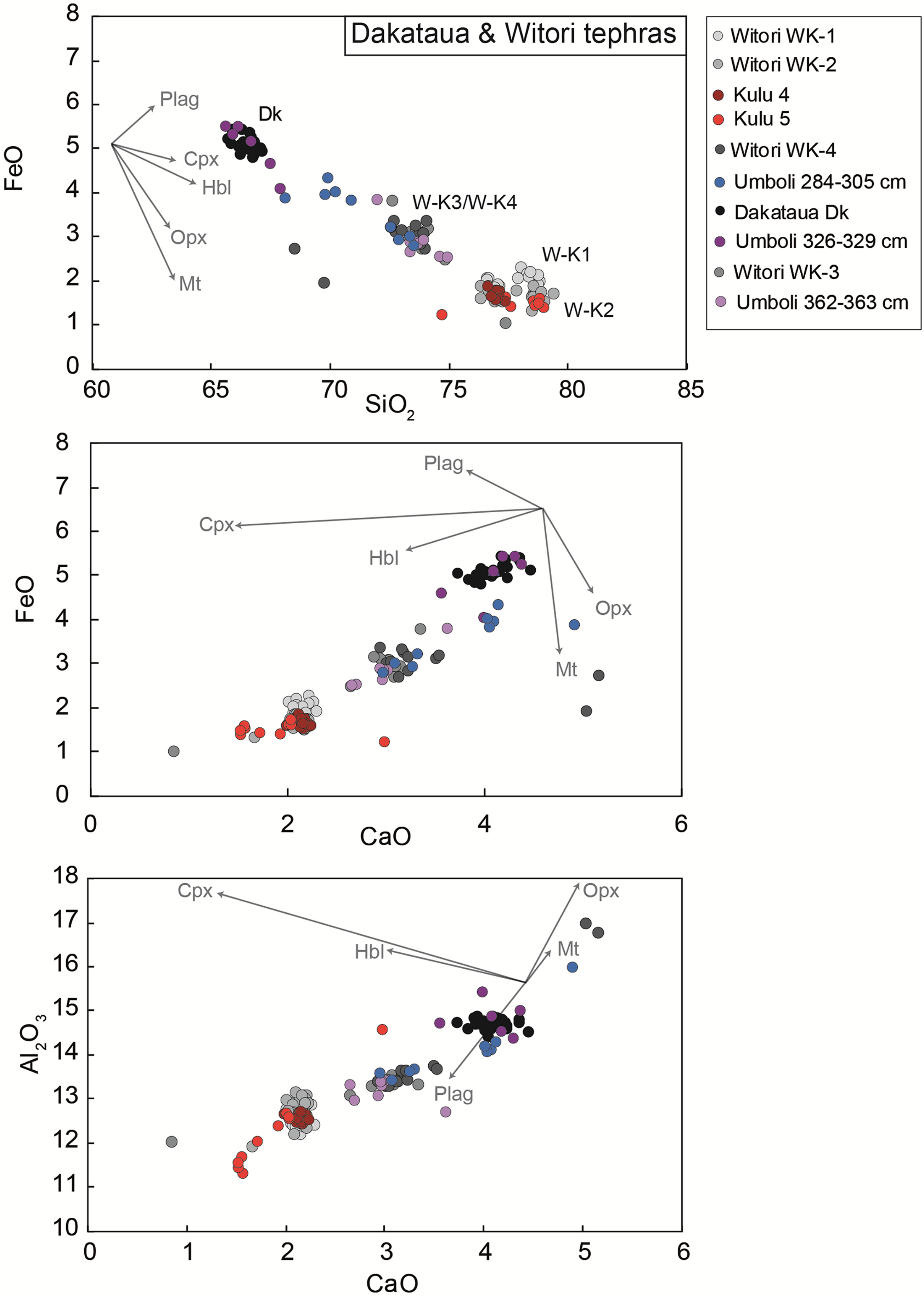

Figure 11. Volcanic glass chemistry for the Dakataua tephra and the four Plinian eruptions from Witori caldera exposed at the FAAH site. Tephras from the Lake Umboli, Kulu 4 and Kulu 5 sites correlate with the W-K1/2, Dakataua and W-K3/4 groups. Vectors portray approximately 15% fractional crystallisation of each mineral, except for magnetite which is approximately 5% crystallisation. Plag = plagioclase, Cpx = clinopyroxene, Hbl = hornblende, Opx = orthopyroxene, Mt = magnetite. Mineral compositions are from the Tauhara dacite in the Taupo Volcanic Zone (Millet *et al*., 2014); see Table S1 for compositions used.

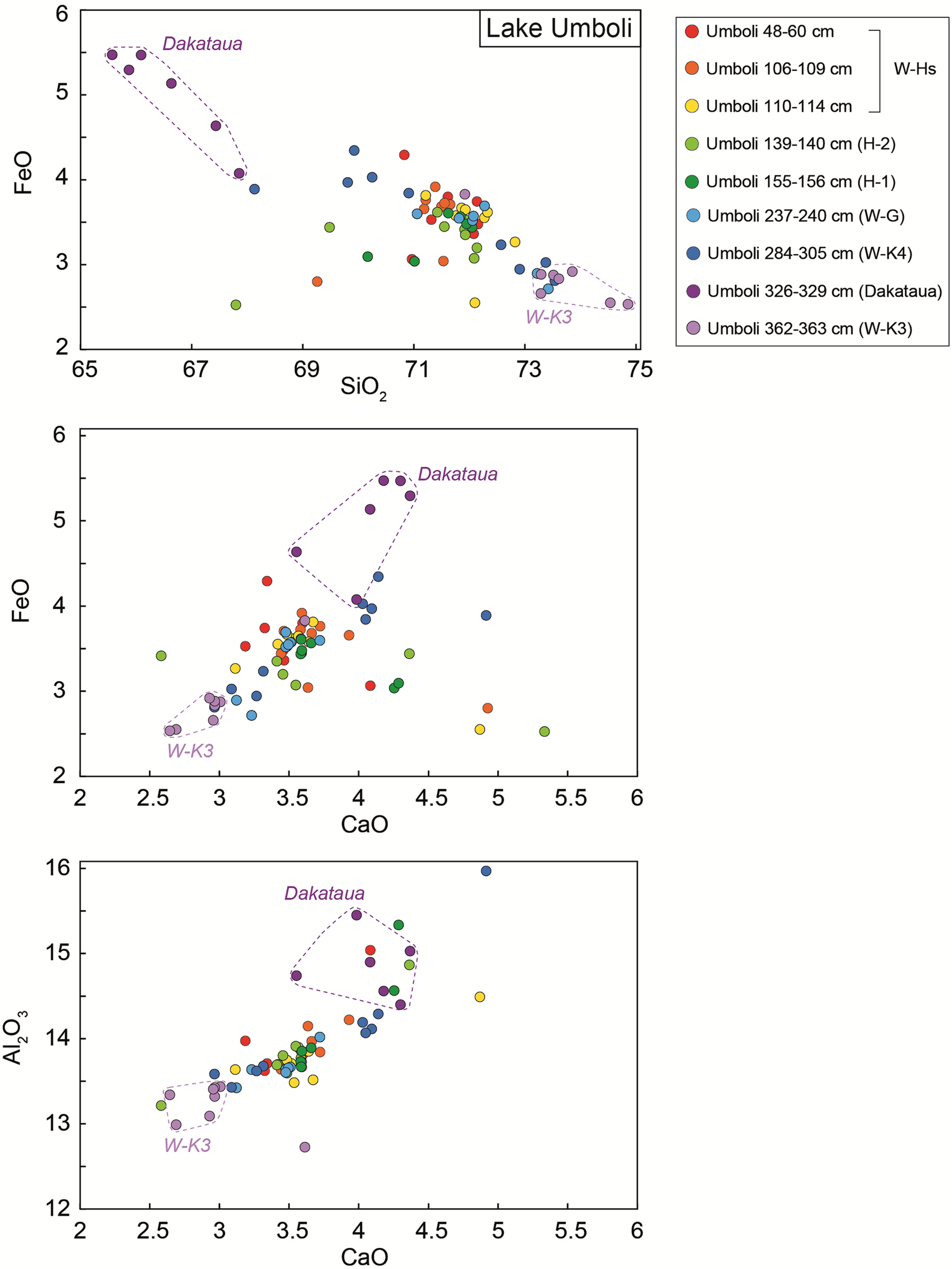

Figure 12. Volcanic glass chemistry for tephras obtained from Lake Umboli. Fields around the 362–363 cm and 326–329 cm samples correlate with W-K3 and Dakataua tephras, respectively (Fig. 11). Tephras labelled in the legend are deduced based on stratigraphic position, thickness, and radiocarbon dates; see discussion.

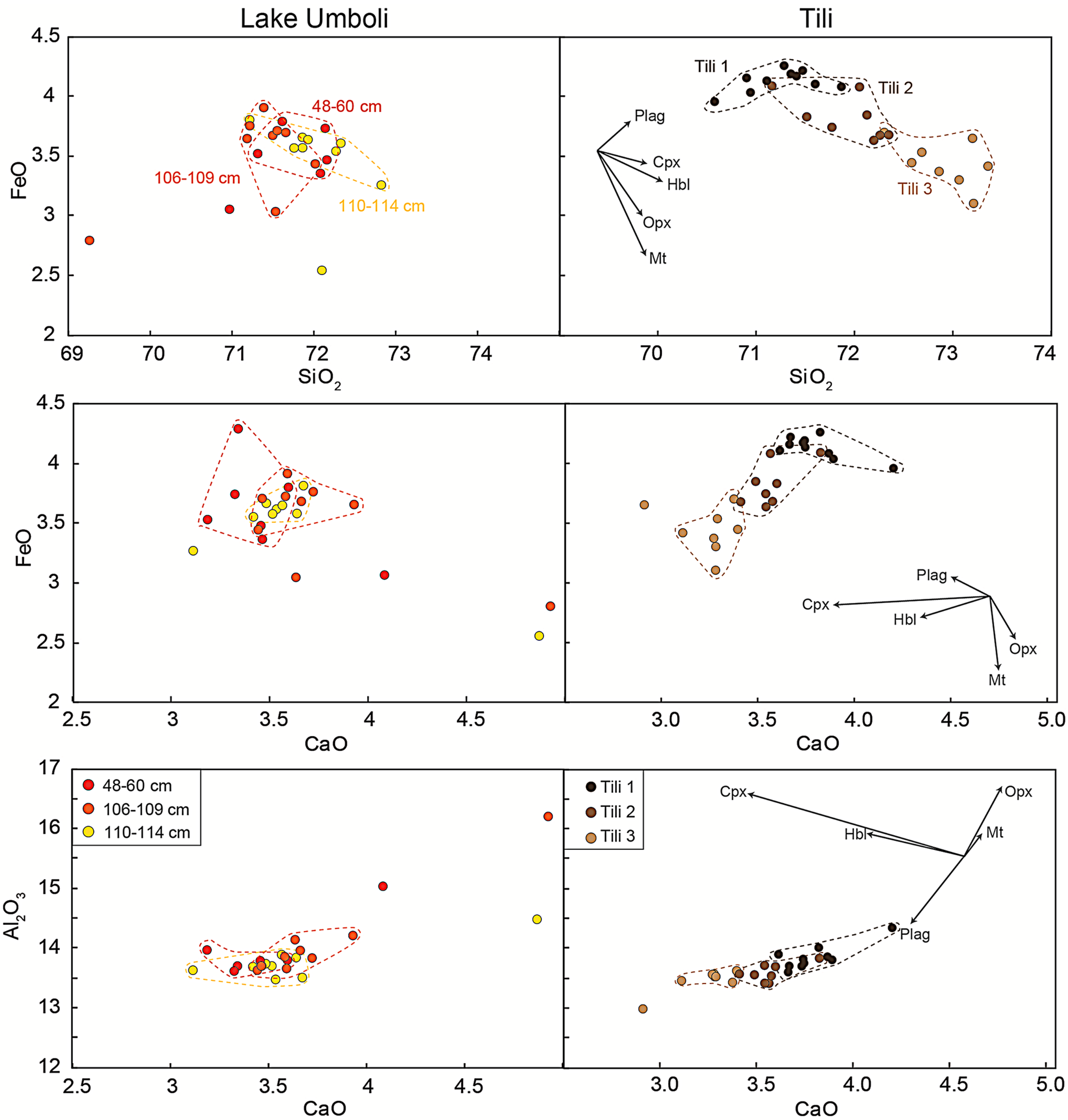

Figure 13. Volcanic glass compositions for the W-H eruptions at Lake Umboli are compared with the volcanic glass compositions at Tili. Mineral vectors are from Fig. 11; note that they are shrunk to fit in the space. Fields drawn around individual tephra samples do not include extreme outliers. The three Tili tephra samples are compositionally distinct, while Lake Umboli samples have considerable overlap.

H2 and superposition distinguish the Hoskins 1 (H1) and Hoskins 2 (H2) tephras. Of particular note in this core is the identification of a very thin lamella of peat preserved within H2 indicating there was a short time interval between the deposition of the upper and lower beds.

The analyses of the three tephras at the Tili site show a fit with the W-H tephra group and a remarkably clear sequence of decreasing SiO_2 and increasing FeO, CaO and Al_2O_3 with time, with very little overlap (middle panel Fig. 13).

Tephras from the Garu site are less straight-forward (Fig. 14), although Garu 1 and 2 have slightly higher FeO contents than Garu 3-4. Because they represent the uppermost two thin tephras in the region it is highly likely that they are W-H6 and W-H7. The lowermost tephra, Garu 5, lies stratigraphically between radiocarbon dates of 775±35 BP (OZF 371) and 725±60 BP (OZG 283) (Jago and Boyd, 2005). Hence this tephra is older than the W-H tephra series as reported by Machida *et al.* (1996) and must be a correlative of either Hoskins 1 or Hoskins 2. From the known record preserved in Lake Umboli, this tephra is likely to be H2 due to its greater thickness. Hence, the two tephras (3 samples) between are likely to represent the W-H4 and W-H5 tephras, since W-H3 is of very restricted distribution (see fig. 5F in Machida *et al.*, 1996).

The results from Kulu 1 show correlation with the W-H tephras (Fig. 14). Analyses from Kulu 2 show the top three samples have a similar identification, but Kulu 2/4, being post-W-K4, fits with a W-G identification, as does Kulu 3 (Fig. 15). The sample from Kulu 6 shows variation between the W-H field, and W-G/H2.

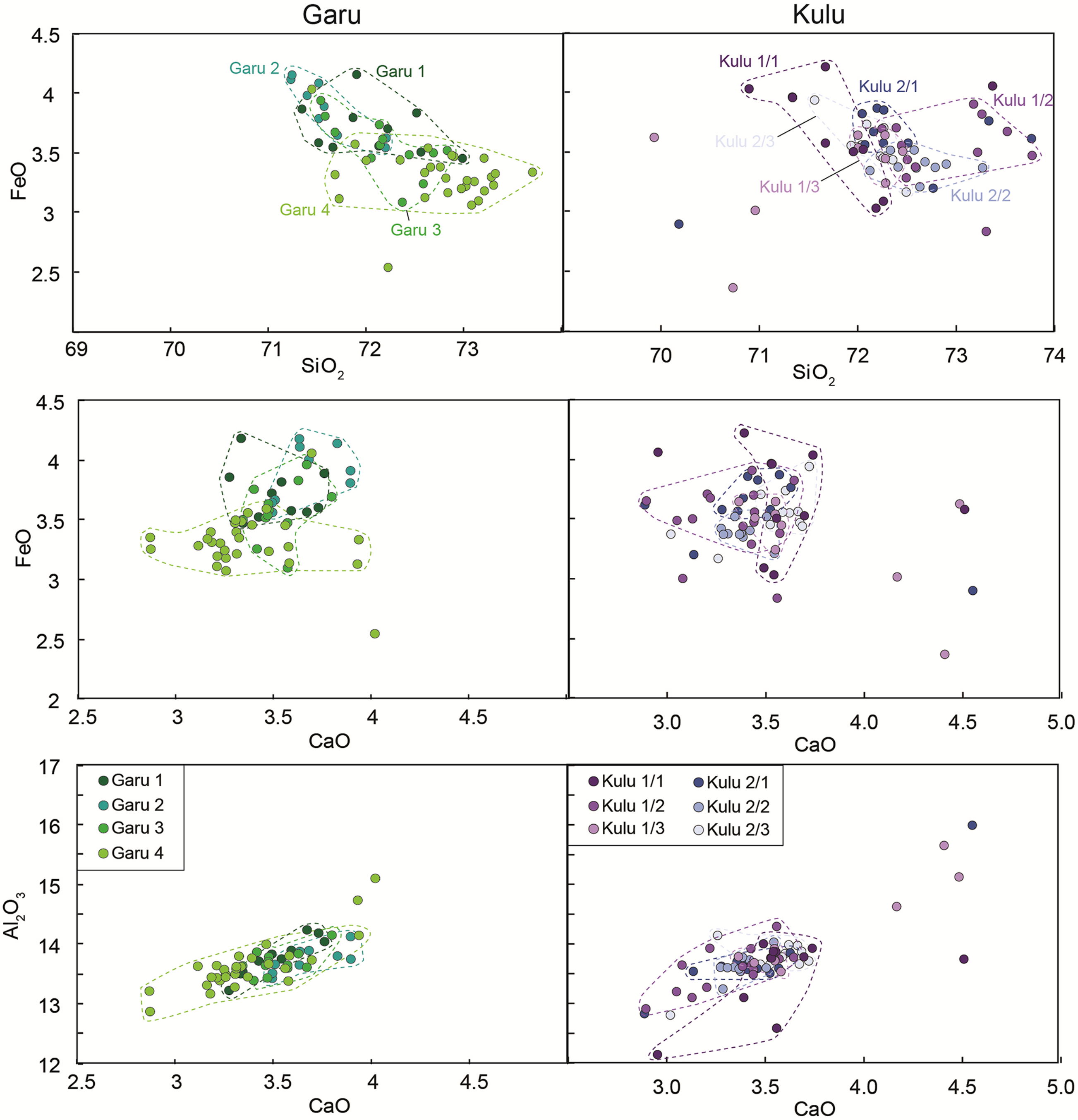

Figure 14. Volcanic glass compositions for the post-W-K4 eruptions from the Garu 1 and 2 sites, and Kulu 1 and Kulu 2 sites. Fields drawn around individual tephra samples do not include extreme outliers. All data overlap considerably, especially in CaO vs Al_2O_3, although Garu 1 and 2 samples extend to somewhat higher FeO.

Discussion

Tephra correlation

The volcanic glass geochemistry of the four Holocene plinian eruptions from Witori caldera (W-K1 to W-K4) have been used to elucidate the identification of unproven tephra correlatives across the Willaumez isthmus region. In addition it has assisted in the identification of alluvial pumice which has been rapidly transported from the nearby mountains down the Kulu-Dulagi River to the lowlands, after the W-K2 eruption, infilling an embayment of the sea to create much of the land forming the Willaumez isthmus.

The volcanic glass geochemistry also allowed unequivocal identification of the lower three tephras in the Lake Umboli core, acting as a strong stratigraphic base line for identifying the overlying tephras (Fig. 2). Using geochemistry and radiocarbon dating of the peat intervals, the next three tephras above are correlated with the W-G (Galilo Pumice of Blake, 1976), H1, and H2 tephras (Machida *et al*., 1996) respectively. Of the tephras preserved between 40 and 114 cm depth in our core, it is clear that none of them match the youngest two thin (1 cm thick) tephras preserved at the Tili site, which show a higher FeO content (Fig. 13). Hence, we interpret that the uppermost tephras in our Lake Umboli core are highly likely to be W-H4 and W-H5 based on the coarseness and thickness of the samples together with the known radiocarbon dating. A thin (< 2 cm) tephra retrieved in a previous unpublished core from Lake Umboli apparently has W-H6 preserved above W-H5.

The three tephras at the Tili site (Fig. 3) are interpreted as W-H6, 5 and 4 (from surface down) based on their glass analyses, thickness and grain size (W-H3 and W-H7 being of more restricted distribution).

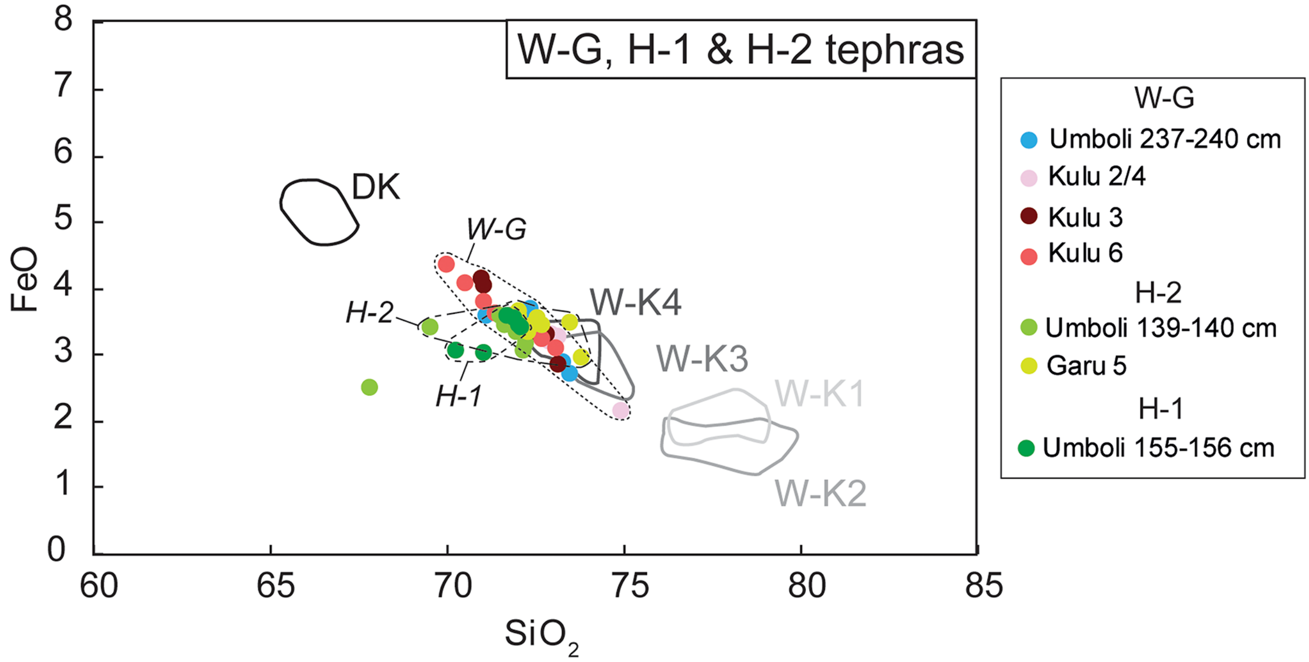

Figure 15. FeO vs SiO_2 for tephra samples from Umboli, Garu and several Kulu sites identified as post the W-K event but before the W-H tephras (based on their stratigraphic position, thickness and radiocarbon dates) show considerable compositional overlap, making correlations challenging based on microprobe data. Fields for Dakataua (DK) and W-K1 to 4 are from Fig. 11.

Glass analyses of the four uppermost tephras at the Garu site (Fig. 14) show they belong to the W-H group. The top two tephras are relatively thin and therefore are a likely match with W-H6 and H7; the lower two correlate with W-H5 and H4. The lowermost tephra (Garu 5) is in a similar stratigraphic position and with similar geochemistry to match with a Hoskins tephra, either H1 or H2. Based on the relative thicknesses of these two tephras in the Lake Umboli core, this tephra is highly likely to be H2.

The three Kulu 1 samples (Fig. 14) are clearly W-H tephras, and are here correlated to W-H6, 5 and 4. The uppermost, W-H6 has probably been overthickened by slight colluvial redeposition.

At Kulu 2 (Fig. 6) there are four samples analysed in stratigraphic order above W-K4. All show overlapping geochemistry which does not enable unequivocal identification (Fig. 14). Based on its stratigraphic position (i.e., post-W-K4) and its geochemistry, sample Kulu 2/4 here correlates with W-G (Galilo Pumice) (Fig. 15). The tephras above are consistent with the geochemistry of the W-H and H tephras and their stratigraphic positions and thicknesses are here interpreted to represent the W-H5 (Kulu 2/1), W-H4 (Kulu 2/2) and H2 (Kulu 2/3) tephras.

The unknown sample from Kulu 3 (Fig. 7) is clearly a post-W-K4 tephra. Its stratigraphic position and geochemistry fit with it being W-G (Galilo Pumice) (Fig. 15).

The Kulu 4 sample is identified in the W-K1 or W-K2 group of geochemical analyses (Fig. 11). It is almost certainly W-K2 because it is the next primary pumiceous tephra beneath 1.22 m of redeposited W-K2 (Fig. 8). Of significance at this site is 10 cm of grey mud between the primary tephra and the redeposited pumice sand and gravel. This records a brief time interval between the deposition of the tephra and its fluvial redeposition from the headwaters of the Kulu-Dulagi River on to the coastal lowlands.

Kulu 5 analyses plot into the W-K2 geochemical field (Fig. 11). This tephra is found beneath W-K3 and beneath 1.5 m of redeposited pumiceous sand and silt (Fig. 9). In this case a 5 cm layer of pinkish light grey silt with organic staining separates the primary from the secondary redeposited W-K2 pumice, recording a brief hiatus.

The unknown sample from Kulu 6 (Fig. 10) shows a spread of geochemical analyses that are equivocal (Fig. 15). Based on its post-W-K4 stratigraphic position and depth below the obvious W-H tephras, it is here correlated to Galilo Pumice (W-G).

Correlation columns of all sites are plotted in Fig. 16, from north-west to south-east and then north to FAAH.

The Garu, Kulu 1 and Kulu 4 records represent the current swampy lowland environment of deposition; the Tili site is a levee alongside a former loop of the Kulu-Dulagi River. The Kulu 3, 5 and 6 sites are all on well drained mounds within the lowlands preserving mostly tephras rather than alluvial deposits. In contrast the Kulu 2 site is an exposure on a hill bordering the southern limits of the Kulu lowlands and hence is well drained and preserves a tephra accretion sequence without interbedded sediments. FAAH is a plateau-topped hill near the eastern coast which is well drained and entirely comprised of tephras. From a paleoenvironmental perspective, it is the Lake Umboli core which is most unusual. Apart from the top 40 cm of unconsolidated lake mud, the remaining time intervals between the identified tephras are represented by black fibrous peat and not lacustrine sediments. This implies one of two scenarios. Either Lake Umboli has risen suddenly over the last 400 years by > 10 m, or it has been gradually rising over the last 1800 years and the peat in the core accumulated marginal to a rising lake level.

The unexpected rubble deposit within the core between 170 and 218 cm depth (Fig. 2) is most likely the result of a natural erosion event on the inner wall of the Lake Umboli depression. This could be either due to (a) a storm-induced erosion event that might be related to a rare tropical cyclone in this region or (b) to a large regional or local shallow earthquake triggering collapse of the Lake Umboli depression's inner wall and accompanying or subsequent heavy rain. The deposit appears to be of a similar age to a tsunami deposit identified on Boduna Island, 40 km to the north off the east coast of the Peninsula (White *et al.*, 2002), suggestive of a large magnitude regional earthquake at this time.

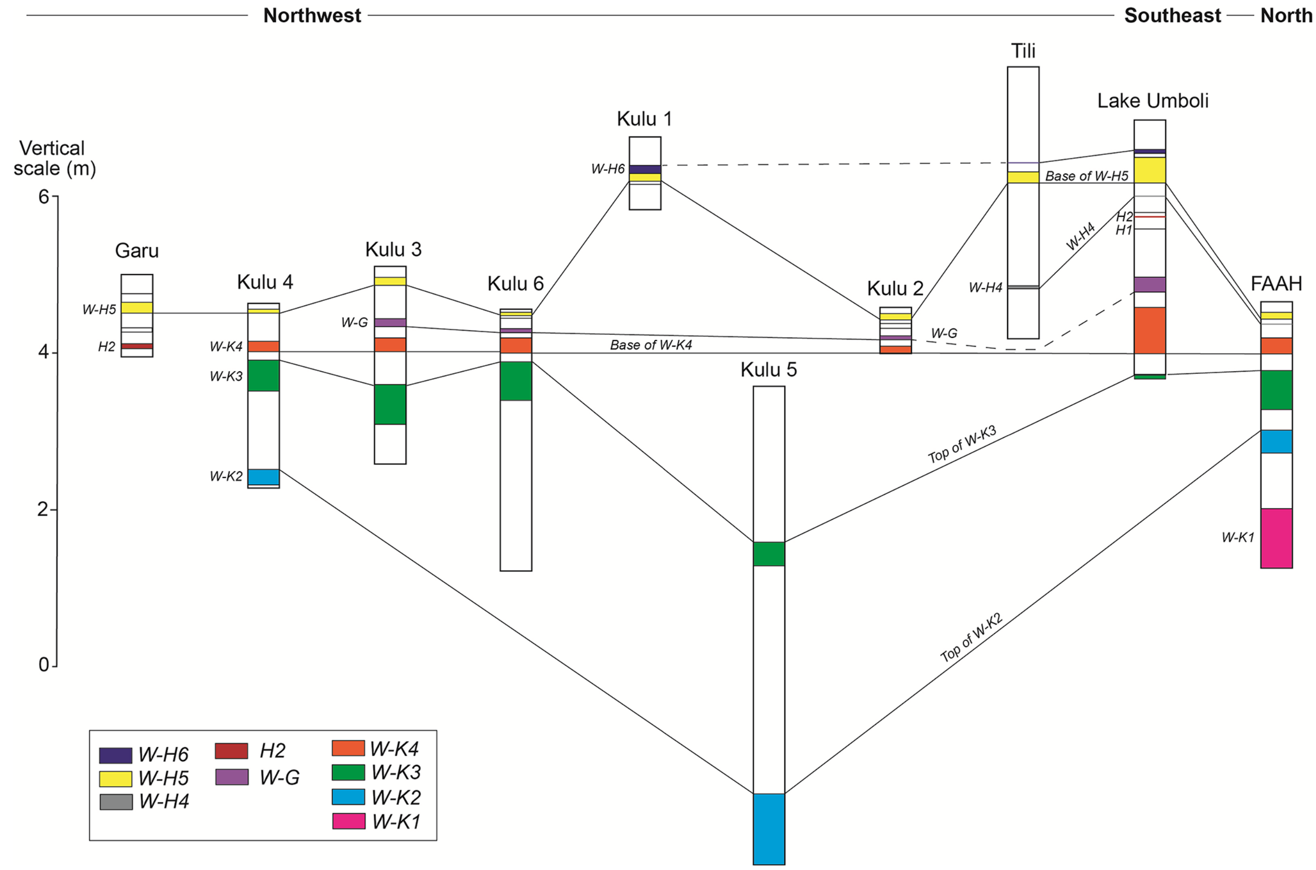

Figure 16. Correlation of stratigraphic columns showing summary tephra identifications between sites described in this paper.

Petrogenesis

All data in this study lie along a similar trend in the chemical plots presented in Figs 11, 12 and 15. Such trends could suggest that the magmas involved are broadly related by fractional crystallisation of genetically similar magmas. Fractional crystallisation vectors shown in Figs 11 and 13 use compositions of phases known to be present in the lavas and tephras of the Witori caldera (Machida *et al*., 1996): see Fig. 11 caption and Table S1 for mineral compositions used in calculating vectors. Glass chemistry is an effective means of assessing melt evolution changes as the shards represent the evolving melt composition without dilution by the phenocrysts. As mineral chemistry is not available for the Witori or Dakataua eruptions, compositions are used from Tauhara volcano in the Taupo Volcanic Zone of New Zealand (Millet *et al*., 2014), as this is a continental arc dacite with a similar mineral assemblage. The W-K3/4 tephras are less evolved than the preceding W-K1/2 tephras; this can be explained by approximately 15% crystallisation of a combination of plagioclase, clinopyroxene, hornblende and magnetite (0.47 : 0.25 : 0.25 : 0.03) between W-K3/4 and W-K1/2-like magma compositions.

This suggests that although the Witori eruptions had the same magmatic source, separate magmatic reservoirs with their own magma histories and timescales may have fuelled the individual eruptions. Similar major element compositions with increasing SiO_2 content for the W-K1 and W-K2 group tephras suggest that the magmas were not strongly affected by fractional crystallisation once attaining high SiO_2 contents; the difference in FeO between W-K1 and W-K2 may be due to small amounts of magnetite crystallisation between magma batches. Although the W-K3 and W-K4 tephras overlap in composition, negative and positive trends in FeO and Al_2O_3 (respectively) with SiO_2 are suggestive of a greater control by fractional crystallisation within these magmas than in the higher SiO_2 tephras. In the Tili samples there is a small gradual change in magma composition most likely due to crystallisation of the mineral assemblage mentioned above between each tephra-producing eruption. Dakataua compositions have comparatively higher FeO and Al_2O_3 than the W-K trend which indicates a somewhat different petrogenetic evolution, as may be expected since they originate from a volcanic system approximately 50 km north of Witori caldera. Further interpretations of the magma generation in these large systems would require a more detailed petrographic and geochemical study involving isotopic data and mineral chemistry.

Conclusion

This study demonstrates the usefulness of volcanic glass geochemistry to enhance stratigraphic and tephra granulometry information for correlating tephras at distal locations, in this case in Papua New Guinea. This work recognises that individual tephras cannot currently be distinguished on unique geochemical criteria but combined with known stratigraphic position can lead to specific identification. The geochemistry is sufficient to distinguish tephra subgroupings that probably match phases of fractional crystallisation of the parent magmas. This has helped strengthen tephra identification and correlation on the Willaumez isthmus which ultimately assists in better constraining the age of Holocene archaeological sites in the region. Future work should involve analysis of Holocene tephras by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to obtain high precision trace element data for individual stratigraphic units. This technique has been effectively used in other tephrochronological studies to fingerprint tephras from a small, highly active region of small scale eruptions (the Quaternary Auckland Volcanic Field: Hopkins *et al*., 2015) and also applied to archaeological sites on the Sepik coast of Papua New Guinea (Golitko *et al*., 2010).

Supplementary data

https://doi.org/10.6084/m9.figshare.14502618

Table S1. Supplementary data is published separately at *figshare*.

Raw and normalised volcanic glass data and standards. All raw and normalised glass chemistry data for the Dakataua tephra, FAAH site and Kulu, Garu and Tili plantation sites are presented in order of depth. Mineral standard data for the analytical sessions and literature data for the fractional crystallisation vectors in Figs 11 and 13 are also given in Neall (2021).

Analytical totals for glass are < 100% due to post-eruption hydration (Shane, 2000), for consistency all major element data presented in figures are normalised to 100%. Both raw and normalised data are presented in Neall (2021).

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References

Blake, D. 1976. Pumiceous pyroclastic deposits of Witori volcano, New Britain, Papua New Guinea. In *Volcanism in Australia*, ed. R. W. Johnson, pp. 191–200. Amsterdam: Elsevier.

Golitko, M., J. Meierhoff, and J. E. Terrell. 2010. Chemical characterization of sources of obsidian from the Sepik coast (PNG). *Archaeology in Oceania* 45(3): 120–129. https://doi.org/10.1002/j.1834-4453.2010.tb00088.x

Hopkins, J. L., M.-A. Millet, C. Timm, C. J. Wilson, G. S. Leonard, J. M. Palin, and H. Neil. 2015. Tools and techniques for developing tephra stratigraphies in lake cores: a case study from the basaltic Auckland Volcanic Field, New Zealand. *Quaternary Science Reviews* 123: 58–75. https://doi.org/10.1016/j.quascirev.2015.06.014

Jago, L. C. F., and W. E. Boyd. 2005. How a wet tropical rainforest copes with repeated volcanic destruction. *Quaternary Research* 64: 399–406. https://doi.org/10.1016/j.yqres.2005.08.012

Lowe, D. J., N. J. G. Pearce, M. A. Jorgensen, S. C. Kuehn, C. A. Tryon, and C. L. Hayward. 2017. Correlating tephras and cryptotephras using glass compositional analyses and numerical and statistical methods: review and evaluation. *Quaternary Science Reviews* 175: 1–44. https://doi.org/10.1016/j.quascirev.2017.08.003

Machida, H., R. J. Blong, H. Moriwaki, J. Specht, R. Torrence, Y. Hayakawa, B. Talai, D. Lolok, and C. F. Pain. 1996. Holocene explosive eruptions of Witori and Dakataua caldera volcanoes in West New Britain, Papua New Guinea. *Quaternary Research* 34–36: 65–78. https://doi.org/10.1016/1040-6182(95)00070-4

McKee, C. O., V. E. Neall, and R. Torrence. 2011. A remarkable pulse of large-scale volcanism on New Britain Island, Papua New Guinea. *Bulletin of Volcanology* 73: 27–37. https://doi.org/10.1007/s00445-010-0401-8

Millet, M.-A., C. M. Tutt, M. R. Handler, and J. A. Baker. 2014. Processes and time scales of dacite magma assembly and eruption at Tauhara volcano, Taupo Volcanic Zone, New Zealand. *Geochemistry, Geophysics, Geosystems* 15(1): 213–237. https://doi.org/10.1002/2013GC005016

Neall, V. 2021. [Supplementary data. Raw and normalised volcanic glass data and standards—Willaumez isthmus]. *figshare*. Dataset. https://doi.org/10.6084/m9.figshare.14502618

Neall, V. E., R. C. Wallace, and R. Torrence. 2008. The volcanic environment for 40,000 years of human occupation on the Willaumez Isthmus, West New Britain, Papua New Guinea. *Journal of Volcanology and Geothermal Research* 176(3): 330–343. https://doi.org/10.1016/j.jvolgeores.2008.01.037

Petrie, C. A., and R. Torrence. 2008. Assessing the effects of volcanic disasters on human settlement in the Willaumez Peninsula, Papua New Guinea: a Bayesian approach to radiocarbon calibration. *The Holocene* 18(5): 729–744. https://doi.org/10.1177/0959683608091793

Potts, P. J., M. Thompson, S. Wilson, and P. Webb. 2005. G-probe-2—an international proficiency test for microbeam laboratories—report on round 2/May 2005 (NKT-1G basaltic glass). *Geostandards Newsletter*.

Shane, P. 2000. Tephrochronology: a New Zealand case study. *Earth-Science Reviews* 49(1): 223–259. https://doi.org/10.1016/S0012-8252(99)00058-6

Specht, J., and R. Torrence. 2007. Lapita all over: land-use on the Willaumez Peninsula, Papua New Guinea. In *Oceanic Explorations: Lapita and Western Pacific Settlement*, ed. S. Bedford, C. Sand, and S. P. Connaughton, pp. 71–96. Terra Australis 26. Canberra: ANU E Press.
https://doi.org/10.22459/TA26.2007.04

Torrence, R., V. Neall, and W. E. Boyd. 2009. Volcanism and historical ecology on the Willaumez Peninsula, Papua New Guinea. *Pacific Science* 63(4): 507–535.
https://doi.org/10.2984/049.063.0404

Torrence, R., V. Neall, T. Doelman, E. Rhodes, C. McKee, H. Davies, R. Bonetti, A. Guglielmetti, A. Manzoni, M. Oddone, J. Parr, and C. Wallace. 2004. Pleistocene colonisation of the Bismarck Archipelago: a different pattern in West New Britain? *Archaeology in Oceania* 39(3): 101–130.
https://doi.org/10.1002/j.1834-4453.2004.tb00568.x

Torrence, R., J. Specht, and R. Fullagar. 1990. Pompeiis in the Pacific. *Australian Natural History* 23(6): 456–463.

White, J. P., C. Coroneos, V. E. Neall, W. Boyd, and R. Torrence. 2002. FEA site, Boduna Island: further investigations. In *Fifty Years in the Field. Essays in Honour and Celebration of Richard Shutter Jr's Archaeological Career*, ed. S. Bedford, C. Sand, and D. Burley, pp. 101–107. New Zealand Archaeological Association Monograph 25. Auckland: New Zeal Archaeological Association.

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Geochemistry and Sources of Stone Tools in South-west New Britain, Papua New Guinea

Alana Pengilley

Department of Anthropology, College of Liberal Arts, University of Texas,
Austin, TX 78712, United States of America

Abstract. The capacity to trace the movement of region-specific materials across landscapes is a key archaeological theme in investigations of community interaction and exchange. In this study I investigate the scale of raw material and artefact procurement and exchange of a range of stone tools from southwest West New Britain Province, Papua New Guinea using a non-destructive geochemical technique—portable x-ray fluorescence (pXRF) spectrometry. The complex geochemistry of the Bismarck Archipelago and previous ethnographic and archaeological studies provide data that allow opportunities to explore the role of stone tools made from igneous rocks by flaking, hammer-dressing and grinding, particularly axe and adze blades, within intra- and inter-island exchange networks. The results indicate that groups residing on the southwest coast of New Britain obtained their stone tools from source regions on the north side of West New Britain, the Gazelle Pen. of East New Britain, and probably even from islands in the Vitiaz Strait and off the north coast of New Guinea. Inclusion of these south coast tools in models of past regional exchange networks, such as down-the-line exchange, greatly expands our knowledge of the role of stone tools in social interactions in the Bismarck Archipelago from the Lapita pottery period onwards.

Introduction

Throughout the Pacific Islands the growth of compositional provenance studies of lithic artefacts continues to refine our understanding of patterns of inter-island and intra-archipelago exchange networks, social interaction, and potentially craft specialisation, especially for artefacts made of basalt, andesite and obsidian (e.g., Weisler and Kirch, 1996; Summerhayes *et al*., 1998; Summerhayes, 2009; Mills *et al.,* 2011; Kirch *et al.,* 2012; Kahn *et al.,* 2013; Clark *et al.,* 2014; Weisler *et al.,* 2016). The relatively recent adoption of non-destructive portable XRF has enabled a new phase of sourcing studies for a wider range of samples within both the Pacific Islands and Australia (Sheppard *et al*., 2010; Attenbrow *et al.,* 2017; Richards, 2019). Within Near Oceania, the region encompassing New Guinea, the Bismarck Archipelago and Solomon Islands, pottery and volcanic glass (obsidian) have been the primary subjects of sourcing studies using various techniques. In the case of obsidian this has been particularly effective (Bird *et al*., 1997; Torrence and Summerhayes, 1997; Summerhayes, 2009; Shaw *et al*., 2020). For Near Oceania, pXRF has been used exclusively for obsidian sourcing (e.g., Torrence *et al.,* 2013; Specht *et al*., 2018), though my analyses of archaeological and ethnographic assemblages of stone axes and adzes on the Willaumez Pen. on the north coast of West New Britain Province, Papua New Guinea has extended the range of applications of pXRF (Pengilley *et al*., 2019). By taking advantage of legacy geochemical data from that region, many of these tools have been successfully grouped into potential source regions and integrated into existing models of regional trade.

The present paper builds on that work to expand our knowledge of the likely geological origins of stone tools in New Britain during the Lapita pottery and post-Lapita periods. It again takes advantage of the legacy data from geological fieldwork undertaken on New Britain by Dr. R. W. Johnson and others at the Bureau of Mineral Resources, Canberra (now Geoscience Australia) in the 1960s and 1970s. Similar to other regions, New Britain stone axes and adzes are comprised almost exclusively of igneous rocks. Whilst there is currently no field evidence of axe and adze

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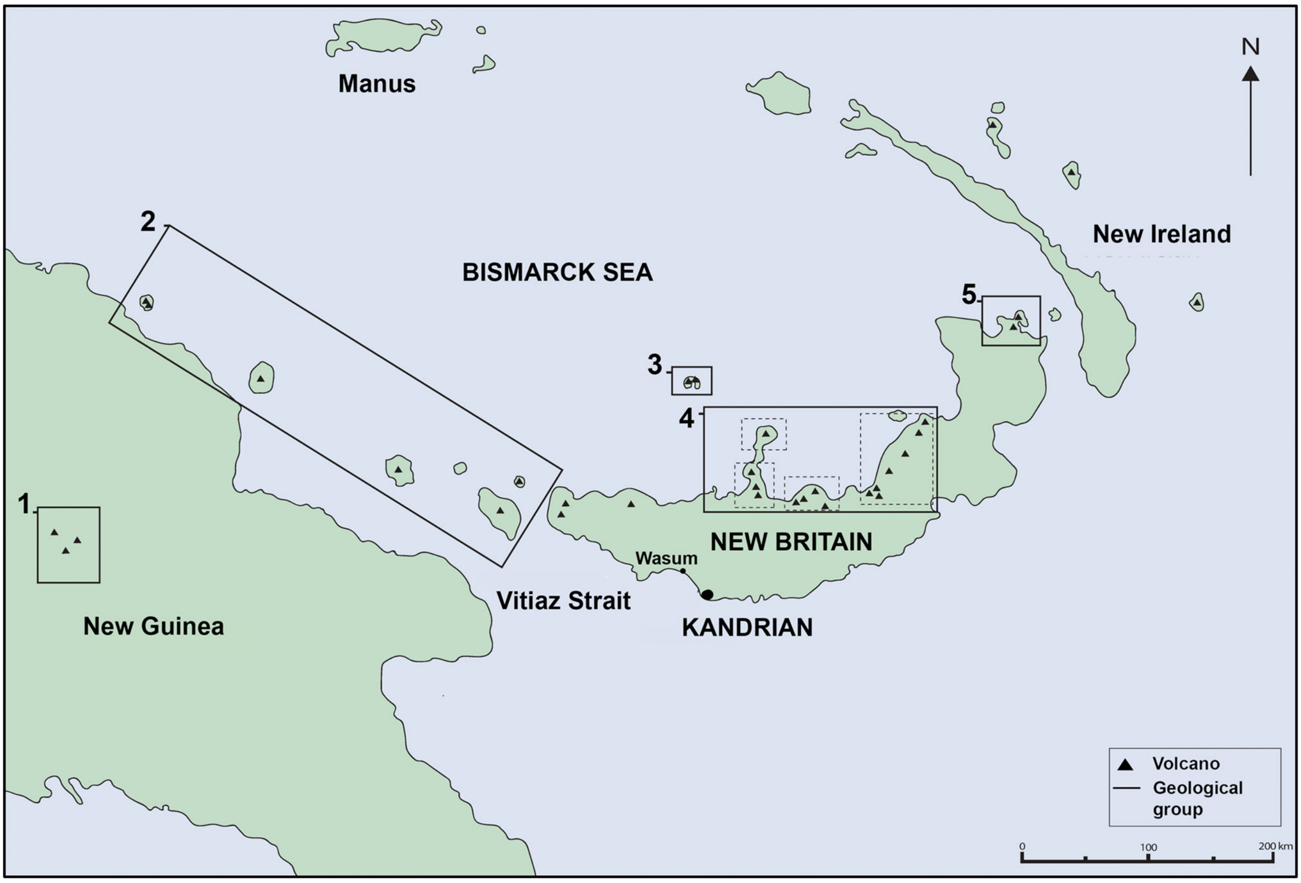

Figure 1. Location of major geological source regions used in this study. 1—New Guinea, 2—Vitiaz Strait, 3—Bali-Witu, 4—West New Britain sources (WPN, WPS, Hoskins, Eastern), 5—Rabaul.

manufacture on New Britain, such as grinding grooves or quarry sites, it is highly likely that raw material was sourced from areas with both abundant outcrops of igneous rock and the requisite production expertise.

In contrast to the extensive volcanic outcrops on the north side of New Britain, the southern half of New Britain is primarily comprised of Miocene sedimentary limestones in the interior and raised Pleistocene coral reef limestone along the coast. To evaluate the scale and scope of Lapita and post-Lapita networks and interaction spheres in this region this paper tests a hypothesis that most igneous stone tools in southern New Britain were imported from the north, focussing on artefacts recovered in the Kandrian and Passismanua regions of southwest New Britain.

Background

Regional interaction

The island of New Britain is located east of mainland New Guinea and is the largest island in the Bismarck Archipelago, a region containing the island provinces of Papua New Guinea (Fig. 1). As elsewhere in the Archipelago, in recent times communities in New Britain were linked through a series of interaction spheres that enabled the movement of region-specific products. Todd (1934a,b) and Chowning (1978) produced detailed ethnographic accounts on exchange networks between New Britain communities within these interaction spheres.

There is only minimal mention of stone tools in these ethnographic accounts as stone tool use had long ceased in New Britain by the time they were written (Chowning, 1978: 300). However, where they are mentioned, stone axe and adze blades appear to have been traded into regions where suitable raw material was not available. Chowning (1978) discusses accounts of exchange between the Kove language groups on the coast to the west of Willaumez Pen., Lakalai speakers on the volcanic Hoskins Pen., and Sengseng speakers in the Passismanua area, inland from Kandrian on the Yalam Limestone. These trade routes are consistent with the stone tools found in archaeological contexts in this region, particularly movement between Hoskins Pen., the base of the Willaumez Pen. and the Passismanua region (Pengilley *et al.,* 2019). Exchange between the Sengseng and other groups was largely dominated by the Sengseng's desire for goods that were only available on or near the coast. These included a variety of shells, coconuts, lizard skins, salt and obsidian imported from the north side of the island, which the Sengseng received in exchange for shields, minerals, betelnut, bark-cloth and chert raw material and artefacts produced from sources in the Yalam limestone of the Passismanua region (Chowning, 1978: 297).

Todd's (1934a,b) accounts of exchange along the south coast of New Britain provide a discussion of the goods involved. These included food bowls, pottery, canoes and round cane baskets that were brought from the Siassi Islands (Vitiaz Strait) and the western end of New Britain along the south coast, as well as shell money from people of the Rabaul area at the eastern end of New Britain. Trans-Vitiaz Strait trade was a prominent network linking New Britain with communities on the New Guinea mainland and the adjacent islands. Harding (1967, 1994) and Lilley (1986, 2004) have detailed a wide range of raw materials, craft goods, valuables and consumables that were passed between trading societies in the region. The Mandok (Siassi) were responsible for a large portion of this trade. Raw materials were a major component and included items such blocks of obsidian from the north coast of New Britain, red earth pigment from Tarawe volcanic centre on Umboi and black earth pigment from Malalamai on the Rai coast of New Guinea (Harding, 1967: 29–60). There is some indication that stone blades were also involved in these trans-Vitiaz exchanges and likely entered the Siassi system from several different sources. Despite the lack of existing archaeological evidence, it also seems likely that stone blades entered New Britain trade networks from sources in the Vitiaz Strait.

In comparison to the expedient nature of obsidian and chert flakes that dominate the New Britain archaeological assemblages (with the exception of mid-Holocene stemmed tools), stone axe and adze blades and their hafts would have required a significant amount of energy and skills to produce finished objects (Torrence, 2011). Taking into account the lack of evidence for the exchange of unmodified raw material or blanks intended for working into axes and adzes, finished stone blades are likely to have played a specific role in exchange networks. For example, a cache of stone axe heads that were found near the provincial town of Kimbe on the north side of New Britain might indicate that these artefacts were of value and deliberately buried at the site (Specht, 2005). Much like stone blades in the highlands of New Guinea, it is likely that New Britain artefacts not only held utilitarian value but also held ceremonial and prestige value and were exchanged, for example, as bride price items. If, as suggested here, axe and adze blades held a significant position in trade networks between different communities they were also probably curated and passed down inter-generationally.

Geological background

Many volcanic regions across the Bismarck Archipelago have produced raw material suitable for the production of stone tools, although due to the geological complexity of the raw material and a lack of field data, it is currently impossible to identify specific sources. However, the geological structure of the region enables geochemical distinctions between different volcanic regions.

New Britain is located in the eastern sector of the 'Bismarck Volcanic Arc', a volcanic chain that extends from the Schouten Islands off the north coast of New Guinea in the far west to Rabaul in the far northeast of East New Britain. This region formed as a result of the subduction of the Solomon Sea plate beneath the South Bismarck plate in the north (Johnson and Molnar, 1972; Neall *et al.,* 2008). New Britain is distinguished by two geologically different landscapes, the Wadati-Benioff zone of volcanic rocks in the north (Bali-Witu Islands, the Willaumez Pen. and the north coast) and the Miocene limestone karst of the central Whiteman mountain range southwards towards the south coast. On south coast, late Cainozic uplift has produced raised terraces of coralline limestone and marine sediment platforms along the mainland coast and formed islands such as Apugi near Kandrian (Ryburn, 1976).

The volcanic ranges of the Willaumez Pen. and adjacent regions in northern New Britain consist of andesitic and basaltic outcrops suitable for the production of stone tools. Non-destructive pXRF geochemical characterisation of stone blades from the Willaumez Pen. points to the Hoskins region as a likely major source of stone artefacts (Pengilley *et al.,* 2019). Similarly, volcanic outcrops in the Bali-Witu Islands and the North region of the Willaumez Pen. appear to have been the origin area for some blades that reached sites on Garua Island and the centre of the Pen.. These results gave rise to a model of exchange networks through which stone blades moved to communities distant from the source areas (Pengilley *et al*., 2019: 9–10). This model will be applied to the south coast assemblage in order to examine whether these same source regions were exploited, or tools were brought into the region from elsewhere.

Materials and methods

Geochemical study

To identify potential geological sources, I accessed a legacy reference geochemical dataset (major and trace elements) for 314 geological samples representing the likely major geological source regions (Fig. 1, Appendix 1). This dataset comprises 203 samples from the Willaumez Pen. and adjacent volcanic ranges and 26 samples from the Bali-Witu Islands; these were analysed at the Department of Geology, Australian National University, Canberra using a Philips PW1220 wave length dispersive XRF spectrometer (Johnson and Chappell, 1979; Woodhead and Johnson, 1993). The sample also includes XRF results for 54 samples from the Rabaul area of New Britain drawn from the GEOROC online database (Heming, 1979; Wood *et al*., 1995; McKee *et al.*, 2011; Patia *et al*., 2017), 15 samples from islands located in Vitiaz Strait and along the north coast of New Guinea (Woodhead *et al*., 2010), and 16 samples from Mounts Hagen, Giluwe, Murray and Bosavi on the New Guinea mainland (Mackenzie, 1976).

This paper compares the legacy compositional dataset to the results of non-destructive geochemical analyses of an archaeological sample from southern New Britain generated with a Bruker Tracer 5i pXRF spectrometer. To allow comparison between the two datasets, the new pXRF data was transformed into quantitative values using an empirical basalt calibration protocol designed for this instrument (Pengilley *et al.,* 2019, Supplementary Data 4 for the calibration routine). This step ensures that the data from different instruments is comparable and allows it to be amalgamated with legacy datasets. Measurements were made over 150 seconds using settings determined by the pre-loaded basalt calibration. Two standards, UHH.MK05.14E.57 and NIST688, were routinely analysed during analysis to estimate precision and accuracy of results (Appendix 2). Data provided from the pXRF analyses of the standards enabled assessment of the machine's capabilities to ensure compatibility between the datasets. Measurements were taken from three different locations on the least weathered surfaces of each artefact to minimise potential contamination, and these were then averaged to reduce the potential effect of sample heterogeneity. Measured elements included nine majors (MgO, K_2O, SiO_2, Al_2O_3, P_2O_5, CaO, TiO_2, MnO, Fe_2O_3) and nine traces (V, Ni, Cu, Zn, Rb, Sr, Y, Zr, Nb). To facilitate comparison with the legacy dataset, major elements (Na to Fe) are reported as weight percent (wt.%) oxides and trace elements (Co to Nb) as parts per million (ppm) (Appendix 3). Under the pre-loaded basalt calibration, improvements in correlation (R^2) were seen in a majority of elements. Because some variance occurred in the recovery data from these standards, MgO, K_2O, SiO_2, V, Ni, Cu and Nb were excluded from further analysis as these elements were either under or over recovered. (see Appendix 2).

The second stage of the geochemical study involved the combined analysis of legacy and pXRF data using Discriminate Function Analysis (DFA) with JMP 14.0

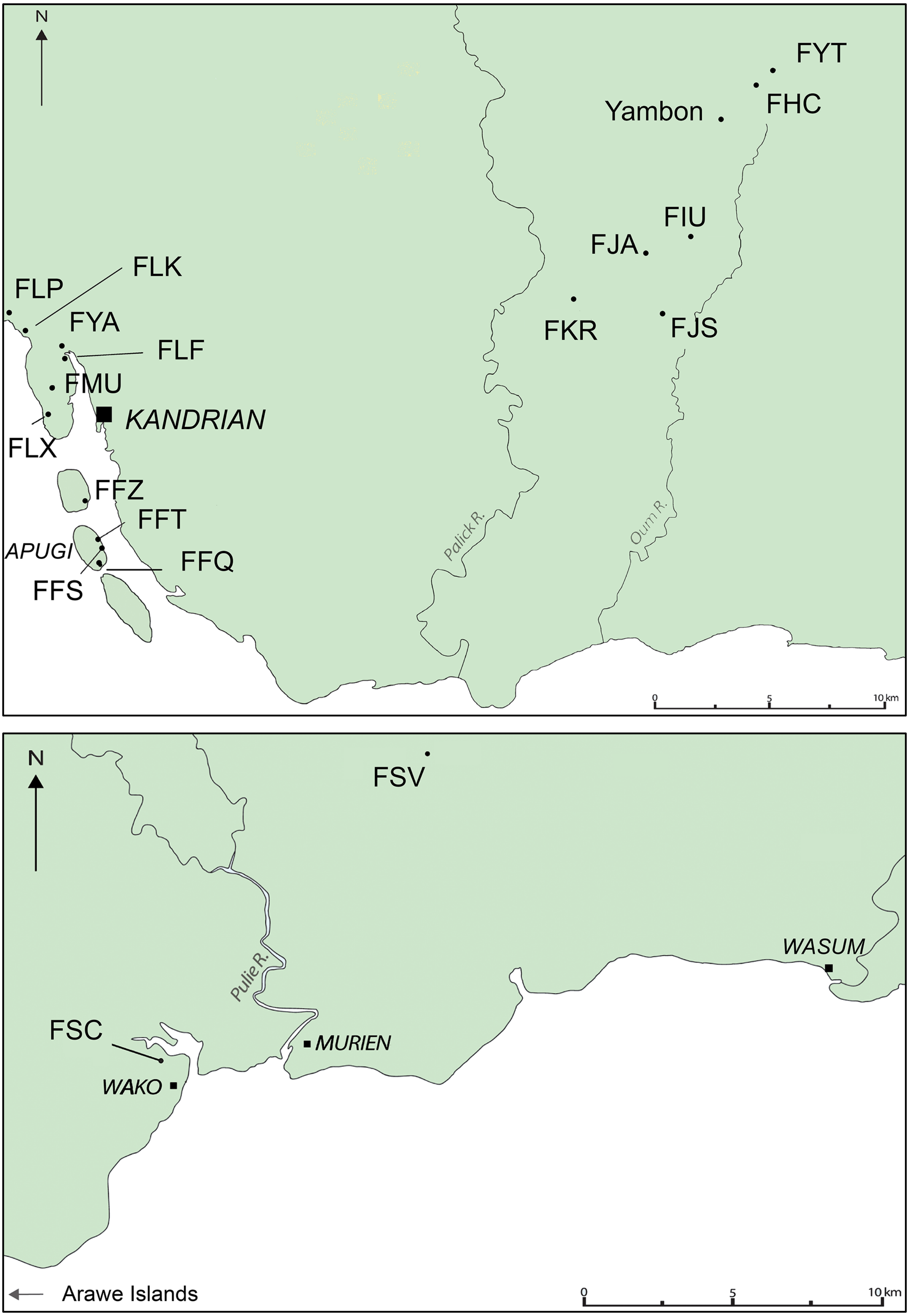

Figure 2. Location of sites where the stone tools were collected or excavated.

software (2018; © SAS Institute Inc.). By combining input variables into composite functions, DFA is able to classify the archaeological samples into source groups based on the training data provided by the geological source data. A degree of probability is provided to each outcome to show the likelihood of each match, and in this study only those items with a predicated posterior probability degree of 0.7 or higher were included. DFA can be used to assign 'unknowns' to a geological source region and has previously been used successfully for this purpose in the Marquesas Islands (McAlister and Allen, 2017), Papua New Guinea (Pengilley *et al.,* 2019) and Tonga and Samoa (Clark *et al.,* 2014). Geochemical regions and social regions were used during analysis to help classify artefacts into potential source groups, a method that was previously employed successfully to classify stone axes and adzes from the north coast of New Britain (Pengilley *et al.,* 2019).

The archaeological sample

This study is based on 67 stone tools from 18 archaeological sites in southwest New Britain, most of which were from surface collections (51) or finds by local people (4), and the rest (12) were from five excavated sites (Fig. 2; Appendix 3). This sample provides an opportunity to analyse the spatial distribution of stone artefacts over a large region. The size of the sample may seem small but is large for New Britain, where stone artefacts are rarely recovered from archaeological excavations. The tools were made by various techniques: flaking, grinding and hammer-dressing, sometimes combining two techniques. The sample includes a pestle (n = 1), possible bark cloth beaters (n = 2), nut-cracking anvils (n = 2), a discoid (n = 1), unidentified flaked pieces (n = 3), a split pebble (n = 1), and axe and adze blades (n = 57). The blades are largely comparable in form and size to those found elsewhere on New Britain, New Guinea and elsewhere in Near Oceania and include waisted and stemmed forms (e.g., Crosby, 1973; Specht, 2005; Pengilley *et al*., 2019: fig. 2). A selection of these tools is presented in Fig. 3. Part of the sample (n = 26) consists of artefacts from surface collections and excavated contexts associated with Lapita style pottery (approx. 3250–2750 BP), providing evidence for possible inclusion of some blades in Lapita exchange networks. The remaining items from surface collections are likely to belong to more recent periods (Torrence, 2011: 30). Only one tool is dated: adze blade FHC/I/95 from Misisil cave (site FHC) came from a dated context ca 1500–750 cal. BP (Lentfer *et al*., 2010: fig. 3), and one blade fragment at site FFT was associated with Lapita pottery.

Results

Discriminating between sources

To establish how well the geological source regions differentiated, a total of nine geochemical groups were employed in this study, each representing a different potential source area for which raw material could be exploited. Four of these groups are situated on the Willaumez Pen. (GN, GS) or in the volcanic ranges located to the east (E, F). These groups are geochemically distinct from each other due to the north-south direction of the underlying Wadati-Benioff zone, and once DFA was applied, good discrimination between the groups was possible (Fig. 4). There was some overlap between groups E and F, discussed further below. The other geological groups include samples from Rabaul, Bali-Witu Islands, Vitiaz Strait and New Guinea highlands. DFA of these samples shows clear separation between these geological regions (Fig. 4).

To address a potential lack of fit between the distribution of cultural groups across the New Britain landscape and the geochemical regions overlying the Wadati-Benioff zone, the concept of 'social regions' was employed in relation to exchange patterns. This potential lack of fit only relates to samples from the north coast of West New Britain. Samples from regions E and F were grouped with those in the Hoskins Pen. and the eastern group. GN and GS samples were mostly unaffected and are renamed as social groups WPN and WPS. When DFA was re-applied to test these new categories, good discrimination was achieved between regions (Fig. 5).

Once source groups were established, DFA was applied to the entire sample to assign artefacts into potential source groups. Artefacts were only grouped if they showed a predicated posterior probability degree of 0.7 or higher and their geological region classification aligned with their social region classification. This approach assigned 39 tools to two source groups (Fig. 6). Four of these tools were from Lapita-associated contexts with matches made to sources both within New Britain and beyond. In Fig. 6, artefacts grouped with a specific source are colour coded; unassigned artefacts are identified as black triangles.

Interpreting possible exchange patterns

Geochemical (Table 1) and social (Table 2) groups were employed to determine potential source regions. The relationship between artefact findspot and origin of raw material is represented in Fig. 6. While the remaining artefacts could not be securely classified, the data suggests these artefacts were of raw materials likely derived from even more distant locations. The wide range of stone sources present on sites south of the central Whiteman Range provides support for the hypothesis that stone artefacts, particularly axe and adze blades, were frequently moved around and were probably well-integrated into exchange relationships.

It is clear that the volcanic region east of the Willaumez Pen. was a major producer of axe and adze blades, a result consistent with the findings of Pengilley *et al.* (2019). Of the total sourced artefacts, 15 (33.3%) were assigned to either E or F geochemical region, and all of these artefacts were assigned to the Hoskins social region, thus excluding the eastern social region (Tables 1, 2). Within the Willaumez Pen., 9 tools (23.1%) could be assigned to the northern part of the Pen. (WPN/GN).

The absence of tools originating from the source region at the base and lower parts of Willaumez Pen. (GS, WPS) is notable as this supports the lack of field evidence for stone tool manufacture in this region. Previous geochemical sourcing of stone blades from sites in this region also produced no matches to volcanic outcrops in the WPS and GS regions (Pengilley *et al.,* 2019: 9). These results suggest that groups which controlled access to the obsidian sources most likely obtained valuables such as stone tools through exchange from nearby regions. Additionally, whereas sites located on the Willaumez Pen. which had artefacts from the Bali-Witu source region, none of the artefacts from the southern sites of New Britain were assigned to the Bali-Witu source region. Thus, the Bali-Witu networks were apparently only linked to communities on the north side of the island and lacked connections to networks to the south of the Whiteman Range.

Thirty eight percent of the matched tools were assigned to source regions beyond the central area of New Britain.

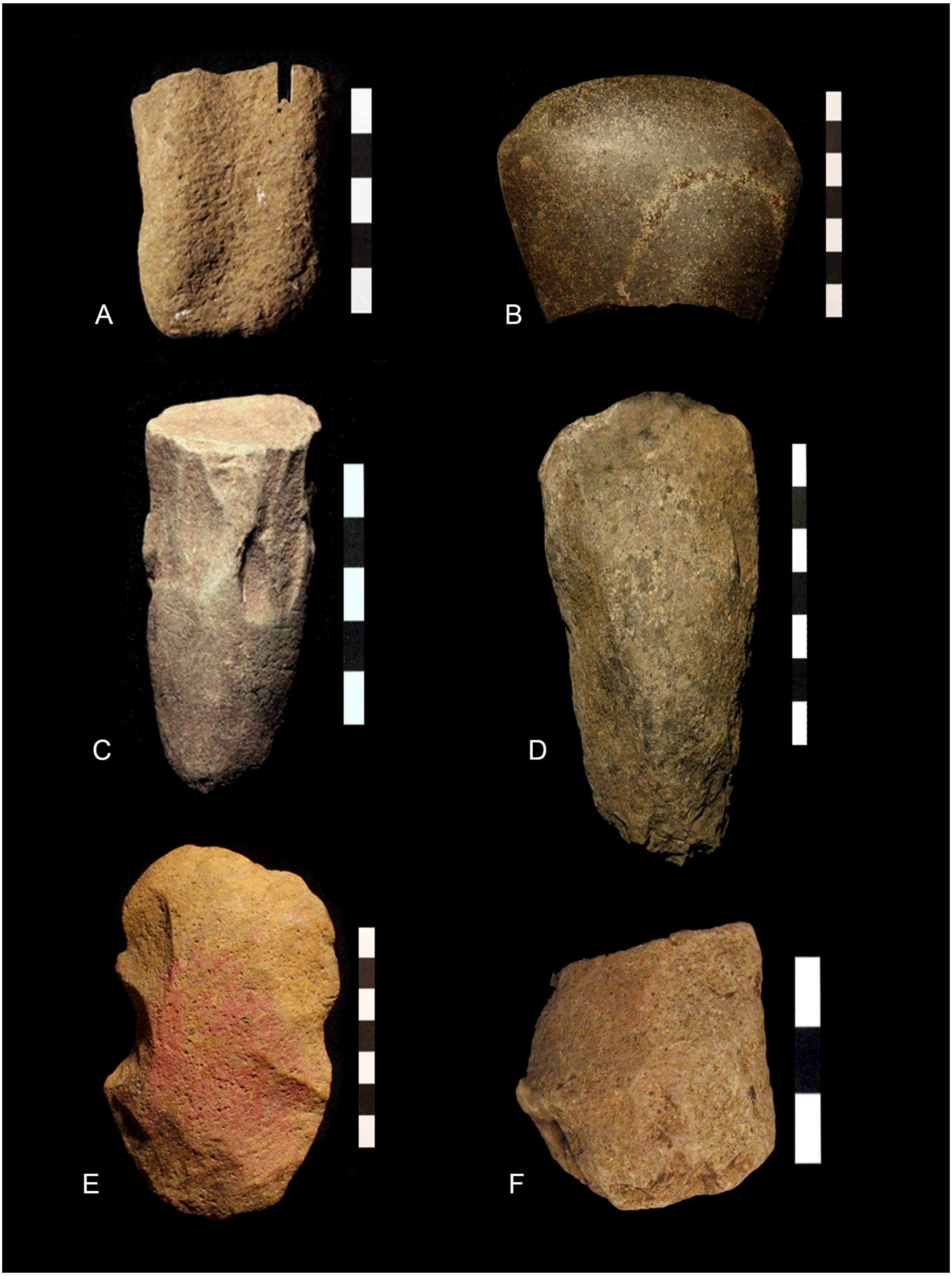

Figure 3. Selection of stone items analysed in this study with their Geochemical/social region. (*A*) File or nut-cracking anvil, surface find at site FLP, Analo village, Kandrian (E/Hoskins). (*B*) Cutting-edge of axe, surface find from site FSV, Giring (Gegering) village, Lamogai, central New Britain (Vitiaz/Vitiaz). Reproduced by courtesy of C. Gosden and R. Fullagar. (*C*) Possible bark-cloth beater, surface find from site FSC, Monkereme near Wako village, south coast New Britain (GN/WPN). Reproduced by courtesy of C. Gosden and R. Fullagar. (*D*) Adze blade, surface find from square 20N/35E at Lapita pottery site FFS, Auraruo, Apugi Island, Kandrian (F/Hoskins). (*E*) Flaked waisted axe or adze made on a pebble, surface find at site FYT, Hauwauyang cave, near site FHC, Misisil cave, Passismanua (GN/WPN). (*F*) Adze or axe butt, excavated from trench III, spit 3 at Lapita pottery site FFT, Rapie area, Iangpun village, Apugi Island, Kandrian (Vitiaz/Vitiaz).

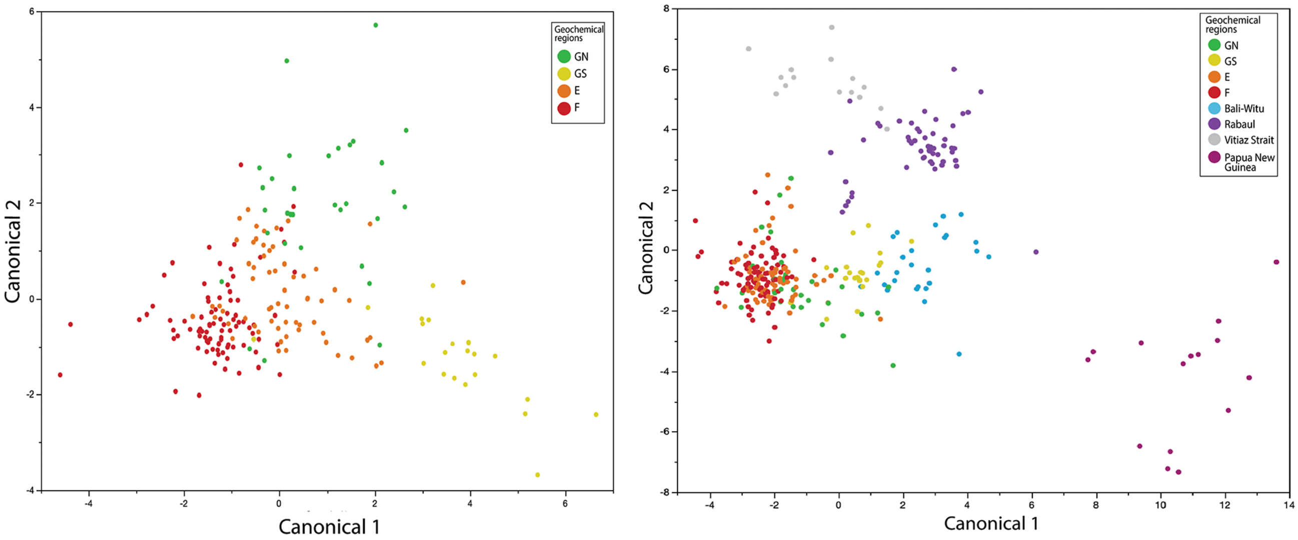

Figure 4. Discriminant Function Analysis of Willaumez Pen. geological regions (left) and all geological regions included in this study (right).

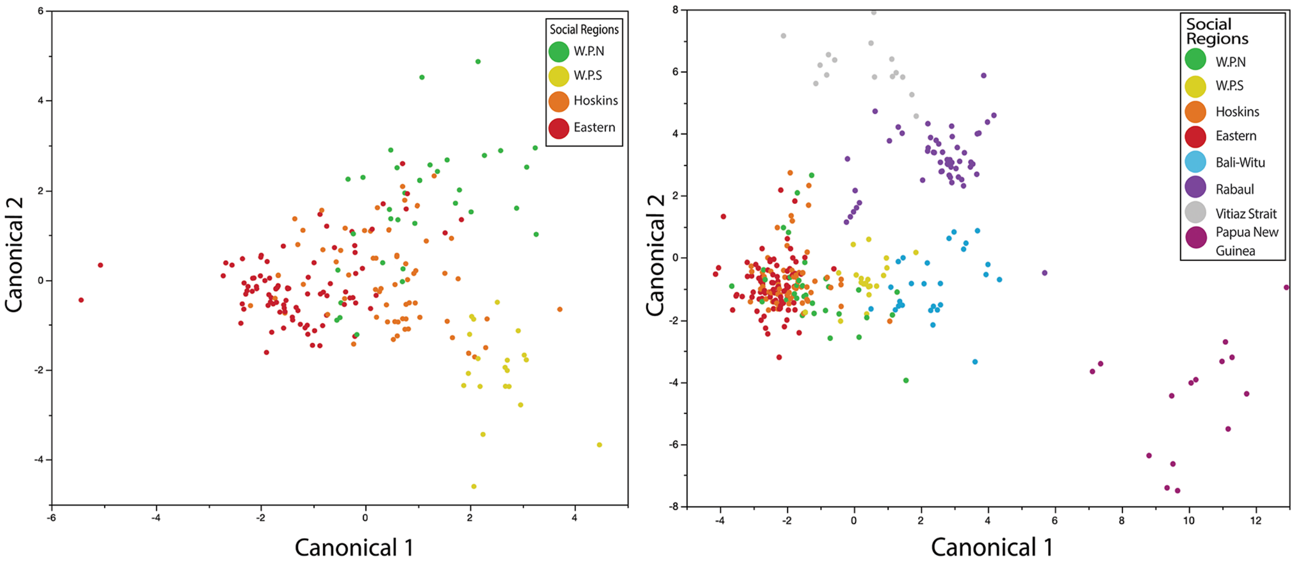

Figure 5. Discriminant Function Analysis of Willaumez Pen. social regions (left) and all social regions included in this study (right).

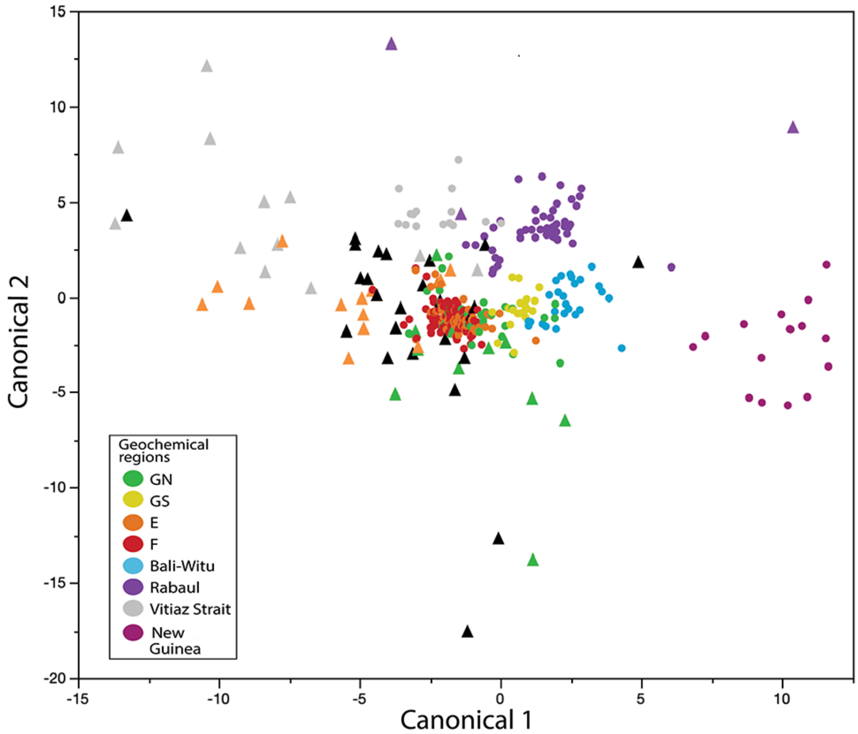

Figure 6. Results of geochemical characterisation. Artefacts classified to a source region are coloured the same as the source to which they have been assigned, and unassigned tools are depicted by black triangles.

Table 1. Items successfully assigned to each geochemical source region. *Kandrian coast group includes one Lamogai/Wasum item in each of the GN and Vitiaz regions.

archaeological area	geochemical source region								
	E	F	GN	GS	H	Rabaul	Vitiaz	New Guinea	totals
Passismanua	0	1	1	0	0	0	3	0	5
Kandrian coast*	4	0	2*	0	0	3	5*	0	14
Apugi Island	4	5	6	0	0	0	4	0	19
Ganglo Island	1	0	0	0	0	0	0	0	1
totals	9	6	9	0	0	3	12	0	39
totals as %	23.1	15.4	23.1	0	0	7.7	30.8	0	100%

No samples matched sources on the New Guinea mainland. Roughly 8% of the sample were assigned to the Rabaul geochemical region at the most easterly part of New Britain. To the west, 30.8% of the tools were assigned to sources located in the Vitiaz Strait and islands along the New Guinea north coast confirming the inclusion of stone tools in long distance trade networks across water along with pigments, pots and other artefacts (Harding, 1994). While the involvement of these stone tools in the networks was suspected, this new data securely links them to the inter-island trade, though specific material sources are not identified.

Change over time

The geochemical analysis of stone tools from sites on the southern side of New Britain also provides an opportunity to study possible change of sources over time. Intensification of exchange networks enabling the movement of larger volumes of region-specific products would be one expected effect of increasing settlement across the region. The results of this study allow us to understand the role stone blades had in these changing interaction spheres. Surface and excavated artefacts from four Lapita sites have successfully been matched to a social region, with 61.5% assigned to Hoskins or WPN (Table 3). Notably, however, 27% were assigned to the Vitiaz Strait social region and 11% to Rabaul.

While only 26 out of 45 artefacts at the Lapita pottery sites could be successfully assigned to a source and the exact date of each artefact is not known, the results provide some indication of the movement of a diverse range of stone tools through the region in early times. While most items in the sample were the product of surface collections and can be assumed to belong to the most recent millennium, our small sample of excavated artefacts includes an axe or adze butt at site FFT on Apugi Island that was clearly associated with Lapita pottery assigned to the Vitiaz social region (Fig. 3F; WNB/S/25 in Appendix 3). This indicates that the connection between the Kandrian and Vitiaz Strait communities was in existence during Lapita times, though the connection might have begun prior to that time, and continued for the next three millennia. At the mainland Lapita site of FLX three of the nine items assigned to a geochemical source are assigned to the Rabaul region, but none of the 36 items analysed from Apugi Island (FFQ, FFS, FFT) can be confidently attributed to the Rabaul region. This marked contrast might be explained in several ways, including the development of links with the Rabaul region after the Lapita pottery period. Testing this possibility will require larger and better contextualised samples.

Discussion and conclusions

The majority of stone tools in this study were made from stone sources in the Hoskins Pen., with smaller numbers coming from northern Willaumez Pen., the Rabaul region, and various islands in the Vitiaz Strait region. These results indicate that while most exchange activity occurred across New Britain from north to south, a substantial number of items also came to the Kandrian-Passismanua areas along the south coast from both the east and the west. These results support the social networks proposed between communities in New Britain and the wider Bismarck Archipelago (Torrence *et al*., 2013).

In recent time exchanges between the north coast and the south coast of New Britain involved the well-known trade of obsidian and pigments moving south in exchange for other products (Chowning, 1978: 297–298). We can now confidently add to these accounts that stone axe and adze blades and other tools also moved from these areas into the south (Fig. 7). Two main source regions have become apparent: the areas inhabited today by the Bulu (North Willaumez Pen.) and Lakalai (Hoskins) communities. It is not possible to trace the exact route or routes by which these

Table 2. Items successfully assigned to each social region. *Kandrian coast group includes one Lamogai/Wasum item in each of the WPN and Vitiaz regions.

Archaeological area	Social region								
	Eastern	Hoskins	WPS	WPN	Bali/Witu	Rabaul	Vitiaz	New Guinea	totals
Passismanua	0	1	0	1	0	0	3	0	5
Kandrian coast*	0	4	0	2*	0	3	5*	0	14
Apugi Island	0	9	0	6	0	0	4	0	19
Ganglo Island	0	1	0	0	0	0	0	0	1
totals	0	15	0	9	0	3	12	0	39
totals as %	0	38.5	0	23.1	0	7.7	30.8	0	100.1%

Table 3. All surface and excavated finds from Kandrian area Lapita pottery sites assigned to social regions.

site	number analysed	WPN	Hoskins	Vitiaz	Rabaul	total assigned (%)
FFS	24	3	9	1	0	13 (54%)
FFT	11	2	0	3	0	5 (45%)
FLX	9	0	1	3	3	7 (78%)
FYA	1	0	1	0	0	1 (n/a)
totals	45	5	11	7	3	26 (57.8%)
totals %		19.2%	42.3%	26.9%	11.5%	99.9%

artefacts reached the southern communities, although based on ethnographic data, it is likely that they travelled through the centre of the island via one of several paths. According to local informants on the south coast, one route led from the Kove area on the north coast via the Lamogai plateau to the south coast, and another ran from the Hoskins region across the island to Gasmata and then westwards along the coast to Kandrian (J. Specht, unpublished 1979 field notes).

In comparison to the ethnographic literature, exchange routes utilised in earlier periods appear to have been similar to those used in recent times. It remains to be seen, however, whether there were any changes in the networks of exchange links over time with a shift to movements of artefacts between communities in the same geographic region.

The characterisation of stone tools to sources outside West New Britain indicates that they were part of trade networks that spanned a much larger area. We can see the movement of tools along a network that linked Rabaul with the Kandrian coast. Stone tools produced in the east were probably traded for specific material such as obsidian that was unique to the Willaumez Pen. or chert from Yalam limestone geological formations in the Passismanua region.

While there is no mention of the involvement of stone tools in ethnographic accounts of trade between New Britain and the islands to the west, the geochemical results indicate there was such trade in pre-contact times. Numerous trading points along the coast would have facilitated movement of goods between communities and it is likely that stone tools produced on the islands of Vitiaz Strait were involved in down-the-line exchanges similar to those described in the ethnographies until they reached communities in Arawe Islands and Kandrian areas, and eventually the inland Passismanua area. When this movement of stone tools into southern New Britain began is unclear at present. The identification of tools of likely origin in the Vitiaz geochemical region at Lapita pottery sites on Apugi Island and the adjacent mainland of New Britain most likely indicate that these west to east connections began during Lapita pottery times. It is noteworthy that Lapita pottery occurs on Tuam Island in Vitiaz Strait (Lilley, 2002), raising the possibility that the Tuam site was a link in a network through which the stone tools passed.

Geochemical characterisation using a combination of pXRF and conventional legacy data has thus significantly increased our understanding of the role stone tools in exchange networks through New Britain and more widely in the Bismarck Archipelago. Further fieldwork focused on the primary source regions that have been isolated in this study might lead to the identification of specific areas of raw material procurement or signs of tool manufacture, such as grinding grooves. Irrespective of whether the transported stone tools were needed for ritual or utilitarian purposes, the pXRF studies allow us to trace their movement to the Kandrian and Passismanua regions from other regions, whereas previously we could previously only speculate about their origins.

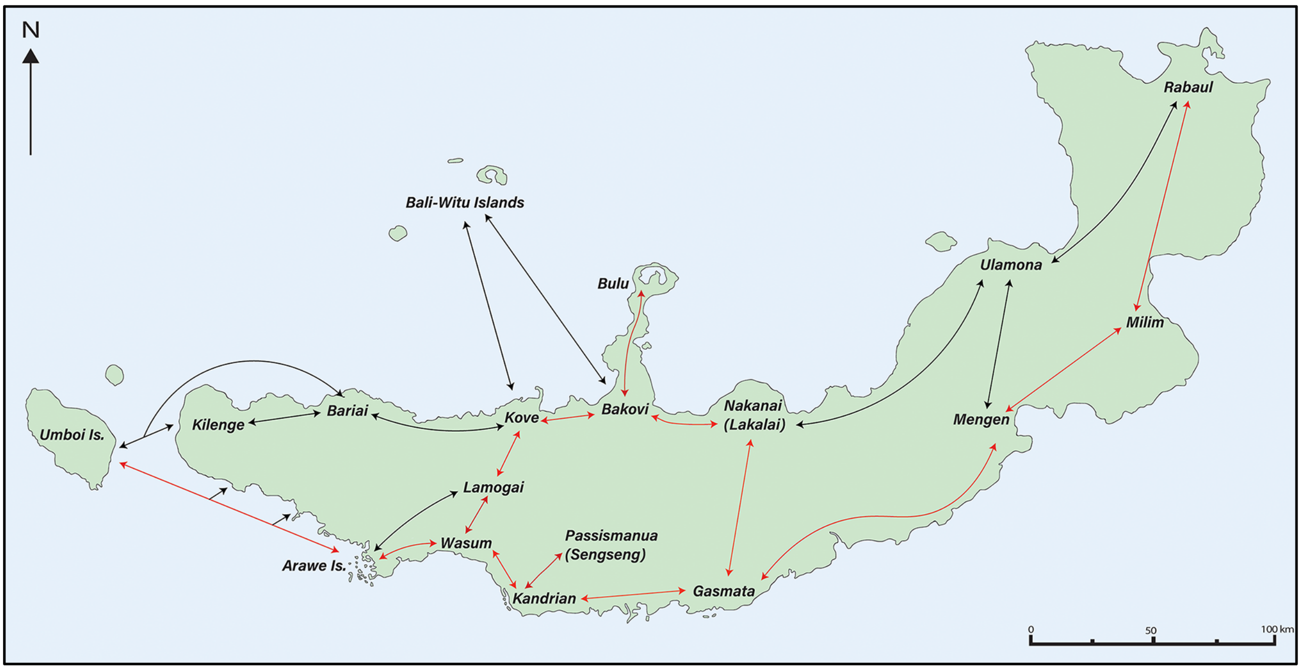

Figure 7. Summary of exchange networks throughout New Britain. Black lines indicate previously established routes of trade and the red lines indicate the possible paths that the stone tools on the south coast could have followed from their original source region.

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References

Attenbrow, V., T. Corkill, R. Pogson, L. Sutherland, and P. Grave. 2017. Non-destructive provenancing of ground-edged mafic artefacts: a Holocene study from the Sydney Basin, Australia. *Journal of Field Archaeology* 42(3): 173–186.
https://doi.org/10.1080/00934690.2017.1324354

Bird, R., R. Torrence, G. R. Summerhayes, and G. Bailey. 1997. New Britain obsidian sources. *Archaeology in Oceania* 32(1): 61–67.
https://doi.org/10.1002/j.1834-4453.1997.tb00371.x

Chowning, A. 1978. Changes in West New Britain trading systems in the twentieth century. *Mankind* 11(3): 296–307.
https://doi.org/10.1111/j.1835-9310.1978.tb00660

Clark, G. R., C. Reepmeyer, N. Melekiola, J. Woodhead, W. R. Dickinson, and H. Martinsson-Wallin. 2014. Stone tools from the ancient Tongan state reveal prehistoric interaction centers in the Central Pacific. *Proceedings of the National Academy of Sciences of the USA* 111(29): 10491–10496.
https://doi.org/10.1073/pnas.1406165111

Crosby, E. 1973. A Comparative Study of Melanesian Hafted Edge-Tools and Other Percussive Cutting Implements. Unpublished PhD thesis, Australian National University, Canberra.
http://hdl.handle.net/1885/109367/

GeoReM. 2019.
http://georem.mpch-mainz.gwdg.de/

Harding, T. G. 1967. *Voyagers of the Vitiaz Strait. A Study of a New Guinea Trade System.* Seattle: University of Washington Press.

Harding, T. G. 1994. Precolonial New Guinea trade. *Ethnology* 33(2): 101–125.
https://doi.org/10.2307/3773892

Heming, R. F. 1979. Undersaturated lavas from Ambittle Island [sic], Papua New Guinea. *Lithos* 12(5): 172–186.
https://doi.org/10.1016/0024-4937(79)90002-1

JMP 14.0. 2018. SAS Institute, Inc.
https://www.jmp.com/en_au/software.html

Johnson, R. W., and B. W. Chappell. 1979. Chemical analyses of rocks from the Late Cainozoic volcanoes of north-central New Britain and the Witu Islands, Papua New Guinea. In *Report. Australia. Bureau of Mineral Resources, Geology and Geophysics 209,* ed. R. W. Johnson and B. W. Chappell, pp. 1–47. Canberra: Australian Government Publishing Service.
https://d28rz98at9flks.cloudfront.net/15120/Rep_209.pdf

Johnson, T., and P. Molnar. 1972. Focal mechanisms and plate tectonics of the southwest Pacific. *Journal of Geophysical Research* 77(26): 5000–5032.
https://doi.org/10.1029/JB077i026p05000

Kahn, J. G., J. Sinton, P. R. Mills, and S. P. Lundblad. 2013. X-ray fluorescence analysis and intra-island exchange in the Society Island archipelago (Central Eastern Polynesia). *Journal of Archaeological Science* 40: 1194–1202.
https://doi.org/10.1016/j.jas.2012.10.003

Kirch, P. V., P. R. Mills, S. P. Lundblad, J. Sinton, and J. G. Kahn. 2012. Interpolity exchange of basalt tools facilitated via elite control in Hawaiian archaic states. *Proceedings of the National Academy of Sciences of the USA* 109(4): 1056–1061.
https://doi.org/10.1073/pnas.1119009109

Lentfer, C., C. Pavlides, and J. Specht. 2010. Natural and human impacts in a 35 000-year vegetation history in central New Britain, Papua New Guinea. *Quaternary Science Reviews* 29(27–28): 3750–3567.
https://doi.org/10.1016/j.quascirev.2010.08.009

Lilley, I. 1986. Prehistoric exchange in the Vitiaz Strait, Papua New Guinea. Unpublished PhD thesis, Australian National University, Canberra.

Lilley, I. 2002. Lapita and Type Y in the KLK site, Siassi, Papua New Guinea. In *Fifty Years in the Field. Essays in honour of Richard Shutler Jr's archaeological career*, ed. S. Bedford, C. Sand, and D. Burley, pp. 79–90. New Zealand Archaeological Association Monograph 25. Auckland: New Zealand Archaeological Association.

Lilley, I. 2004. Trade and culture history across the Vitiaz Strait, Papua New Guinea: the emerging Post-Lapita coastal sequence. *Records of the Australian Museum, Supplement* 29: 89–96.
https://doi.org/10.3853/j.0812-7387.29.2004.1405

Mackenzie, D. E. 1976. Nature amid origin of late Cainozoic volcanoes in western Papua New Guinea. In *Volcanism in Australasia*, ed. R. W. Johnson, pp. 221–238. Elsevier: Amsterdam.

McAlister, A., and M. S. Allen. 2017. Basalt geochemistry reveals high frequency of prehistoric tool exchange in low hierarchy Marquesas Islands (Polynesia). PLoS ONE 12(12): 1–28.
https://doi.org/10.1371/journal.pone.0188207

McKee, C. O., V. E. Neall, and R. Torrence. 2011. Remarkable pulse of large-scale volcanism on New Britain Island, Papua New Guinea. *Bulletin of Volcanology* 73(1): 27–37.
https://doi.org/10.1007/s00445-010-0401-8

Mills, P. R., and S. P. Lundblad. 2006. Preliminary Field Report: The Geochemistry of the Ko`oko`olau Complex, Mauna Kea Adze Quarry (50-10-23-4136) TMK:4-4-15:10. Report prepared for the Hawaii Natural Area Reserves System (NARS) Commission. Hilo: University of Hawaii.
https://hilo.hawaii.edu/faculty/millsp/documents/NARreport.pdf

Mills, P. R., S. P. Lundblad, K. Hon, J. J. Moniz-Nakamura, L. K. Kahahane, A. Drake-Raue, T. M. Souza, and T. Wei. 2011. Reappraising craft specialization and exchange in pre-contact Hawai'i through non-destructive sourcing of basalt adze debitage. *Journal of Pacific Archaeology* 2(2): 79–92.
https://pacificarchaeology.org/index.php/journal/article/view/34

Neall, V. E., R. C. Wallace, and R. Torrence. 2008. The volcanic environment for 40,000 years of human occupation on the Willaumez Isthmus, West New Britain, Papua New Guinea. *Journal of Volcanology and Geothermal Research* 176(3): 330–343.
https://doi.org/10.1016/j.jvolgeores.2008.01.037

Patia, H., S. M. Eggins, R. J. Arculus, C. O. Mckee, R. W. Johnson, and A. Bradney. 2017. The 1994–2001 eruptive period at Rabaul, Papua New Guinea: Petrological and geochemical evidence for basalt injections into a shallow dacite magma reservoir, and significant SO2 flux. *Journal of Volcanology and Geothermal Research* 345: 200–217.
https://doi.org/10.1016/j.jvolgeores.2017.08.011

Pengilley, A., C. Brand, J. F. Flexner, J. Specht, and R. Torrence. 2019. Detecting exchange networks in New Britain, Papua New Guinea: geochemical comparisons between axe and adze blades and in situ volcanic rock sources. *Archaeology in Oceania* 54(3): 200–213.
https://doi.org/10.1002/arco.5188

Richards, M. J. 2019. Duff's adze typology versus Polynesian adze exchanges. *Archaeology in Oceania* 54(3): 173–183.
https://doi.org/10.1002/arco.5194

Ryburn, R. J. 1976. *Cape Raoult-Arawe, Papua New Guinea, 1:250 000 Geological Series—Explanatory Notes: SB/55-8, SB/55-12*. Canberra: Australian Government Publishing Service.

Shaw, B., S. Coxe, V. Kewibu, J. Haro, E. Hull, and S. Hawkins. 2020. 2500-year cultural sequence in the Massim region of eastern Papua New Guinea reflects adaptive strategies to small islands and changing climate regimes since Lapita settlement. *The Holocene*: 1–16.
https://doi.org/10.1177/0959683620908641

Sheppard, P., B. Trichereau, and C. Milicich. 2010. Pacific obsidian sourcing by portable XRF. *Archaeology in Oceania* 45(1): 21–30.
https://doi.org/10.1002/j.1834-4453.2010.tb00074.x

Specht, J. 2005. Stone axe blades and valuables in New Britain, Papua New Guinea. In *A Polymath Anthropologist: Essays in Honour of Ann Chowning*, ed. C. Gross, H. D. Lyons, and D. A. Counts, pp. 15–22. Research in Anthropology and Linguistics Monograph Number 6. Auckland: Department of Anthropology, University of Auckland.

Specht, J., A. Ford, and J. Kariwiga. 2018. Obsidian from the Jacquinot Bay area, East New Britain, Papua New Guinea. *Journal of Pacific Archaeology* 9(2): 35–43.
https://www.pacificarchaeology.org/index.php/journal/article/view/254

Summerhayes, G. R. 2009. Obsidian network patterns in Melanesia—sources, characterisation and distribution. *Bulletin of the Indo-Pacific Prehistory Association* 29: 110–124.
https://doi.org/10.7152/bippa.v29i0.9484

Summerhayes, G. R., J. R. Bird, R. Fullagar, C. Gosden, J. Specht, and R. Torrence. 1998. Application of PIXE-PIGME to archaeological analysis of changing patterns of obsidian use in West New Britain, Papua New Guinea. In *Archaeological Obsidian Studies*, ed. S. Shackley, pp. 129–158. Plenum: New York.
https://doi.org/10.1007/978-1-4757-9276-8_6

Todd, J. A. 1934a. Report on research work in South-west New Britain, Territory of New Guinea. *Oceania* 5(1): 80–101.
https://doi.org/10.1002/j.1834-4461.1934.tb00132.x

Todd, J. A. 1934b. Report on research work in South-west New Britain, Territory of New Guinea. *Oceania* 5(2): 193–213.
https://doi.org/10.1002/j.1834-4461.1934.tb00140.x

Torrence, R. 2011. Finding the right question: Learning from stone tools on the Willaumez Peninsula, Papua New Guinea. *Archaeology in Oceania* 46(2): 29–41.
https://doi.org/10.1002/j.1834-4453.2011.tb00097.x

Torrence, R., S. Kelloway, and P. White. 2013. Stemmed tools, social interaction, and voyaging in early-mid Holocene Papua New Guinea. *Journal of Island and Coastal Archaeology* 8(2): 287–310.
https://doi.org/10.1080/15564894.2012.761300

Torrence, R., and G. R. Summerhayes. 1997. Sociality and the short distance trader: Intra-regional obsidian exchange in the Willaumez region. *Archaeology in Oceania* 32(1): 74–84.
https://doi.org/10.1002/j.1834-4453.1997.tb00373.x

Weisler, M. I., and P. V. Kirch. 1996. Interisland and inter-archipelago transfer of stone tools on prehistoric Polynesia. *Proceedings of the National Academy of Sciences of the USA* 93(4): 1381–1385.
https://doi.org/10.1073/pnas.93.4.1381

Weisler, M. I., R. Bolhar, J. Ma, E. St Pierre, P. Sheppard, R. K. Walter, Y. Feng, J.-x. Zhao, and P. V. Kirch. 2016. Cook Island artifact geochemistry demonstrates spatial and temporal extent of pre-European interarchipelago voyaging in East Polynesia. *Proceedings of the National Academy of Sciences of the USA* 111(29): 8150–8155.
https://doi.org/10.1073/pnas.1608130113

Wood, C. P., I. A. Nairn, C. O. McKee, and B. Talai. 1995. Petrology of the Rabaul Caldera area, Papua New Guinea. *Journal of Volcanology and Geothermal Research* 69(3): 285–302.
https://doi.org/10.1016/0377-0273(95)00034-8

Woodhead, J. D., J. Hergt, M. Sandiford, and W. Johnson. 2010. The Big Crunch: physical and chemical expressions of Arc/Continent collision in the Western Bismarck Arc. *Journal of Volcanology and Geothermal Research* 190(1): 11–24.
https://doi.org/10.1016/j.jvolgeores.2009.03.003

Woodhead, J. D., and R. W. Johnson. 1993. Isotopic and trace element profiles across the New Britain island arc, Papua New Guinea. *Contributions to Mineralogy and Petrology* 113(4): 479–491.
https://doi.org/10.1007/BF00698317

Appendix 1. Geochemical data for geological reference collections used in this study. Abbreviations: *Geo*. Geochemial Region; *N.G.* New Guinea; *Pen*. Peninsula; *Social* Social Region.

name	location	Geo.	Social	material	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	V	MnO	FeO2O3	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb
E1:68490025	Mt. Witori area	E	Hoskins	Andesite	2.81	17.58	57.33	0.16	0.51	8.41	0.61	240	0.16	3.27	10	75	86	6.1	420	19	34	0
E1:68490031	Mt. Witori area	E	Hoskins	Dacite	1.47	15	66.28	0.16	0.88	5.15	0.48	97	0.14	1.91	0.2	17	76	12	330	20	50	0
E1:68490033	Mt. Witori area	E	Hoskins	Dacite	1.36	15.13	66.43	0.14	0.9	5.24	0.47	94	0.14	2.74	0.2	15	86	13	370	21	58	0
E1:68490030	Mt. Witori area	E	Hoskins	Dacite	1.1	14.74	69.44	0.16	1.03	4.38	0.4	43	0.12	1.73	0.2	9	67	14	310	16	58	0
E1:75710021	Mt. Witori area	E	Hoskins		1.57	14.63	65.8	0.15	0.88	5.31	0.48	80	0.15	1.71	0.1	9	84	13	355	15	59	0.1
E1:WP01001	Mt. Witori area	E	Hoskins	Basalt	2.595	18.739	49.382	0.253	0.974	0	0.88	191	0.175	0	16	0	99	16	404.7	36	96	1.4
E1:W00013	Mt. Witori area	E	Hoskins	Basalt	2.263	17.893	48.718	0.202	0.935	0	0.82	171	0.174	0	14	0	104	16	398	34	95	2
E1:WP01003	Mt. Witori area	E	Hoskins	Andesite	1.956	16.348	58.886	0.258	1.573	0	0.825	120	0.142	0	16	0	91	19.4	301.1	37.2	120	1.7
E1:WP01002	Mt. Witori area	E	Hoskins	Andesite	1.793	15.987	58.919	0.279	1.629	0	0.825	118	0.144	0	16	0	88	20.6	293.3	38.4	125	1.8
E2:51NG3028	Sulu Range	E	Eastern		2.8	18.6	55.8	0.06	0.35	9.4	0.64	253	0.17	2.4	4	202	82	5.2	251	11	26	0.1
E2:51NG3035	Sulu Range	E	Eastern		4.95	16.5	56.8	0.05	0.59	8.95	0.45	189	0.15	4.4	24	97	69	8	217	11	37	0.1
E2:51NG3039B	Sulu Range	E	Eastern		7.05	15.7	55	0.06	0.36	10	0.38	197	0.16	1.94	43	114	68	5.8	224	10	31	0.1
E3:51NG0113	Mt. Galloseulo, Hargy	E	Eastern		1.69	14.3	65.1	0.12	0.67	5.7	0.66	181	0.14	1.5	2	90	85	17.4	255	16	62	0.1
E3:51NG0199	Mt. Galloseulo, Hargy	E	Eastern		3.4	17.2	57.8	0.06	0.57	8.65	0.46	211	0.16	2.3	11	62	74	6.8	268	10	31	0.1
E3:51NG0202	Mt. Galloseulo, Hargy	E	Eastern		5.1	17.3	55.9	0.05	0.4	9	0.35	209	0.16	3	19	60	72	6.8	256	9	22	0.1
E3:51NG0205	Mt. Galloseulo, Hargy	E	Eastern		7.45	15.1	55.6	0.05	0.22	9.7	0.39	226	0.17	2.25	56	79	69	6	221	8	25	0.1
E3:51NG0208	Mt. Galloseulo, Hargy	E	Eastern		2.2	18.3	58.3	0.06	0.7	8.74	0.49	219	0.11	1.75	6	96	66	9.8	285	11	36	0.1
E3:51NG0209	Mt. Galloseulo, Hargy	E	Eastern		2.15	18.1	58.7	0.07	0.64	9	0.5	223	0.11	2.2	7	101	64	9.8	298	11	36	0.1
E3:51NG0213	Mt. Galloseulo, Hargy	E	Eastern		2.75	16.2	59.5	0.08	0.81	8.4	0.53	258	0.12	1.85	12	85	77	11.4	271	12	41	0.1
E4:51NG0166	Mt. Bamus	E	Eastern		3.35	18.7	56.8	0.12	0.44	8.55	0.75	159	0.15	2.5	6	37	65	6.8	277	14	54	0.1
E4:51NG0171	Mt. Bamus	E	Eastern		1.86	19.5	58.3	0.09	0.53	9.35	0.72	144	0.12	1.7	4	64	55	8.2	276	15	47	0.1
E4:51NG0193	Mt. Bamus	E	Eastern		3.9	18.5	54.3	0.09	0.33	8.8	0.62	243	0.14	4.2	20	75	80	1	260	18	46	0.1
E4:51NG0195M	Mt. Bamus	E	Eastern		2.9	18.1	57.3	0.09	0.34	8.8	0.58	259	0.15	2.55	15	100	78	3.6	257	15	51	0.1
E4:51NG0195X	Mt. Bamus	E	Eastern		2.4	19.8	57	0.09	0.45	8.9	0.62	161	0.13	1.78	4	100	59	7.4	239	15	50	0.1
E4:51NG2604	Mt. Bamus	E	Eastern		4.3	18.4	55.2	0.06	0.37	8.95	0.9	213	0.15	2.85	8	102	84	4	252	20	45	0.1
E4:51NG3006	Mt. Bamus	E	Eastern		10.1	13.8	53.9	0.09	0.46	8.8	0.41	222	0.15	2.8	170	64	74	4.6	176	10	33	0.1
E4:51NG3020	Mt. Bamus	E	Eastern		4.3	17.9	55.7	0.09	0.46	8.8	0.61	204	0.15	2.8	9	64	72	6.4	224	16	52	0.1
E4:75710019	Mt. Bamus	E	Eastern		4.74	17.93	55.44	0.05	0.37	8.21	0.76	203	0.21	3.27	7	39	73	5.6	220	12	42	0.1
E4:75710020	Mt. Bamus	E	Eastern		3.38	17.93	58.4	0.12	0.47	8.03	0.63	118	0.17	2.62	4	24	63	8.2	262	14	58	0.1
E5:51NG0065B	Mt. Ulawun	E	Eastern		4.69	18.66	52.32	0.08	0.32	10.6	0.76	290	0.17	3.22	21	81	81	4.6	297	13	21	0.1
E5:51NG0066	Mt. Ulawun	E	Eastern		4.79	18.8	52.5	0.1	0.35	10.67	0.76	301	0.16	3.29	18	81	78	4.6	290	12	22	0.1
E5:51NG0079	Mt. Ulawun	E	Eastern		4.9	19.16	52.47	0.09	0.32	10.76	0.75	294	0.17	3.4	22	80	82	4.2	301	13	21	0.1
E5:51NG0091	Mt. Ulawun	E	Eastern		5.54	17.71	52.33	0.07	0.32	10.43	0.73	319	0.2	4.05	21	53	87	4	321	12	18	0.1
E5:51NG0094	Mt. Ulawun	E	Eastern		4.75	17.85	55.48	0.06	0.39	10	0.52	282	0.14	3.3	41	99	67	5.6	333	11	27	0.1
E5:51NG0150	Mt. Ulawun	E	Eastern		5.47	17.05	54.95	0.05	0.34	9.82	0.49	261	0.18	3.17	21	104	78	5	289	10	21	0.1
E5:51NG0156	Mt. Ulawun	E	Eastern		5.17	17.8	52.43	0.08	0.36	10.61	0.77	322	0.18	3.32	20	69	85	5	309	13	22	0.1
E5:51NG0158	Mt. Ulawun	E	Eastern		6.32	17.13	51.84	0.08	0.33	10.77	0.77	312	0.2	2.92	25	73	87	4.6	314	12	19	0.1
E5:51NG0822	Mt. Ulawun	E	Eastern		3.87	20.37	51.98	0.1	0.37	11.17	0.72	250	0.15	2.16	14	79	70	4.8	336	13	22	0.1
E5:74710020	Mt. Ulawun	E	Eastern		4.55	18.6	52.7	0.1	0.4	10.6	0.85	320	0.16	3.35	18	85	85	6.8	294	16	31	0.1
E5:74710021	Mt. Ulawun	E	Eastern		4.5	18.3	52.5	0.1	0.4	10.7	0.9	317	0.17	3.7	19	102	84	5.6	288	16	29	0.1
E5:74710022	Mt. Ulawun	E	Eastern		4.6	18.4	52.4	0.09	0.38	10.6	0.89	309	0.17	4.2	19	95	84	6	296	16	28	0.1
E5:74710023	Mt. Ulawun	E	Eastern		4.6	18.6	52.3	0.09	0.38	10.6	0.94	312	0.17	3.35	20	93	82	5.8	287	16	28	0.1
E5:51NG0098	Mt. Ulawun	E	Eastern		5.85	18.06	51.79	0.09	0.32	10.98	0.74	295	0.17	2.51	15	94	89	0	0	0	0	0
E6:53NG0850A	Mt. Likurunga	E	Eastern		4.25	17.9	55.3	0.07	0.46	9.3	0.5	230	0.15	3.35	19	111	68	4.6	372	12	26	0.1
E6:53NG0850B	Mt. Likurunga	E	Eastern		3.85	18.7	53.8	0.07	0.44	10.1	0.67	264	0.15	3.1	14	146	71	5.6	358	11	24	0.1
E6:53NG0857A	Mt. Likurunga	E	Eastern		1.95	15.7	64.7	0.07	0.93	5.2	0.48	103	0.13	3.65	4	52	49	13.2	308	15	55	0.1
E6:53NG0857B	Mt. Likurunga	E	Eastern		4.25	16.2	55.2	0.06	0.55	7.25	0.59	187	0.17	6.05	9	172	52	7.2	259	15	28	0.1
E6:53NG1014	Mt. Likurunga	E	Eastern		5.05	17.3	54.6	0.06	0.24	9.55	0.61	252	0.17	3.4	14	46	87	2.2	329	18	28	0.1
E6:53NG2517	Mt. Likurunga	E	Eastern		5.65	16.8	54.1	0.06	0.19	9.55	0.69	278	0.18	3.4	26	49	77	1	302	12	21	0.1
E2:51NG0217F	Sulu Range	E	Eastern		9.2	14.7	53.1	0.03	0.28	10.9	0.3	188	0.16	1.91	88	97	68	2.6	167	6	14	0.1
E2:51NG2649	Sulu Range	E	Eastern		3	18.9	54.8	0.05	0.28	9.7	0.61	275	0.16	2.25	10	128	80	5	256	11	25	0.1
E2:51NG3032A	Sulu Range	E	Eastern		0.81	13.4	72.4	0.03	1.64	2.75	0.31	30	0.07	0.88	0.1	8	35	23	200	14	84	0.1
E2:51NG0217B	Sulu Range	E	Eastern		8.35	15.7	43.2	0.04	0.2	10.7	0.33	187	0.17	1.95	87	100	66	1.8	177	7	15	0.1
E2:51NG3032C	Sulu Range	E	Eastern		0.86	13.8	71.2	0.03	1.64	3.2	0.31	34	0.08	1.04	0.1	12	35	24.5	208	14	86	0.1
E2:51NG3038B	Sulu Range	E	Eastern		0.73	12.5	68.6	0.04	1.06	3.4	0.22	30	0.07	0.64	1	8	29	19.4	204	12	78	0.1
E2:51NG3038G	Sulu Range	E	Eastern		5.15	17.2	55.1	0.05	0.46	9.85	0.43	205	0.16	2.2	19	129	69	6.4	224	11	32	0.1
E3:51NG0111	Mt. Galloseulo, Hargy	E	Eastern		1.68	13.9	65.2	0.12	1.11	5.3	0.67	166	0.12	2.3	1	67	79	16.8	256	17	63	0.1
E3:51NG0115	Mt. Galloseulo, Hargy	E	Eastern		3.57	17.5	55.78	0.1	0.59	9.19	0.6	275	0.14	3.63	17	105	83	7	296	12	36	0.1
E3:51NG0116	Mt. Galloseulo, Hargy	E	Eastern		1.76	14	64.8	0.11	1.16	5.7	0.67	182	0.13	1.78	3	104	83	17.2	256	16	61	0.1
E3:51NG0117	Mt. Galloseulo, Hargy	E	Eastern		2.51	19.27	57.97	0.08	0.6	9.35	0.4	178	0.11	1.99	10	98	61	8.8	293	10	31	0.1
E3:51NG0122	Mt. Galloseulo, Hargy	E	Eastern		4.7	16.4	56.8	0.07	0.53	9.35	0.51	236	0.16	3	22	74	76	7.4	249	11	33	0.1
E3:51NG0123	Mt. Galloseulo, Hargy	E	Eastern		2.3	16	60.4	0.06	0.77	7.9	0.56	246	0.14	1.96	7	118	71	12.4	284	12	45	0.1
E3:51NG0201	Mt. Galloseulo, Hargy	E	Eastern		2.8	18.6	57.5	0.06	0.67	8.95	0.42	185	0.12	2.3	9	58	63	8.8	284	11	32	0.1
E4:51NG0174A	Mt. Bamus	E	Eastern		4.5	17.9	56.7	0.09	0.44	8.7	0.63	167	0.15	2.2	17	44	61	7	258	13	46	0.1
E4:51NG0191A	Mt. Bamus	E	Eastern		2.45	19.9	56.8	0.09	0.45	8.8	0.64	165	0.14	1.91	5	75	60	7.4	241	16	52	0.1

name	location	Geo.	Social	material	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	V	MnO	FeO2O3	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb
E5:51NG0059	Mt. Ulawun	E	Eastern		5.64	17.17	51.31	0.09	0.33	10.7	0.94	326	0.19	3.16	19	73	89	4.8	266	16	24	0.1
E5:51NG0077	Mt. Ulawun	E	Eastern		6.56	16.37	51.92	0.08	0.34	10.66	0.78	333	0.19	3.77	38	91	93	4.6	284	14	21	0.1
E5:70400504	Mt. Ulawun	E	Eastern		5.3	17.51	52.51	0.1	0.38	10.5	0.94	338	0.18	3.1	24	91	91	5.6	270	16	29	0.1
E5:51NG0095	Mt. Ulawun	E	Eastern		4.9	16.67	53.47	0.1	0.44	9.78	0.86	289	0.19	2.17	15	94	88	6.4	288	16	28	0.1
E5:70400505	Mt. Ulawun	E	Eastern		5.74	17.44	51.41	0.09	0.32	11	0.98	329	0.19	3.3	20	81	86	5.2	267	15	24	0.1
E5:75710027	Mt. Ulawun	E	Eastern		5.54	17.01	51.63	0.1	0.32	10.85	0.88	316	0.2	3.3	19	77	84	4.8	258	14	24	0.1
E5:51NG0089	Mt. Ulawun	E	Eastern		6.52	16.78	52.1	0.09	0.32	10.84	0.75	319	0.19	3.07	38	84	89	0	0	0	0	0
E6:53NG0852A	Cape Reilnitz	E	Hoskins		3.9	18.5	53.9	0.07	0.36	9.7	0.67	261	0.15	2.95	13	99	67	5.8	351	21	23	0.1
E6:53NG0871D	Cape Reilnitz	E	Hoskins		6.3	16.9	53.1	0.05	0.27	10.6	0.5	270	0.18	3.1	28	104	70	4.4	348	10	19	0.1
E6:53NG0871E	Cape Reilnitz	E	Hoskins		9.95	15.7	51.2	0.04	0.21	11.2	0.48	234	0.17	2.5	100	88	63	2.8	245	8	12	0.1
E6:53NG1010B	Cape Reilnitz	E	Hoskins		2.55	16.9	63.1	0.08	0.63	6.05	0.47	92	0.14	3.75	7	33	58	5.4	298	14	60	0.1
E6:53NG1015	Cape Reilnitz	E	Hoskins		2.4	16.7	64.3	0.08	0.71	5.8	0.46	116	0.13	2.3	5	27	52	7.8	319	12	60	0.1
E6:53NG2514A	Cape Reilnitz	E	Hoskins		4.95	18.4	54.5	0.06	0.27	9.4	0.48	282	0.15	3.75	30	157	73	2.6	354	9	18	0.1
E6:53NG1037	Cape Reilnitz	E	Hoskins		4.05	15.6	58.9	0.1	0.71	8.05	0.57	340	0.14	2.9	23	163	80	11	384	12	34	0.1
E6:53NG2514C	Cape Reilnitz	E	Hoskins		4.25	18.2	54.6	0.06	0.34	9.65	0.44	231	0.15	3.15	14	180	69	4.6	378	10	19	0.1
RU1	Ru River	E	Hoskins		2.87	17.36	50.04	0.13	0.09	7.79	1.06	123.67	0.17	10.52	15.00	100.67	61.33	1.33	306.33	18.33	53.00	5.33
RU2	Ru River	E	Hoskins		2.81	17.54	55.62	0.09	0.41	8.01	0.75	87.00	0.20	8.11	2.67	19.00	69.00	4.33	332.33	9.67	42.00	2.67
RU3	Ru River	E	Hoskins		3.54	14.99	36.79	0.08	0.14	6.80	1.12	137.00	0.15	12.69	33.67	36.67	74.67	1.67	266.00	17.33	37.33	4.67
RU4	Ru River	E	Hoskins		6.17	13.03	42.91	0.09	0.39	11.11	1.32	217.33	0.19	14.38	42.00	24.00	87.67	4.00	197.00	29.00	49.33	9.33
RU5	Ru River	E	Hoskins		4.04	11.10	39.03	0.06	0.18	5.81	1.06	171.33	0.20	14.23	46.33	219.00	122.67	5.00	196.67	26.67	48.00	7.33
RU6	Ru River	E	Hoskins		3.44	14.73	58.56	0.06	0.09	6.85	1.14	159.67	0.20	9.90	11.67	106.33	85.67	1.67	181.00	17.67	56.00	7.00
F1:51NG0269	Mt. Krummel Area	F	W.P.S		6.2	16.6	53	0.1	0.43	9.3	0.5	245	0.21	4.2	24	107	83	5.2	335	13	35	0.1
F1:51NG0274	Mt. Krummel Area	F	W.P.S		4.9	17.6	54.8	0.07	0.41	9.2	0.43	256	0.16	3.85	25	97	81	5	369	14	25	0.1
F1:51NG0277	Mt. Krummel Area	F	W.P.S		6.65	17	53.7	0.07	0.23	10.4	0.38	231	0.15	4	48	89	71	2.4	361	9	21	0.1
F1:51NG0283	Mt. Krummel Area	F	W.P.S		4.6	18.3	55.2	0.07	0.34	9.45	0.44	210	0.15	2.6	24	96	70	4	350	12	25	0.1
F2:51NG2682	Mt. Du Faure	F	Hoskins		1.81	17.7	62.6	0.13	1.1	5.9	0.5	113	0.08	3.3	7	86	59	17.2	499	14	71	2
F4:68490003	Cape Hoskins	F	Hoskins		5.12	17.79	54.56	0.12	0.3	9.94	0.49	240	0.15	2.91	35	89	71	2.1	400	15	27	0
F4:68490013	Cape Hoskins	F	Hoskins	Andesite	2.97	17.92	57.13	0.15	0.56	8.4	0.58	250	0.15	2.66	12	115	76	6.2	435	18	35	0
F4:68490047	Cape Hoskins	F	Hoskins	Andesite	4.31	17.48	55.48	0.14	0.47	8.87	0.52	275	0.15	2.84	27	115	74	4.9	400	19	27	0
F4:68490102	Cape Hoskins	F	Hoskins	Andesite	5.42	17.26	55	0.17	0.46	9.41	0.52	225	0.16	3.37	34	88	76	5.2	380	16	28	0
F4:68490108	Cape Hoskins	F	Hoskins	Andesite	2.28	16.99	61.24	0.24	0.88	6.19	0.52	135	0.14	3.37	3	56	67	9.2	430	23	50	0
F4:68490151	Cape Hoskins	F	Hoskins	Basalt	5.69	17.76	52.78	0.17	0.24	10.33	0.48	285	0.18	3.34	21	105	77	1.1	380	18	21	0
F4:68490152B	Cape Hoskins	F	Hoskins	Andesite	4.34	17.59	54.93	0.17	0.49	8.9	0.5	230	0.17	4.68	15	130	80	5.7	410	14	27	0
F4:68490153	Cape Hoskins	F	Hoskins		1.41	15.36	66.99	0.18	1.05	4.83	0.41	79	0.13	2.61	0.2	20	57	11	375	25	63	0
F4:68490154	Cape Hoskins	F	Hoskins		1.88	16	64.5	0.18	1.12	5.62	0.47	120	0.13	2.64	3	53	68	16	385	23	72	0
F4:68490162	Cape Hoskins	F	Hoskins		4.28	16.2	59.96	0.12	0.86	7.77	0.44	190	0.14	3.06	25	165	68	12	305	16	53	0
F4:68490164	Cape Hoskins	F	Hoskins	Dacite	1.43	15.2	68.16	0.15	1.41	4.05	0.4	76	0.1	2.99	2	25	44	18	330	19	83	0
F4:68490171B	Cape Hoskins	F	Hoskins	Andesite	3.75	17.26	54.74	0.15	0.5	8.68	0.51	185	0.12	5.26	13	93	74	6.5	420	13	37	0
F4:68490174	Cape Hoskins	F	Hoskins		3.85	16.37	57.26	0.17	0.83	8.33	0.54	190	0.14	3.83	13	100	72	13	390	19	58	0
F5:51NG0225	Wulai Island	F	Hoskins		4.35	17.8	56.4	0.09	0.49	8.25	0.5	205	0.14	3.19	14	85	69	5.8	413	15	38	0.1
F5:51NG0233	Wulai Island	F	Hoskins		3.05	18.8	56.7	0.1	0.63	7.9	0.53	177	0.14	3.4	9	31	62	6	433	13	40	0.1
F5:51NG0236	Wulai Island	F	Hoskins		5	18.4	55.1	0.09	0.43	8.65	0.56	253	0.15	3.25	24	43	71	5.8	413	12	35	0.1
F5:51NG0239	Wulai Island	F	Hoskins		5.6	17.9	52.5	0.08	0.48	10.2	0.49	266	0.16	4.05	30	159	70	4.2	403	10	24	0.1
F6:51NG0220A	Cape Reilnitz	F	Hoskins		0.5	14.3	71.4	0.12	1.72	2.75	0.46	24	0.08	2.55	0.1	8	56	28.5	276	26	100	0.1
F7:53NG0814B	Lolobau, Banban Is.	F	Eastern		5.2	16.8	54.7	0.09	0.4	9.8	0.57	279	0.17	6.15	18	96	77	6	302	14	32	0.1
F7:53NG0832	Lolobau, Banban Is.	F	Eastern		3.7	19	54.4	0.1	0.41	9.8	0.6	265	0.16	2.7	14	101	76	6.2	325	15	32	0.1
F7:53NG1058A	Lolobau, Banban Is.	F	Eastern		1.14	15.8	68.8	0.09	1.05	4.35	0.41	48	0.11	2.5	0.1	19	47	12.2	320	16	59	0.1
F1:51NG0270B	Mt. Krummel Area	F	W.P.S		5.45	17.1	53.5	0.11	0.44	10.4	0.62	269	0.15	4.05	25	103	81	6.6	439	14	33	0.1
F1:51NG0276	Mt. Krummel Area	F	W.P.S		4.95	18	54.5	0.08	0.42	9.55	0.36	243	0.15	3.15	31	98	76	4.4	424	11	22	0.1
F1:51NG0279	Mt. Krummel Area	F	W.P.S		4.85	18.5	54.5	0.09	0.41	9.55	0.45	253	0.15	3.85	29	61	73	4.4	452	11	25	0.1
F2:51NG2683A	Mt. Du Faure	F	Hoskins		2.4	16.3	63.4	0.1	1.15	6	0.37	136	0.1	3.8	7	42	57	17.6	480	9	57	0.1
F2:51NG2683C	Mt. Du Faure	F	Hoskins		2.8	16.3	62.8	0.1	1.24	5.9	0.38	155	0.1	2.65	7	42	52	17.6	484	8	54	0.1
F2:51NG2683D	Mt. Du Faure	F	Hoskins		3.1	19.9	59	0.1	0.8	7.2	0.45	180	0.12	1.42	13	57	62	11.8	560	9	50	0.1
F2:51NG2683E	Mt. Du Faure	F	Hoskins		3.75	17.9	57.2	0.1	0.66	7.45	0.57	203	0.14	3.9	7	77	64	9.2	477	23	43	0.1
F2:51NG2685A	Mt. Du Faure	F	Hoskins		4.8	15.7	58	0.18	1.11	8.75	0.53	190	0.12	3.1	23	83	63	12.8	625	13	59	2
F2:51NG2685B	Mt. Du Faure	F	Hoskins		4.7	15.9	58.3	0.13	0.88	8.15	0.46	177	0.13	3.65	19	71	65	11.8	441	13	49	0.1
F2:51NG2699	Mt. Du Faure	F	Hoskins		5.25	15.4	57.5	0.09	0.84	8.4	0.46	184	0.14	3.2	24	76	74	11.2	429	50	45	0.1
F3:51NG3062A	Mt. Wago	F	Hoskins		5.7	16.9	53.5	0.1	0.35	9.75	0.66	265	0.15	4	35	107	79	2.2	390	73	41	0.1
F3:51NG2686	Mt. Wago	F	Hoskins		3.9	16.3	57.2	0.16	0.9	8.15	0.65	289	0.13	4.05	30	165	75	13.8	442	41	67	0.1
F4:68490077	Cape Hoskins	F	Hoskins	Andesite	4.82	17.3	53.85	0.12	0.56	9.45	0.52	230	0.15	3.68	22	71	74	8.3	410	16	38	0
F4:68490092B	Cape Hoskins	F	Hoskins		1.34	16.44	65.28	0.21	1.35	5.05	0.42	76	0.13	2.81	0.2	13	64	14	355	23	66	0
F4:68490159A	Cape Hoskins	F	Hoskins		3.66	15.41	63.31	0.13	1.05	6.75	0.4	140	0.12	2.08	19	46	54	13	330	15	60	0
F4:174	KO	F	Hoskins	Andesite	3.85	16.37	57.26	0.17	0.83	0	0.54	190	0.14	0	13	0	72	13	390	19	58	0
F4:162	Mululus	F	Hoskins	Andesite	4.28	16.2	59.96	0.12	0.86	0	0.44	190	0.14	0	25	0	68	12	305	16	53	0
F4:159A	Mululus	F	Hoskins	Dacite	3.66	15.41	63.31	0.13	1.05	0	0.4	140	0.12	0	19	0	54	13	330	15	60	0
F4:108	Mt. Lolo	F	Hoskins	Andesite	2.28	16.99	61.24	0.24	0.88	0	0.52	135	0.14	0	3	0	67	9.2	430	23	50	0
F4:154	Mt. Oto	F	Hoskins	Dacite	1.88	16	64.5	0.18	1.12	0	0.47	120	0.13	0	3	0	68	16	385	23	72	0
F4:92B	Mululus	F	Hoskins	Dacite	1.34	16.44	65.28	0.21	1.35	0	0.42	76	0.13	0	0	0	64	14	355	23	66	0

name	location	Geo.	Social	material	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	V	MnO	FeO2O3	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb
F4:164	Mululus	F	Hoskins	Dacite	1.43	15.2	68.16	0.15	1.41	0	0.4	76	0.1	0	2	0	44	18	330	19	83	0
F5:51NG0241	Wulai Island	F	Hoskins		5.55	18.6	52.2	0.08	0.26	9.85	0.49	260	0.17	4.1	28	102	71	3.4	409	11	23	0.1
F6:51NG0218B	Cape Reilnitz	F	Hoskins		4.85	15.7	55.6	0.06	0.52	9.1	0.56	285	0.16	2.55	16	81	83	7.2	263	21	30	0.1
F6:51NG3052B	Cape Reilnitz	F	Hoskins		5.35	16.5	56.5	0.1	0.62	8.5	0.47	211	0.15	2.4	37	94	72	7.6	358	11	31	0.1
F7:53NG0814C	Lolobau, Banban Is.	F	Eastern		0.96	13.9	68.5	0.2	1.6	3.1	0.7	21	0.13	1.43	0.1	4	95	22.5	246	34	118	2
F7:53NG0839A	Lolobau, Banban Is.	F	Eastern		5.5	17.6	50.9	0.05	0.19	10.8	0.58	347	0.2	2.8	16	146	82	1.8	250	10	15	0.1
F7:53NG1047C	Lolobau, Banban Is.	F	Eastern		2.65	15.1	60.7	0.16	0.83	6.7	0.84	301	0.16	7.4	7	186	88	12.6	296	24	71	0.1
F7:53NG1051	Lolobau, Banban Is.	F	Eastern		1.1	13.7	69.2	0.24	1.28	3.8	0.74	38	0.14	0.99	0.1	9	83	21	255	33	111	1
F7:53NG2523C	Lolobau, Banban Is.	F	Eastern		6.7	15.9	53.6	0.09	0.39	10.6	0.61	282	0.17	3.5	37	55	73	4.6	296	15	30	0.1
F7:53NG2526A	Lolobau, Banban Is.	F	Eastern		1.13	14.3	69.4	0.22	1.2	3.75	0.69	19	0.15	1.18	0.1	5	95	20.5	267	33	110	2
F7:53NG0819B	Lolobau, Banban Is.	F	Eastern		1.53	15.5	65.9	0.18	1.05	4.55	0.67	82	0.14	1.96	0.1	21	75	16	279	27	88	0.1
F7:53NG0827A	Lolobau, Banban Is.	F	Eastern		5.75	17.1	53.5	0.06	0.37	10.6	0.59	256	0.17	2.7	25	114	68	4.8	259	12	25	0.1
F7:53NG0835G	Lolobau, Banban Is.	F	Eastern		3.2	18.2	55.9	0.09	0.56	9.25	0.68	255	0.15	2.75	14	90	72	8	303	16	39	0.1
F7:53NG1049	Lolobau, Banban Is.	F	Eastern		1.95	14.5	63.9	0.18	0.99	5.7	0.8	193	0.15	1.81	4	106	82	16.2	278	26	85	1
F7:53NG1054	Lolobau, Banban Is.	F	Eastern		2.2	14.5	62.2	0.24	0.97	5.85	0.91	92	0.16	2.2	1	4	102	15.2	300	28	82	0.1
F7:53NG0846	Lolobau, Banban Is.	F	Eastern		2.5	14.5	59.9	0.15	0.84	6.25	0.83	257	0.16	3.2	6	143	93	14.4	292	26	72	0.1
Gn1:114	North Willaumez Pen.	GN	W.P.N	Pyroxene Andesite	3.22	15.38	58.6	0.25	1.46	7.02	0.89	235	0.18	2.22	70	155	100	15	395	20	75	5
Gn1:263	North Willaumez Pen.	GN	W.P.N	Basalt	6.42	16.87	51.4	0.24	0.7	10.88	0.75	305	0.14	6.35	75	140	75	5	540	10	30	0.5
Gn1:296B	North Willaumez Pen.	GN	W.P.N	Basalt	7.42	14.91	52.42	0.17	0.8	10.84	0.73	340	0.18	2.3	105	155	75	15	300	20	40	0.5
Gn1:306	North Willaumez Pen.	GN	W.P.N	Dacite	1.48	14.63	66.34	0.21	2.14	4.04	0.71	40	0.14	1.63	75	70	90	25	270	25	115	0.5
Gn1:308	North Willaumez Pen.	GN	W.P.N	Dacite	2.22	15.15	63.39	0.21	1.89	5.33	0.74	125	0.14	2.12	50	90	75	20	285	20	90	0.5
Gn1:311	North Willaumez Pen.	GN	W.P.N	Basalt	6.73	15.91	51.57	0.11	0.44	11.74	0.8	275	0.17	2.74	100	175	80	5	355	5	30	0.5
Gn1:319	North Willaumez Pen.	GN	W.P.N	Dacite	1.29	14.5	66.91	0.11	2.22	3.76	0.53	65	0.14	1.04	45	35	90	25	275	30	130	0.5
Gn1:339	North Willaumez Pen.	GN	W.P.N	Basaltic Andesite	4.36	15.42	53.83	0.21	0.92	8.83	1.01	300	0.2	5	55	235	115	15	480	25	55	5
Gn1:51NG0256	North Willaumez Pen.	GN	W.P.N		1.31	14.4	67.2	0.24	2.15	3.75	0.68	49	0.13	1.45	2	26	87	28	280	36	127	2
Gn1:51NG0257	North Willaumez Pen.	GN	W.P.N		3.15	15.6	58.8	0.25	1.26	6.9	0.86	233	0.18	2.35	8	130	97	15.4	409	28	75	1
Gn1:75710018	North Willaumez Pen.	GN	W.P.N		3.1	15.09	58.56	0.25	1.33	6.95	0.87	227	0.19	2.16	10	130	99	16	412	28	78	0.1
Gn1:WP01010	Dakataua	GN	W.P.N	Basaltic Andesite	4.037	16.317	54.581	0.215	1.017	0	0.764	311	0.176	0	27	0	84	13.9	444.9	24.8	44	0.7
Gn1:WP01007	Dakataua	GN	W.P.N	Basaltic Andesite	3.464	15.482	55.382	0.218	1.075	0	0.719	267	0.153	0	24	0	82	14.8	384.2	25.6	52	0.8
Gn1:G02051	Dakataua	GN	W.P.N	Basaltic Andesite	2.632	17.65	53.065	0.262	1.053	0	0.728	241	0.177	0	20	0	0	18.1	404.9	36.5	109	1.6
Gn1:G02055	Dakataua	GN	W.P.N	Basaltic Andesite	3.081	17.092	54.302	0.145	0.901	0	0.745	274	0.155	0	23	0	0	16.8	423.4	26.6	89	1.3
Gn1:G02050	Dakataua	GN	W.P.N	Basaltic Andesite	1.751	14.126	53.549	0.189	1.337	0	0.566	167	0.139	0	10	0	0	22.4	330.9	37.3	111	1.7
Gn1:WP01006	Dakataua	GN	W.P.N	Andesite	1.76	16.689	60.276	0.252	1.659	0	0.816	104	0.154	0	10	0	95	20.6	304.1	39.1	121	1.8
Gn1:WP01012	Dakataua	GN	W.P.N	Andesite	1.867	15.079	62.731	0.265	1.816	0	0.747	115	0.143	0	11	0	86	22.3	289.8	37.8	106	1.6
Gn1:DR10706	Dakataua	GN	W.P.N		3.34	9.92	26.34	0.25	0.32	7.78	0.52	77.33	0.18	13.06	47.67	88.33	98.00	7.00	464.00	12.00	37.00	2.00
Gn1:DR10707	Dakataua	GN	W.P.N		2.50	12.84	40.87	0.15	0.62	7.68	0.74	148.33	0.16	11.11	40.33	138.67	90.00	6.67	385.67	21.67	53.00	5.33
Gn1:DR16286	Dakataua	GN	W.P.N		1.18	7.95	52.21	0.05	2.07	1.01	0.19	21.33	0.03	1.64	8.67	13.00	20.00	37.33	134.67	16.67	96.33	1.00
Gn1:DR10694	Dakataua	GN	W.P.N		5.31	10.15	36.92	0.34	0.50	8.11	2.77	301.33	0.32	16.26	80.33	111.00	149.33	17.33	194.00	45.67	214.33	25.00
Gn1:DR10720	Dakataua	GN	W.P.N		2.28	9.49	29.15	0.08	0.59	6.15	0.56	83.67	0.14	12.21	60.00	265.33	79.00	10.00	490.00	17.33	46.33	3.67
Gn1:DR10731	Dakataua	GN	W.P.N		1.36	10.81	50.32	0.12	1.59	3.00	0.59	33.00	0.12	5.48	20.00	28.00	68.67	23.00	219.00	37.33	107.33	11.33
Gn1:DR10730	Dakataua	GN	W.P.N		1.59	13.43	60.93	0.17	1.94	3.55	0.73	59.00	0.15	5.69	2.00	20.00	77.67	23.00	233.00	34.00	107.67	13.00
Gn1:51NG0258A	North Willaumez Pen.	GN	W.P.N		1.46	14.6	66.7	0.25	2	3.75	0.73	52	0.14	1.98	0.1	21	87	28	279	35	123	1
Gn1:75710026	North Willaumez Pen.	GN	W.P.N		3.12	15.64	58.22	0.25	1.35	7.05	0.94	222	0.19	2.15	9	122	96	15.2	414	29	76	1
Gn1:341	North Willaumez Pen.	GN	W.P.N	Pyroxene Andesite	2.92	16.87	58.93	0.2	1.63	6.87	0.62	200	0.16	2.71	30	80	75	20	525	15	70	5
Gn2:51NG0242	Kimbe Island	GN	W.P.N		4.5	18.6	52.6	0.09	0.4	9.85	0.76	258	0.15	3.6	17	102	70	3.8	400	14	30	0.1
Gn2:51NG0246	Kimbe Island	GN	W.P.N		10.1	15.3	49.2	0.06	0.19	13	0.52	258	0.18	2.55	119	127	65	1.2	228	13	21	0.1
Gn2:51NG0248	Kimbe Island	GN	W.P.N		5.75	18.5	51.1	0.07	0.43	10.6	0.67	284	0.16	3.8	30	66	74	4	382	11	20	0.1
Gn2:51NG0245A	Kimbe Island	GN	W.P.N		1.79	15.1	66.1	0.12	1.03	4.75	0.51	93	0.11	3.35	12	27	86	10	286	31	102	1
Gn2:51NG0250A	Kimbe Island	GN	W.P.N		5.05	18.5	51.1	0.07	0.42	10.5	0.69	277	0.16	3.6	21	87	73	3.4	385	12	23	0.1
Gs1:51NG3063	Mt. Garbuna, Welcker	GS	W.P.S		4.5	18.6	52.6	0.09	0.4	9.85	0.76	258	0.15	3.6	17	102	70	3.8	400	14	30	0.1
Gs1:51NG3064	Mt. Garbuna, Welcker	GS	W.P.S		1.27	14.6	68.5	0.16	2.8	3.6	0.54	60	0.09	1.8	0.1	24	56	41	406	20	117	1
Gs1:51NG3065	Mt. Garbuna, Welcker	GS	W.P.S		3.2	15.3	62.7	0.11	1.9	6.2	0.49	149	0.12	2.75	11	74	59	28	393	18	84	1
Gs1:75710022	Mt. Garbuna, Welcker	GS	W.P.S		3.75	16.52	57.25	0.13	1.4	7.78	0.6	186	0.18	4.36	9	70	60	15	565	14	45	0.1
Gs1:75710023	Mt. Garbuna, Welcker	GS	W.P.S		1.62	14.09	68.62	0.1	2.68	3.75	0.4	61	0.09	1.34	6	26	40	36	335	18	108	1
Gs:G02002	Garbuna	GS	W.P.S	Andesite	3.42	14.80	61.45	0.08	1.91	0.00	0.35	180.00	0.11	0.00	28.00	0.00	0.00	26.20	277.70	16.20	115.00	1.90
Gs:G02003	Garbuna	GS	W.P.S	Dacite	3.35	14.21	63.81	0.07	2.00	0.00	0.31	160.00	0.10	0.00	27.00	0.00	0.00	27.20	293.50	16.60	97.00	1.60
Gs2:51NG2707A	Mt. Bangum	GS	W.P.S		6.9	15.6	50.9	0.11	0.62	11.7	0.52	269	0.1	5.2	34	68	67	8.6	560	13	31	0.1
Gs2:51NG2707B	Mt. Bangum	GS	W.P.S		2.95	15.1	62	0.13	2.1	6.15	0.51	137	0.11	2.05	6	45	53	26	431	16	83	2
Gs2:51NG2708	Mt. Bangum	GS	W.P.S		3.4	16.9	59	0.14	1.34	6.7	0.51	129	0.13	3.15	8	71	53	8.8	488	18	83	1
Gs2:51NG2709	Mt. Bangum	GS	W.P.S		3.23	15.7	60.6	0.15	1.9	6.8	0.59	168	0.13	3.35	13	28	60	25.5	500	15	73	2
Gs3:279B	Garua Harbour	GS	W.P.S		0.58	12.62	72.19	0.02	3.7	2.07	0.33	30	0.05	3.14	30	25	35	60	245	20	160	10
Gs3:343	Garua Harbour	GS	W.P.S		0.24	12.58	75.33	0.02	3.82	1.25	0.27	35	0.07	1.58	40	20	40	55	200	20	150	0.5
Gs3:51NG0255	Garua Harbour	GS	W.P.S		7.35	13.2	57.1	0.11	1.26	9.05	0.5	185	0.14	3.5	83	74	63	17.4	394	16	54	0.1
Gs3:51NG0271	Garua Harbour	GS	W.P.S		0.26	12.8	75.6	0.03	3.85	1.22	0.27	6	0.07	0.33	0.1	3	38	55	206	21	150	2
Gs1:51NG0145B	Mt. Garbuna, Welcker	GS	W.P.S		3.3	15.7	61.6	0.13	1.85	6.55	0.5	168	0.13	3.15	13	66	60	25	447	16	77	2
Gs1:51NG0262	Mt. Garbuna, Welcker	GS	W.P.S		1.08	14.9	67	0.16	2.75	4	0.55	92	0.09	2.9	4	65	61	37	430	22	106	2
Gs1:51NG4004C	Mt. Garbuna, Welcker	GS	W.P.S		4.15	15.3	59.6	0.1	1.62	7.4	0.44	175	0.13	2.95	16	80	64	21.5	412	20	67	0.1
Gs2:51NG2713A	Mt. Bangum	GS	W.P.S		3.4	15.1	61.8	0.14	2.05	6.55	0.5	166	0.12	3.1	13	79	61	25.5	466	17	78	0.1

name	location	Geo.	Social	material	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	V	MnO	FeO2O3	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb
Gs2:51NG2713C	Mt. Bangum	GS	W.P.S		3.4	15.3	61.7	0.13	1.77	6.8	0.51	162	0.13	2.95	11	75	58	25	465	16	77	1
Gs2:51NG2714C	Mt. Bangum	GS	W.P.S		2.85	15.4	62.4	0.13	2.05	6.1	0.52	153	0.11	3.05	7	48	58	28	453	18	86	1
H1:48NG0013	Unea Island	H	Bali-Witu	Basalt	4.8	16.1	53.7	0.23	0.93	9.2	1.07	316	0.18	5.3	25	354	93	41.8	385	27	88	3
H1:48NG0020	Unea Island	H	Bali-Witu	Basalt	2.4	15.6	57.5	0.4	1.78	5.75	1.14	247	0.13	5.15	4	86	108	68	446	42	130	4
H1:48NG0500	Unea Island	H	Bali-Witu	Basalt	6.95	15.3	53.7	0.17	1.12	10.2	0.58	198	0.15	2.35	57	76	61	36.6	425	19	76	2
H1:48NG0505	Unea Island	H	Bali-Witu	Basalt	4	16.6	58	0.23	1.72	7.35	0.53	161	0.18	3.05	19	108	61	53.5	488	23	113	3
H1:48NG0520	Unea Island	H	Bali-Witu	Basalt	2.8	15.4	59.5	0.28	2.3	5.65	0.8	147	0.17	3.7	9	58	74	74.5	365	40	163	5
H1:48NG0523	Unea Island	H	Bali-Witu	Basalt	3.15	16.4	60.1	0.25	1.91	6.25	0.36	128	0.14	3.15	13	75	56	59.5	493	25	126	4
H2:48NG0028	Garove Island	H	Bali-Witu	Dacite	1.51	14.3	64.9	0.34	1.21	4.05	1.25	42	0.2	1.4	0.1	6	104	86.2	244	67	286	11
H2:48NG0033	Garove Island	H	Bali-Witu	Basalt	5.5	15.7	52.6	0.16	0.41	10.5	1.42	301	0.2	2.1	27	56	90	36	238	30	97	3
H2:48NG0034	Garove Island	H	Bali-Witu	Dacite	1.69	14.3	63.9	0.39	1.21	4.5	1.28	52	0.19	1.25	0.1	9	106	89	239	69	298	11
H2:48NG0036	Garove Island	H	Bali-Witu	Basalt	5.3	16.3	52.6	0.16	0.41	9.8	1.43	294	0.2	1.8	24	50	89	36.2	243	30	98	4
H2:48NG0526	Garove Island	H	Bali-Witu	Dacite	1.85	14.6	64.6	0.27	1.25	4.1	1.2	66	0.19	1.6	5	17	86	80.5	223	60	273	10
H2:48NG0532	Garove Island	H	Bali-Witu	Rhyolite	0.73	13.4	70.3	0.14	1.68	2.6	0.66	11	0.15	0.9	0.1	4	83	88	191	62	307	12
H2:48NG0556	Garove Island	H	Bali-Witu	Basaltic Andesite	3.8	15	54.9	0.25	0.51	7.35	1.75	325	0.23	4.9	5	20	114	48.4	287	42	120	5
H3:48NG0044	Wambu Island	H	Bali-Witu	Basalt	10.3	15.9	49.6	0.12	0.24	10.8	1.11	228	0.18	2.3	170	88	67	23	218	20	67	3
H3:48NG0048A	Narage Island	H	Bali-Witu	Basalt	5.8	18.4	47.5	0.37	0.72	12.6	0.95	276	0.19	6.2	31	116	68	24.6	748	18	64	1
H3:48NG0582	Munda Island	H	Bali-Witu	Basalt	11.3	15	49.2	0.11	0.25	10.8	1.14	234	0.18	3.45	227	81	70	24.6	195	21	68	3
H3:48NG0592	Munda Island	H	Bali-Witu	Olivine Tholeiite	9.15	16.6	49.9	0.1	0.21	11.1	1.01	225	0.17	2.3	152	73	68	24	210	21	58	1
H3:48NG0601	Wingoru, Witu Is	H	Bali-Witu	Basalt	5.95	17.2	51.8	0.19	0.83	10.6	1.03	247	0.18	2.95	38	116	69	35.2	396	21	72	3
H3:48NG0605	Mundua, Witu Is	H	Bali-Witu	Quartz Tholeiite	6.45	16.9	51.7	0.18	0.75	10.9	0.99	246	0.18	2.95	50	128	66	33.6	367	21	71	3
H1:48NG0006	Unea Island	H	Bali-Witu	Basalt	8.55	15.4	50.5	0.09	0.41	12	0.68	252	0.17	3.6	75	82	64	20.8	335	16	40	1
H1:48NG0022	Unea Island	H	Bali-Witu	Basalt	4.45	19.5	50.4	0.15	0.59	11.2	0.8	241	0.16	2.7	18	77	70	26.6	538	18	48	2
H1:48NG0509	Unea Island	H	Bali-Witu	Basalt	3.4	16.6	56.1	0.28	1.64	7.35	0.9	235	0.16	4.15	9	106	86	49.8	448	32	113	4
H2:48NG0559	Garove Island	H	Bali-Witu	Basaltic Andesite	4.35	16.4	55.4	0.17	0.53	8.1	1.38	194	0.2	3	18	25	87	44.6	247	37	130	4
H2:48NG0572	Garove Island	H	Bali-Witu	Basalt	7.95	16.5	49.7	0.08	0.2	12.9	0.85	261	0.18	1.55	61	60	67	20	228	17	42	2
H2:48NG0538	Garove Island	H	Bali-Witu	Basaltic Andesite	3.45	15.6	55.2	0.22	0.88	7.3	1.55	306	0.21	2.95	4	51	109	48	298	41	120	5
H3:48NG0038A	Undaka, Witu Is	H	Bali-Witu	Quartz Tholeiite	10.8	14.4	49.2	0.11	0.19	11.4	1.15	230	0.18	1.4	196	86	71	23.4	208	21	69	3
samp. 8014	Rabaul	Rabaul	Rabaul	Basalt	5.64	18.99	48.19	0.13	0.5	0	0.81	294	0.16	0	34	0	73	26	551	13	35	7
samp. 7084	Rabaul	Rabaul	Rabaul	Basalt	4.64	18.89	50.11	0.19	0.94	0	0.95	353	0.18	0	24	0	87	56	643	35	42	7
samp. 8080	Rabaul	Rabaul	Rabaul	Basalt	4.4	18.5	51	0.26	1.39	0	0.96	262	0.28	0	29	0	73	41	691	13	70	0
samp. 7007	Rabaul	Rabaul	Rabaul	Basalt	4.42	17.45	52.44	0.19	0.97	0	0.99	313	0.19	0	27	0	89	32	464	13	51	6
samp. 6985	Rabaul	Rabaul	Rabaul	Basaltic Andesite	3.79	16.7	54.71	0.2	1.21	0	1.07	291	0.35	0	13	0	94	32	457	13	64	0
samp. 7066	Rabaul	Rabaul	Rabaul	Basaltic Andesite	3.8	17.4	55.27	0.23	1.53	0	0.86	275	0.15	0	27	0	71	65	593	39	77	0
samp. 8015	Rabaul	Rabaul	Rabaul	Andesite	2.3	16.1	60.27	0.28	2.22	0	0.9	122	0.28	0	16	0	86	64	394	23	118	5
samp. 8087	Rabaul	Rabaul	Rabaul	Andesite	2.42	15.4	61.56	0.37	2.44	0	0.96	131	0.16	0	94	0	102	64	365	23	124	0
samp. 8016	Rabaul	Rabaul	Rabaul	Andesite	2.04	15.43	62.26	0.34	2.57	0	0.88	113	0.16	0	8	0	90	70	388	35	118	0
samp. 8042	Rabaul	Rabaul	Rabaul	Dacite	1.51	15.52	64.54	0.27	2.81	0	0.91	66	0.18	0	77	0	94	70	359	23	165	10
samp. 8047	Rabaul	Rabaul	Rabaul	Dacite	1.51	15.41	64.66	0.32	2.79	0	0.86	70	0.16	0	69	0	90	76	370	29	153	10
samp. 8058	Rabaul	Rabaul	Rabaul	Dacite	1.42	15.25	64.95	0.3	2.89	0	0.84	61	0.24	0	8	0	98	70	353	23	171	10
samp. RAB53	Rabaul	Rabaul	Rabaul	Basalt	5.44	20.27	48.85	0.12	0.45	0	0.72	316	0.14	0	24	0	64	18	556	13	29	0
samp. RAB97B	Rabaul	Rabaul	Rabaul	Basalt	6.08	17.7	50.05	0.13	0.81	0	0.82	322	0.15	0	30	0	77	26	498	17	46	0
samp. RAB182E	Rabaul	Rabaul	Rabaul	Basaltic Andesite	3.25	16.3	54.81	0.42	1.82	0	1.18	249	0.19	0	6	0	113	57	490	31	89	0
samp. RAB11A	Rabaul	Rabaul	Rabaul	Andesite	2.07	15.34	59.55	0.39	2.83	0	1.11	146	0.18	0	0	0	111	85	371	36	160	0
samp. RAB184D	Rabaul	Rabaul	Rabaul	Andesite	1.98	15.45	61.94	0.34	2.59	0	0.87	108	0.16	0	7	0	86	75	376	36	147	0
samp. RABB20G	Rabaul	Rabaul	Rabaul	Dacite	1.36	15.36	63.99	0.32	2.4	0	0.86	50	0.17	0	0	0	107	74	391	37	142	0
samp. RAB401	Rabaul	Rabaul	Rabaul	Dacite	1.63	15.57	63.42	0.36	2.69	0	0.87	89	0.15	0	0	0	82	74	375	38	149	0
samp. RAB105A	Rabaul	Rabaul	Rabaul	Dacite	1.56	15.21	63.32	0.19	3.05	0	0.74	89	0.12	0	0	0	61	78	289	35	186	0
samp. RAB125	Rabaul	Rabaul	Rabaul	Dacite	1.26	15.03	64.73	0.27	2.83	0	0.8	72	0.16	0	3	0	90	85	348	46	157	0
samp. RAB167	Rabaul	Rabaul	Rabaul	Dacite	0.99	14.78	64.82	0.22	3.77	0	0.77	10	0.15	0	7	0	95	101	331	37	192	0
samp. RAB182A	Rabaul	Rabaul	Rabaul	Rhyolite	0.47	13.03	73.28	0.05	1.66	0	0.31	13	0.08	0	0	0	42	53	206	32	139	0
samp. RP98413	Rabaul	Rabaul	Rabaul	Dacite	3.34	14.79	62.31	0.07	0.98	0	0.46	128	0.13	0	12	0	59	36	281	24	78	1
samp. RP98410	Rabaul	Rabaul	Rabaul	Rhyolite	0.8	13.19	70.91	0.07	1.66	0	0.31	26	0.1	0	0	0	52	54	253	34	127	1
samp. RAB59	Rabaul	Rabaul	Rabaul	Rhyolite	1.18	13.04	73.11	0.06	1.58	0	0.31	23	0.08	0	0	0	43	50	203	29	135	0
samp. RAB159	Rabaul	Rabaul	Rabaul	Rhyolite	0.85	12.87	72.25	0.06	1.65	0	0.31	19	0.07	0	7	0	42	49	204	29	131	0
samp. RP98411	Rabaul	Rabaul	Rabaul	Rhyolite	0.46	13.16	74.17	0.06	1.58	0	0.34	12	0.08	0	0	0	51	56	238	36	138	2
samp. RP98415	Rabaul	Rabaul	Rabaul	Rhyolite	0.57	12.63	72.19	0.05	1.83	0	0.3	18	0.08	0	0	0	44	55	211	32	135	1
samp. TAVQ-817	Rabaul	Rabaul	Rabaul	Andesite	2.81	15.88	59.46	0.29	2.1	0	0.88	146	0.155	0	10	0	96	57.5	425	30	117	2
samp. TAVT820	Rabaul	Rabaul	Rabaul	Andesite	2.48	15.91	61.57	0.33	2.36	0	0.89	104	0.164	0	6	0	90	64.5	409	33	131	2
samp. TAVW-823	Rabaul	Rabaul	Rabaul	Andesite	2.18	15.81	62.58	0.329	2.48	0	0.904	103	0.16	0	4	0	92	66.5	401	34	136	2
samp. VULA-801	Rabaul	Rabaul	Rabaul	Andesite	1.92	15.79	63.21	0.363	2.55	0	0.912	102	0.16	0	0	0	95	68.5	399	35	141	2
samp. VULM-813	Rabaul	Rabaul	Rabaul	Andesite	1.97	15.82	63.37	0.363	2.53	0	0.912	99	0.16	0	0	0	93	68	400	34	141	2
samp. VULP-816	Rabaul	Rabaul	Rabaul	Andesite	1.84	15.64	61.66	0.352	2.57	0	0.895	89	0.16	0	0	0	95	69	397	35	144	2
samp. VULN-814	Rabaul	Rabaul	Rabaul	Andesite	1.86	15.81	63.48	0.363	2.58	0	0.912	89	0.16	0	0	0	92	69.5	406	35	144	2
samp. VULG-807	Rabaul	Rabaul	Rabaul	Andesite	1.8	15.79	63.4	0.352	2.63	0	0.904	92	0.16	0	0	0	94	71	392	36	146	2
samp. VULH-808B	Rabaul	Rabaul	Rabaul	Andesite	1.79	15.75	63.19	0.36	2.62	0	0.91	91	0.162	0	0	0	96	70	393	35	144	2
samp. VULK811	Rabaul	Rabaul	Rabaul	Andesite	1.89	15.88	62.77	0.36	2.54	0	0.907	100	0.161	0	0	0	97	69	404	35	140	2
samp. SER40	Rabaul	Rabaul	Rabaul	Andesite	2.26	15.8	62.22	0.33	2.48	0	0.91	106	0.165	0	4	0	86	62	380	31	129	2

name	location	Geo.	Social	material	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	V	MnO	FeO2O3	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb
samp. RP98020	Rabaul	Rabaul	Rabaul	Andesite	2.81	15.72	61.43	0.32	2.32	0	0.88	114	0.162	0	2	0	86	67.2	400.5	34.5	131.8	3.1
samp. RP96-030	Rabaul	Rabaul	Rabaul	Andesite	1.83	15.74	63	0.35	2.6	0	0.91	98	0.164	0	0	0	90	66	380	33	137	2
samp. RP96-049	Rabaul	Rabaul	Rabaul	Andesite	3.25	15.65	60.44	0.31	2.24	0	0.89	138	0.169	0	14	0	90	58	378	29	115	2
samp. RP96080	Rabaul	Rabaul	Rabaul	Andesite	1.9	15.43	61.51	0.358	2.54	0	0.907	89	0.162	0	0	0	85	65	389	33	140	3
samp. RP96100	Rabaul	Rabaul	Rabaul	Andesite	3.7	15.58	59.9	0.29	2.11	0	0.88	139	0.166	0	19	0	94	54.5	385	28	115	2
samp. RP97001	Rabaul	Rabaul	Rabaul	Andesite	3.55	15.53	60.17	0.312	2.16	0	0.873	127	0.166	0	19	0	85	56	384	29	118	2
samp. RP97030	Rabaul	Rabaul	Rabaul	Andesite	1.92	15.8	63.17	0.357	2.54	0	0.91	93	0.166	0	0	0	88	65.5	385	33	140	3
samp. RP97212	Rabaul	Rabaul	Rabaul	Andesite	4.48	15.84	58.03	0.274	1.85	0	0.825	144	0.167	0	29	0	82	49	389	26	103	2
samp. RP97222	Rabaul	Rabaul	Rabaul	Andesite	1.9	15.8	63.14	0.358	2.53	0	0.914	93	0.165	0	0	0	87	65.5	385	33	140	3
samp. RP98048	Rabaul	Rabaul	Rabaul	Andesite	2.61	15.86	61.47	0.334	2.35	0	0.906	112	0.165	0	8	0	81	68.4	407.4	35.4	129.7	2.6
samp. RP98051	Rabaul	Rabaul	Rabaul	Andesite	2.13	15.76	62.19	0.347	2.47	0	0.907	100	0.163	0	2	0	82	71	402.1	36.1	136.6	2.4
samp. RP99007	Rabaul	Rabaul	Rabaul	Andesite	1.99	15.74	62.46	0.357	2.54	0	0.921	96	0.164	0	0	0	84	73.7	392.5	37.5	139.2	2.6
samp. RP99011	Rabaul	Rabaul	Rabaul	Andesite	2.5	15.72	59.9	0.321	2.19	0	0.877	132	0.158	0	8	0	96	66.1	398.1	34.1	120.7	1.9
samp. RP0015P17	Rabaul	Rabaul	Rabaul	Andesite	1.95	15.79	62.85	0.356	2.54	0	0.928	133	0.168	0	0	0	0	69.5	363.1	37.1	145.7	3.05
samp. 18NG-1010	Bam Island	Vitiaz	Vitiaz	Basaltic Andesite	5.41	16.5	54.9	0.19	1.36	0	0	269	0.16	0	14	0	63	29.6	731	11	30	0.5
samp. 18NG-1023	Bam Island	Vitiaz	Vitiaz	Andesite	3.4	17.1	58.8	0.23	1.27	0	0	217	0.14	0	5	0	66	36	792	12	39	0.67
samp. 19NG-0953	Boisa (Aris)	Vitiaz	Vitiaz	Basaltic Andesite	8.2	14.5	53	0.14	0.55	0	0	266	0.17	0	45	0	67	20.6	615	10	20	0.34
samp. 7471-0030	Manam Island	Vitiaz	Vitiaz	Basaltic Andesite	6.4	16.6	53.5	0.2	1.03	0	0	320	0.16	0	48	0	78	30.5	585	15	43	0.75
samp. 7471-0001	Karkar Island	Vitiaz	Vitiaz	Basaltic Andesite	3.15	19.6	53.8	0.16	0.88	0	0	263	0.16	0	10	0	77	31.6	490	15	34	0.8
samp. 7571-0015	Karkar Island	Vitiaz	Vitiaz	Basaltic Andesite	4.15	15.3	54.69	0.2	1.04	0	0	393	0.22	0	11	0	106	37.8	407	18	45	0.95
samp. 26NG-0788	Bagabag Island	Vitiaz	Vitiaz	Basalt	6.5	16.4	51.2	0.18	0.57	0	0	310	0.18	0	44	0	82	28.4	354	16	45	1.71
samp. 26NG-0787	Bagabag Island	Vitiaz	Vitiaz	Basalt	5.5	17.2	52.1	0.19	0.7	0	0	246	0.18	0	19	0	77	30	369	18	48	2.16
samp. 32NG-0754	Long Island	Vitiaz	Vitiaz	Basalt	6.85	17.9	48.1	0.15	0.72	0	0	338	0.2	0	28	0	77	19.4	787	12	24	0.44
samp. 32NG-0143A	Long Island	Vitiaz	Vitiaz	Basalt	4.4	17.4	51.4	0.25	1.33	0	0	318	0.22	0	7	0	99	38.5	706	16	45	0.89
samp. 32NG-0124	Long Island	Vitiaz	Vitiaz	Basaltic Andesite	3.1	15.1	56.7	0.39	2.25	0	0	255	0.25	0	4	0	133	61.5	665	25	74	1.47
samp. 32NG-0726	Tolokiwa Island	Vitiaz	Vitiaz	Basalt	7.5	16.7	48.9	0.22	0.88	0	0	273	0.19	0	61	0	69	27.2	588	18	35	0.68
samp. 32NG-0679	Umboi Island	Vitiaz	Vitiaz	Basalt	5.55	18.7	49.5	0.16	0.66	0	0	353	0.2	0	19	0	83	20.2	633	13	23	0.45
samp. 32NG-0111	Umboi Island	Vitiaz	Vitiaz	Basalt	14.9	12	49.9	0.11	0.56	0	0	259	0.18	0	388	0	73	19.8	372	10	24	0.38
samp. 32NG-0682	Umboi Island	Vitiaz	Vitiaz	Basalt	7.05	15.8	50	0.14	0.53	0	0	334	0.21	0	26	0	79	18.4	499	12	20	0.33
s_1 [5432]	Mount Hagen	N.G.	N.G.	Shoshonite [5432]	12.4	13.5	50.5	0.58	2.35	7.85	0.92	210	0.14	1.53	340	75	0	74	560	20	83	3.1
s_2 [5432]	Mount Hagen	N.G.	N.G.	Shoshonite [5432]	8.2	15.1	52.2	0.59	2.35	8.8	1.01	230	0.15	1.45	115	105	0	69	615	21	92	2.1
s_3 [5432]	Mount Hagen	N.G.	N.G.	Andesite, Olivine-Hornblende-Augite-Hypersthene [5432]	6.6	15.3	54.4	0.45	2.32	7.65	1	205	0.14	2.65	75	129	0	65	980	24.5	155	3.7
s_4 [5432]	Mount Hagen	N.G.	N.G.	Andesite, Olivine-Hornblende-Augite-Hypersthene [5432]	5.15	17.2	56.8	0.23	1.85	5.6	0.81	150	0.12	2.65	75	59	0	41.5	705	18	155	5
s_5 [5432]	Mount Hagen	N.G.	N.G.	Andesite, Hornblende-2 Pyroxene [5432]	3.45	18	58.4	0.29	1.7	5.75	0.72	125	0.12	2.5	25	53	0	48.5	755	17.5	145	6.3
s_6 [5432]	Mount Hagen	N.G.	N.G.	Andesite, Tridymite-2 Pyroxene-Hornblende [5432]	2.1	18.2	60.8	0.31	2.3	5.45	0.5	69	0.11	2.25	11	20	0	64	935	18	180	4.8
s_7 [5432]	Mount Giluwe	N.G.	N.G.	Shoshonite [5432]	6.5	17.3	51.2	0.58	2.35	8.75	0.99	260	0.14	2.8	81	122	0	65.5	770	21	84	2.4
s_8 [5432]	Mount Giluwe	N.G.	N.G.	Andesite, Olivine-2 Pyroxene [5432]	5.55	16.7	54.9	0.55	2.3	7.5	0.85	185	0.12	2.15	70	85	0	82.5	815	21.5	98	2.1
s_9 [5432]	Mount Giluwe	N.G.	N.G.	Andesite, 2-Pyroxene [5432]	6.45	15.8	56.1	0.47	2.9	6.35	0.78	145	0.12	2.2	130	78	0	108	710	22	145	5.8
s_10 [5432]	Mount Giluwe	N.G.	N.G.	Andesite, Hornblende-2 Pyroxene [5432]	2.85	18.8	56.8	0.79	2.4	6.4	0.62	69.3	0.13	4.78	10	30	0	82	945	21.5	125	4.4
s_11 [5432]	Mount Murray	N.G.	N.G.	Basalt, Olivine [5432]	8.55	14.7	49.9	0.69	1.75	9.6	1.34	285	0.17	1.85	95	135	0	38	635	21.4	115	6.3
s_12 [5432]	Mount Murray	N.G.	N.G.	Basalt, Olivine [5432]	5.2	16.8	52.3	0.7	2.05	7.95	1.48	280	0.16	2.45	33	100	0	43	765	24.5	135	9
s_13 [5432]	Mount Murray	N.G.	N.G.	Andesite, Hornblende-2 Pyroxene [5432]	2.25	17.1	58.5	0.5	2.7	6.4	1.01	130	0.16	3.55	8	22	0	81	785	23.5	285	12
s_18 [5432]	Mount Bosavi	N.G.	N.G.	Basalt, Alkaline, Olivine [5432]	11.7	14.1	47.1	0.42	0.95	9.9	1.28	280	0.18	3.45	222	68	0	29	675	20.5	146	8.9
s_19 [5432]	Mount Bosavi	N.G.	N.G.	Basalt, Olivine [5432]	6.75	16.2	52.5	0.5	1.8	8.2	1.01	195	0.18	2.95	97	52	0	39.5	690	22	187	13.5
s_20 [5432]	Mount Bosavi	N.G.	N.G.	Andesite, Hornblende-2 Pyroxene [5432]	2.1	17.3	60.2	0.34	2.5	6	0.68	120	0.12	2.95	10	42	0	71	765	21.5	256	14

Appendix 2

Precision and accuracy of the pXRF instrument as determined by comparison with basalt standards UHH MK.05.14E.57 and NIST688. Figure A2.1 courtesy of P. Grave, University of New England.

Analysis of the PXRF data from the two basalt standards UHH MK.05.14E.57 and NIST688 show that there is variation among the elemental concentrations. Overall, majority of elements were recovered well and remain close to 100% recovery, however some elements were not sufficiently recovered and were excluded from analysis (Mgo, K_2O, SiO_2, V, Ni, Cu, and Nb). Recovery % for elements taken from both standards is shown in Fig. A2.1 and the mean differences for elements analysed is shown in Fig. A2.2.

Table A2.1. Comparison of PXRF calibration and EDXRF Calibration. *Upper part of table*: UHH MK.05.14E.57 Basalt standard; *lower part of table*: NIST688 Basalt standard.

	UHH MK.05.14E.57 Basalt on Bruker Instrument 900F4708			UHH MK.05.14E.57 Basalt on QuanX EDXRF (Mills and Lundblad, 2006)	
element	mean	sd	rsd %	mean	sd
MgO (%)	6.693	0.341	5.1	3.497	0.099
Al_2O_3 (%)	13.451	0.574	4.3	13.365	0.031
SiO_2 (%)	47.667	2.016	4.2	52.360	0.035
K_2O (%)	1.181	0.075	6.4	0.8570	0.0078
CaO (%)	9.720	0.423	4.4	7.719	0.036
TiO_2 (%)	4.223	0.192	4.5	3.564	0.016
V (ppm)	386.6	20.403	5.3	444	17
MnO (ppm)	1949	0.005	2.5	1510	24
Fe2O3T (%)	12.963	0.387	3.0	11.350	0.010
Ni (ppm)	57.8	9.121	15.8	30.7	1.6
Cu (ppm)	53	5.244	9.9	79.8	7.7
Zn (ppm)	126.8	12.357	9.7	148.4	4.5
Rb (ppm)	22	5.612	25.5	31.6	1.1
Sr (ppm)	502.6	17.111	3.4	568.1	2.5
Y (ppm)	33	1.871	5.7	41.4	1.2
Zr (ppm)	267.4	9.503	3.6	351.5	2.4
Nb (ppm)	25.6	1.517	5.9	34.3	1.5
	NIST688 Basalt on Bruker Instrument 900F4708			NIST688 Basalt[a]	
element	mean	sd	rsd %	mean	sd
MgO (%)	5.654	0.270	4.8	8.46	0.14
Al_2O_3 (%)	14.912	0.212	1.4	17.35	0.13
SiO_2 (%)	41.980	0.994	2.4	48.35	0.997
K_2O (%)	0.280	0.012	4.2	0.187	0.009
CaO (%)	11.553	0.093	0.8	12.17	0.115
TiO_2 (%)	1.157	0.011	0.9	1.168	0.030
V (ppm)	119.25	15.650	13.1	250	13.890
MnO (%)	0.166	0.003	1.8	0.167	0.008
Fe2O3T (%)	11.403	0.201	1.8	10.34	0.007
Ni (ppm)	114	11.045	9.7	150	17.739
Cu (ppm)	74.25	6.4	8.6	96	4.439
Zn (ppm)	82.75	5.058	6.1	58	8.571
Rb (ppm)	1.75	0.5	28.6	1.19	1.253
Sr (ppm)	141.25	1.708	1.2	169.2	27.574
Y (ppm)	22.75	0.957	4.2	19	5.065
Zr (ppm)	48	1.414	2.9	59	60.243
Nb (ppm)	8.25	0.957	11.6	5.7	1.276

[a] Major elements: National Bureau of Standards, Standard Reference Material 688. Trace elements: GeoReM, 2019.

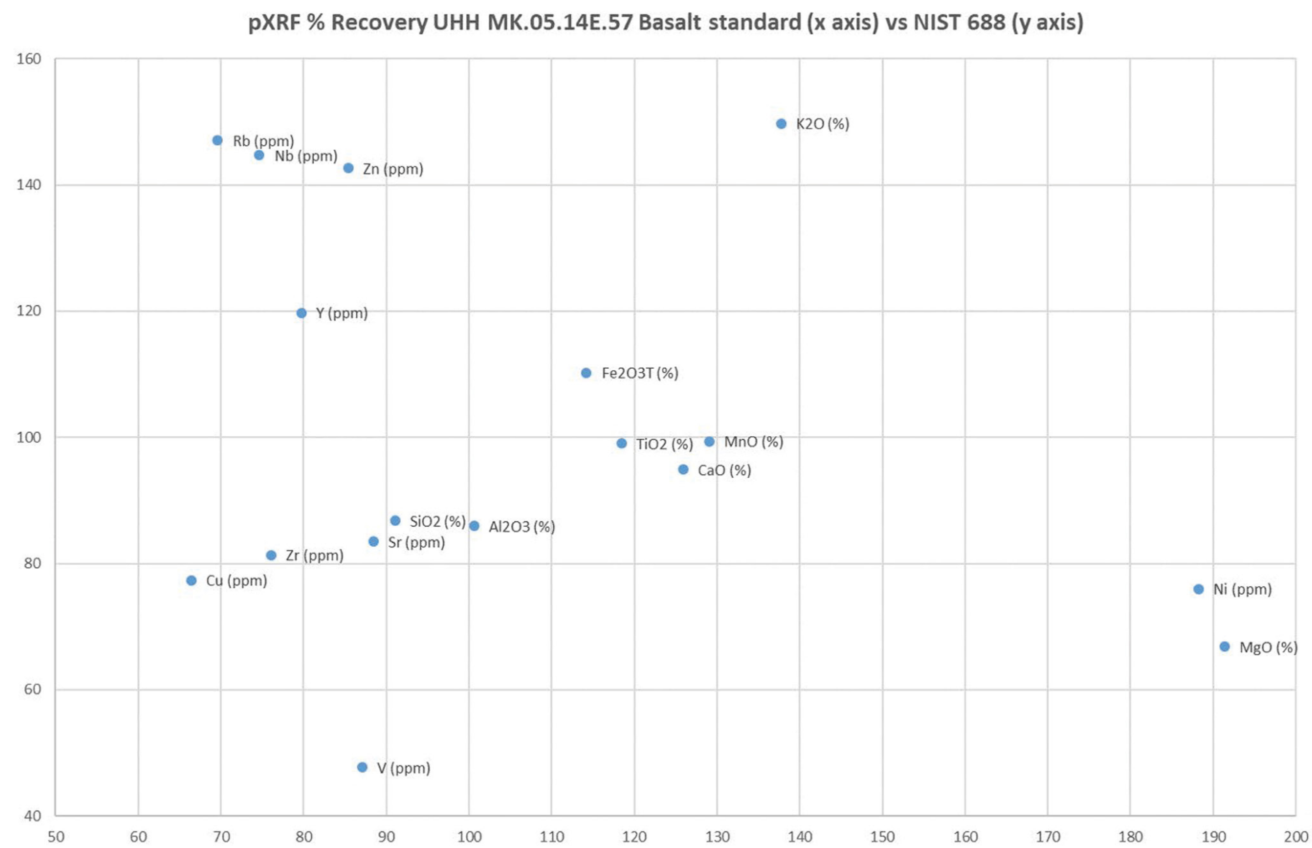

Figure A2.1. Recovery % for PXRF results against UHH MK.05.14E.57 Basalt standard and NIST688 Basalt standard (courtesy of Peter Grave).

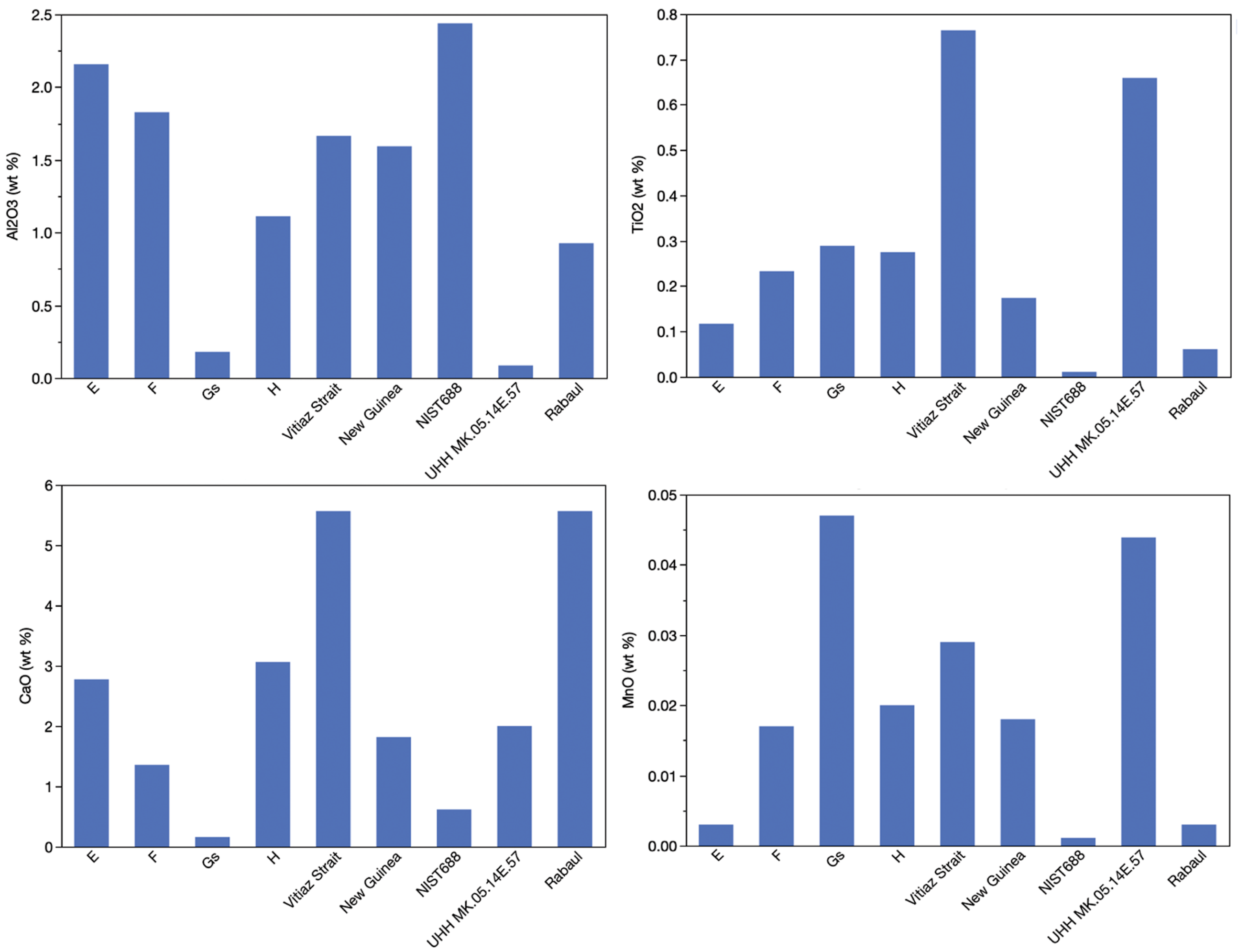

Figure A2.2. Mean differences for elements included in analysis between the Northern Willaumez Pen. geological region and all other geological regions used in this study, and the mean difference between the certified and experimental data for both standards. [*Fig. A2.2 continued on next page*].

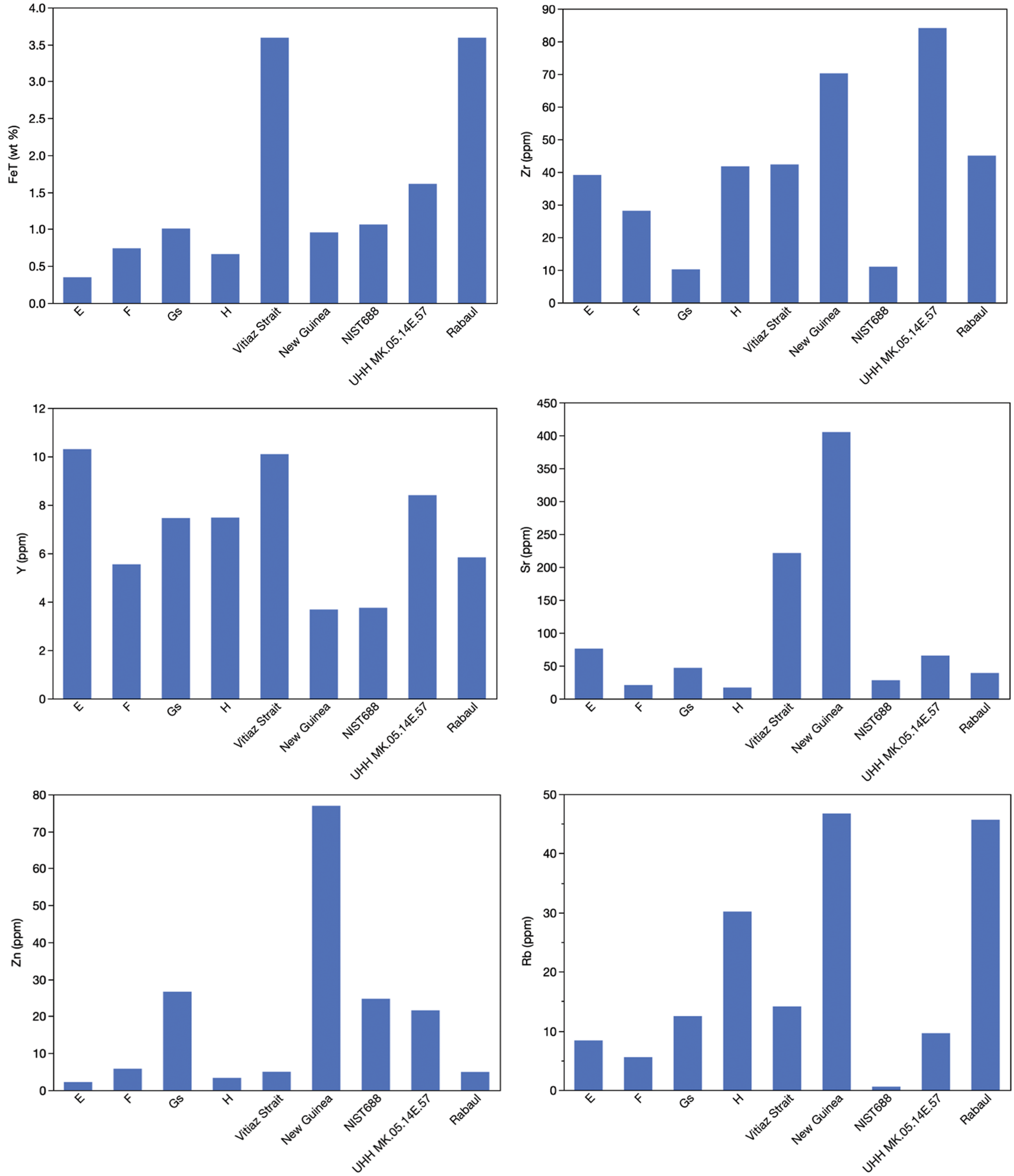

Figure A2.2 [*Continued from previous page*]. Mean differences for elements included in analysis between the Northern Willaumez Pen. geological region and all other geological regions used in this study, and the mean difference between the certified and experimental data for both standards.

Appendix 3. pXRF data for the archaeological sample, with assignments to geochemical and social regions. Artefacts with a DFA probability degree of 0.7 or higher are highlighted. Abbreviations of column-headings in this table: *pXRF*—pXRF sample code; *site*—Papua New Guinea site code; *Geo.*—Geochemical Region; *Social*—Social Region.

pXRF	site	location	context	item	Geo.	Social	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	V	MnO	FeO_2O_3	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb
WNB/S/5	FSV	Lamogai	Surface	axe cutting edge (CE) fragment	Vitiaz (0.9948)	Vitiaz (0.9984)	4.9	15.19	43.07	0.44	0.19	7.25	0.75	152.67	0.31	13.72	52	21.67	194.67	2	117.33	12.67	26.67	2.67
WNB/S/4	FSE	Konomwate	Surface	axe, complete	F (0.6468)	Hoskins (0.9168)	2.71	15.83	46.24	0.27	1.08	8.98	0.65	196.33	0.23	12.82	33.33	137.33	110.67	13.33	464.67	10	42.33	1.33
WNB/S/3	FSE	Konomwate	Surface	?adze or chisel fragment	n/a	n/a	2.83	12.2	33.28	9.03	3.96	10.67	0.86	77	0.22	10.84	15	54.67	235	78.33	983.33	21.67	116.33	0
WNB/S/1	FSC	Monkereme	Surface	?adze or chisel fragment	Gn (0.9885)	WPN (0.9738)	5.43	12.26	36.85	0.75	1.39	8.02	1.75	163	0.25	16.52	84.33	91	206	25	440.33	29	107.33	7
WNB/S/50	FLX	Iumielo	Surface	axe CE fragment	Rabaul (0.9942)	Rabaul (0.9946)	1.03	12.85	57.68	0.09	3.76	1.97	0.33	13	0.16	5.06	8.67	26.33	96.67	69.33	229.67	35	139.67	9
WNB/S/51	FLX	Iumielo	Surface	axe/adze CR or butt fragment	E (0.7183)	Hoskins (0.7322)	4.05	11.48	46.52	0.31	0.95	3.23	1.61	150	0.24	15.18	24.33	33	236	17.67	215.33	46.33	75	14.33
WNB/S/55	FLX	Iumielo	Surface	?flaked axe fragment	GN (0.7479)	WPN (0.6153)	1.76	14.63	52.09	0.47	0.97	4.36	1.17	66.67	0.16	9.39	6	15	103	23	244.67	40.33	145.33	10.67
WNB/S/60	FLX	Iumielo	Surface	axe CE chip	Vitiaz (1.0000)	Vitiaz (1.0000)	5.04	13.05	38.44	0.34	1.61	9.18	0.76	172	0.35	14.63	67.33	39.33	125.67	14.67	627.33	15	49.67	1.33
WNB/S/57	FLX	Iumielo	Surface	waisted axe fragment	Rabaul (1.0000)	Rabaul (1.0000)	2.66	14.37	56.2	0.16	1.38	1.17	1.15	84.33	0.2	11.63	5	30.67	239	111.67	261.67	21.33	48.67	0.67
WNB/S/58	FLX	Iumielo	Surface	axe CE chip	Rabaul (0.9788)	Rabaul (1.0000)	2.45	13.77	56.25	0.25	1.43	3.58	1.16	101.33	0.12	8.75	20.67	20.33	140.33	113.33	1676.33	14.33	106.33	0
WNB/S/56	FLX	Iumielo	Surface	axe/adze fragment	E (0.9492)	Hoskins (0.5033)	3.79	14.52	37.41	0.25	0.39	4.42	2.02	177.33	0.27	16.45	38.33	16.67	226.67	13.33	367.67	20	68	3.33
WNB/S/53	FLX	Iumielo	Surface	axe/adze butt fragment	Vitiaz (0.9079)	Vitiaz (0.8828)	3.95	15.53	47.44	0.43	0.27	7.79	1.13	136.33	0.28	10.91	15.67	20.33	273	11.33	303	29.67	54.67	7.33
WNB/S/59	FLX	Iumielo	Surface	?adze fragment	Vitiaz (1.0000)	Vitiaz (1.0000)	3.68	14.74	45.46	0.2	0.24	5.39	1.92	269.67	0.48	14.16	25	13.33	318.67	12.33	171.33	28.67	58.67	8
WNB/S/48	FLF	Iumielo	III layer 1 spit 1	axe fragment	GN (0.8484)	WPN (0.7192)	3.9	12.32	37.76	0.21	1.29	10.21	0.71	64.67	0.14	11.31	76.33	69	88.33	7.67	497	10.33	40.33	0.67
WNB/S/30	FFS	Apugi Island	Surface	?bark-cloth beater fragment	F (0.7432)	Hoskins (0.9693)	2.63	16.33	48.03	0.71	0.89	6.51	1.63	94.33	0.24	13.98	29.33	19.33	301	7	387.67	34	98.33	9
WNB/S/31	FFS	Apugi Island	Surface	?adze fragment	H (0.7051)	Rabaul (0.5746)	3.49	15.57	48.63	0.31	1.26	6.44	1.47	166.67	0.2	10.9	17	36.33	117	53.67	919.67	23.33	121.67	2.67
WNB/S/32	FFS	Apugi Island	Surface	axe/adze CE fragment	E (0.9742)	Eastern (0.4013)	4.3	13.55	50.89	0.37	0.35	7.96	1.61	323	0.27	13.08	28	32	209.67	26.67	203.67	24	51	7
WNB/S/33	FFS	Apugi Island	Surface	axe/adze CE fragment	E (0.9877)	Eastern (0.5269)	4.95	14.43	45.25	0.63	0.27	8.58	1.94	397	0.3	14.69	22.33	26.33	415.67	12	213.67	20.33	38	5.67
WNB/S/35	FFS	Apugi Island	Surface	flaked piece	GN (0.4068)	Hoskins (0.5454)	3.53	15	49.58	0.36	0.27	6.67	1.14	117.33	0.29	10.89	18.33	12.67	161.67	5.33	316.67	28.33	79.67	8.33
WNB/S/36	FFS	Apugi Island	Surface	axe CE fragment	E (0.8212)	WPN (0.7771)	4.46	13.18	45.16	0.38	0.31	6.49	1.73	420	0.34	15.24	23.33	27	184.67	12.67	196	25	43.67	8
WNB/S/37	FFS	Apugi Island	Surface	?adze butt fragment	GN (0.9434)	WPN (0.9390)	2.69	12.15	49.21	0.44	1.55	5.6	1.36	100	0.27	10.81	13.33	15.67	174.33	37	305.67	36.33	90.33	9
WNB/S/38	FFS	Apugi Island	Surface	?adze or wedge	E (0.9602)	Hoskins (0.5722)	3.29	14.11	50.2	0.32	0.31	7.38	1.3	170.67	0.23	11.32	18.67	27.67	181	17	179.33	26	51	8.33
WNB/S/40	FFS	Apugi Island	Surface	?tool fragment	E (0.7239)	Hoskins (0.5741)	1.88	14.17	53.03	0.33	1.01	3.55	0.97	28	0.14	7.72	7.67	20	161	61.33	248	40.33	160.67	9.33
WNB/S/41	FFS	Apugi Island	20N/30E surface	?axe stem	F (0.9218)	Hoskins (0.8804)	2.8	15.46	37.81	1.04	0.34	8.37	1.18	103	0.19	12.85	29.33	16	180.33	6.33	304.33	20	52.33	4.33
WNB/S/42	FFS	Apugi Island	20N/30E surface	?axe stem	Vitiaz (1.0000)	Vitiaz (1.0000)	4.89	12.28	55.7	0.48	0.2	5.68	1.8	189.67	0.44	11.68	11	19.33	291	5	228.67	33.67	49	13.33
WNB/S/43	FFS	Apugi Island	20N/30E surface	adze butt	F (0.9259)	Hoskins (0.9730)	3.74	15.76	38.06	0.76	1.02	9.88	0.69	178	0.23	14.22	63.33	111.67	139	13.33	345.67	10	30	1.33
WNB/S/45	FFS	Apugi Island	25N/30E spit 3	flaked piece	F (0.9577)	WPN (0.7840)	2.08	20.1	33.48	3.18	0.78	3.7	1.88	151	0.07	16.3	71.33	334	343.67	17.33	1428	100.33	235.33	21
WNB/S/46	FFS	Apugi Island	35N/40E spit 2	?axe butt or stem	GN (0.9948)	WPN (0.9965)	4.08	13.04	48.9	0.48	0.3	10.87	1.22	131.67	0.15	9.65	37.33	21.33	98	3.33	630.33	19	119.33	4.67
WNB/S/7	FFT	Apugi Island	Surface	?axe CE fragment	Vitiaz (1.0000)	Vitiaz (1.0000)	2.05	17.82	41.08	0.53	0.62	6.34	0.94	76.67	0.32	13.92	10.67	18.33	227.67	19.33	299.67	28	62.33	6.33
WNB/S/11	FFT	Apugi Island	Surface	?axe/adze fragment	GN (0.8678)	WPN (0.8494)	3.62	16.58	50.54	0.47	1.29	8.54	1.51	169	0.26	11.32	17	26.67	106.33	10.67	351	26.67	76.33	7
WNB/S/12	FFT	Apugi Island	Surface	?axe/adze fragment	GN (0.8348)	WPN (0.9133)	3.52	14.21	53.79	0.76	0.57	9.8	1.5	250	0.24	10.07	14.67	16	152	10.33	196	24.33	58.67	8.67
WNB/S/14	FFT	Apugi Island	Surface	axe/adze chip	GN (0.6259)	WPN (0.6077)	4.21	14.71	44.89	0.76	0.31	6.85	1.74	293.33	0.3	15.07	19.33	25	184	6.33	227.67	32.33	57.33	10
WNB/S/16	FFT	Apugi Island	Surface	axe/adze fragment	GN (0.7556)	WPN (0.5580)	3.38	17.61	36.21	0.92	0.21	7.32	2.19	201.67	0.27	17.65	31.67	39	255.33	5.33	568.33	38.33	122.33	8
WNB/S/19	FFT	Apugi Island	III spit 1	discoid, flaked	Vitiaz (0.9823)	Vitiaz (0.9770)	2.23	16.08	41.42	0.49	2.51	4.66	0.89	230.33	0.23	15.71	38.33	249.67	157.33	33.33	572	20.33	59.67	2.33
WNB/S/22	FFT	Apugi Island	III spit 2	axe fragment	E (0.9990)	Eastern (0.6031)	2.54	17.72	47.88	0.23	0.5	7.05	1.25	155.67	0.13	12.94	26	41.67	164	26.33	223.67	18	40.33	4.33
WNB/S/24	FFT	Apugi Island	III spit 3	adze fragment	E (0.7005)	WPN (0.5736)	6.01	13.92	39.93	0.17	0.5	7.94	1.5	171.67	0.18	14.54	57.33	32.33	116.33	20.67	283.33	25	81	6.67
WNB/S/25	FFT	Apugi Island	III spit 3	?adze butt fragment	Vitiaz (0.8671)	Vitiaz (0.9951)	5.42	14.76	54.52	0.23	0.43	6.7	1.95	340	0.27	13.16	23	78.33	421.33	21.33	347.33	25	43.67	8.33
WNB/S/26	FFT	Apugi Island	III spit 3	?adze butt fragment	GN (0.8951)	Vitiaz (0.5164)	6.62	14.43	50.35	0.66	1.54	6.3	2.04	249.33	0.35	14.01	32	42.33	268.33	16	1127.33	18.33	86	1
WNB/S/29	FFT	Apugi Island	IV spit 2	?bark-cloth beater fragment	n/a	n/a	2.42	14.9	42.78	0.4	0.82	2.55	1.38	66	0.36	16.65	34.33	56.67	777.67	36.67	339.67	32	81.67	7
WNB/S/64	FJS	Awat	30–40 cm deep	pestle, complete	F (0.9268)	Hoskins (0.9086)	1.23	15.15	37.72	0.51	3.06	13.69	0.34	50	0.19	10.63	19.33	107	211	31.33	474.67	14	42.33	1.67
WNB/S/63	FYA	Iumielo	I layer 1 spit 8	axe/adze CE fragment	E (0.7391)	Hoskins (0.8938)	4.45	15.55	40.07	0.45	0.63	10.01	1.1	143.33	0.23	14.09	45.33	18	121.67	7.67	200.33	25	49	6.33
AKIULI1	n/a	Akiuli	Surface	axe, complete	E (0.6813)	WPN (0.5711)	4.88	15.09	53.8	0.22	0.18	9.99	1.41	343.33	0.21	10.58	18.67	32.67	120	1.33	248	22.33	51.67	8.67
YAMBON1	n/a	Yambon	Surface	axe, complete	F (0.6108)	Hoskins (0.8839)	6.3	14.34	48.43	0.41	0.37	9.48	0.71	160	0.18	11.26	50.33	23	106.67	2.67	238	13	28.67	4
YAMBON2	n/a	Yambon	Surface	axe, complete	Vitiaz (0.9589)	Vitiaz (0.8986)	2.81	11.84	50.8	0.6	0.21	4.36	0.91	199.33	0.28	14.18	8	21.33	180.67	2.33	192.67	16.33	27.67	5.33
YAMBON3	n/a	Yambon	Surface	axe, complete	F (0.5502)	WPN (0.9476)	5.51	10	33.62	1.85	0.41	12.79	0.73	116.33	0.18	14.64	59.33	37.33	129	2.33	200	15.33	28.67	4
FHC/1/95	FHC	Misisil	I layers ⅔ interface	adze, flaked, ground, complete	GN (0.9899)	WPN (1.0000)	2.81	4.77	21.08	0.97	0.58	27.1	0.76	65	0.11	10.67	34.67	30	168.33	15	194.67	39	118	8.33
FYT/1	FYT	Hauwauyang	Surface	waisted axe, flaked, complete	Vitiaz (1.0000)	Vitiaz (1.0000)	2.96	10.34	44.43	0.62	0.55	4.87	1.87	143	0.42	15.17	19.33	58.33	416.67	8.67	176.33	39.67	170	8.67
FLK/25	FLK	Aringilo	Surface	axe fragment	E (0.9548)	Hoskins (0.9589)	4.51	15.71	36.64	0.25	0.19	7.36	1.15	132	0.22	14.59	57.33	83.67	135	3.67	192.67	27	55.33	7.67
FKR/4	FKR	Mihak	Surface	adze fragment	n/a	n/a	2.27	18.39	31.67	1.04	1.44	6.91	1.34	128.67	0.37	17.21	35.33	65.67	583	23	213	29.33	49.33	7
FIU/6	FIU	Akiuli	Surface	pebble, broken	Vitiaz (1.0000)	Vitiaz (1.0000)	3.46	14.93	37.43	0.39	0.91	4.24	1.47	131.33	0.44	17.05	20	37.33	398	49.33	722.33	30.67	74	2.67
FJA/8	FJA	Womilo	Surface	stemmed axe fragment	E (0.6342)	WPN (0.8062)	4.49	16.33	43.77	0.53	0.19	3.96	2.35	195.67	0.47	16.87	26	28	225.33	6	223	48.67	108.33	14.33
FLP/1	FLP	Analo	Surface	axe fragment	F (0.5747)	Hoskins (0.4617)	5.62	13.73	47.69	0.42	0.47	13.66	0.72	143	0.17	10.23	51.67	26	95.33	2.67	191.33	12	27.33	4

pXRF	site	location	context	item	Geo.	Social	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	V	MnO	FeO_2O_3	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb
FLP/2	FLP	Analo	Surface	axe fragment	Vitiaz (1.0000)	Vitiaz (1.0000)	2.98	17.75	40.4	0.42	0.38	5.98	1.31	155.67	0.38	15.43	46	29.67	256.67	34.67	279.33	29.33	102.33	5.67
FLP/3	FLP	Analo	Surface	?nut-cracking anvil	E (0.9607)	Hoskins (0.8487)	2.12	15.41	36.3	0.3	0.45	5.44	1.08	88.33	0.21	11.64	17.67	39.33	101.67	36.33	182.33	35	59.33	7.33
FFZ/23	FFZ	Ganglo Island	Surface	?nut-cracking anvil	E (0.9760)	Hoskins (0.9330)	3.82	15.6	39.72	0.32	0.19	7.75	1.13	128.33	0.22	14.22	40.33	29	157.33	4	177.33	19.67	32.33	6.33
FFQ/1	FFQ	Apugi Island	Surface	adze fragment	GN (0.8178)	WPN (0.9240)	4.03	14.66	51.4	0.21	0.22	9.32	1.58	290.33	0.29	11.39	25	13.67	153.33	1.67	248.33	39	124.33	14.33
FMU/147 (P/T/S/3)	FMU	Iumielo	Surface	adze fragment	E (0.7932)	WPN (0.4961)	6.35	12.53	42.33	0.26	0.18	9.77	1.11	181	0.26	13.87	51.33	18	132.67	3	179.67	15.33	23.33	4.67
FFS/AURARUO/1	FFS	Apugi Island	Surface	axe CE fragment	GN (0.8348)	WPN (0.8926)	3.15	15.68	55.3	0.33	0.38	9.89	1.35	134.67	0.21	8.96	20.33	16.33	47	4	143.33	33.33	100.33	12
FFS/AURARUO/2	FFS	Apugi Island	Surface	waisted tool—?net-sinker	E (0.8572)	Hoskins (0.9864)	3.22	15.01	35.28	0.53	0.23	5.46	1.46	109.67	0.16	14	31.67	21.33	287.67	4.33	220	30.33	81	6
FFS/AURARUO/3	FFS	Apugi Island	Surface	axe/adze fragment	F (0.8922)	Hoskins (0.9891)	1.02	18.13	47.46	0.73	2.92	2.68	0.5	13.33	0.18	6.73	2.33	23.67	128.33	69	230.33	50	154.33	9
FFS/1	FFS	Apugi Island	30N/25E surface	?axe/adze stem or butt fragment	E (0.8573)	Hoskins (0.9352)	4.14	16.01	41.04	0.59	0.23	9.23	1.15	160.33	0.25	13.7	48.33	27.33	167.67	8.33	168.33	21.67	39.67	5.67
FFS/2	FFS	Apugi Island	45N/30E surface	?adze butt fragment	E (0.5260)	WPN (0.6617)	2.91	14.45	49.97	0.51	0.45	6.93	1.48	180.33	0.25	11.17	19.33	16.33	178.67	24.33	287.33	23.67	65.67	6.67
FFS/3	FFS	Apugi Island	20N/35E surface	adze, complete	E (0.8485)	Hoskins (0.7384)	4.04	12.9	43.74	0.43	0.36	5.91	1.26	190.67	0.25	13.7	32.33	27.33	154.33	12.33	136	26.67	40	8
FFS/4	FFS	Apugi Island	20N/35E surface	flaked piece	F (0.8882)	Hoskins (0.8886)	3.46	10.17	42.93	0.62	0.13	6.5	0.44	44.33	0.18	13.22	80.33	31.33	127	5.33	105	21	46.33	6.67
FFS/6	FFS	Apugi Island	25N/35E surface	?adze fragment	F (0.6977)	Hoskins (0.8319)	3.24	15.91	47.02	0.82	0.37	6.99	1.56	158	0.29	13.81	19.33	31	210.33	6.33	247	40.33	70.67	12.67
FFS/7	FFS	Apugi Island	15N/45E surface	adze fragment	E (0.9560)	Hoskins (0.9917)	5.29	15.13	48.79	0.53	0.52	3	1.84	188.33	0.18	15.39	16.33	40.33	275	5	187	43	71.33	14.67
FFS/8	FFS	Apugi Island	30N/65E surface	?axe/adze butt	GN (0.5501)	WPN (0.8635)	3.15	13.71	56.03	0.27	0.2	7.15	1.77	148.33	0.23	10.25	15.33	15.67	124.67	14.33	177.67	26.33	63.67	9.67

Notes

The *pXRF sample code* column = West New Britain/South coast/sample number.

The WNB/S/- samples were run in 2020; the remaining samples were run in 2018 (Pengilley *et al*. 2019).

Yambon/1, -/2, -/3, AKIULI/1 were handed in by local people, findspots unknown.

In the *item* column, CE = cutting-edge.

In the columns for *geochemical and social regions*, matching allocations are highlighted; ‘n/a’ = not assigned.

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Cannibalism and Developments to Socio-Political Systems from 540 BP in the Massim Islands of south-east Papua New Guinea

Ben Shaw[1,2] and Simon Coxe[3]

[1] Evolution of Cultural Diversity Initiative, School of Culture, History and Language College of Asia and the Pacific, The Australian National University, Canberra ACT 0200, Australia

[2] Changing Earth School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney NSW 2052, Australia

[3] Monash Indigenous Studies Centre, Monash University, Clayton VIC 3800, Australia

Abstract. The consumption of human flesh, popularly defined as cannibalism, has arguably occurred throughout much of human history. In New Guinea, it has been associated ethnographically with warfare, mortuary rites and nutrition. However, it often evades detection in the archaeological record because of difficulties in distinguishing it from other social practices. Here we disentangle colonial myths associated with the consumption of human flesh and report disarticulated, burnt and cut human skeletal remains from two coastal sites spanning the past 540 years in the Massim island region of southeast Papua New Guinea. These sites, Wule and Morpa, both occur on Rossel Island. The skeletal evidence is contemporary with the construction of large stone platforms where human victims were often killed and consumed, and inland villages which were established in response to a well-attested period of conflict on Rossel and throughout the region. Within an ethnoarchaeological framework, we argue that cannibalism became increasingly prevalent in association with feasting as a means of maintaining social relationships and personal power. The findings are placed first within an island, then a regional model of emerging pressures on existing socio-political systems.

Introduction

Cannibalism—popularly but narrowly defined as eating the flesh of another person—has long been a subject of macabre fascination among public audiences because of its association with primitive behaviour (Kilgour, 1998). Yet, the consumption of human flesh has occurred globally throughout much of human history, and for reasons other than the acquisition of food (Fernandez-Jalvo *et al*., 1999; Andrews and Fernandez-Jalvo, 2003; Boulestin *et al*., 2009; Defleur and Desclaux, 2019). In most archaeological studies the social and psychological factors which make it a functionally useful practice are poorly defined, although economical, religious, and political motivations are often elicited (Villa, 1992; Conklin, 1995; Metcalf, 1987; Degusta, 2000). In the Pacific region, disarticulated, burnt and cut human bone have been attributed to cannibalism. However, the possible social implications are rarely discussed in detail (Kirch, 1984: 159; Poulsen, 1987: 250; Spennemann, 1987; Barber, 1992; Rechtman, 1992; Rieth, 1998; Degusta, 1999, 2000; Steadman *et al*., 2000; Bedford, 2006: 228; Pietrusewsky *et al*., 2007; Stodder and Reith, 2011). In large part, this is due to uncertainty in attributing skeletal evidence to disarticulation and cooking rather than to some other explanation, and likely also for fear of misrepresentation (Poulsen, 1987; Villa *et al*., 1986; Vilaca, 2000; Carbonell

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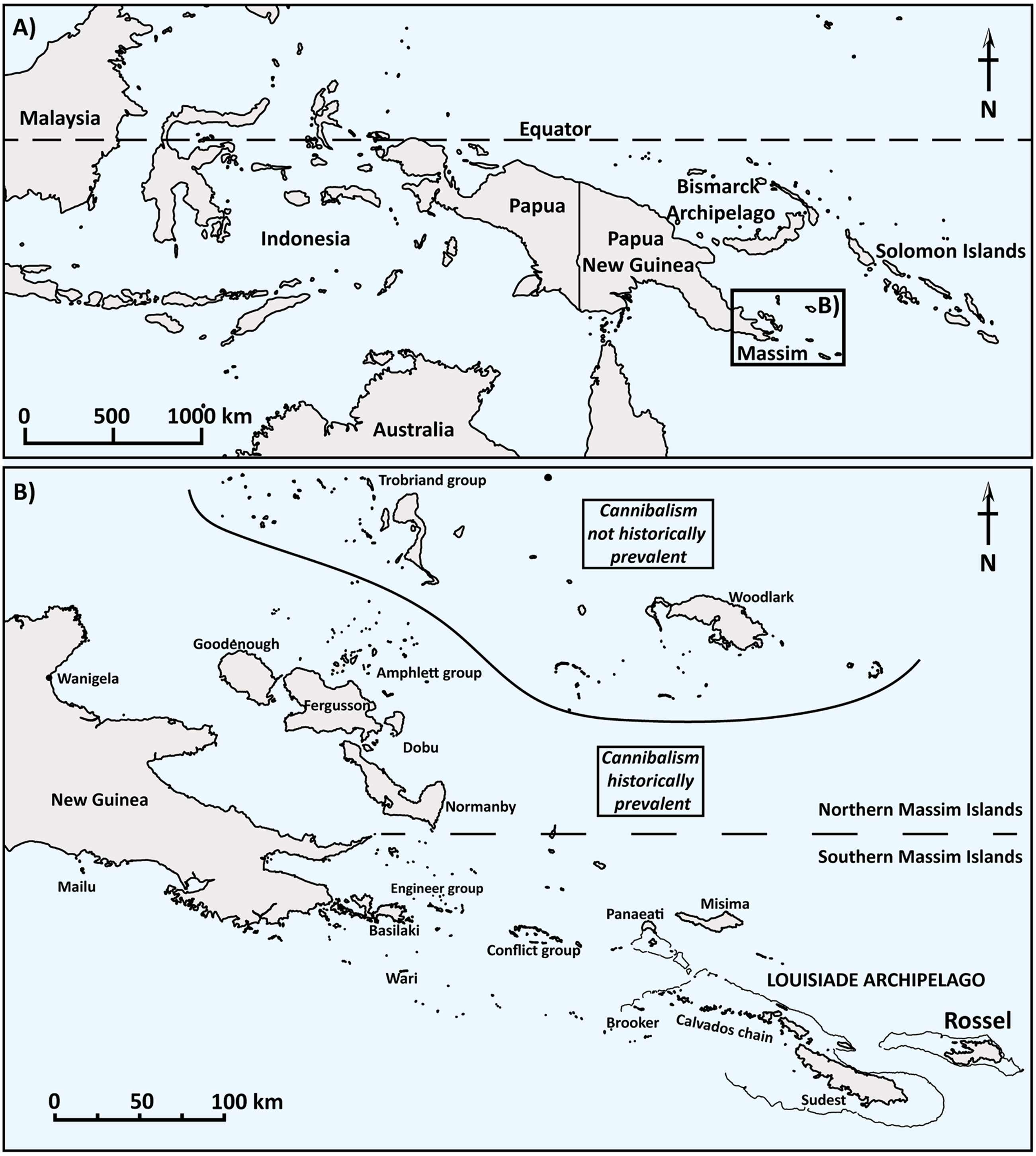

Figure 1. (*A*) Map of the Indo-Pacific region, showing the location of the Massim islands. (*B*) Location of Rossel Island within the Massim.

et al., 2010; Bello *et al*., 2016).

In this paper burnt and cut human skeletal remains recovered from excavations on Rossel Island in the Massim island region of Papua New Guinea (Fig. 1) are argued to reflect deliberate disarticulation and cooking. The Massim islands are well placed to investigate the significance of cannibalism in an archaeological context, because many detailed ethnographic descriptions of mortuary ritual, conflict and cannibalism are available and indicate that these activities continued until the recent past (Lee, 1912: 58–59; Malinowski, 1922: 27–28; Lepowsky, 1981; Macintyre, 1983: 138; Damon and Wagner, 1989; Liep, 2009: 82–84). Cranial and post-cranial skeletal remains from the Wule and Morpa sites span the past 540 years and were analysed within a comparative ethnoarchaeological framework, drawing on anthropological accounts of cannibalism and mortuary practices from Rossel Island to interpret the excavated data. Cremation and deliberate bone destruction were excluded as explanations for the condition of the human bone because neither practice is known historically or archaeologically in the Massim.

Prior to colonial pacification on Rossel Island, mortuary feasts following the death of high-status individuals involved the killing, cooking and distribution of a victim from another clan to reinforce social relationships in a similar manner to the distribution of cooked pig meats. We argue that such cannibalism was ritualised, and its prevalence coincided with a significant shift in island social organisation when individual rivalries had intensified to maintain social control of a rapidly emerging inter-island trade market.

Separating colonial myth from indigenous reality

Cannibalism—both the word and its connotative meaning—is wholly a colonial construct (Sanborn, 1998). Identifying cannibalism is of limited interpretive value unless the reasons why it was practised can also be defined so that Eurocentric racial stereotypes can be avoided. Fortunately, 20th century ethnographers have increasingly viewed the practice from a culturally relative perspective which has highlighted a myriad of reasons why societies historically consumed human flesh (Villa, 1992; Turner and Turner, 1995; Kilgour, 1998; Rumsey, 1999). Identifying cannibalism archaeologically can therefore contribute significantly to the modelling of past social systems by contributing time and contextual dimensions to the practice.

Accounts of expeditions in New Guinea from as early as 1606 AD have inferred the prevalence of cannibalism among coastal, island and highland cultural groups (Rochas, 1861: 87; Chalmers, 1887: 62; Lindt, 1887; McFarlane, 1888: 15; Beaver, 1920; Booth, 1929; Hilder, 1980: 75). Presumed evidence for cannibalism was commonly based on human bones observed hanging in houses or villages (Moresby, 1876: 133; Lyne, 1885: 166; Thompson, 1890). These remains were often determined later to be the curated bones of ancestors displayed at the final stage of prolonged traditional mortuary practices, and in some cases, were the skulls of enemies.

Some researchers have argued that cannibalism has not been directly observed historically and cannot be distinguished from other social practices in the archaeological record (Arens, 1979; Bahn, 1992). However, systematic analyses of human skeletal remains have been successful in identifying cannibalism based on taphonomic markers (Villa, 1992; White, 1992; Turner and Turner, 1999). In New Guinea, Stodder and Reith (2011) analysed prehistoric skeletal remains from the Sepik region and further stressed that interpreting remains in a context of historically and archaeologically documented mortuary practices allowed regionally nuanced patterns of body treatment to be identified.

Identifying cannibalism in the archaeological record is culturally sensitive. It requires detailed consideration of indigenous perspectives on why and how it was undertaken. Despite the well-known limitations of constructing behavioural analogies based on historical sources (e.g., see Torrence, 2003) it remains the best heuristic means of making sociological sense of the distant past. Even though many historical observations of indigenous social institutions were made after extensive change resulting from the influence of missionaries, traders and government agents (Macintyre, 1995; Roscoe, 2000; Spriggs, 2008), these institutions have their own histories and evolutionary trajectories that can be identified archaeologically in relatable forms in earlier times.

A particularly relevant example of a Massim social institution transformed in the post-colonial era is the regionally networked Kula exchange system, first recorded in detail by Malinowski (1922). Archaeological analyses have indicated that the historic Kula had antecedent roots at least five centuries earlier (Egloff, 1978; Irwin *et al*., 2019) and it has become increasingly evident that the level of complexity described by Malinowski was only made possible after government intervention ended endemic warfare at the turn of the 20th century (see also Swadling and Bence, 2016; Singh Uberoi, 1962).

Thus, the important question is how far back in time can we extend the historical accounts of Rossel Island social systems and the role(s) of cannibalism within them? Comparatively little is known about Massim society before the late 19th century. However, recorded oral testimonies of local inhabitants have gone some way in explaining aspects of the more distant past, particularly cannibalism, mortuary ritual and conflict. Here we recognise that while these practices were relatively quick to change following colonial pacification, the underlying belief systems associated with them did not undergo the same rapid transformation (Liep, 1983). The rationale for cannibalism and potentially related practices is still well known in Rossel Island society. Archaeological records in the Massim and adjacent coastal regions within the past 500–1000 years are now also relatively well known. Modelling the data has shed further light on the time depth and transformations of historically known practices (Bulmer, 1982; Shaw, 2016a; Skelly and David, 2017; Allen, 2017). Skeletal evidence on Rossel can therefore be interpreted within a relatively detailed ethnoarchaeological framework.

The historical rationale for cannibalism in the Massim islands

To understand how cannibalism was articulated within Rossel society, here we model the similarities and differences of pre- and post-colonial cannibalism according to the rationales for this activity in the Massim. Prior to colonial pacification at the turn of the 20th century inter-island trading in the Massim was interspersed with violent raids. Occasionally this involved the capture of human victims for cannibalism and skull trophies, which became objects of exchange (Lepowsky, 1991; Moore, 1991; Macintyre, 1994; Liep, 2009: 32). On the islands of Dobu, Misima, Panaeati, the Calvados chain, and certainly others, all of which are close to each other, war leaders held an elevated status in their communities because of their perceived strength and ability to organise inter-island raids (Whiting, 1975; Berde, 1983; Kuehling, 2014). The frequency of raids intensified throughout the southern Massim in the 19th century. Attacks were often undertaken by groups from small impoverished islands because of increasing population pressure on land and access to resources. The relative isolation of Rossel from neighbouring islands—at least 33 km across a rough open sea passage—limits inter-island contact even in the present-day. Historically, inter-island raids from Rossel did not occur and thus were not an explanation for cannibalism.

Unlike the southern Massim, raiding and cannibalism was not widely practised in the northern islands (Seligmann, 1910: 7). However, symbolic tasting of decomposing flesh during mortuary rituals is reported to have occurred on the Trobriand Islands (Malinowski, 1929: 156). Venturi (2002) recorded long bones and skulls with cut and puncture marks in a Trobriand cave dating to < 540 cal. BP. Their association with large *Tridacna* sp. shells and pottery suggests these were likely secondary burials involving disarticulation (see Ollier and Holdsworth, 1969; Egloff, 1972). Nonetheless, disarticulation for other purposes before burial cannot be ruled out.

The most detailed overview of cannibalism in the Massim is provided by Seligmann (1910: 548–564), with aspects having since been confirmed, clarified and elaborated by others (Macintyre, 1995; Jenness and Ballantyne, 1920: 32–35; Roheim, 1954). Most cases were attributed to one of three reasons. The first was eating deceased relatives exhumed soon after burial, with the belief that the dead person in one form or another was regenerated through the transfer of substance or vitality to a living person.

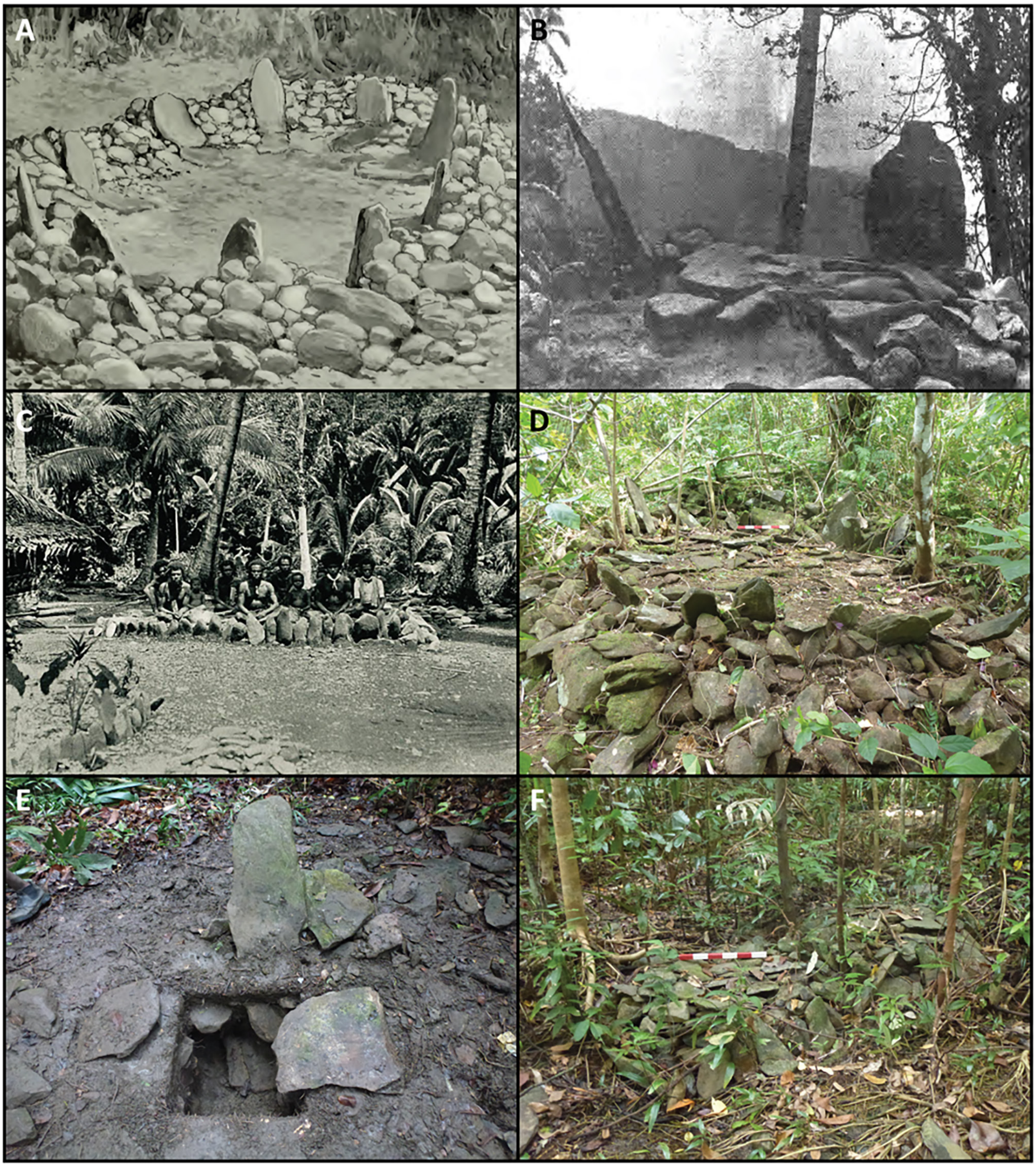

Figure 2. Stone structures associated with cannibal feasts in the Massim. (*A*) Stone circle (*gahana*) on Taupota Island, from Seligmann (1910: 465–466). (*B*) Stone platform on Goodenough Island, photo taken by Patrol Officer R. A. Vivian c. 1920 (Cochrane, 1986: 102). (*C*) Rossel Islanders sitting in a stone structure within their village, 1921 (Armstrong, 1928: 112–113). (*D*) Keyvu, platform with upright stones as part of a larger stone complex excavated by the lead author, Rossel Island in 2011. (*E*) Ndapa, paving and upright stone excavated by the lead author in 2012, Rossel Island. (*F*) Stones used in ground ovens to cook cannibal victims on NE Rossel Island.

Consumption of the recently-deceased was also seen as an act of piety or remembrance (Malinowski, 1929: 156). The second was for the pleasure of eating the flesh. 'Nutritional cannibalism' had also been reported in the Gulf region where human flesh was preferred over pig because of the superior flavour, and because stomach cramping or vomiting did not occur as frequently after excessive eating (Murray, 1933: 14; Seligmann, 1910: 552–553; Roheim, 1954). The best pieces of the body were reportedly the tongue, hands, feet, breasts, and the brain, which had to be extracted from the skull, with other parts needing to be disarticulated.

The third, and most prevalent reason was to avenge the death of a clan member that had occurred during a previous raid. The killing and eating of enemies were widely reported throughout New Guinea and was especially common in the Bismarck Archipelago, the island group to the north of the Massim (Parkinson, 1999: 203; Hahl, 1980: 86–87). Revenge killings and associated cannibalism in the Massim were typically organised events and planned well ahead of a raid (Young, 1971: 115). A raid could involve the taking of a targeted individual or a clan member from a related village. Cannibalism, therefore, occurred within an established

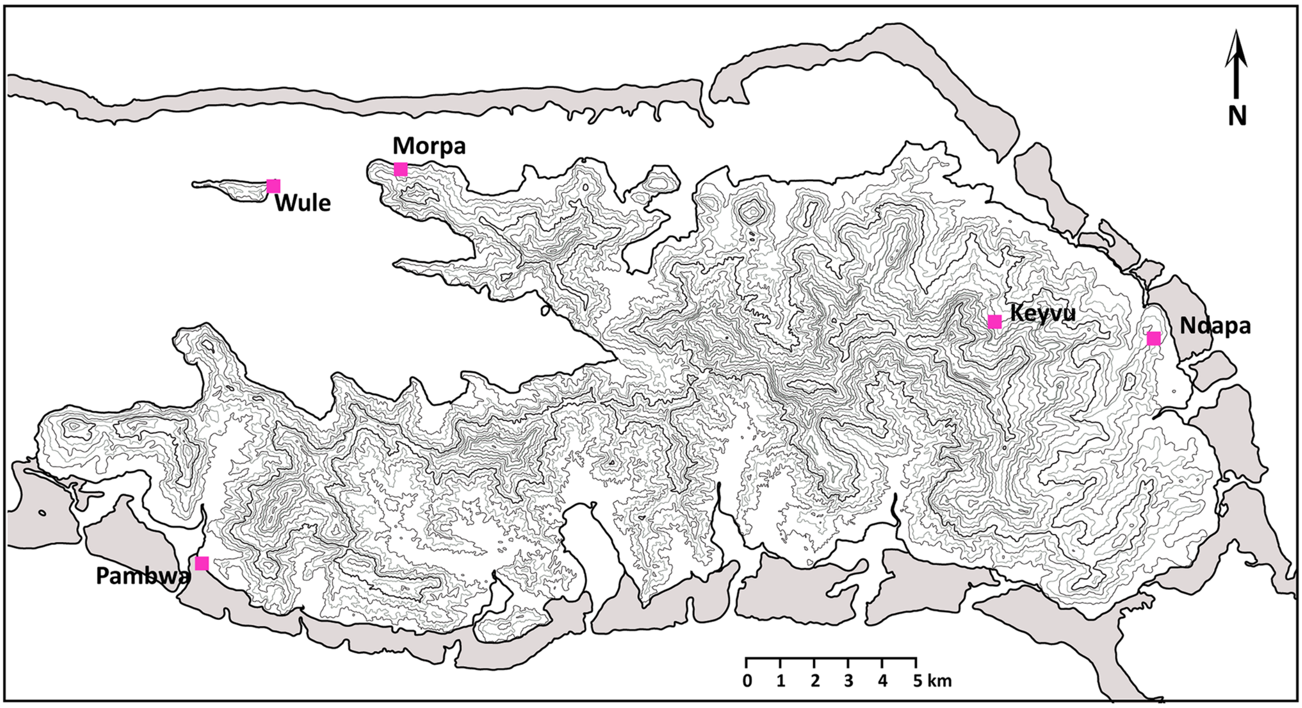

Figure 3. Rossel Island marked with sites mentioned in text.

context of island, clan, and familial organisation, which involved the preparation of a feast and payment of shell valuables and pigs to the individual who captured the victim.

Stone platforms and their connection to cannibalism

Stone circles were often the focal point of the feast where the victim was killed, cooked, dismembered, and distributed. These structures have been reported in several Massim island and mainland villages (Brass, 1959: 31) (Fig. 2a–c). Two stone platform complexes, Ndapa and Keyvu, closely associated with oral histories of cannibalism, were excavated on Rossel (Fig. 2d,e). Radiocarbon dating indicates Ndapa was built between 510 and 300 cal. BP (ANU 32531: 350±60), and Keyvu within the past 290 years (ANU 25131: 165±30; ANU 25130: 155±30). The stone platforms therefore overlap in time with historically recorded accounts of cannibalism on the island. Stones used in ground ovens (ntêmo) to cook men and women victims separately are located only 500 m away from Ndapa on the same ridge as part of a broader ritual landscape connected with local deities (Liep, 2009: 77; Henderson and Henderson, 1999: 73) (Fig. 2f).

Keyvu was abandoned sometime after the 1920s when indigenous communities relocated to the coast as colonial contact become more frequent (Shaw, 2015, vol. 2: 46–54). A Rossel man, Ben Kwelu, was born at Keyvu around 1920 and witnessed his father participating in a cannibal ritual there when he was a young boy. This story provides a direct connection between the Keyvu stone platforms and cannibalism. In contrast to Rossel and the southern Massim, the larger megalithic structures on the northern islands of Trobriand and Woodlark, although known places of burial, have no demonstrated association with cannibalism. These are, however, several hundred years older (Ollier *et al*., 1973; Bickler and Ivuyo, 2002).

Cannibalism, sorcery, feasting and leadership on Rossel Island

Rossel Island is infamously associated with cannibalism, at least in a historical context (Fig. 3). The earliest documented account was in 1793 when Captain John Hayes, during a brief visit to the island, observed human remains at the site of a feast (Lee, 1911: 588). In 1858 Rossel Island made global headlines after a French ship, the *St Paul*, was wrecked on the reef with more than 300 people left on board. They were killed and eaten over a period of three months (Rochas, 1861; Anderson, 2009). The event, although unusual in its magnitude, demonstrated that cannibalism was still practised in earnest in the mid-19th century. Less frequent instances have also been reported well into the first half of the 20th century (Moreton, 1905: 29; Murray, 1908: 15; Armstrong, 1928: 103–114; Shaw, 2015, vol. 2: 48–49). Oral histories attest that cannibalism was a relatively late development in Rossel society, introduced as the population grew and taboos were established to maintain 'law', with individuals killed and eaten as punishment for breaking those taboos (Shaw, 2015, vol. 1: 58–59).

The rationale for cannibalism on Rossel differed to other island communities in the Massim. It most often involved local victims rather than those from another island and was practised primarily as part of mortuary feasts following the death of a prominent individual. However, Armstrong (1928: 112) suspected that it also occurred under less formal conditions. Liep (1989) provides a concise account of the association of cannibalism with mortuary feasts, which corroborates and expands earlier descriptions by Moreton (1905: 29) and Armstrong (1928):

> When a big man died a victim had to be procured for the mortuary feast. Usually the deceased's relatives made strong allegations of sorcery, most often against affines of the deceased. To avoid being slain the suspected sorcerer must kill somebody else and take the body to the deceased's village. The compensation paid to the victim's relatives constituted the largest prestation in the Rossel prestige economy and involved the highest-ranking ndap shells and other valuables. The soliciting of valuables for the payment resulted in debts and replacements that probably took years to settle (Liep, 1989: 240–241).

To direct a person to be killed required considerable social power. This was held by only a few individuals on the island at any given time. In the case of a mortuary feast, discussions between leaders reportedly took place to decide who was to be killed and from what clan (Armstrong, 1928). Leadership on Rossel, like all Massim cultural groups except the Trobriand Islands, is not hereditary (Weiner, 1988). Authority is therefore temporary, limited in scope and always at risk if not continually reinforced (Lepowsky, 1991). Accruing status is almost entirely based on the ability to manipulate social relationships, to organise feasts and to accumulate high-value exchange items (greenstone axes, shell money, pigs, and ceremonial spatulas). The successful undertaking of a feast demonstrated the strength of the support given by other clans (Liep, 2007: 93). Population increase and mounting pressure on land resources in the centuries before colonial intervention may have led to the increased complexity of mortuary feasting, including the involvement of cannibalism (Liep, 1989).

No death on the island was considered natural no matter the individual's age, whether it be an infant or an older person, and in almost all cases, sorcery was the putative cause. Cannibalism on Rossel must therefore be understood with reference to Rossel belief systems concerning sorcery and in the context of clan organisation. For example, the killing of an individual might be understood as revenge for the murder of a family/clan member, but eating this individual could not be explained in the same way. Nor could the payment of high value shell money (ndap) to the victim's relatives, which burdened the killers with debts. Indeed, the distribution of food and the exchange of shell money at a feast is wholly aimed at forming and maintaining social relationships. In this context mortuary cannibalism can be understood as a social exchange in a similar way that a butchered and cooked pig is distributed at a feast to maintain such relationships.

Personhood in the Massim—a link to cannibalism

Consideration of personhood as a social construct in the Massim provides an important link in understanding why a killed individual is dismembered, cooked, distributed and consumed, rather than just killed. Unlike European perceptions of a person as an individual with inseparable qualities, in many Melanesian societies a person is considered as partible and dividual, defined by their social relations over a lifetime (Poole, 1984; Knauft, 1989; Wagner, 1991; Mosko, 1992, 2000; Strathern and Stewart, 1998). In the Massim, partible personhood is tangibly expressed through the exchange of objects such as ceremonial axes or spatulas and substances such as pig meat, blood and fat, which can have symbolic (metaphorical and metonymical) associations with a body part (Weiner, 1976; Strathern, 1988; Macintyre, 1984, 1995). In this respect, object exchange connects individuals in a delayed reciprocal relationship.

When a person dies on Rossel, the eating of food at the mortuary feast is equivalent to eating a lifetime of relationships. At Rossel funeral feasts, as in many Massim communities, objects and substances can therefore represent parts of a corpse (Liep, 1989; Battaglia, 1990: 190–191). These are exchanged with individuals who had a social relationship with the deceased as a means of regenerating or ending those connections (Battaglia, 1983; Damon and Wagner, 1989). Pigs are most often consumed because they represent social debt and require considerable investment of time and energy to rear, with a piglet often selected for a feast several years beforehand (Macintyre, 1984; Liep, 2009: 259–282). The past practice of cannibalism would likely have functioned within the same social framework, with the consumption of an individual fulfilling similar social obligations as a pig for the means of reproducing social relationships.

Distinguishing cannibalism from other mortuary ritual and conflict

Outlining pre-colonial mortuary practices and conflict on Rossel Island assists in distinguishing between cannibalised and non-cannibalised disarticulated human skeletal remains found in an archaeological context. Fortunately, both practices have been documented in detail by several observers over a century and there is excellent consistency between them (MacGregor, 1894: 3–7; Bell, 1909: 103–109; Armstrong, 1928: 103–106; Liep, 1989). After a death on Rossel Island, the corpse was usually buried in a shallow grave under the house, and sometimes in a sitting or crouched position. After several months, the decomposed body was exhumed, and the bones cleaned by close relatives. The skull and long bones (arm/legs) were curated in the house, and after some years they were transferred to a rock-shelter in the bush. The trunk of the body was sometimes wrapped in a covering of sago leaves, lashed into the fork of a tree, and left until decomposition was complete.

The excavation of a primary burial at the Pambwa site (Fig. 4) documents a pre-colonial burial practice on Rossel Island, dating to between 510 and 310 cal. BP (ANU 33527: 370±35 BP). The skull or head had been removed after soft-tissue decomposition had commenced, as indicated by the disarticulated axis vertebra and 17 teeth that had fallen out when it was removed. Skull removal, as well as the body position (supine with crouched legs), are similar to historically documented mortuary accounts (Shaw, 2015, vol. 1: 358–371). Rat gnawing on the bones further suggests that the body was partially exposed in a shallow grave while still fleshed. A gnawed skull fragment also indicated that the skull may have been fractured when the victim was alive or at least when the skull was still fleshed, and that this injury may have been the cause of death.

Figure 4. Primary burial at Pambwa, Rossel Island, with evidence for secondary removal of the skull. Dentition remaining in the grave fill, where the head was, indicates skull removal took place after decomposition.

Figure 5. Wule and Morpa sites and environs. (*A*) Wule beachfront and bay. (*B*) Wule excavation on shell midden. (*C*) Morpa Bay. (*D*) Morpa excavation.

Pambwa residents considered it likely the individual was a cannibal victim as the body had been buried in a midden heap. They noted that skull removal occurred with both cannibal victims and deceased family members, but that additional long bone removal only occurred with the latter and not the former, as was the case here. Because the body was not disarticulated, they suggested that it was only buried rather than eaten because payment had not been made. Examples of this were known to the community.

Neither bodies nor skeletal remains in ethnographic or archaeologically documented mortuary contexts were smoked or burnt, nor were the bones deliberately cut or broken. Head-hunting was also not historically practised on the island. Murder was relatively common, but this was typically undertaken using a spear or by collapsing the rib cage and puncturing the lungs (Armstrong, 1928: 106). There are also no known instances on Rossel of endocannibalism—the consumption of a deceased individual by family members. Evidence of burning, cut marks, substantive fracturing, and representation of body parts favoured for eating might therefore be associated with exocannibalism—the consumption of an individual from outside of the immediate social/clan group, rather than as a direct mortuary ritual or as mutilation of an enemy.

Wule and Morpa site chronologies, skeletal remains and pottery

Two sites excavated on Rossel Island in 2012, Wule and Morpa, produced fragmented human skeletal remains with evidence consistent with disarticulation and cooking. Both sites were on the northwest side of the island, with Wule situated on a small offshore island of the same name within the Rossel lagoon. At Wule 4 m^2 was excavated into a dense refuse midden deposit which had accumulated relatively rapidly between 540 and 290 cal. BP (ANU 32537: 440±30 BP; ANU 33525: 400±35 BP; ANU 32538: 286±22 BP) against the hillslope at the back of a narrow beachfront (Fig. 5a,b). At Morpa 3 m^2 was excavated into a buried cultural surface on a coastal flat and dated no earlier than 290 cal. BP (ANU 32533: 130±45 BP) (Fig. 5c,d).

Excavated pottery in the same context as the human skeletal remains was identified as Early-Middle Southern Massim Pottery (SMP) at Wule, and Late SMP at Morpa. On Rossel, Early SMP dates to 550–400 BP, Middle SMP to 400–200 BP and Late SMP to < 200 BP (Fig. 6). SMP has also been dated on several other islands in the Massim to the same age range, further confirming the antiquity of the skeletal remains (Irwin *et al*., 2019; Shaw *et al*., 2020). No pottery is made on Rossel Island, and pottery was only introduced to the island in large quantities c. 550 years ago (Shaw, 2016b). The Rossel population was drawn into regional trade at this time, probably to obtain high-quality shell necklaces (bagi) which are manufactured on Rossel and are a high-value exchange object throughout the Massim (Campbell, 1983). A transition from relatively shallow bowls in Early SMP to larger, open pots in Middle-Late SMP has been argued to reflect the increased use of pots in communal feasts where greater cooking volume was required (Fig. 6f,g) (Negishi, 2008; Shaw *et al*., 2020; Shaw and Dickinson, 2017). Specifically, large pots with clay banding, most common in Late SMP, are typically used at modern feasts to present sago pudding as a prestige food item, as well as other foods (Liep, 2009: 68). Excavated pottery at Wule and Morpa, therefore, supports increased feasting in the past 400 years on Rossel and throughout the southern Massim.

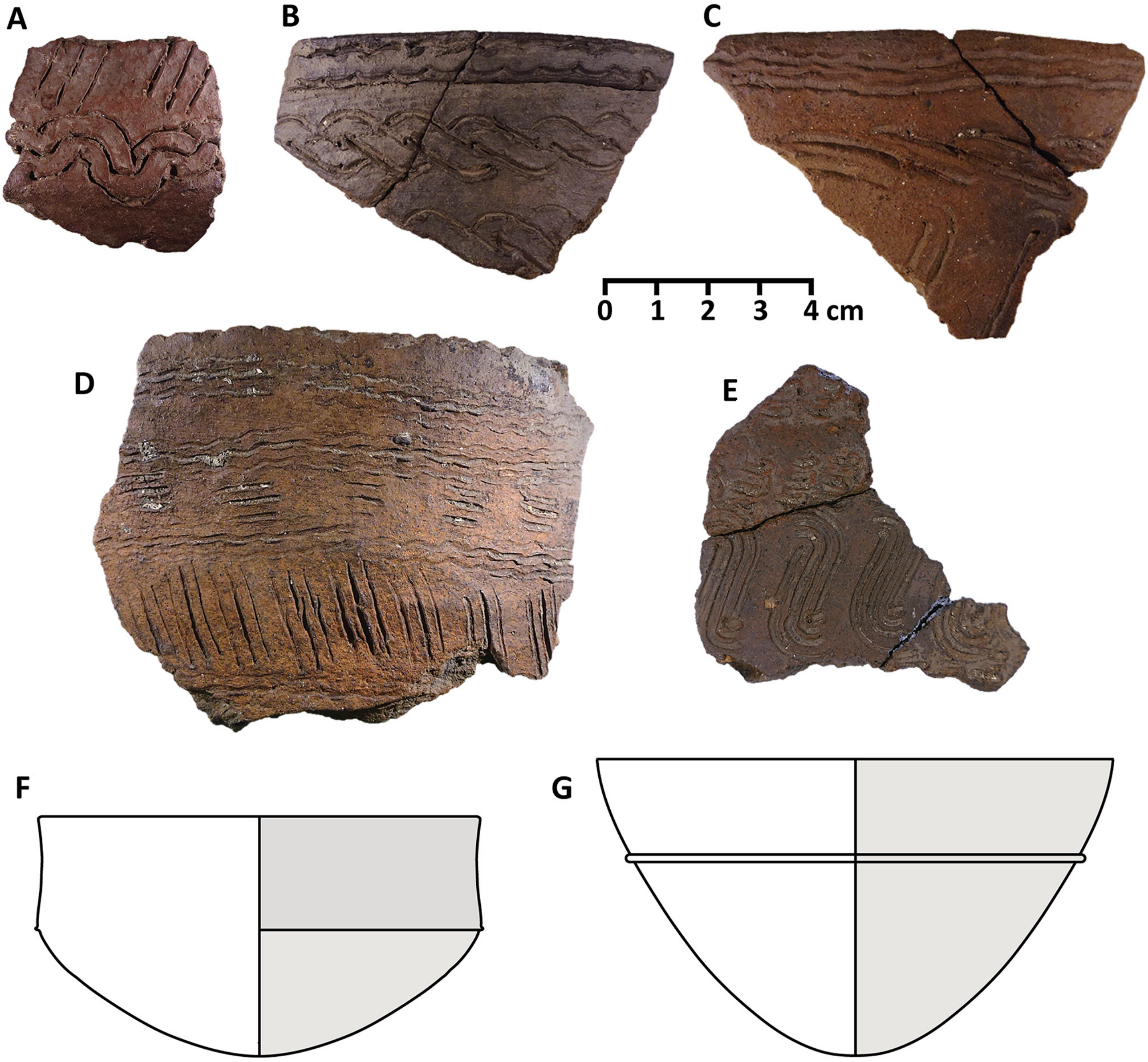

Figure 6. Southern Massim pottery recovered from Wule and Morpa. (*A,B*) Early SMP, Wule. (*C*) Middle SMP, Wule. (*D,E*) Late SMP, Morpa. (*F*) Early Southern Massim Pottery vessel. (*G*) Late SMP vessel with banding.

Skeletal remains

A partial mandible, three cranial fragments, a humeral and metatarsal shaft, and 12 human teeth were recovered from Wule, and clustered long bone fragments were recovered from Morpa (Table 1). The mandible had evidence of blunt force trauma to the ascending ramus, with cut marks on the medial aspect of the ramus suggesting deliberate breakage and defleshing (Fig. 7a). A humeral shaft had a large fracture resulting from direct blunt force trauma, with cut marks in several directions around the point of impact (Fig. 7b). The fracture was likely inflicted to extract marrow or to separate the upper limb from the torso.

Of the cranial fragments, one had charring on the interior and exterior surfaces with deep cut marks along the bone margin suggesting the direction of breakage was controlled and deliberate (Fig. 7c). The second was partially cut with weathering of the cut marks indicting they occurred after the skull had broken (Fig. 7d). The third fragment had extensive rat gnawing, but no anthropogenic modifications, indicating the fragment was discarded on the ground when it still contained flesh rather than having been interred. The metatarsal shaft fragment had both ends cut before discard (Fig. 7e). The long bone fragments at Morpa had all been heavily burnt (Fig. 7f,g).

The blackened colour of the burnt human bone fragments at Wule and Morpa (Fig. 7c,f,g) indicates they had been exposed for a prolonged period to a relatively low-temperature fire. Bones take on a black appearance between 300 and 450°C as they undergo carbonisation and subsequently trend to white from 450–645°C during the calcination process (Correia, 1997; Shipman, 1984). The discolouration was identical to pig, fish and bird bone discarded as food refuse at these sites. The human bone had, therefore, likely also been cooked on a fire while fleshed and subsequently discarded as refuse.

The extent of occlusal wear of the teeth was used to estimate age following the method of Lovejoy (1985), and to estimate the number of individuals represented. No attempt was made to identify sex because of the highly fragmented nature of the remains. Of the 12 teeth, ten derived from the maxilla (Table 2). At least three individuals are represented at Wule as a conservative estimate, but as many as 4–6 individuals may be present based on relative tooth size. Most of the teeth (n = 11) trend in wear rates from sub-adult (12–18) through to young

Figure 7. Human skeletal remains recovered from excavations at Wule and Morpa with evidence of cut marks, fractures, burning and gnawing. (*A*) Partial mandible with third molar, Wule, Unit D, Layer 3–4. (*B*) Fractured humeral shaft, Wule, Unit D, Layer 3–4. (*C*) Cranial fragment with a cut margin and burning on the interior and external surfaces, Wule, Unit B, Layer 4. (*D*) Cranial fragment with a cut mark on interior surface, Wule, Unit B, Layer 4. (*E*) Metatarsal shaft with cut marks and gnawing on the distal and proximal ends, Wule, Unit D, Layer 3–4. (*F,G*) Burnt long bone fragments, Morpa, Unit C, Layers 1–2.

adult (24–35), with at least two individuals represented to account for this range of wear (Fig. 8). A third individual was indicated by a third molar with advanced occlusal wear which re-fitted with the partial mandible (Fig. 7a). At Morpa, the skeletal fragments may have come from a single individual.

Discussion

Human skeletal evidence from Wule and Morpa is consistent with ethnographically documented occurrences of cannibalism. Secondary mortuary practices and interpersonal violence were ruled out archaeologically, suggesting cannibalism on Rossel Island had occurred at least within the past 540 years. Although earlier incidents are likely to have occurred, its coincident occurrence with the establishment of interior settlements and the use of stone platforms is probably significant. The excavated stone platforms at Ndapa and Keyvu, dating to within the past 510 years, are of central importance in Rossel oral history as they are associated with migrations of people into the interior of the island. The establishment of interior settlements occurred throughout the Massim and coastal New Guinea as raids on coastal villages by neighbouring groups became more commonplace (Lepowsky, 1983; Irwin, 1985; Bickler, 1998; Irwin *et al*., 2019). On Rossel, there is a direct correlation between the demonstrated antiquity of cannibalism and the construction of stone platforms.

Regional and local influences

Southern Massim Pottery was introduced to Rossel en masse within the past 550 years and is linked to the increased frequency of inter-island trade, as well as the emergence of regional cultural identities (Shaw, 2016b). The impetus for trade seemingly occurred as a risk-reduction strategy between smaller, drought-prone islands in the Calvados chain and with islands closer to the New Guinea mainland following a prolonged period of reduced rainfall (Shaw *et al*., 2020; Skelly and David, 2017). Trade may have occurred alongside instances of raiding in a way similar to that documented ethnographically (Liep, 2009; Macintyre, 1994; Moore, 1991; Lepowsky, 1991). During the past five or six centuries, Rossel Islanders were drawn into this regional trade network probably because they manufactured high-quality shell necklaces (bagi or soulava) that were sought after valuables in trade networks such as the Kula, operating elsewhere in the Massim (Shaw, 2016b).

While there is no archaeological evidence for Rossel having been in regular contact with neighbouring islands in the Massim prior to the introduction of pottery, conflict on the island between clan groups must have intensified enough to justify movement to inland villages. Once Rossel was incorporated into regional trade, the sites of Wule and Morpa were either established or inhabited more intensively because they are situated in coastal locations of great strategic importance. Both are located at the western end of Rossel where the populations could have engaged with

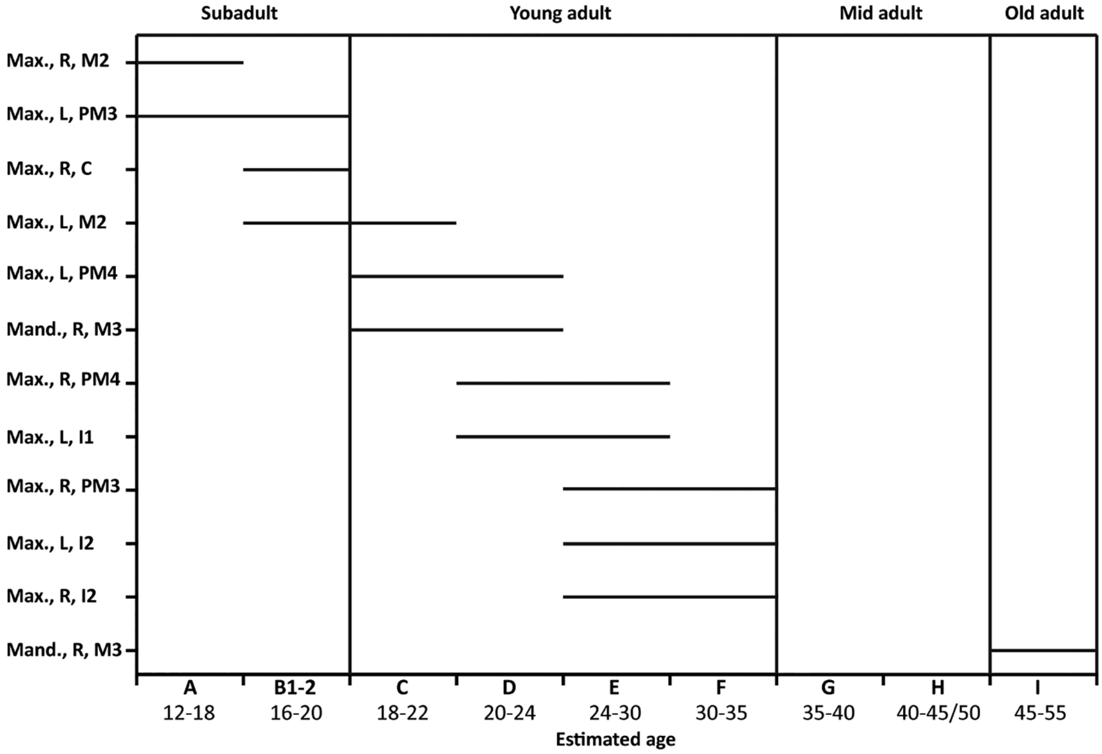

Figure 8. Estimated age based on dental wear of isolated teeth at Wule. At least three individuals are represented. Wear scores and age ranges after Lovejoy (1985). Age categories (Sub, young, mid and old) based on Buckley *et al*. (2008) for prehistoric Pacific Island human populations.

Table 1. Human skeletal remains recovered from the excavations on Rossel Island.

site	unit	spit	context	layer	element
Wule	B	6	sieve	4	cranial fragment
		7			cranial fragment
	D	3	in situ	3–4	humeral shaft
			in situ		cranial fragment
		4	sieve		metatarsal
		5	in situ		partial mandible
Morpa	C	1	sieve	1–2	long bone fragments
		2			

Table 2. Human teeth recovered from excavation at Wule. Wear scores and age ranges after Lovejoy (1985).

unit	spit	layer	side	position	tooth	no.	wear score	estimated age
A	6	4	left	maxilla	premolar	PM4	C–D	18–24
			right			PM4	D–E	20–30
			left		incisor	I2	E–F	24–35
	8	5a	right		premolar	PM3	E–F	24–35
	9				incisor	I2	E–F	24–35
C	4	3	left		molar	M2	B–C	16–22
	7	4			incisor	I1	D–E	20–30
					canine	C	B1–B2	16–20
	8		right		premolar	PM3	A–B	12–20
D	5	3/4		mandible	molar	M3	I	45–55
	6	5a		maxilla	molar	M2	A	12–18
	7			mandible		M3	C–D	18–24

incoming trade canoes from neighbouring islands before they could travel further around the coast. Indeed, Wule is also one of the earliest Massim sites where Early SMP has been identified (Shaw, 2016b). Trade goods could therefore be re-distributed across the island from these western settlements. In sum, there are several lines of historical and archaeological evidence indicating that a significant disruption to social systems occurred on Rossel Island at this time.

Liep (1989: 235) argued that historically Rossel did not engage in trade to the degree that would tend to intensify food production for export and make agricultural resources the object of competition. While this may have been the case, increased inter-island trade, as indicated by the large scale introduction of pottery, and predominantly to the western end of the island, would have provided the necessary impetus for an intensification of local competition. If such competition was not for agricultural resources, it was necessary to secure access to land adjacent to sheltered harbours where canoes could be moored and external trade partners could be met (Shaw, 2016b). Distinct dialects are spoken on the western and eastern ends of the island with western communities having loan words from languages spoken on the neighbouring island of Sudest (Levinson, 2006). Such a division was likely created or at least exacerbated by increased external connections to western Rossel where the sites of Wule and Morpa are situated. The integration of Rossel communities into a more extensive and structurally complex regional socio-political system could, therefore, have enabled some populations to acquire control over the movement of people, goods, and information. Controlling this market would then allow individuals to enhance their social status and to dominate other groups (Liep, 1989: 233).

Cannibalism and a connection to mortuary contexts

It is within this context that cannibalism on Rossel Island can be linked to mortuary rites, the consumption of individuals from neighbouring clans (exocannibalism), and the maintenance of social control following the death of a prominent person. If leadership is temporary, then the death of an influential individual can leave social relationships nullified if they are not reinforced by their clan or by a related person with elevated social status. As only powerful individuals had influence enough to arrange someone to be killed, this may have been enacted on behalf of either the deceased leader or by an emerging leader who sought to use the opportunity to take the position of the deceased by reinforcing established social relationships. However, as with the short-lived central involvement of Tubetube Island in Kula exchange (see Irwin *et al*., 2019), the rise in complexity of trade, mortuary practices and cannibalism by 550 years ago on Rossel was disrupted only centuries later following colonial pacification.

The rise of feasts as a political tool

One final consideration expands the significance of these findings beyond the shores of Rossel Island and into the wider Massim region—the increased prevalence of feasting pots in the southern Massim archaeological record. Detailed analysis of Southern Massim Pottery has enabled changes in form and social use to be modelled (Shaw *et al*., 2020; Irwin *et al*., 2019). During the Middle SMP (400–200 BP) and Late SMP (< 200 BP) phases, pots became progressively larger and with an increased frequency of prominent appliqué bands. Bigger appliqué banded, open-mouthed pots are widely attested historically and in the modern-day as feasting pots capable of holding larger quantities of food for communal gatherings. In this context, the emergence of feasting pots within the last four centuries suggests feasts had also become a regionally important practice, which besides mortuary settings, are closely linked to a prevalence of 'revenge cannibalism' elsewhere in the southern Massim. The appearance of SMP, the expansion of regional trade networks, cannibalism, interior settlements, and stone platform complexes, therefore, indicates relatively dramatic changes to the political structure of Rossel and Massim communities within the past five or six centuries.

Conclusion

The identification of fragmented, cut and burnt human skeletal remains on Rossel Island is strongly consistent with detailed ethnographic accounts of cannibalism. Dismemberment, cooking and eating a victim is a social practice which coincided with local and regional changes in socio-economic systems involving increased regulation of social institutions, including, but not limited to feasting and mortuary rites. The findings, when articulated within an ethnoarchaeological framework, contribute to regional models indicating a transformation of coastal and island lifeways over the past 550 years, within which time historically documented exchange systems such as Kula emerged. A shift in how individuals and groups might accrue power led to increased levels of local and regional conflict, ritualised killings, and feasts which only ceased or were augmented following colonial intervention at the turn of the 20th century.

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References

Allen, J. 2017. *Excavations on Motupore Island, Central District, Papua New Guinea*. Working Papers in Anthropology, Number 4. Dunedin: University of Otago.

Anderson, S. 2009. *Pelletier: The Forgotten Castaway of Cape York*. Melbourne: Melbourne Books.

Armstrong, W. E. 1928. *Rossel Island: An Ethnological Study*. Cambridge: Cambridge University Press.

Bahn, P. 1992. Cannibalism or ritual dismemberment? In *Cambridge Encyclopedia of Human Evolution,* ed. S. Jones, R. Martin, and D. Pilbeam, p. 330. Cambridge: Cambridge University Press.

Barber, I. 1992. Archaeology, ethnography, and the record of Maori cannibalism before 1815: a critical review. *Journal of the Polynesian Society* 101(3): 241–292.
https://www.jstor.org/stable/20706459

Battaglia, D. 1983. Syndromes of ceremonial exchange in the eastern Calvados: the view from Sabarl Island. In *The Kula: New Perspectives on Massim Exchange,* ed. J. Leach and E. Leach, pp. 445–465. Cambridge: Cambridge University Press.

Battaglia, D. 1990. *On the Bones of the Serpent: Person, Memory, and Mortality in Sabarl Island Society*. Chicago: The University of Chicago Press.

Beaver, W. N. 1920. Unexplored New Guinea: A Record of the Travels, Adventures, and Experiences of a Resident Magistrate amongst the Head-Hunting Savages and Cannibals of the Unexplored Interior of New Guinea. London: Seely, Service and Co.

Bedford, S. 2006. *Pieces of the Vanuatu Puzzle: Archaeology of the North, South and Centre*. Terra Australis 23. Canberra: ANU Press.
https://doi.org/10.22459/PVP.02.2007

Bell, A. R. M. 1909. Appendix D: Account of a patrol in Rossel Island. In Papua, Report for the Year Ending 30 June 1909, pp. 103–109. Victoria: J. Kemp Government Printers.

Bello, S. M., R. Wallduck, V. Dimitrijevic, I. Zivaljevic, and C. B. Stringer. 2016. Cannibalism versus funerary defleshing and disarticulation after a period of decay: comparisons of bone modifications from four prehistoric sites. *American Journal of Physical Anthropology* 161(4): 722–743.
https://doi.org/10.1002/ajpa.23079

Berde, S. 1983. The impact of colonialism on the economy of Panaeati. In *The Kula: New Perspectives on Massim Exchange*, ed. J. Leach and E. Leach, pp. 431–443. Cambridge: Cambridge University Press.

Bickler, S. 1998. *Eating Stone and Dying: Archaeological Survey on Woodlark Island, Milne Bay Province, Papua New Guinea*. Unpublished PhD thesis, University of Virginia, Charlottesville.

Bickler, S. H., and B. Ivuyo. 2002. Megaliths of Muyuw (Woodlark Island), Milne Bay Province, PNG. *Archaeology in Oceania* 37(1): 22–36.
https://doi.org/10.1002/j.1834-4453.2002.tb00498.x

Booth, D. R. 1929. *Mountains Gold and Cannibals*. Sydney: Cornstalk Publishing Company.

Boulestin, B., A. Zeeb-Lanz, C. Jeunesse, F. Haack, R. Arbogast, and A. Denaire. 2009. Mass cannibalism in the linear pottery culture at Herxheim (Palatinate, Germany). *Antiquity* 83: 968–982.
https://doi.org/10.1017/S0003598X00099282

Brass, L. J. 1959. Results of the Archibold expeditions. No. 79: Summary of the fifth Archibold Expedition to New Guinea (1956–1957). *Bulletin of the American Museum of Natural History* 118: 1–70.
http://hdl.handle.net/2246/1263

Buckley, H. R., N. G. Tayles, M. Spriggs, and S. Bedford. 2008. A preliminary report on health and disease in Early Lapita skeletons, Vanuatu: possible biological costs of island colonization. *Journal of Island and Coastal Archaeology* 3(1): 87–114.
https://doi.org/10.1080/15564890801928300

Bulmer, S. 1982. West of Bootless Inlet: archaeological evidence for prehistoric trade in the Port Moresby area and the origins of the Hiri. In *The Hiri in History: Further Aspects of Long Distance Motu Trade in Central Papua*, ed. T. Dutton, pp. 117–130. Canberra: Australian National University.

Campbell, S. F. 1983. Attaining rank: a classification of Kula shell valuables. In *The Kula: New Perspectives on Massim Exchange*, ed. J. Leach and E. Leach, pp. 229–248. Cambridge: Cambridge University Press.

Carbonell, E., I. Caceres, M. Lozano, P. Saladie, J. Rosell, C. Lorenzo, J. Vallverdu, R. Huguet, A. Canals, and J. de Castro. 2010. Cultural cannibalism as a paleoeconomic system in the European Lower Pleistocene: The case of level TD6 of Gran Dolina (Sierra de Atapuerca, Burgos, Spain). *Current Anthropology* 51(4): 539–549.
https://doi.org/10.1086/653807

Chalmers, J. 1887. *Pioneering in New Guinea*. London: Religious Tract Society.

Cochrane, S. 1986. *Massim Art: A Review of the Visual Arts of Some Societies in the Massim Area, their Development, Diffusion and Distinction*. Unpublished MA (Hons) thesis, University of Wollongong.

Conklin, B. 1995. Thus are our bodies, thus was our custom: mortuary cannibalism in an Amazonian society. *American Anthropologist* 22(1): 75–101.
https://doi.org/10.1525/ae.1995.22.1.02a00040

Correia, P. 1997. Fire modification of bone: a review of the literature. In *Forensic Taphonomy: the Postmortem Fate of Human Remains*, ed. W. D. Haglund and M. Sorg, pp. 275–293. Boca Ranton: CRC Press.

Damon, F. H., and R. Wagner, eds. 1989. *Death Rituals and Life in the Societies of the Kula Ring*. Dekalb: Northern Illinois University Press.

Defleur, A. R., and E. Desclaux. 2019. Impact of the last interglacial climate change on ecosystems and Neanderthals behavior at Baume Moula-Guercy, Ardèche, France. *Journal of Archaeological Science* 104: 114–124.
https://doi.org/10.1016/j.jas.2019.01.002

Degusta, D. 1999. Fijian cannibalism: osteological evidence from Navatu. *American Journal of Physical Anthropology* 110(2): 215–241.
https://doi.org/10.1002/(SICI)1096-8644(199910)110:2<215::AID-AJPA7>3.0.CO;2-D

Degusta, D. 2000. Fijian cannibalism and mortuary ritual: bioarchaeological evidence from Vunda. *International Journal of Osteoarchaeology* 10(1): 76–92.
https://doi.org/10.1002/(SICI)1099-1212(200001/02)10:1<76::AID-OA506>3.0.CO;2-#

Egloff, B. J. 1972. The sepulchral pottery of Nuamata Island, Papua. *Archaeology and Physical Anthropology in Oceania* 7(2): 145–163.
https://www.jstor.org/stable/40386172

Egloff, B. J. 1978. The Kula before Malinowski: a changing configuration. *Mankind* 11(3): 429–435.
https://doi.org/10.1111/j.1835-9310.1978.tb00671.x

Fernandez-Jalvo, Y., J. C. Diez, I. Caceres, and J. Rosell. 1999. Human cannibalism in the early Pleistocene of Europe (Gran Dolina, Sierra de Atapuerca, Spain). *Journal of Human Evolution* 37(3–4): 591–622.
https://doi.org/10.1006/jhev.1999.0324

Hahl, A. 1980. *Governor in New Guinea* (translated by P. G. Sack and D. Clark). Canberra: ANU Press.

Henderson, J., and A. Henderson. 1999. *Rossel to English, English to Rossel Dictionary*, 2nd edition. Ukarumpa: Summer Institute of Linguistics.

Hilder, B. 1980. *The Voyage of Torres: The Discovery of the Southern Coastline of New Guinea and Torres Strait by Captain Luis Baez de Torres in 1606*. Brisbane: University of Queensland Press.

Irwin, G. 1985. *The Emergence of Mailu as a Central Place in Coastal Papuan Prehistory*. Terra Australis 10. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.

Irwin, G., B. Shaw, and A. McAlister. 2019. The origins of the Kula ring: archaeological and maritime perspectives from the southern Massim and Mailu areas of Papua New Guinea. *Archaeology in Oceania* 54(1): 1–16.
https://doi.org/10.1002/arco.5167

Jenness, D., and A. Ballantyne. 1920. *The Northern D'Entrecasteaux*. Oxford: Clarendon Press.

Kilgour, M. 1998. The function of cannibalism at the present time. In *Cannibalism and the Colonial World*, ed. F. Barker, P. Hulme, and M. Iversen, pp. 238–259. Cambridge: Cambridge University Press.

Kirch, P. V. 1984. *The Evolution of Polynesian Chiefdoms*. Cambridge: Cambridge University Press.

Knauft, B. M. 1989. Bodily images in Melanesia: cultural substances and natural metaphors. In *Fragments for a History of the Human Body*, ed. M. Feher, pp. 198–279. New York: Zone Books.

Kuehling, S. 2014. The converted war canoe: cannibal raiders, missionaries and "Pax Britannica" on Dobu Island, Papua New Guinea. *Anthropologica* 56(2): 269–284.
https://www.jstor.org/stable/24467304

Lee, I. 1911. A forgotten navigator: Captain (afterwards Sir) John Hayes, and his voyage of 1793. *The Geographical Journal* 38(6): 580–590.
https://www.jstor.org/stable/1778839

Lee, I. 1912. *Commodore Sir John Hayes: His Voyage and Life (1767–1831), with Some Account of Admiral d'Entrecasteaux's Voyage of 1792–3*. London: Longmans, Green, and Co.

Lepowsky, M. 1981. *Fruit of the Motherland: Gender and Exchange on Vanatinai, Papua New Guinea*. Unpublished Ph.D. thesis, University of California, Berkeley.

Lepowsky, M. 1983. Sudest Island and the Louisiade Archipelago in Massim exchange. In *The Kula: New Perspectives on Massim Exchange*, ed. J. Leach and E. Leach, pp. 467–501. Cambridge: Cambridge University Press.

Lepowsky, M. 1991. The way of the ancestors: custom, innovation, and resistance. *Ethnology* 30(3): 217–235.
https://www.jstor.org/stable/3773632

Levinson, S. C. 2006. The language of space in Yélî Dnye In *Grammars of Space: Explorations in Cognitive Diversity*, ed. S. C. Levinson and D. P. Wilkins, pp. 157–204. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511486753

Liep, J. 1983. "This civilising influence": the colonial transformation of Rossel Island society. *The Journal of Pacific History* 18(2): 113–131.
https://doi.org/10.1080/00223348308572462

Liep, J. 1989. The day of reckoning of Rossel Island. In *Death Rituals and Life in the Societies of the Kula Ring*, ed. F. Damon and R. Wagner, pp. 230–253. DeKalb: Northern Illinois University Press.

Liep, J. 2007. Massim mortuary rituals revisited. *Journal de la Société des Océanistes* 124: 89–96.
https://doi.org/10.4000/jso.802

Liep, J. 2009. *A Papuan Plutocracy: Ranked Exchange on Rossel Island*. Aarhus: Aarhus University Press.

Lindt, J. W. 1887. *Picturesque New Guinea, With an Historical Introduction and Supplementary Chapters on the Manners and Customs of the Papuans*. London: Longmans Green and Co.

Lovejoy, C. O. 1985. Dental wear in the Libben population: its functional pattern and role in the determination of adult skeletal age at death. *American Journal of Physical Anthropology* 68 (1): 47–56.
https://doi.org/10.1002/ajpa.1330680105

Lyne, C. 1885. *New Guinea: An Account of the Establishment of the British Protectorate over the Southern Shores of New Guinea*. London: Sampson Low, Marston, Searle and Rivington.

MacGregor, W. M. 1894. Appendix B: despatch reporting visit to various islands at the eastern end of the possession. In *Annual Report on British New Guinea from 1st July, 1892, to 30th June, 1893; With Appendices*, pp. 3–7. Brisbane: Edmund Gregory Government Printers.

Macintyre, M. 1983. *Changing Paths. An Historical Ethnology of the Traders of Tubetube*. Unpublished PhD thesis, Australian National University, Canberra.

Macintyre, M. 1984. The problem of the semi-alienable pig. *Canberra Anthropology* 7(1–2): 109–122.
https://doi.org/10.1080/03149098409508563

Macintyre, M. 1994. Too many chiefs: leadership in the Massim in the colonial era. *History and Anthropology* 7(1–4): 241–262.
https://doi.org/10.1080/02757206.1994.9960847

Macintyre, M. 1995. Violent bodies and vicious exchanges: personification and objectification in the Massim. *Social Analysis: The International Journal of Anthropology* 37: 29–43.
https://www.jstor.org/stable/23171770

Malinowski, B. 1922. *Argonauts of the Western Pacific*. London: Routledge and Kegan Paul.

Malinowski, B. 1929. *The Sexual Life of Savages in North-West Melanesia. An Ethnographic Account of Courtship, Marriage and Family Life Among the Natives of the Trobriand Islands, British New Guinea*. New York: Eugenics Publishing Company.

McFarlane, S. 1888. *Among the Cannibals of New Guinea: The Story of the New Guinea Mission of the London Missionary Society*. Philadelphia: Presbyterian Board of Publication and Sabbath School Work.

Metcalf, P. 1987. Wine of the corpse: endocannibalism and the great feast of the dead in Borneo. *Representations* 17: 96–109.
https://www.jstor.org/stable/3043794

Moore, C. 1991. The Life and death of William Bairstow Ingham: Papua New Guinea in the 1870s. *Journal of the Royal Historical Society of Queensland* 14: 414–432.

Moresby, J. 1876. *Discoveries and Surveys in New Guinea and the D'Entrecasteaux Islands*. London: John Murray.

Moreton, M. H. 1905. Appendix C. In *British New Guinea Annual Report for the Year Ending 30th June, 1904*, pp. 28–31. Melbourne: Robt S. Brain Government Printers.

Mosko, M. 1992. Motherless sons: 'divine kings' and 'partible persons' in Melanesia and Polynesia. *Man* 27: 697–717.
https://www.jstor.org/stable/2804170

Mosko, M. 2000. Inalienable ethnography: keeping-while-giving and the Trobriand case. *Journal of the Royal Anthropological Institute* 6(3): 377–396.
https://doi.org/10.1111/1467-9655.00022

Murray, J. H. P. 1908. *Papua: Report for the Year Ending 30th June 1908*. Melbourne: J. Kemp Government Printers.

Murray, J. H. P. 1933. Reports in the Western Division, Delta Division and Gulf Division. In *Territory of Papua: Annual Report for the Year 1931–1932*, pp. 11–21. Canberra: L. F. Johnston.

Negishi, Y. 2008. Comb and appliqué: typological studies of two ceramic traditions during the last thousand years in Eastern Papua New Guinea. *Bulletin of the Department of Archaeology (University of Tokyo)* 22: 119–161.

Ollier, C. D., and D. K. Holdsworth. 1969. Caves of Vakuta, Trobriand Islands, Papua. *Helictite* 7: 50–61.

Ollier, C. D., D. K. Holdsworth, and G. Heers. 1973. Megaliths, stones and bwala on Kitava, Trobriand Islands, Papua. *Archaeology and Physical Anthropology in Oceania* 8(1): 41–50.
https://www.jstor.org/stable/40386188

Parkinson, R. R. H. 1999 [1907]. *Thirty Years in the South Seas. Land and People, Customs and Traditions in the Bismarck Archipelago and on the German Solomon Islands*. Translated by J. Dennison, edited by J. P. White. Bathurst: Crawford House Publishing with Oceania Publications, University of Sydney.

Pietrusewsky, M., M. Douglas, E. E. Cochrane, and S. Reinke. 2007. Cultural modification in an adolescent earth-oven interment from Fiji: sorting out mortuary practice. *Journal of Island and Coastal Archaeology* 2(1): 44–71.
https://doi.org/10.1080/15564890701228579

Poole, F. J. P. 1984. Symbols of substance: Bimin-Kuskusmin models of procreation, death, and personhood. *Taja: The Australian Journal of Anthropology* 14(3): 191–216.
https://doi.org/10.1111/j.1835-9310.1984.tb01401.x

Poulsen, J. 1987. *Early Tongan Prehistory: The Lapita Period on Tongatapu and its Relationships*. Terra Australis 12. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.

Rechtman, R. B. 1992. *The Evolution of Sociopolitical Complexity in the Fiji Islands*. Unpublished PhD thesis, University of California, Los Angeles.

Rieth, T. 1998. *Early Evidence for Fijian Cannibalism: Refining the Methods for Identifying Cannibalism in the Archaeological Record*. Unpublished BA (Hons) thesis, University of Hawaii.

Rochas, R. 1861. Naufrage et scènes d'anthropophagie a L'île Rossell, dans l'archipel de la Louisiade (Melanésie). *Le Tour du Monde: Nouveau Journal des Voyages* 2: 81–95.

Roheim, G. 1954. Cannibalism in Duau, Normanby Island, D'Entrecasteaux Group, Territory of Papua. *Mankind* 4(12): 487–495.
https://doi.org/10.1111/j.1835-9310.1954.tb00205.x

Roscoe, P. 2000. New Guinea leadership as ethnographic analogy: a critical review. *Journal of Archaeological Method and Theory* 7: 79–126.
https://doi.org/10.1023/A:1009512726844

Rumsey, A. 1999. The white man as cannibal in the New Guinea highlands. In *The Anthropology of Cannibalism*, ed. L. R. Goldman, pp. 105–121. Westport: Bergin and Garvey.

Sanborn, G. 1998. *The Sign of the Cannibal: Melville and the Making of a Postcolonial Reader*. Durham (North Carolina): Duke University Press.

Seligmann, C. G. 1910. *The Melanesians of British New Guinea*. Cambridge: Cambridge University Press.

Shaw, B. 2015. *The Archaeology of Rossel Island, Massim, Papua New Guinea: Towards a Prehistory of the Louisiade Archipelago*. 2 volumes. Unpublished PhD thesis, Australian National University.

Shaw, B. 2016a. The Massim region of Papua New Guinea: a review and proposed chronology. *Journal of Pacific Archaeology* 7(1): 106–125.
https://pacificarchaeology.org/index.php/journal/article/view/172

Shaw, B. 2016b. The late prehistoric introduction of pottery to Rossel Island, Louisiade Archipelago, Papua New Guinea: insights into local social organisation and regional exchange in the Massim. *Archaeology in Oceania* 51 Supplement 1: 61–72.
https://doi.org/10.1002/arco.5104

Shaw, B., S. Coxe, V. Kewibu, J. Haro, E. Hull, and S. Hawkins. 2020. 2500-year cultural sequence in the Louisiade Archipelago (Massim region) of eastern Papua New Guinea reflects adaptive strategies to remote islands since Lapita settlement. *The Holocene* 30(7): 1–16.
https://doi.org/10.1177/0959683620908641

Shaw, B., and W. R. Dickinson. 2017. Excavation on Nimowa Island, Louisiade Archipelago, Papua New Guinea: insights into cultural practices and the development of exchange networks in the Southern Massim region. *The Journal of Island and Coastal Archaeology* 12(3): 398–427.
https://doi.org/10.1080/15564894.2016.1188335

Shipman, P. 1984. Burnt bones and teeth: an experimental study of color, morphology, crystal structure and shrinkage. *Journal of Archaeological Science* 11(4): 307–325.
https://doi.org/10.1016/0305-4403(84)9 X

Singh Uberoi, J. P. 1962. *Politics of the Kula ring: An Analysis of the Findings of Bronislaw Malinowski.* Manchester: Manchester University Press.

Skelly, R. J., and B. David. 2017. *Hiri: Archaeology of Long-Distance Maritime Trade along the South Coast of Papua New Guinea*. Honolulu: University of Hawaii Press.

Spennemann, D. H. R. 1987. Cannibalism in Fiji: the analysis of butchering marks on human bones and the historical record. *Domodomo* 5: 29–46.

Spriggs, M. 2008. Ethnographic parallels and the denial of history. *World Archaeology* 40(4): 538–552.
https://doi.org/10.1080/00438240802453161

Steadman, D. W., S. C. Anton, and P. V. Kirch. 2000. Ana Manuku: a prehistoric ritualistic site on Mangaia, Cook Islands. *Antiquity* 74: 873–883.
https://doi.org/10.1017/S0003598X0006052X

Stodder, A. L. W., and T. Reith. 2011. Ancient mortuary ritual and human taphonomy. *Fieldiana: Anthropology* 42: 197–217.
https://doi.org/10.3158/0071-4739-42.1.197

Strathern, A., and P. J. Stewart. 1998. Seeking personhood: anthropological accounts and local concepts in Mount Hagen, Papua New Guinea. *Oceania* 68(3): 170–188.
https://doi.org/10.1002/j.1834-4461.1998.tb02664.x

Strathern, M. 1988. *The Gender of the Gift: Problems with Women and Problems with Society in Melanesia*. Berkeley: University of California Press.
https://doi.org/10.1525/9780520910713

Swadling, P., and P. Bence. 2016. Changes in Kula valuables and related supply linkages between the Massim and South Papuan coast between 1855 and 1915. *Archaeology in Oceania* 51 Supplement 1: 50–60.
https://doi.org/10.1002/arco.5106

Thompson, B. 1890. Rossel Island (a cannibal island). *Journal of the Manchester Geographical Society* 6: 7–11.

Torrence, R. 2003. 'Like everywhere you've never been': archaeological fables from Papua New Guinea. In *Theory, Method, and Practice in Modern Archaeology*, ed. R. J. Jeske and D. K. Charles, pp. 287–300. London: Praeger.

Turner II, C. G., and J. A. Turner. 1995. Cannibalism in the prehistoric American Southwest: occurrence, taphonomy, explanation, and suggestions for standardized world definition. *Anthropological Science* 103(1): 1–22.
https://doi.org/10.1537/ase.103.1

Turner II, C. G., and J. A. Turner. 1999. *Man Corn: Cannibalism and Violence in the Prehistoric American Southwest*. Salt Lake City: University of Utah Press.

Venturi, G. 2002. The Budou and Selai burial caves in Labai. In *The Archaeology of the Trobriand Islands, Milne Bay Province, Papua New Guinea*, ed. G. Burenhult, pp. 107–114. Oxford: Archaeopress.

Vilaca, A. 2000. Relations between funerary cannibalism and warfare cannibalism: the question of predation. *Ethnos* 65(1): 83–106.
https://doi.org/10.1080/001418400360652

Villa, P. 1992. Cannibalism in prehistoric Europe. *Evolutionary Anthropology* 1(3): 93–104.
https://doi.org/10.1002/evan.1360010307

Villa, P., C. Bouville, J. Courtin, D. Helmer, E. Mahieu, P. Shipman, G. Belluomini, and M. Branca. 1986. Cannibalism in the Neolithic. *Science* 233: 431–437.
https://doi.org/10.1126/science.233.4762.431

Wagner, R. 1991. The fractal person. In *Big Men and Great Men*, ed. M. Godelier and M. Strathern, pp. 159–173. Cambridge: Cambridge University Press.

Weiner, A. 1976. *Women of Value, Men of Renown. New Perspectives in Trobriand Exchange*. Austin: University of Texas Press.

Weiner, A. B. 1988. *The Trobrianders of Papua New Guinea*. Orlando: Harcourt Brace Jovanovich College Publishers.

White, T. D. 1992. *Prehistoric Cannibalism at Mancos 5MTUMR-2346*. Princeton: Princeton University Press.
https://doi.org/10.1515/9781400852925

Whiting, S. 1975. *Death and Leadership on Misima*. Unpublished MA thesis, Monash University, Melbourne.

Young, M. 1971. *Fighting with Food. Leadership, Values and Social Control in a Massim Society*. Cambridge: Cambridge University Press.

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Avanata: A Possible Late Lapita Site on Fergusson Island, Milne Bay Province, Papua New Guinea

Anne Ford[1], Vincent Kewibu[2], and Kenneth Miamba[3]

[1] Archaeology Program, School of Social Sciences,
University of Otago, Dunedin, New Zealand

[2] School of Humanities and Social Sciences,
University of Papua New Guinea, Port Moresby, Papua New Guinea

[3] National Museum and Art Gallery of Papua New Guinea,
Port Moresby, Papua New Guinea

Abstract. West Fergusson obsidian has been identified in a number of Lapita and Early Papuan pottery (EPP) sites on the south coast of Papua New Guinea and wider afield in the Pacific. Yet, the archaeological history of the island and its obsidian sources remains mostly unknown. Recent fieldwork aimed at establishing a chronological sequence for human occupation of the island, identified the site of Avanata, on the south coast of the Kukuia Peninsula. It has a pottery assemblage decorated with shell impression and paint, techniques not previously recorded on Massim pottery. Although no dateable material was obtained from the site, we argue that archaeological correlates on the Papuan mainland indicate that Avanata belongs to an early ceramic occupation of Fergusson Island dating > 1000 years ago and possibly to the late Lapita period.

Introduction

Papua New Guinea is home to four different, geochemically distinct obsidian regions: the Admiralties, West New Britain (WNB), East Fergusson and West Fergusson (Fig. 1). Of these, the WNB and Admiralties sources both have histories of use during the Late Pleistocene (Fredericksen, 1997; Torrence *et al*., 2004; Summerhayes and Allen, 1993). In the late Holocene, new patterns emerged for the Admiralties and WNB sources with the arrival of the Lapita peoples. Obsidian from these two regions is found in the earliest Lapita sites in the Bismarck Archipelago and is also part of the material cultural package that is transported into the Western Pacific as part of the Lapita migration into this previously uninhabited region (Reepmeyer *et al*., 2010). Because of their long history of use, most previous research on obsidian sources in Papua New Guinea has focused on the Admiralties and WNB. This includes Robin Torrence's seminal work in WNB where she mapped the spatial extent of the different obsidian sources, and described their physical nature, quality and accessibility to better understand how these factors impacted obsidian source selection (Torrence, 2004; Torrence *et al*., 1992; Torrence *et al*., 1996.

While Fergusson Island obsidian does not occur in Lapita sites as commonly as the Admiralty and WNB sources, it had a wide distribution along the Papuan south coast, being present in Lapita sites (Mialanes *et al*., 2016; Skelly *et al*., 2016) and later EPP sites (Irwin, 1991; Allen *et al*., 2011). However, little is yet known about the archaeology of Fergusson Island itself, including whether there is possible Lapita occupation. Evidence for Lapita presence within the Massim region is growing, with two sites now dated: Wari Island (Chynoweth *et al.,* 2020; Negishi and Ono, 2009) and Malakai on Nimowa Island (Shaw *et al.,* 2020), and a third site identified based on the presence of Late Lapita pottery styles (site BQN on Tubetube Island) (Shaw, 2016a).

Keywords: Fergusson Island; Massim; Papua New Guinea; Lapita; pottery; obsidian
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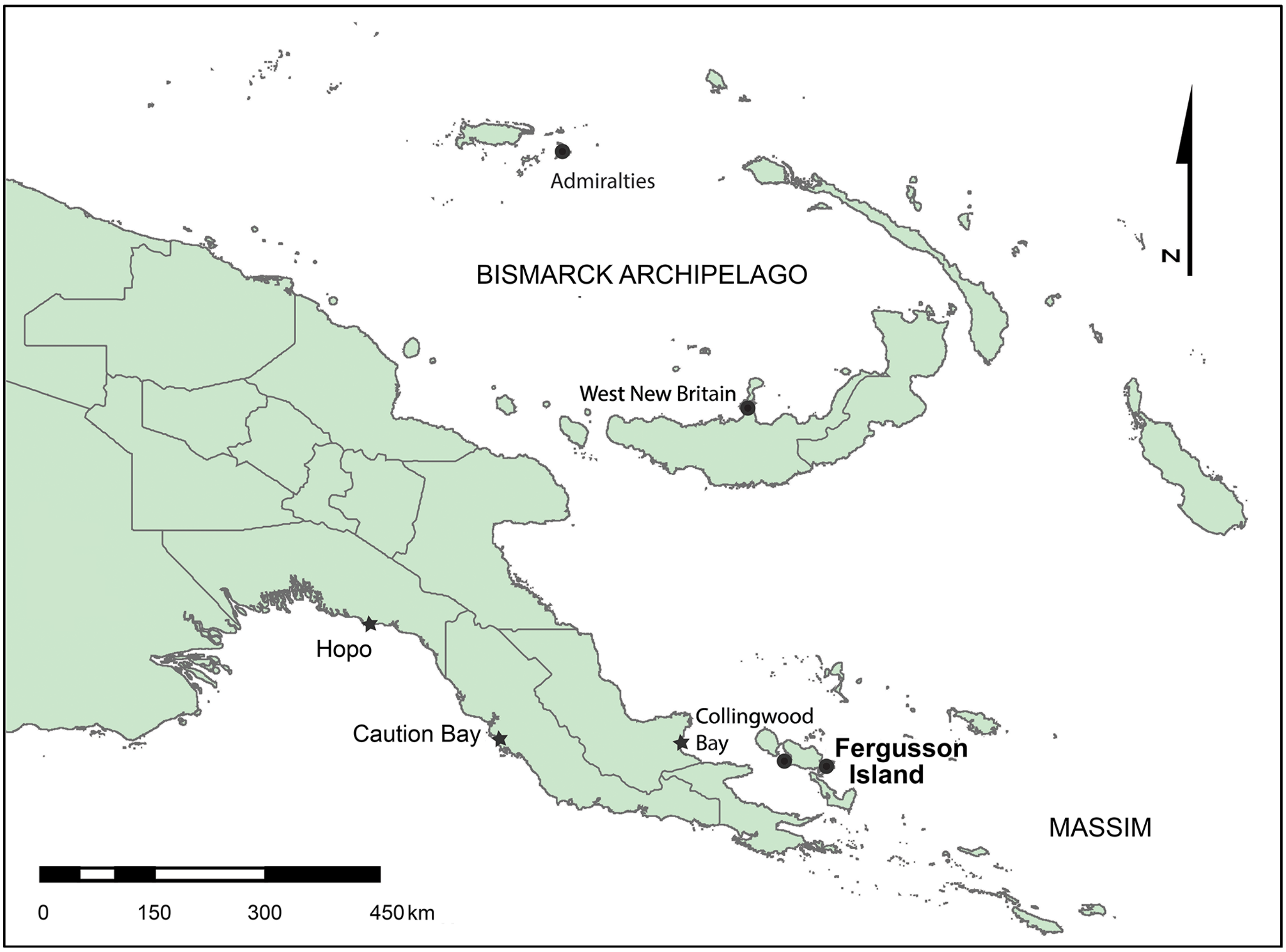


Figure 1. Location of obsidian sources in Papua New Guinea (marked by circles) and key archaeological regions discussed in text (marked by stars). The westernmost source on Fergusson Island, Avanata, is shown in detail in Fig. 2.

Ambrose visited both the West Fergusson and East Fergusson obsidian sources (Fig. 1) in 1974 to collect samples for geochemical sourcing, obtaining four samples from two sources (Fagalulu and Kukuia) in West Fergusson, and six samples from three sources (Numanuma Bay, Dobu Island and Sanaroa Island) on East Fergusson (Ambrose, 1976; Bird *et al*., 1991). These samples have remained the sole Fergusson references for all geochemical analyses of obsidian completed up until now.

There has been little additional survey completed for any part of Fergusson Island beyond these obsidian studies. Lauer (1974), as part of his ethnographic research into pottery production on Goodenough and the Amphlett Islands, recorded three surface scatters of pottery (NMAG site codes: BFE, BFF and BFG) on Bwaioa Peninsula, which is located on the eastern side of Fergusson Island, directly to the west of Numanuma Bay. A fourth pottery scatter, NMAG site code: BFC, was located at Yayavana, on the north western point of Fergusson Island and also home to the clay source used by Amphlett Islanders to produce pottery (Lauer, 1974: 143).

A four-week field season was completed in January–February 2017 that aimed to map, describe and sample the obsidian sources to expand our understanding of their geochemical complexity and to record other archaeological sites. Survey concentrated on the Kukuia and Fagalulu obsidian sources and also inland at Niobua to ascertain whether obsidian outcrops were also present in this area. The archaeological survey involved both surface survey and extensive village consultation to establish potential locations for archaeological sites. Subsurface survey was completed in areas where stratified archaeological deposits were thought likely to be present. A large number of sites contained pottery that was stylistically similar to pottery produced on Goodenough or the Amphletts islands. However, the Avanata site contained an assemblage that clearly sat outside of this group, identified by distinctive shell impressed and painted decoration. No dates could be obtained for the site because no charcoal or other organic materials were present.

Because the pottery decoration is so different to other known Massim assemblages it appears likely to pre-date them. If so Avanata may provide insights into the earliest phase of occupation of Fergusson Island by ceramic-using peoples.

The site of Avanata, Kukuia Peninsula

The site of Avanata (NMAG Site Code: BALZ) is found at Avanata village on the south side of the Kukuia Peninsula, approximately 100 m inland from the coast (Fig. 2A,B). Avanata village is the most easterly village on the Kukuia Peninsula that belongs to the Minavega language group, and marks the boundary between the Igwageta and Toagesi district wards. Continuing to the east from here means passing into the Molima language group, which marks an important cultural and linguistic boundary. For example, the people of the Kukuia Peninsula traditionally traded with people on Goodenough Island and the mainland, while the Molima people were aligned with the southern D'Entrecasteaux island groups (Jenness and Ballantyne, 1920). Ross (1992) records that the Minavega language group is associated with other language groups located from Cape Vogel to East Cape, on the mainland.

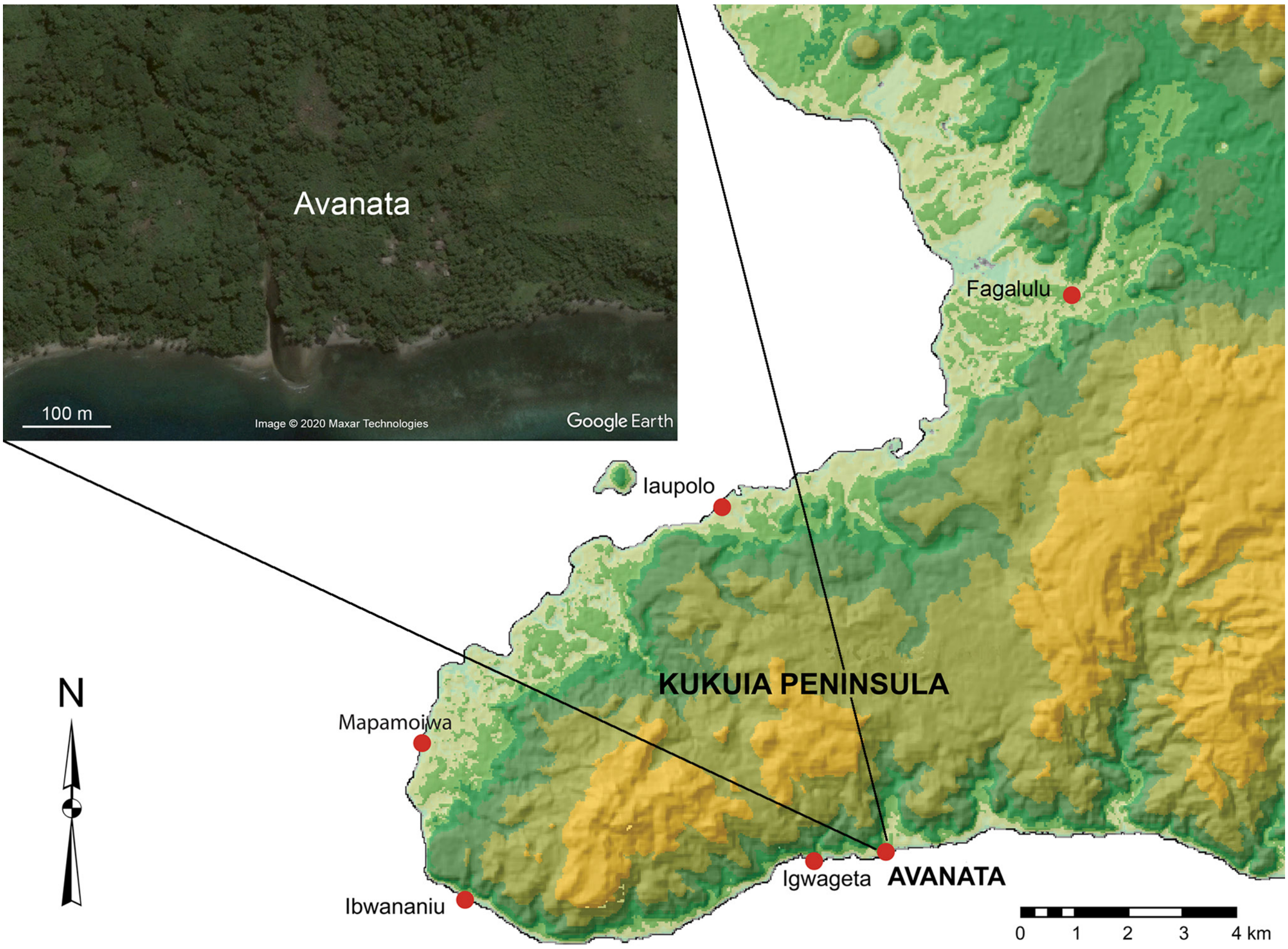


Figure 2. West Fergusson Island. (*A*) Kukuia Peninsula with key villages marked; (*B*) location of Avanata (site BALZ).

In February 2017 the field team visited Avanata village and were shown a pottery scatter by Peter Tauduba, which he had found digging post holes for a house. This pottery scatter was visible on the surface, located between Peter's two houses. A collection of surface pottery was made by the field team and a small test pit (measuring 66 cm N/S, 80 cm E/W) was excavated to assess sub-surface deposits. This test pit was excavated by spade according to stratigraphic layer, with all sediment sieved through 6 mm sieves. Artefacts were plotted according to the stratigraphic layer from which they were excavated.

The sediments from the test pit reflect the site's location on the floodplain of the Waguva River and primarily comprise river sands (Fig. 3). Pottery and obsidian were found in the top 46 cm of the site, which corresponds to Layers 1–3 of the test pit. In Layers 4 and 5 only obsidian was present. No artefacts were found within Layer 6, which is a very loose, golden brown, coarse river sand, although obsidian artefacts were recorded at the base of the transitional Layer 5. The test pit was excavated to a total depth of 95 cm, with no artefacts found below 75 cm. Unfortunately, no charcoal or bone was found in the test pit. Because of time constraints further excavation was postponed until the following season. Planned field seasons for late 2017 and 2018 had to be cancelled because of piracy in the area and no further excavations have yet been undertaken. Because the Avanata pottery is unlike any of the other surface or excavated material collected on Fergusson Island, we report it here in advance of further excavations.

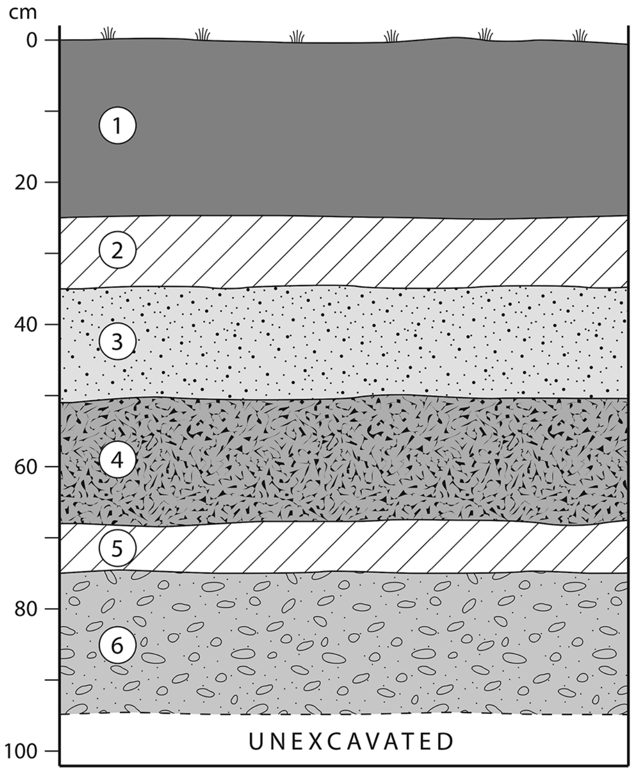
The Avanata pottery

The collection contains 38 pottery sherds. Eight of these are from surface collections and include a rim found by Peter Tauduba while digging post-holes (Fig. 4J). The remainder were obtained from Avanata Test Pit 1. As the surface material is clearly related to the assemblage from the test pit, it is included in this analysis.

Of the eight surface sherds, five have rims, two are sherds with carinations and one is a body sherd. From Test Pit 1, seven rim sherds were excavated, two of which conjoin (Fig. 4C), plus 23 body sherds, one with a carination. Of the 12 identifiable vessels, eight are open bowls with direct rims. The other four are dishes/bowls, two of which have horizontal rims with flat lip profiles (Fig. 4C,D), one has a direct rim with a round lip (Fig. 4G), and the fourth has a flat everted rim (Fig. 4E). For the open bowls, lip profiles are predominately round, with the exception of one flat lip with a pointed edge and one flat lip with a round edge.

Decoration is remarkably consistent across the assemblage and includes the application of red paint, long wavy lines of shell impression in different motifs and carinations with notching. Ten rim sherds have decoration, with only one plain rim present, while 14 body sherds have decoration.

Four sherds, including one rim (S1) and three sherds with carinations (S3, S7 and TP1-7) have exterior decorations that include long wavy lines of shell impression, with red paint applied between the shell impressions, that lie above a notched carination (Fig. 4A,B,H,K). This notch is cut out to form a diamond shape, with straight sides leading down



1. Compact dark brown sandy silt
2. Transitional layer
3. Compact light brown sand with waterworn pebbles
4. Loose dark brown sand with waterworn pebbles
5. Transitional layer
6. Very loose golden brown coarse river sand with waterworn pebbles

Figure 3. Stratigraphic profile of Avanata Test Pit 1, South wall.

to the base of the cut. Two of the sherds also have horizontal lines of red paint applied beneath this carination. On one of these, a nubbin is also present that sits above the carination and adjacent to the shell impression (Fig. 4H). For the rim and one of the carinations (Fig. 4B) which is clearly broken just below the rim, there is also another horizontal band of red paint applied on the interior of the rim. The lines of shell impression vary in motif between these four sherds and include V-shaped motifs, horizontal and vertical joins, as well as horizontal lines. Although the motifs vary, the lines are consistent in that they are always multiple when forming the design, varying from two to three lines of impression applied together. Of the two sherds that can be used to assess vessel form, these are both open bowls with direct rims.

The other rim sherds of open bowls vary slightly in decoration. Three of these (S5, TP1-6, TP1-29) have the same long wavy multiple lines of shell impression in horizontal and diagonal decorations, with red paint included on the exterior of TP1-29. A fourth sherd (PT1) also has lines of shell impression but these are in horizontal and vertical lines, forming a T-intersection (Fig. 4J). This sherd also has horizontal bands of red paint on the interior and exterior of the rim. One open bowl is plain in terms of decoration but with a flat lip profile (TP1-4). The final open bowl is much thicker than the other bowls and has red paint on the inside of the rim in vertical lines, as well as short shell impressions along the lip (Fig. 4G).

The dishes/bowls with the horizontal lips do not have any shell impression but all are marked by red paint (S4, TP1-1, TP1-2, TP1-18/19), particularly on the lip. S4 has paint in vertical lines on the interior surface (Fig. 4D), TP1-1 has red paint on the lip and the entire interior surface (Fig. 4E) and TP1-2 has red paint on the lip and interior as well as notching on the lip (Fig. 4F). TP1-18/19 are two rim conjoins that have red paint on the lip, in a horizontal band at the top of the inside rim, and then vertical lines running down the interior of the dish (Fig. 4C). This rim conjoin also has triangular cut-outs present on the horizontal lip.

For the body sherds (exclusive of the carinations described above), decoration is again split between six sherds with red paint only and four sherds with shell impression, similar to the decorations described above. There is no clear difference in decorations based on the stratigraphic layer that the sherds come from (Table 1). The pottery is also relatively thin, ranging from 3-8 mm in thickness (with the exception of S2 which has a body thickness of 14 mm). The average thickness is 6.4 mm.

Sourcing and technology of obsidian

There are a total of 103 obsidian artefacts within Test Pit 1. All obsidian artefacts were shot with a Bruker Tracer III-SD pXRF, using optimal settings for the mid-Z elements (40 kV, 30 μA) with a filter (12 mil Al + 1 mil Ti + 6 mil Cu), for a 300-second run time, and compared to 42 obsidian source samples from Papua New Guinea, including West Fergusson, East Fergusson, Admiralties (Pam and Lou Islands), and West New Britain (Mopir, Kutau/Bao, Baki and Gulu) which were shot using the same settings. Calibration to parts per million (ppm) for the obsidian artefacts and sources was processed using Bruker's obsidian (OB40) calibration in S1CalProcess.

A pelletised international standard (BHVO-2) was analysed to understand the accuracy of the instrument before each run and after 15 samples during a run. The results of this analysis are presented in Table 2. Not surprisingly, all of the obsidian sources to West Fergusson (Fig. 5). In terms of appearance, the obsidian is mostly black or banded black in colour, with two pieces of red-black obsidian and one piece of banded translucent obsidian.

Sixty-one percent of the obsidian shows cortex that appears to be largely water-rolled (Fig. 6A). During the pedestrian survey of the southern side of the Kukuia Peninsula, from Ibwananiu to Avanata, all waterways were examined for presence of obsidian cobbles. The only river where we identified water-rolled obsidian is the nearby Waguva River, where large cobbles occur. Obsidian is also locally available at Naimatu Ridge as a scree slope, which is the only place recorded during survey that obsidian was present in this form. In addition, obsidian cobbles were also recorded as present on the beach at Igwageta, both by the current field team and by Wal Ambrose in his survey (Bird *et al*., 1981).

Although our survey terminated at this language boundary between Minavega and Molima, it is at least clear that on the southwestern side of the Kukuia Peninsula, Avanata is located at a point where obsidian could be sourced from a number of locations. It is not clear if obsidian is also available locally on the unsurveyed coast to the east of Avanata. On the evidence of the cortex it seems likely that the Waguva River was the source for the obsidian from all stratigraphic layers.

The Avanata obsidian assemblage comprises large pieces, with an average maximum length of complete flakes of 28.76 mm, which likely reflects proximity to source. Artefact types are split between cores, angular fragments, flakes and retouched flakes. Of the four cores, one is bipolar. The

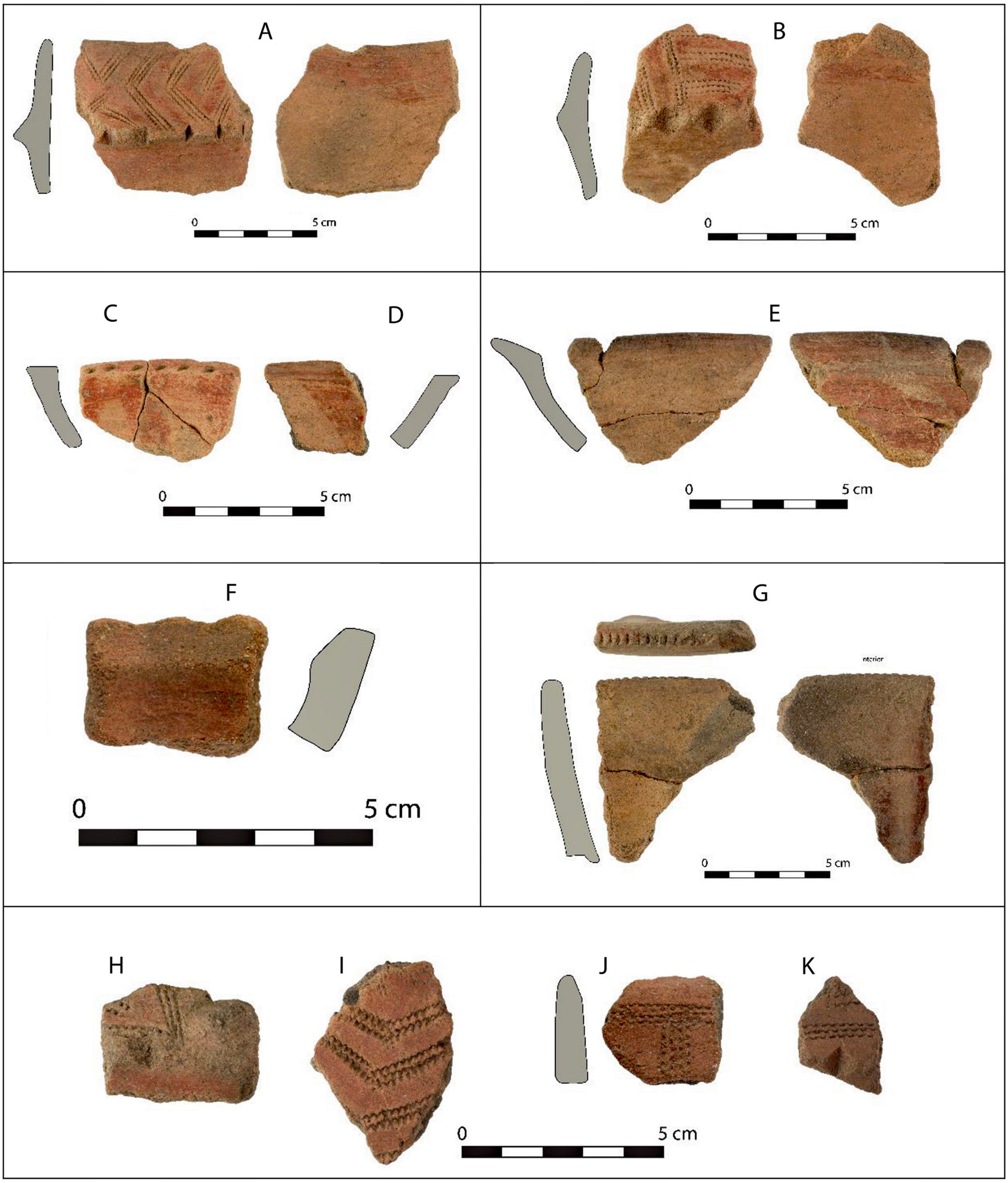


Figure 4. Decorated pottery from Avanata (surface and Test Pit 1). (*A*) S1; (*B*) S3; (*C*) TP1-18/19; (*D*) S4; (*E*) TP1-1; (*F*) TP1-2; (*G*) S2; (*H*) S7; (*I*) TP1-3; (*J*) PT1; (*K*) TP1-7.

presence of cores, three platform removal flakes, angular fragments and cortical surfaces all suggest on-site flaking. There is also a considerable amount of usewear. Of the 63 flakes (including the three platform removal flakes), 25 (40%) are used (e.g., Fig. 6D). Nine flakes (Fig. 6A) and three fragments are also retouched; of the discernable tool types, two are possible burins (Fig. 6G,H) and one is a notched scraper (Fig. 6C). There is also evidence for the presence of a blade technology, with seven used and one retouched blade (Fig. 6B,E,F).

Comparing Avanata to known Massim pottery assemblages

Situating the Avanata pottery assemblage within the cultural sequences of the Massim is hampered by the small number of archaeologically derived pottery assemblages and associated radiocarbon dates. There are currently no obvious parallels between Avanata pottery and the known assemblages from either the Southern or Northern Massim, which have a good coverage of styles back to approximately 500 years ago

Table 1. Diagnostic features of the Avanata (site BALZ) pottery assemblage.

sherd number	layer	sherd type	vessel form	red paint	shell impression	notched band	lip notching	triangulars cut outs	nubbin
S1	surface	rim	open bowl	●	●	●	—	—	—
S2	surface	rim	open bowl	●	—	—	● (shell)	—	—
S3	surface	carination	open bowl	●	●	●	—	—	—
S4	surface	rim	dish/bowl	●	—	—	—	—	—
S5	surface	rim	open bowl	—	●	—	—	—	—
S6	surface	body		●	●	—	—	—	—
S7	surface	carination		●	●	●	—	—	●
TP1-1	1	rim	dish/bowl	●	—	—	—	—	—
TP1-2	1	rim	dish/bowl	●	—	—	●	—	—
TP1-3	1	body	—	●	●	—	—	—	—
TP1-4	1	rim	open bowl	—	—	—	—	—	—
TP1-5	1	body		●	—	—	—	—	—
TP1-6	1	rim	open bowl	—	●	—	—	—	—
TP1-7	1	carination		—	●	●	—	—	—
TP1-12	1	body		—	●	—	—	—	—
TP1-14	1	body		●	—	—	—	—	—
TP1-16	1	body		●	●	—	—	—	—
TP1-17	3	body		●	—	—	—	—	—
TP1-18/19	2–3	rim	dish/bowl	●	—	—	—	●	—
TP1-23	2–3	body		●	—	—	—	—	—
TP1-25	2–3	body		●	—	—	—	—	—
TP1-28	2–3	body		●	—	—	—	—	—
TP1-29	2–3	rim	open bowl	●	●	—	—	—	—
PT1		rim	open bowl	●	●	—	—	—	—

(Bickler, 1998; Egloff, 1972, 1979; Irwin *et al.,* 2019; Lauer, 1974; Shaw, 2016b; Shaw *et al*., 2020). Irwin *et al*. (2019) specifically identify a lack of shell impression in the Massim, which is the dominant decoration style for the Avanata assemblage. As the other pottery sites identified during our Fergusson fieldwork largely fit within the currently recorded Northern Massim sequence of pottery from Goodenough and Amphletts, with some mainland and Southern Massim styles also present, it would suggest that the Avanata assemblage is likely to predate the current sequences.

Within the Massim, the closest match for the Avanata assemblage is Egloff's (1972) Group P pottery which he identified in Collingwood Bay, the Trobriand Islands and from Lauer's assemblages from Goodenough Island. Egloff attributed Group P to an Early Ceramic Phase, dated to more than 1000 years ago. This pottery includes triangular cut-outs or impressions on the labial flanges of the rims of pedestalled bowls (Egloff, 1979) and has been considered to be a possible Lapita assemblage. A pottery sherd that Egloff associated with Group P is decorated with shell impression in rectilinear designs above a medial flange with triangular cut-outs (Egloff, 1972: plate 8c), which mimics at least the use of shell impression of Avanata. However, there are also distinct differences with Egloff's Group P, including the addition of painting and the wider use of shell impression in the Avanata assemblage.

Shell impression is a common Papuan pottery decoration technique beyond the Massim. It occurs, for example, in EPP assemblages along the south coast of Papua New Guinea, in Style H from Nebira 4 (Allen, 1972) and Style A from Oposisi (Vanderwal, 1973, fig.VI-6) However, the shell impression from these sites is largely short and dense in application, rather than the multiple long wavy lines of Avanata. Apart from shell impression, there appears little to connect the EPP assemblages with the Avanata assemblage in terms of pottery, although obsidian from West Fergusson is present in a range of EPP sites, from Mailu to Oposisi (Summerhayes and Allen, 2007).

Three sites in the Gulf of Papua, Hopo (OJS), Kaveharo (OJV) and Hohelavi (OJT) contain similar pottery decoration in terms of the long wavy lines of shell impression (Skelly and David, 2017). These include two red-slipped/painted rim sherds (OJV-A-35-1; OJV-B-27-13) from bowls that date to 2185-2708 cal. BP and two body sherds (OJT-A-27-4; OJT-A-22-1) that date to 1932-2701 cal. BP. OJS has one rim sherd (OJS-B-33-2) from a bowl that has a horizontal finger groove running beneath the rim and then a pattern of long wavy shell impressed lines beneath the groove; this sherd dates to 1632-2748 cal. BP. The main difference between these sherds and the Avanata collection is that while the style of decoration is similar, with horizontal and diagonal lines forming simple motifs, the Avanata assemblage always

Table 2. Error ranges of BHVO-2 geological standard shot at University of Otago.

elements	Mn	Fe	Rb	Sr	Y	Zr	Nb
USGS standard median (ppm)	1290	86300	9.8	389	26	172	18
Otago pXRF average (ppm) (n = 16)	1105	79980	14.86	338	23	152	16
Otago Standard Dev.	60.37	823.67	0.75	4.08	0.89	2.75	0.76
Otago RSD (%)	5.46	1.03	5.06	1.21	3.86	1.81	4.62

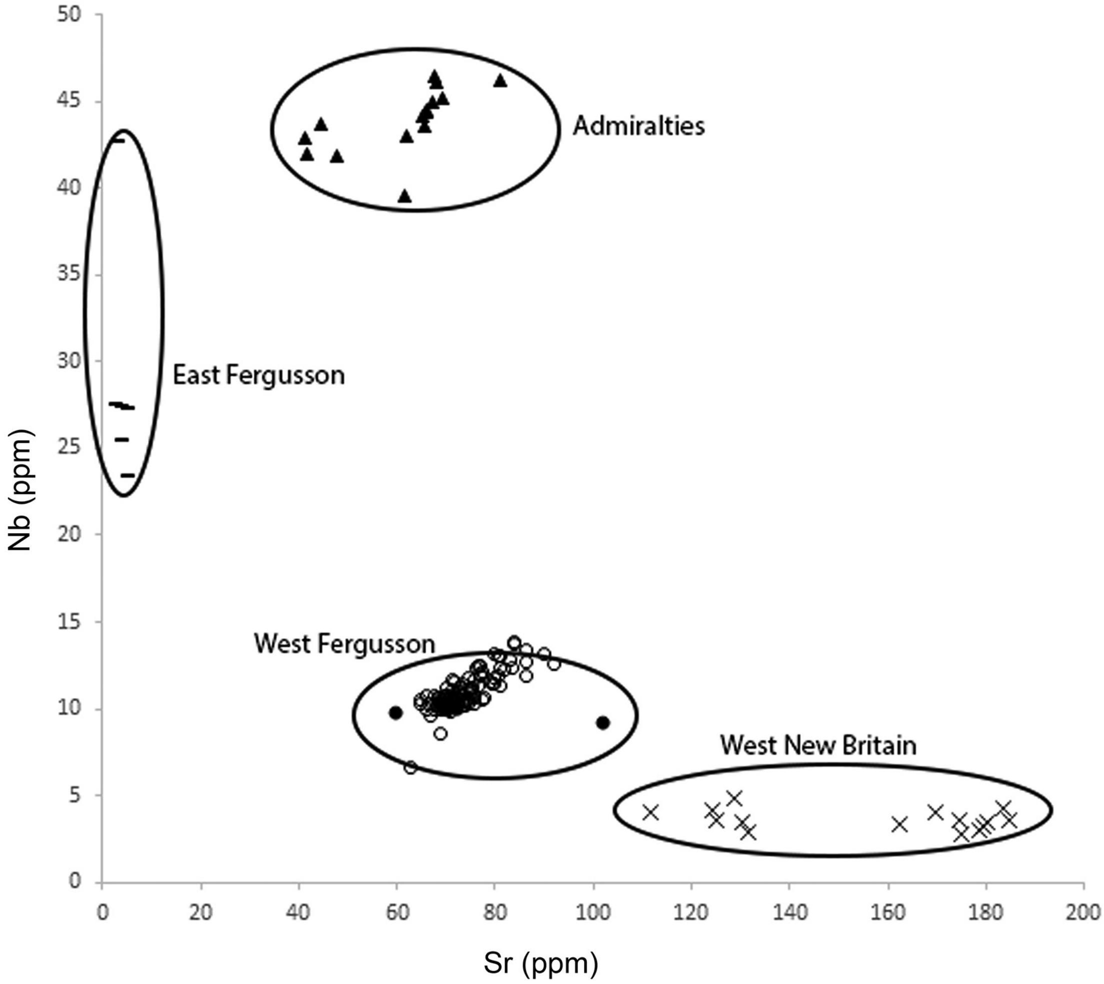


Figure 5. pXRF analysis of Avanata artefacts (open circles) compared to PNG obsidian source material.

comprises multiple lines impressed together, whereas in the Gulf assemblages they are usually single. While the Gulf of Papua may appear to be an unusual location to investigate parallels to the Avanata assemblage, it is noted that two of the sites with shell impressed sherds (OJS and OJT) also have West Fergusson obsidian in associated layers (Skelly *et al*., 2016).

Similar wavy shell impressed lines occur in pottery decoration at Edubu 1 and Moiapu 3, two Caution Bay sites near Port Moresby. While Caution Bay has Lapita pottery assemblages with dentate-stamped designs from c. 2600-2900 cal. BP (McNiven *et al*., 2011), the wavy lines of shell impression are limited to the end of the Lapita phase, with the Edubu 1 assemblage dating between 2350-2650 cal. BP (McNiven *et al*., 2012) and Moiapu 3 dating between 2410-2630 cal. BP (David *et al.,* 2019). Edubu 1 has two sherds with parallel shell impressed lines, and one sherd with a more complex design that includes central horizontal lines of shell impression, with inverted triangles beneath this centre, and V-shapes turned on their side above (McNiven *et al*., 2012: fig. 7e). This design, while largely completed in singular wavy lines rather than multiple, is similar in expression to Avanata Fig. 4A. It is also worth noting here that dentate designs from this site are also similar in design to some of the Avanata examples, with multiple lines of dentate forming both horizontal lines and inverted V-shapes (McNiven *et al*., 2012: fig. 6). The design is comparable in style to that seen in Avanata Fig. 4J, although the Avanata sherd is shell impressed rather than dentate-stamped. However, while the tool used in the impression is different, the intent and overall effect is arguably the same.

At Moiapu 3, there are seven sherds with wavy lines created by shell impression, one of which is described as a single line and the others as parallel lines. Although the sherds are small and it is difficult to identify patterns, at least one sherd (David *et al*., 2019: fig. 3.12C) has multiple shell impressed lines similar to the Avanata sherds. As with the Gulf sites, both Edubu 1 and Moiapu 3 also contain obsidian sourced to West Fergusson. In the matter of single lines being more common at Caution Bay and multiple lines more common at Avanata, the Fergusson site is more similar to traditional Lapita dentate style decorations which usually employ multiple lines of dentate-stamping to produce motifs (McNiven *et al.,* 2012). Painting is also not distinguished at any of the Gulf/Caution Bay sites, although this may be partly because these assemblages have 'red-slipped' and 'painted' combined as a single category. Also, the notched carination does not occur at Caution Bay, although fingernail/stick-impressed decorations are present at both OJS and Edubu 1, superficially similar to Avanata.

Further comparison can be made with the Linear Shell Edge-Impressed Tradition, a pottery style slightly later in time at 2150-2100 cal. BP that is also found at Caution Bay and the Gulf sites. Although overlapping in time with the EPP shell impressed sherds discussed above, David *et al*. (2012) note differences between EPP shell impressed and Linear Shell Edge-Impressed, where the edges of *Anadara* shells have been impressed into the surface of the pottery, leaving largely triangular indentations in a range of patterns, including columns and lines. Some of the patterns described in David

Figure 6. Obsidian artefacts from Avanata Test Pit 1. (*A*) retouched flake with cobble cortex; (*B*) used blade; (*C*) notched scraper; (*D*) used flake; (*E*) used blade; (*F*) used blade; (*G*) possible burin; (*H*) possible burin.

et al. (2012) are reminiscent of the Avanata assemblage, including the use of multiple lines and the style of applying 'angled lines meeting angled lines at an obtuse angle' (David *et al*., 2012: 86) (see Fig. 4A,I). However, there are also distinct differences. For most of the rim sherds identified at Bogi 1 and the Gulf sites of OKA and OJS, a finger groove was present above the shell impression, which is a decoration not seen at Avanata. Bogi 1 and the Gulf sites also lack the notched carination described for Avanata. The triangular nature of the Linear Shell Edge-Impression (see David *et al*., 2012: fig. 6; Skelly and David, 2017: fig. 115m-q) is also largely different from the long wavy lines of the Avanata shell impression. The use of the shell impression to create 'short' lines (see David *et al*., 2012: fig. 6I-K) is also unlike its application at Avanata. Finally, in comparison to Bogi 1, there is a greater diversity in decoration types at Avanata. Apart from the 275 shell impressed sherds in Bogi 1 Squares A and B, there are only nine contemporary sherds with other decorative types, including dentate stamping and incision.

This discussion indicates that there are no clear parallels between the Avanata assemblage and the pottery sequences recorded within the Northern or Southern Massim for the past 500 years and that there are stronger links with pottery styles located on the south coast of mainland Papua New Guinea that date to either late/terminal Lapita or immediately post-Lapita. Connections with these sites are based on the presence of shell impressed decoration, as well as the use of West Fergusson obsidian at these sites. However, none of the south coast mainland assemblages are exact matches for the Avanata assemblage, a fact that emphasises the difficulty of comparing assemblages on the presence or absence of particular decoration techniques and their different applications.

Discussion and conclusion

The Avanata pottery assemblage does not match any of the currently recorded sequences for the Northern and Southern Massim that date back to at least 500 years ago. Therefore it is argued that this assemblage must be older than this date. Indeed, the collection differs significantly from all previously recorded prehistoric Massim pottery, with the possible exception of Egloff's Group P, which has been described as resembling Lapita assemblages and is itself largely undated and not well described. The Avanata assemblage also shares little with EPP pottery along the Papuan south coast. Instead, we argue that the pottery decoration is most similar to assemblages from the Gulf and Caution Bay that have been described as terminal to transformative Lapita, and that also contain West Fergusson obsidian. Shell impression and the simplification of dentate-stamped motifs into simple geometrics have been noted in other Late Lapita assemblages in Papua New Guinea and the Pacific (Bedford, 2015; Kirch, 1997: 155; Summerhayes, 2000) as well as evidence for painting (Bedford, 2006). Further excavation may show Avanata to be a terminal Lapita site, associated with feeding West Fergusson obsidian into networks extending along the south coast of Papua New Guinea.

The location of Avanata is an important part of the hypothesis. The main purpose of the Fergusson fieldwork was to map the obsidian sources on the western part of the island and to describe their physical nature, in a similar way to that completed by Torrence for West New Britain (Torrence, 2004; Torrence *et al*., 1992; Torrence *et al*., 1996). During the survey, Avanata was the only place where large amounts of obsidian occurred near the coast. Here, obsidian is abundant on the beach and in the Waguva River, which appears to be the main source for the obsidian in the Avanata test pit. The nearby Naimatu Ridge is the only other place observed where obsidian effectively 'outcrops' as a scree slope directly onto the coast, although as this was the boundary for our field survey, it is possible that this also happens further to the east. The coincidence of a possible early site based on pottery style, the known use of West Fergusson obsidian from Lapita and later sites at Caution Bay and the Gulf, and the abundance of obsidian at this location, especially when compared to the remainder of the survey, lends weight to the possibility that Avanata formed part of the network that transported West Fergusson obsidian to the south coast of Papua New Guinea from Lapita time onwards. This hypothesis can be tested by future fieldwork that dates the Avanata site.

What is obvious from the available Massim pottery assemblages is that we do not yet understand the role of pottery in the Massim prior to 500 years ago. This obviously limits the use of pottery decoration or vessel forms as comparative chronological tools. Further fieldwork needs to be completed at potentially early sites in the Massim region, including on the mainland in Collingwood Bay, to provide better pottery sequences and a deeper understanding of the nature of obsidian sources and the chronology and nature of human occupation in the Massim region.

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References

Allen, J. 1972. Nebira 4: an early Austronesian site in Central Papua. *Archaeology and Physical Anthropology in Oceania* 7(2): 92–124.
https://www.jstor.org/stable/40386170

Allen, J., G. Summerhayes, H. Mandui, and M. Leavesley. 2011. New data from Oposisi: implications for the Early Papuan Pottery phase. *Journal of Pacific Archaeology* 2(1): 1–13.

Ambrose, W. 1976. Obsidian and its prehistoric distribution in Melanesia. In *Ancient Chinese Bronzes and Southeast Asian Metal and other Archaeological Artifacts*, ed. N. Barnard, pp. 351–378. Melbourne: National Gallery of Victoria.

Bedford, S. 2006. The Pacific's earliest painted pottery: an added layer of intrigue to the Lapita debate and beyond. *Antiquity* 80: 544–557.
https://doi.org/10.1017/S0003598X00094023

Bedford, S. 2015. Going beyond the known world 3000 years ago: Lapita exploration and colonization of Remote Oceania. In *The Lapita Cultural Complex in Time and Space: Expansion Routes, Chronologies and Typologies*, ed. C. Sand, S. Chiu, and N. Hogg, pp. 25–47. Noumea: Institut d'archéologie de la Nouvelle-Calédonie et du Pacifique (IANCP).

Bickler, S. 1998. *Eating Stone and Dying: Archaeological Survey on Woodlark Island, Milne Bay Province, Papua New Guinea*. Unpublished PhD thesis, Department of Anthropology, University of Virginia.

Bird, J. R., W. R. Ambrose, L. H. Russell, and M. D. Scott. 1981. *The Characterization of Melanesian Obsidian Sources and Artefacts using the Proton Induced Gamma-Ray Emission (PIGME) Technique*. Lucas Heights, Sydney: Australian Atomic Energy Commission.

Chynoweth, M., G. R. Summerhayes, A. Ford, and Y. Negishi. 2020. Lapita on Wari Island: What's the problem? *Asian Perspectives* 59(1): 100–116.
https://doi.org/10.1353/asi.2020.0009

David, B., I. J. McNiven, M. Leavesley, B. Barker, H. Mandui, T. Richards, and R. Skelly. 2012. A new ceramic assemblage from Caution Bay, south coast of mainland PNG: the Linear Shell Edge-Impressed Tradition from Bogi 1. *Journal of Pacific Archaeology* 3(1): 73–89.

David, B., K. Aplin, H. Peck, R. Skelly, M. Leavesley, J. Mialanes, K. Szabo, B. Koppel, F. Petchey, T. Richards, S. Ulm, I. J. McNiven, C. Rowe, S. J. Aird, P. Faulkner, and A. Ford. 2019. Moiapu 3: settlement on Moiapu Hill at the very end of Lapita, Caution Bay hinterland. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 61–88. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.03

Egloff, B. 1972. The sepulchral pottery of Nuamata Island, Papua. *Archaeology and Physical Anthropology in Oceania* 7(2): 145–163.
https://doi.org/10.1002/j.1834-4453.1972.tb00153.x

Egloff, B. 1979. *Recent Prehistory in Southeast Papua*. Terra Australis 4. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.

Fredericksen, C. 1997. Changes in Admiralty Islands obsidian source use: the view from Pamwak. *Archaeology in Oceania* 32(1): 68–73.
https://doi.org/10.1002/j.1834-4453.1997.tb00372.x

Irwin, G. 1991. Themes in the prehistory of coastal Papua and the Massim. In *Man and a Half: Essays in Pacific Anthropology and Ethnobiology in Honour of Ralph Bulmer*, ed. A. Pawley, pp. 503–510. The Polynesian Society Memoir 48. Auckland: The Polynesian Society.

Irwin, G., B. Shaw, and A. McAlister. 2019. The origins of the Kula Ring: archaeological and maritime perspectives from the southern Massim and Mailu areas of Papua New Guinea. *Archaeology in Oceania* 54(1): 1–16.
https://doi.org/10.1002/arco.5167

Jenness, C., and A. Ballantyne. 1920. *The Northern D'Entrecasteaux*. Oxford: Clarendon Press.

Kirch, P. V. 1997. *The Lapita Peoples: Ancestors of the Oceanic World*. Oxford: Blackwell.

Lauer, P. K. 1974. *Pottery Traditions in the D'Entrecasteaux Islands of Papua*. Occasional Papers in Anthropology No. 3. St Lucia: Anthropology Museum, University of Queensland.

McNiven, I. J., B. David., T. Richards, K. Aplin, B. Asmussen, J. Mialanes, M. Leavesley, P. Faulkner, and S. Ulm. 2011. New direction in human colonization of the Pacific: Lapita settlement of the south coast New Guinea. *Australian Archaeology* 72: 1–6.
https://doi.org/10.1080/03122417.2011.11690525

McNiven, I. J., B. David, K. Aplin, J. Mialanes, B. Asmussen, S. Ulm, P. Faulkner, C. Rowe, and T. Richards. 2012. Terrestrial engagements by terminal Lapita maritime specialists on the southern Papuan coast. In *Peopled Landscapes: Archaeological and Biogeographic Approaches to Landscape,* ed. S. G. Haberle and B. David, pp. 121–156. Terra Australis 34. Canberra: ANU E Press.
https://doi.org/10.22459/TA34.01.2012.05

Mialanes, J., B. David, A. Ford, T. Richards, I. J. McNiven, G. R. Summerhayes, and M. Leavesley. 2016. Imported obsidian at Caution Bay, south coast of Papua New Guinea: cessation of long distance procurement c. 1,900 cal BP. *Australian Archaeology* 82: 248–262.
https://doi.org/10.1080/03122417.2016.1252079

Negishi, Y., and R. Ono. 2009. Kasasinabwana shell midden: the prehistoric ceramic sequence of Wari Island in the Massim, Eastern Papua New Guinea. *People and Culture in Oceania* 25: 23–52.
http://hdl.handle.net/1885/53789

Reepmeyer, C., M. Spriggs, S. Bedford, and W. Ambrose. 2010. Provenance and technology of lithic artifacts from the Teouma Lapita site, Vanuatu. *Asian Perspectives* 49(1): 205–225. https://doi.org/10.1353/asi.2010.0004

Ross, M. 1992. The position of Gumawana among the languages of the Papuan Tip Cluster. *Language and Linguistics in Melanesia* 23: 139–165.

Shaw, B. 2016a. The Massim region of Papua New Guinea: a review and proposed chronology. *Journal of Pacific Archaeology* 7(1): 106–125.

Shaw, B. 2016b. The late prehistoric introduction of pottery to Rossel Island, Louisiade Archipelago, Papua New Guinea: insights into local social organization and regional exchange in the Massim. *Archaeology in Oceania* 51: 61–72. https://doi.org/10.1002/arco.5104

Shaw, B., S. Coxe, V. Kewibu, J. Haro, E. Hull, and S. Hawkins. 2020. 2500-year cultural sequence in the Massim region of eastern Papua New Guinea reflects adaptive strategies to small islands and changing climate regimes since Lapita settlement. *The Holocene* 30(7): 1–16. https://doi.org/10.1177/0959683620908641

Skelly, R., A. Ford, G. Summerhayes, J. Mialanes, and B. David. 2016. Chemical signatures and social interactions: implications of west Fergusson Island obsidian at Hopo, east of the Vailala River (Gulf of Papua), Papua New Guinea. *Journal of Pacific Archaeology* 7(1): 126–138.

Skelly, R. J., and B. David. 2017. *Hiri: Archaeology of Long-Distance Maritime Trade Along the South Coast of Papua New Guinea*. Honolulu: University of Hawai'i Press.

Summerhayes, G. R. 2000. *Lapita Interaction*. Terra Australis 15. Canberra: Department of Archaeology and Natural History and the Centre for Archaeological Research, Australian National University.

Summerhayes, G. R., and J. Allen. 1993. The transport of Mopir obsidian to late Pleistocene New Ireland. *Archaeology in Oceania* 28(3): 144–148. https://doi.org/10.1002/j.1834-4453.1993.tb00305.x

Summerhayes, G. R., and J. Allen. 2007. Lapita writ small? Revisiting the Austronesian colonization of the Papuan south coast. In *Oceanic Explorations: Lapita and Western Pacific Settlement*, ed. S. Bedford, C. Sand, and S. P. Connaughton, pp. 97–122. Terra Australis 26. Canberra: ANU E Press. https://doi.org/10.22459/TA26.2007.05

Torrence, R. 2004. Now you see it, now you don't: changing obsidian source use in the Willaumez Peninsula, Papua New Guinea. In *Explaining Social Change: Studies in Honour of Colin Renfrew*, ed. J. Cherry, C. Scarre, and S. Shennan, pp. 115–125. Cambridge: McDonald Institute for Archaeological Research, University of Cambridge.

Torrence, R., V. Neall, T. Doelman, E. Rhodes, C. McKee, H. Davies, R. Bonetti, A. Guglielmetti, A. Manzoni, M. Oddone, J. Parr, and C. Wallace. 2004. Pleistocene colonisation of the Bismarck Archipelago: new evidence from West New Britain. *Archaeology in Oceania* 39(3): 101–130. https://doi.org/10.1002/j.1834-4453.2004.tb00568.x

Torrence, R., J. Specht, R. Fullagar, and R. Bird. 1992. From Pleistocene to present: obsidian sources in West New Britain, Papua New Guinea. *Records of the Australian Museum, Supplement* 15: 83–98. https://doi.org/10.3853/j.0812-7387.15.1992.86

Torrence, R., J. Specht, R. Fullagar, and G. R. Summerhayes. 1996. Which obsidian is worth it? A view from the West New Britain Sources. In *Oceanic Culture History: Essays in Honour of Roger Green*, ed. J. M. Davidson, G. Irwin, B. F. Leach, A. Pawley, and D. Brown, pp. 211–224. Dunedin: New Zealand Journal of Archaeology.

Vanderwal, R. 1973. *Prehistoric Studies in Central Coastal Papua*. Unpublished PhD thesis, Australian National University, Canberra.

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Moving On or Settling Down? Studying the Nature of Mobility through Lapita Pottery from the Anir Islands, Papua New Guinea

Nicholas W. S. Hogg[1], Glenn R. Summerhayes[1,2], and Yi-lin Elaine Chen[1]

[1] Archaeology Programme, School of Social Sciences, University of Otago, Dunedin, New Zealand

[2] School of Social Science, University of Queensland, St Lucia QLD 4072, Australia

Abstract. Summerhayes has argued that changes in the mobility of Lapita communities within the Bismarck Archipelago of Papua New Guinea is reflected in numerous aspects of their pottery assemblages. Such changes are seen most markedly in a reduction in the number of clay and temper combinations over time, which indicates less movement across the landscape to collect clays and tempers for pottery production. This pattern was identified in the Arawe Islands and Mussau Islands, and more tentatively in the Anir Islands of southern New Ireland Province. This research reviews and re-interprets the previous studies of the Anir pottery assemblages through mineralogical and geochemical analyses to test whether the Arawes and Mussau model applies in this region. Previous work upon pottery assemblages from the Tanga islands is also brought into the discussion as a means of comparison and to identify possible exchange relationships between the Anir and Tanga groups.

Introduction

Extensive research by Anson (1983, 1986), Hunt (1989) and Summerhayes (2000a, 2000b, 2000c, 2003, 2010) upon Lapita ceramic assemblages from sites of the Bismarck Archipelago of Papua New Guinea, has begun to isolate clear differences between Early Lapita ceramic assemblages and those from Middle/Late Lapita contexts. The differences stem from both the function of the ceramic assemblages and changes occurring within Lapita society.

Based upon a comparison of assemblages from the Arawe Islands and the mid north coast of New Britain, the Mussau Islands off northern New Ireland, and the results of preliminary analyses conducted on the Anir Islands sites, Summerhayes (2000a: 231–233, 2001a, 2001b: 61) argued that Lapita ceramic assemblages could be functionally divided between vessels with dentate stamping and those without, and these two components had variable rates of change, where the former changed dramatically over time while the latter changed very little.

This pattern was first identified in the Arawe Islands assemblages, whereby the ratio of dentate stamped wares and the vessel forms primarily associated with such decoration (bowls and stands) declined over time from the Early to Middle Lapita periods, while vessels without dentate stamping, such as outcurving jars, remained the same in terms of decoration and numbers (Summerhayes, 2000a: 155–156, 231; 2000c: 301). Similar observations were made with preliminary research undertaken on material from the Anir Islands, where Early Lapita deposits in Kamgot (ERA) have higher proportions of dentate stamping as well as bowls and stands, as opposed to the later sites of Balbalankin (ERC) and Malekolon (EAQ) which have a much higher proportion of carinated jars lacking dentate stamping. Additionally, such patterns can also be seen in the Early and Middle/Late Mussau Lapita assemblages (Summerhayes, 2000a: 232–233; 2000b: 57–62; 2003: 139–140).

Alongside the changes occurring with form and decoration, Summerhayes (2000a: 225–290) also argued for changes in pottery production, whereby Early Lapita

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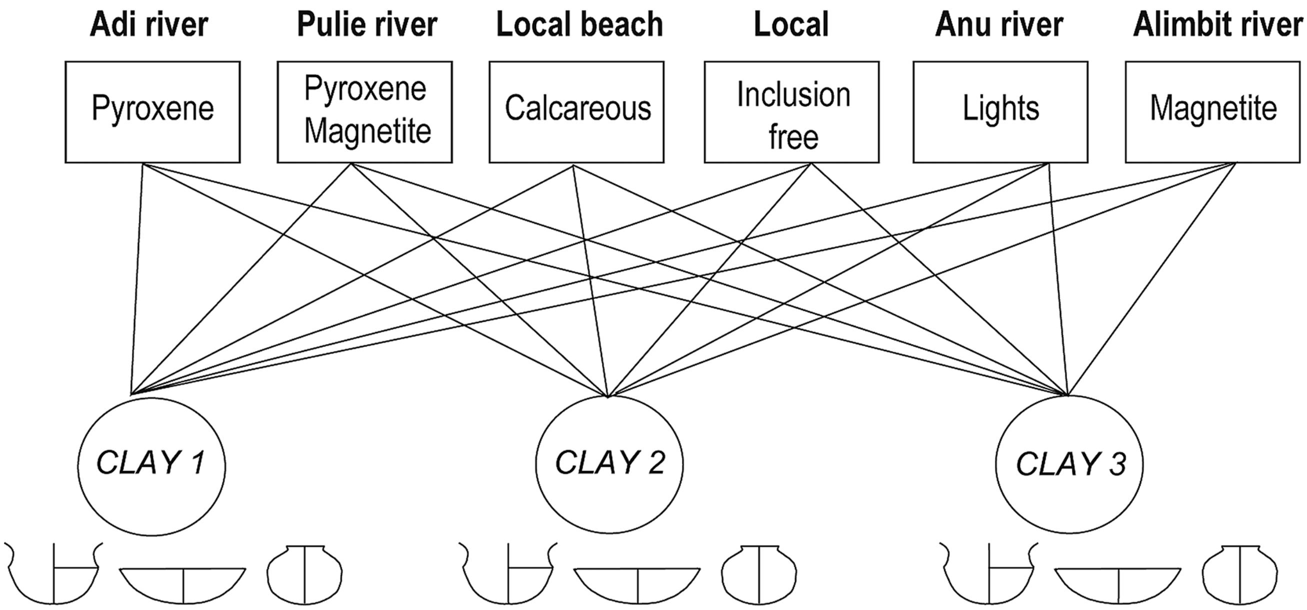

Figure 1. Early Lapita production model identified with the Arawe assemblages (after Summerhayes and Allen, 2007: fig. 5).

pottery was produced using a wide range of temper sands and clays, and Middle/Late pottery was produced using a narrower range of such materials. This change arguably reflects a decrease in population mobility. In this model, highly mobile early populations were exploring and moving around the landscape to acquire resources for pottery production, resulting in the use of an eclectic mixture of clays and tempers. However, over time such populations became more sedentary and conservative and thus used a more restricted range of resources collected from the vicinity of their settlements. The model was argued using the comparison of Early Lapita assemblages from the Arawe Islands (Adwe, Paligmete and lower layers of Apalo) and the Middle/Late Lapita assemblages from Garua Island, Boduna Island and upper layers of Apalo. The early assemblages were made with a number of local clays and temper sands from various rivers along the south coast of New Britain (Fig. 1), while the later assemblages were made from one or two local clays in combination with a small number of locally sourced sands (Fig. 2). Interestingly, no specific clays and temper sands were used exclusively for any specific vessel forms (Summerhayes, 2000a: 225–229, 2003: 140–141).

Referencing a preliminary fabric analysis (discussed below), Summerhayes (2001b) tentatively proposed that similar changes in pottery production may have occurred in the Anir Islands. Following this publication, studies undertaken upon Lapita ceramics from the Anir Islands by Hennessey (2007) and Hogg (2007) provide important contributions to the discussion of Anir pottery production and will be reviewed in detail in the following sections. A similar reduction in the number of fabric-clay combinations over time was also observed by Hunt (1989: 134–146, 193–213) in the Mussau Lapita assemblages, though Kirch (1990: 123; 1997: 242–246) interpreted this as resulting from the importation of pottery from fewer pottery production localities due to the regionalisation of long-distance exchange networks.

Finally, Cath-Garling (2017: 128, table 5.25) identified a similarly complex pattern of production in her analyses of Early-Middle Lapita pottery (arguably produced using at

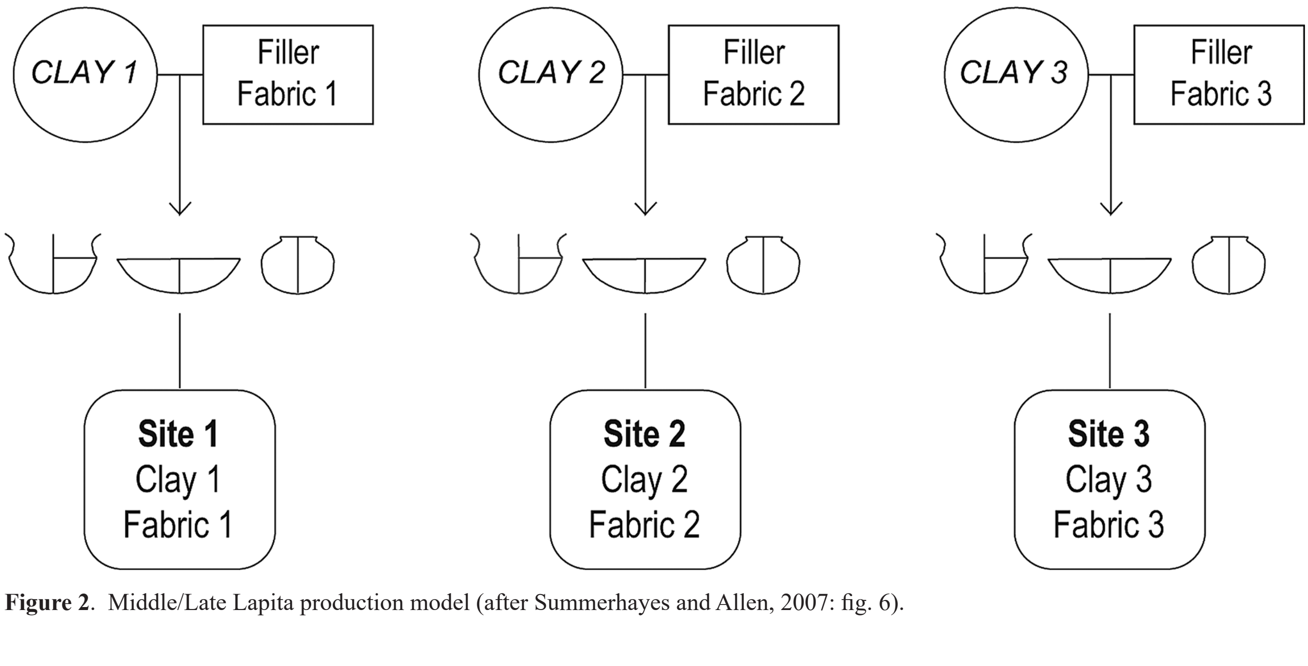

Figure 2. Middle/Late Lapita production model (after Summerhayes and Allen, 2007: fig. 6).

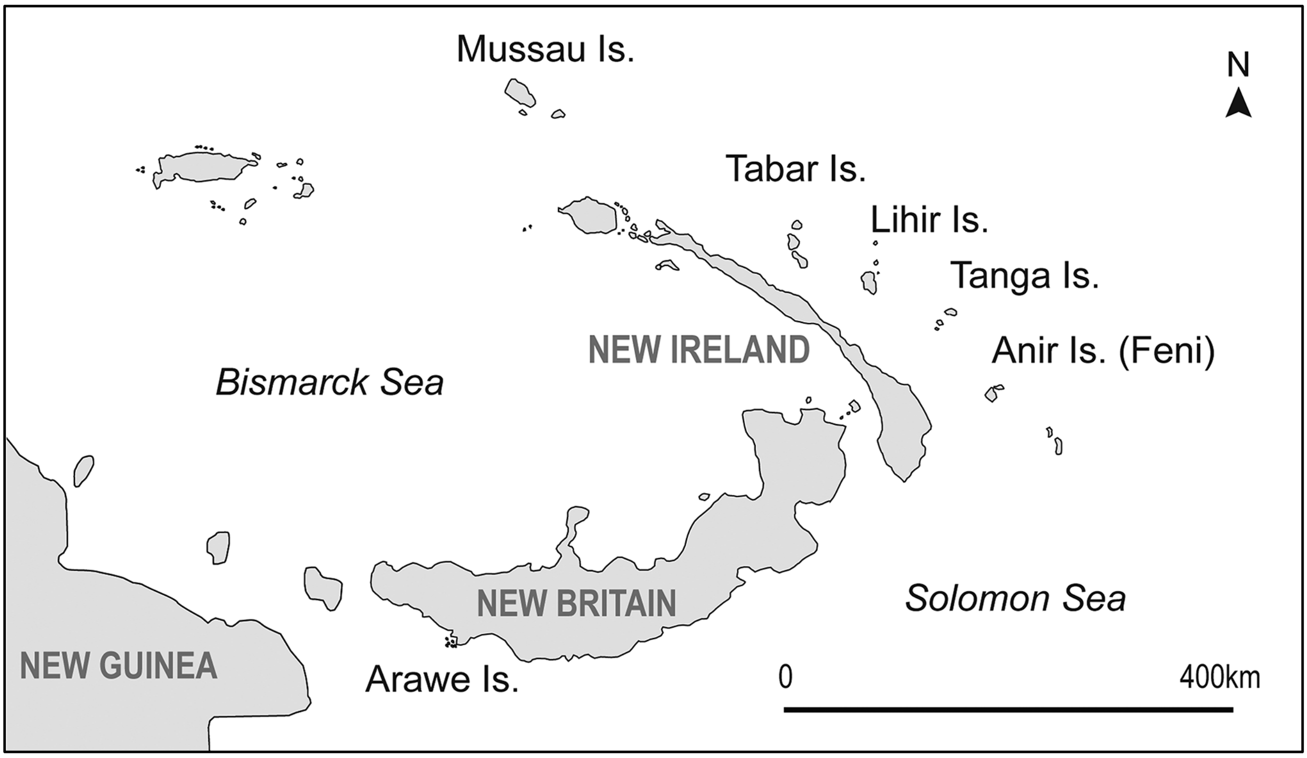

Figure 3. Bismarck Archipelago showing relevant island groups.

least three clays in combination with eight temper groups) from the Angkitkita (ETM) site on Lif Island in the Tanga group of islands. Importantly, she suggested that some tempers and clays are exotic to the Tanga Islands and might ultimately derive from the Anir Islands, thus potentially indicating the movement of pottery. Interestingly, no link was made between the exotic pottery and any known Lapita sites in the Anir group; however, she argued that some post-Lapita pottery from ETM had similar tempers to Lapita pottery analysed by Dickinson (2004a) from Malekolon (EAQ) on Ambitle (Cath-Garling, 2017: 149).

In this paper, the form, decoration and fabric of pottery from three Anir sites, Kamgot, Balbalankin and Malekolon are studied to further refine our understanding of Lapita society within and between the Early and Middle/Late Lapita periods.

The archaeology of the Lapita occupation of the Anir Island Group

The Anir Islands (also known as the Feni Islands), consisting of the two islands of Ambitle and Babase, is the last in the Tabar, Lihir, Tanga and Feni (TLTF) chain which runs down the northeast coast of New Ireland in the Bismarck Archipelago, Papua New Guinea (Fig. 3). Ambitle, the larger of the two islands, is 14 km long with a maximum width of 10 km, while Babase is 10 km long and 5 km at its widest point (Fig. 4). Geologically the two islands are composed of Neogene alkalic volcanic rocks of basanite, tephrite and trachybasalt (Wallace *et al*., 1983). Ambitle Volcano occupies all of Ambitle Island and has a maximum elevation of 479 m; the cone of this volcano is composed primarily of lava flows with pyroclastic and epiclastic rocks. Underlying the

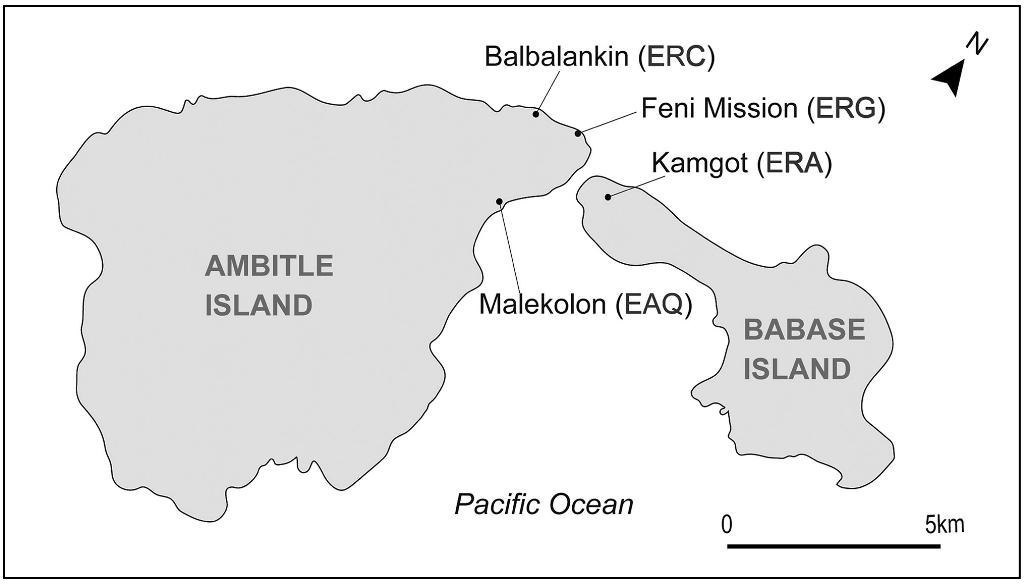

Figure 4. Map of the Anir Islands (see Fig. 3) displaying the locations of the sites of Balbalankin (ERC), Malekolon (EAQ), Feni Mission (ERG), and Kamgot (ERA).

volcanic deposits are Oligocene basement rocks (Lindley, 2015: 532). Similarly, Babase Island consists of a volcanic cone to the east, with an extrusion extending to the west overlain by Oligocene limestone (Horz *et al*., 2004: 88; Woolley, 2019: 291).

Early Lapita settlement site of Kamgot (ERA), Babase Island

ERA is located 100 m inland near the village of Kamgot on the northwest coast of Babase Island (Fig. 4). The site was extensively excavated in 23 test pits (77 m^2) in a north-aligned 200 x 100 m grid. Abundant cultural remains were unearthed at the site with over 20,000 pottery sherds, 1000 pieces of obsidian, a variety of tools and ornaments made of shell, coral, and other materials, and a large amount of faunal and shell remains (Summerhayes, 2000b, 2004; Szabó and Summerhayes, 2002; Summerhayes *et al*., 2019).

The chronology of the Early Lapita occupation of ERA is based upon two pairs of charcoal and marine shell determinations from Layer 2 in Test Pit 1 (Summerhayes, 2001a: table 3; 2007: 146; Summerhayes *et al*., 2019: 100). All determinations discussed in this section and those provided in the following section were calibrated using OxCal v. 4.4.1 (Bronk Ramsey, 2009) using the IntCal13 calibration curve for charcoal determinations and the Marine13 curve for marine shell dates (Reimer *et al*., 2013) and employing a Delta R correction of –69±51 years (see Summerhayes, 2010: 20–24 for more details).

The radiometric ages are:

1 Spit 6: 3035±45 BP (Wk-7561, charcoal) and 3260±45 BP (Wk-7560, marine shell), which calibrate to 3361–3080 cal. BP and 3353–2981 cal. BP at 2σ, respectively.
2 Spit 9: 3075±45 BP (Wk-7563, charcoal) and 3350±45 BP (Wk-7562, marine shell), which calibrate to 3381–3170 cal. BP and 3451–3100 cal. BP at 2σ, respectively.

Middle–Late Lapita settlement sites of Malekolon (EAQ) and Balbalankin (ERC), Ambitle Island

EAQ is located 0.5 km inland on a plantation situated in a V-shaped valley on the north-eastern coast of the island of Ambitle. The site is bordered to the north, south and west by cliffs and the sea and an offshore reef to the east. Five test pits were excavated across the site to gain an understanding of site formation processes. Only Test Pit 4 contained cultural material, while the remainder were culturally sterile (Summerhayes, 2004: 147). The cultural materials include 2459 pottery sherds, 211 obsidian pieces, a stone adze, a possible stone chisel, and a small amount of quartz and chert (Summerhayes, 2000b: 170, table 4).

The deposits in the test pits suggest that the Lapita occupation identified in Test Pit 4 was located next to an embayment with a fringing reef. Earlier occupation of the site (discussed below) was situated on the beach, which due to subsequent progradation and infilling of the valley over time, is represented by deposits situated further inland. Massive post-depositional disturbance of these earlier deposits is a result of a major volcanic eruption on Ambitle dated to 2300 years ago (Licence *et al*., 1987: 274) which deposited tephras that were subsequently eroded into the valley and built up behind the reef.

Two radiocarbon dates associated with cultural materials in Test Pit 4 are available (Summerhayes, 2001a: table 3):

1 ANU-11190 (spit 10), charcoal: 2110±240 BP, 2727–1570 cal. BP at 2σ.
2 ANU-11193 (spit 11), charcoal: 3220±170 BP, 3872–2997 cal. BP at 2σ.

In addition, a further two radiocarbon determinations associated with the earlier deposits are available:

1 ANU-957 (basal deposit), charcoal from *Canarium* sp. nutshell: 2050±210 BP, 2697–1541 cal. BP at 2σ (Anson, 1983: 12; Ambrose, pers. comm. 2020).
2 ANU-771 (basal deposit), charcoal: 1340±230 BP, 1773–786 cal. BP at 2σ (Anson, 1983: 12).

In line with the earlier argument made by Summerhayes (2004: 147), ANU-11190 and ANU-957 are seen as dating the volcanic eruption, while ANU-11193 dates the cultural deposits in Test Pit 4. Because of the large standard error associated with this date, the upper range limit overlaps with that of the Early Lapita period when calibrated to 2σ. However, this broad range can be narrowed considerably by reference to obsidian source exploitation within the deposit, which closely aligns with Middle Lapita sites within the Bismarck Archipelago dating to between c. 2900 to 2700–2600 BP (Summerhayes, 2004: table 2, 150). Thus, the most parsimonious interpretation of the available archaeological evidence is that the cultural material within Test Pit 4 dates to the Middle Lapita period.

This interpretation does not preclude the presence of earlier occupation further inland. Indeed, specific pottery from the site (discussed below) is arguably early in nature, while a dentate stamped sherd from the deposit was dated to 3200 BP using thermoluminescence dating. That said, other aspects of the pottery assemblage, together with the radiocarbon determination ANU-771 (above) and a second thermoluminescence date of 2500 BP, all strongly point to the early deposits being highly disturbed (Ambrose quoted in Anson, 1983: 12).

Site ERC is located approximately 140–200 m inland on an area of flat garden land backed by an escarpment, to the south of the hamlet of Farangot on the north-western tip of Ambitle Island. Eight test pits were excavated across the site to establish the presence of cultural material and identify site formation processes. Cultural materials recovered include 1416 pottery sherds, a single piece of chert, earth oven stones, fragments of two *Tridacna* armbands, and abundant faunal remains (Summerhayes, 2001b: 170).

The site's occupational sequence is based upon a single radiocarbon determination from Test Pit 1, spit 5 (Summerhayes, 2001a: table 3):

1 ANU-11188, charcoal: 2620±110 BP, 2950–2365 cal. BP at 2σ.

Previous research on pottery assemblages from the Anir Islands

Peter White and Jim Specht conducted the first analysis of Lapita pottery from the Anir Islands. This assemblage consisted of 77 sherds collected by Mr. G. Carson at Malekolon (known then as Malekolon Plantation) and sent into the Australian Museum in 1969 (White and Specht, 1971: 88–90). Most of the collection is plain, with only 24 decorated sherds identified. Despite this, a wide range of decoration types was identified, including dentate stamping, incision, notching, slashing, plain circle, crescent stamping and another form of stamping thought to be fingernail impression by the authors. Vessel forms were also tentatively identified and included multiple forms of bowls, including both a straight-sided form with an outward rim/wall orientation, an open form, and lastly a restricted bowl form. Other forms identified included globular pots with everted rims and, lastly, vertical-walled 'beakers' (White and Specht, 1971: 89–90).

Wal Ambrose subsequently undertook archaeological excavations (19 m^2) at the Malekolon site (EAQ) in 1970 and 1971 and although little has been written on the excavations, the pottery was used by Anson (1983: 264, 1986: 162) in his formulation of a Far Western Lapita style. An article by Ambrose (1973: 372) also contained images of Lapita pottery which we would classify as Early Lapita. Yet the pottery that Ambrose recorded covered a variety of decoration types, including incision, appliqué and shell impressions, alongside a large amount of plain ware. As noted above, the EAQ dates suggest disturbance; this conclusion is reinforced by Ambrose, who observed that the materials derived from these excavations had been 'jumbled by water' (Ambrose n.d. quoted in Anson, 1983: 12).

Most recently, Summerhayes undertook archaeological research on both Ambitle and Babase Islands. This consisted of a series of excavations between 1995 and 2002 at a number of locations including Malekolon, Kur Kur, and Balbalankin on Ambitle, and Kamgot on Babase (Summerhayes, 2000b, 2001a, 2001b, 2003, 2004). As already argued, excavations on Malekolon in 1995 confirmed that the earlier deposits of Ambrose were disturbed post-depositionally, while those in the later Middle Lapita occupation in Test Pit 4 were intact.

Research resulting from the Summerhayes excavations also provided a preliminary analysis of form, decoration and fabric from each site. The study found that between 8.1% and 11.1% of sherds from the ERA Test Pits 1, 2 and 17 were dentate stamped, while at ERC and EAQ only 1% and 0.5% had dentate stamping, respectively (Summerhayes, 2001b, table 1). The broad fabric analysis indicated that ferromagnesium fabrics were dominant within all three assemblages, making up 67% of the fabrics identified in ERA, 75% in ERC and 97% in EAQ. Light fabrics were noted as present in ERA (28%) and ERC (23%) together with a small amount of calcareous fabrics (4% and 2% respectively). The remaining 3% of the fabrics in EAQ were not discussed (Summerhayes, 2001b: 60).

The final aspect of the preliminary study was to provide basic counts of vessel forms within each of the three assemblages. The discussion below is limited to vessel form counts (Summerhayes, 2001b: table 4) for ERA, as those presented for ERC and EAQ have since been superseded by the results presented in this paper (see below). The most common vessel forms identified in ERA Test Pits 1, 2 and 17 were the open bowl and outcurving carinated jar, both of which comprised 36% of vessels identified, followed by stands (12%) and lastly globular pots (10%).

Following on from the research discussed above, two complementary studies of the production of pottery from the Anir Islands were undertaken by Hennessey (2007) focusing upon Early Lapita ceramics from ERA Test Pit 1 and Hogg (2007) upon Middle-Late material from the sites of ERC, EAQ and Feni mission (ERG). The results of the two studies are presented in this paper.

The two studies employed a shared methodology for chemical analysis, using electron microscopy to selectively analyse the non-plastic inclusions and clay matrix of pottery samples. Data generated from the analysis of the clay matrix was then interpreted via the concept of the 'Chemical Paste Compositional Reference Unit' (CPCRU), whereby each distinct group defined within an elemental dataset on the basis of elemental similarity is considered a single CPCRU or, put more simply, a distinct clay source (Bishop and Rands, 1982; Bishop *et al*., 1982: 302–306; see also Summerhayes, 2000a; Summerhayes and Allen, 2007 for its application).

Table 1. Temper groups identified by Dickinson from the sites of ERA, ERC, and EAQ.

temper group	ERA	ERC	EAQ	total
hornblendic non-placer	0	3	2	5
pyroxenic non-placer	1	2	2	5
pyroxenic placer	5	3	1	9
totals	6	8	5	19

Finally, W. R. Dickinson examined petrographically 19 pottery thin-sections from the three Anir Island sites, eight from ERC, six from ERA and five from EAQ (Dickinson, 2000, 2004b, 2006: appendix table A1) (Table 1). Dickinson (2006: 76), noted that sherds from ERA typically contain more iron oxide (i.e. more placered) than those from EAQ (more non-placered), while ERC has both placer and non-placer tempers. He identified the temper sands within the samples as indigenous to the Anir Islands and belonging to the 'postarc' temper class which is abundant in clinopyroxene and plagioclase feldspar minerals, alongside lesser amounts of hornblende and olivine (Dickinson, 2006: table 1, table 16). Postarc tempers are one of five temper classes defined by Dickinson (2006: 13) for temper sands within Oceanic pottery and can be defined simply as those 'derived from eruptive suites that postdate subduction along dormant island arcs' (Dickinson, 2007: 988). He categorised the Anir tempers into three groups as follows (Dickinson, 2004b: 1–2):

1 Hornblendic non-placer temper: plagioclase-rich or lithic rich volcanic sands with clinopyroxene dominant over hornblende.
2 Pyroxenic non-placer temper: placer volcanic sands with clinopyroxene and iron oxides dominant over hornblende.
3 Pyroxenic placer temper: plagioclase-rich and lithic-rich volcanic sands with hornblende dominant over clinopyroxene.

The clinopyroxenes in the Anir sherds are exclusively augite with high optic axial angles (2V > 75°), a unique greenish cast and a particular faint yellow pleochroism under polarised light that is a distinctive trait of the TLTF chain tempers (Wallace *et al*., 1983; Dickinson, 2006: 76). On the other hand, green-brown to red-brown hastingsitic hornblende are commonly found in Anir tempers, which makes them distinguishable from the other TLTF tempers; in fact, seven sherds from the Tanga Islands were suggested to be of Anir origin based on the paucity of such hornblende (Dickinson, 2004a: 8, 2006: 76). Unfortunately, because of the small sample size, ceramic transfer between the Ambitle and Babase Island sites could not be proved (Dickinson, 2004b: 2). This issue is discussed further below.

Formal and decoration analyses of the Anir Island pottery assemblages

Sherds assessment: macroscopic fabric classification

Prior to the formal and decoration analyses, each of the Anir Island assemblages had a basic macroscopic fabric classification undertaken with a low powered binocular microscope (17× magnification). Fabric groups were

Table 2. Number of samples per fabric group (after Hogg, 2007: tables 4.3–4.4, and Hennessey, 2007: table 1).

fabric group	ERA	ERC	EAQ
ferromagnesium–magnetite (M)	1	—	—
ferromagnesium–pyroxene (P)	20	9	18
ferromagnesium–pyroxene/magnetite (PM)	7	—	—
ferromagnesium–light (PL)	7	7	2
calcareous (CA)	3	—	—
light inclusions (L)	5	2	—
totals	43	18	20

summarised based upon the predominant inclusions visible upon each sherd, including Ferromagnesium-magnetite (M), Ferromagnesium-pyroxene (P), Ferromagnesium-pyroxene/magnetite (PM), Ferromagnesium-light (PL), Calcareous (CA), and Light inclusions (L) (Table 2). The creation of fabric groups is useful as it provides a basic indication of fabric composition and provides both a preliminary means of sorting temper types to aid in vessel form identification, and acts as a foundation for targeted sample selection for the more in-depth techniques of petrography and chemical analysis.

Methodology

The method of formal and decoration analyses employed in this study focused on the rim as the most diagnostic element of a vessel, a method that has been successfully applied by a large number of studies (e.g., Poulsen, 1987: 87; Summerhayes, 2000a: 33; Bedford, 2006: 76–77). The attributes of rim direction, rim profile, lip profile, extra rim features, thickness, and orifice diameter were analysed to assign sherds to vessel form. Following Summerhayes (2000a: 33, 93) vessel forms include: Form I—open bowl/cup; Form II—open pot/bowl; Form IV—jar; Form V—carinated jar; Form VI—globular pot; Form VII—incurving bowl; Form VIII—pot stand (Fig. 5). Form III—possible open bowl with horizontal rim, is generally rare and does not occur in the Anir assemblages. The calculation of minimum number of vessels (MNV) was achieved using the rim attributes above in combination with those collected for the decoration analysis, including technology (type of decoration) and location of decoration, together with the fabric analysis, as this allowed the accurate identification of sherds belonging to the same vessel (see Summerhayes, 2000a: 33–37 for a detailed discussion of the allocation of sherds to vessel form and the calculation of MNV). To ensure all variation was accounted for within each assemblage, unique sherds (i.e. those with rare form, decoration, or fabric) were also selected (Table 3).

Table 3. Number of excavated sherds, number of rim/stand sherds, and the minimum number of vessels (MNV).

site	sherds excavated	rim/stand sherds	MNV
ERA (Test Pit 1)	498	172	88
ERC	1416	29	13
EAQ	2459	61	14

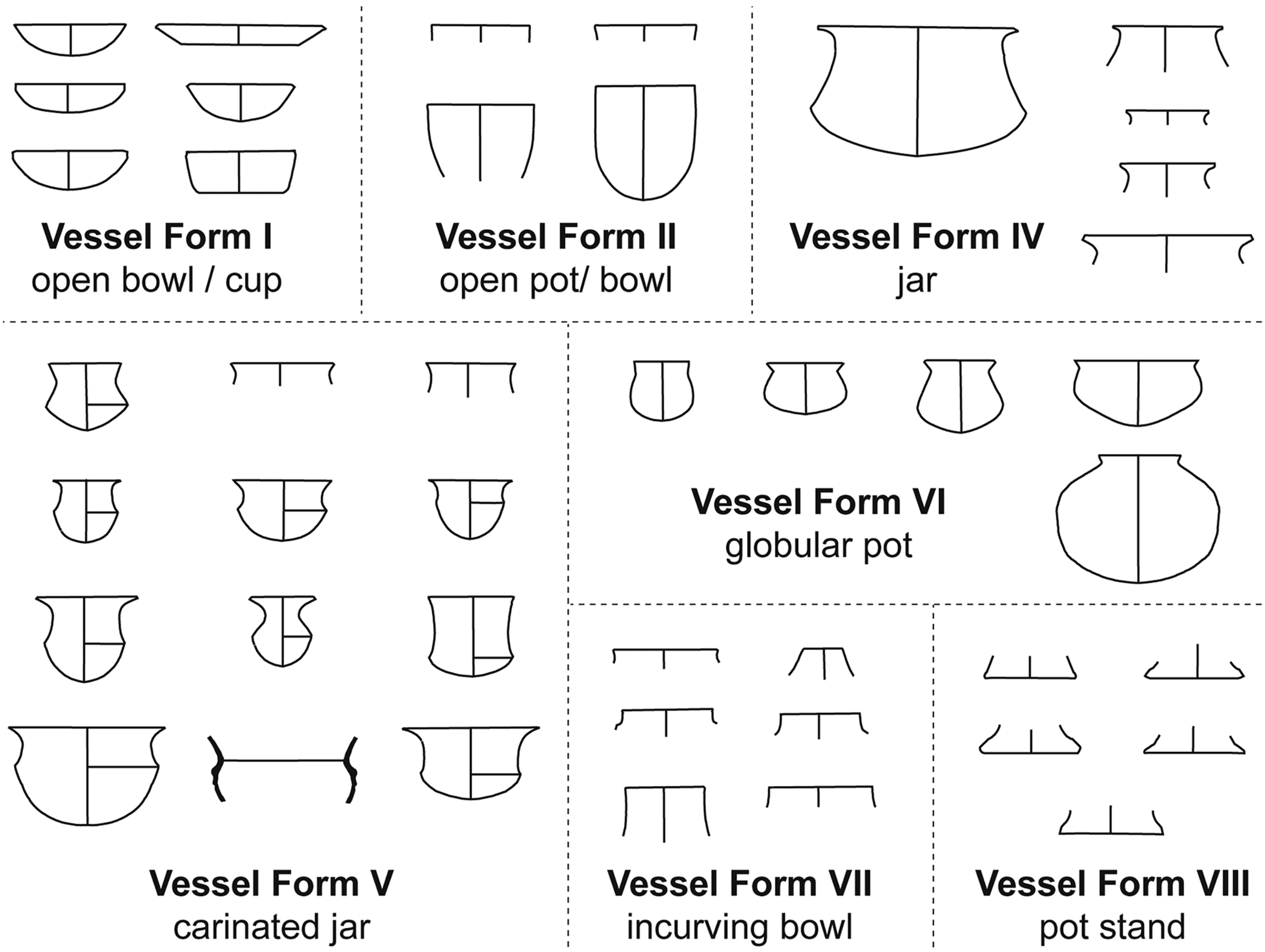

Figure 5. Vessels forms identified in the study (after Summerhayes, 2000a: figs 4.1–4.3).

Figure 6. Decorated pottery from the sites of ERA, ERC, and EAQ. Top row: dentate stamped and single tool impressed rim sherd, and dentate stamped and stamped impressed stand sherd (ERA); bottom row: incised rim sherd and dentate stamped rim sherds (ERC and EAQ).

Kamgot (ERA) results

Test Pit 1 produced 498 sherds, of which 172 are diagnostic rim or stand sherds (Table 3, Fig. 6). An MNV of 88 vessels was calculated for seven vessel forms present in this assemblage (Table 4); the vessel forms reported in this study represent the most up-to-date data available and supersede those in Hennessey (2007: table 3). The most common form is the open bowl/cup which makes up over 56% of the vessels identified, followed by the pot stand, carinated jar and globular pot which comprise 16%, 10% and 10% of the assemblage, respectively. Three other vessel forms were also identified in the assemblage, but only in minimal quantities. Decoration is dominated by dentate stamping, which was identified on 62 vessels or 70% of all vessels identified (Table 5). The only other decoration types identified in any quantity are stamped impression and the combined group of gouging, cut-out triangle and excision found upon approximately 15% of vessels each. Dentate stamping is also found to have been applied alongside a wide range of other decorations and in varying combinations (Table 6 lists the most common combinations) but was most commonly used with single tool impression and stamped impression, and in combination with gouging, cut-out triangle and excision.

Table 4. Vessel forms identified at the sites of ERA, ERC, and EAQ.

vessel form	ERA		ERC		EAQ	
	count	%	count	%	count	%
I, open bowl/cup	49	56	3	23	4	29
II, open pot/bowl	2	2	—	—	—	—
IV, jar	3	3	—	—	—	—
V, carinated jar	9	10	8	62	7	50
VI, globular pot	9	10	1	8	3	21
VII, incurving bowl	2	2	—	—	—	—
VIII, pot stand	14	16	1	8	—	—
totals	88		13		14	

Table 5. Types of decoration in the ERA Test Pit 1, ERC, and EAQ assemblages by vessel form (vessels can be counted more than once).

decoration type	ERA								ERC			EAQ			
	I	II	IV	V	VI	VII	VIII	total	I	V	total	I	V	VI	total
dentate stamping	41	1	3	1	—	2	14	62	2	1	3	3	—	—	3
stamped impression	12	—	—	—	—	1	1	14	—	—	—	—	—	—	—
single tool impression	6	—	—	1	—	1	—	8	—	—	—	—	—	—	—
fingernail impression	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—
stick impression	1	—	—	—	—	—	—	1	—	2	2	—	—	—	—
notched lip	3	1	—	5	—	—	—	9	—	5	5	—	4	1	5
cut lip	5	—	—	1	1	—	1	8	—	1	1	—	2	—	2
scalloped lip	—	—	—	—	—	—	—	—	—	—	—	1	1	—	2
incision	—	—	—	—	—	—	—	—	1	1	2	—	—	—	—
linear incision	—	—	—	1	—	—	—	1	1	1	2	—	—	—	—
miscellaneous incision	1	—	1	—	—	—	—	2	—	—	—	—	—	—	—
groove/channel	2	—	—	—	—	—	—	2	—	—	—	—	—	—	—
gouging, cut-out triangle, excision	8	—	—	—	—	—	5	13	—	—	—	—	—	—	—
carving	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—
appliqué (nubbin)	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—
brushing	2	—	—	1	—	—	1	4	—	—	—	—	—	—	—
indeterminate	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—
totals	83	2	4	10	1	4	23	127	5	11	16	4	7	1	12
%	65	2	3	8	1	3	18		31	69		33	58	8	

Finally, looking at the relationship between vessel form and decoration, most of the forms are associated with two to six decoration types, though open bowls/cups are decorated much more variably and are associated with 12 types. Discussion focuses on the decoration on open bowls/cups, carinated jars, and pot stands which comprise 91% of all decoration identified.

Considering decoration on open bowls/cups, 12 types are present with the most common being dentate stamping (84%, n = 41) and stamped impression (24%, n = 12). Only three other types are present on more than 10% of vessels, including gouging, cut-out triangle and excision, single tool impression and cut lip.

Carinated jars are associated with six decoration types but are dominated by notched lips which represent 56% (n = 5) of all the decoration identified. Dentate stamping and linear incision are equally represented with only one instance each.

Six types of decoration occur on pot-stands, though only dentate stamping occurs on all of them. Gouging, cut-out triangle and excision also occur (36%, n = 5).

Looking at the formal and decoration data for ERA Test Pit 1, this assemblage is dominated by dentate stamped open bowls/cups and to a lesser extent pot stands (or the former vessels with such stands attached). The removal of these forms from the assemblage would remove the vast majority of the decorated sherds from the assemblage. The importance of this result will be discussed further below.

Balbalankin (ERC) results

The total ceramic assemblage from ERC comprises 1416 sherds, of which 29 are rim/stands (Table 3, Fig. 6). An MNV of 13 was calculated for this assemblage (Table 4); the vessel forms and decoration reported in this study for ERC and EAQ (discussed below) represents the most up-to-date data available and supersedes those in Hogg (2007: tables 3.1–3.2). The most common form is the carinated jar which comprises 62% of the vessels identified, followed by the open bowl/cup which makes up 23% of all of the identified vessels. Single examples of a pot stand and a globular pot are also present.

Decoration identified for the assemblage is limited to eight types, of which notched lip (38%, n = 5) and dentate stamping (23%, n = 3) are the most common (Table 5). Only five decoration combinations were identified in the assemblage, each with one example. These include dentate stamping with incision, dentate stamping with carving, dentate stamping with stick impression, notched lip with stick impression and notched lip with linear incision.

Finally, the only decorated vessels in ERC are open bowls/cups and carinated jars. Carinated jars are associated with the broadest range of decorations, including dentate stamping, incision, linear incision, stick impression, notched lip and cut lip, whereas open bowls/cups have dentate stamping, incision, linear incision, stick impression and carving.

Table 6. Common dentate stamped decoration combinations for the ERA Test Pit 1 assemblage by vessel form (vessels can be counted more than once).

decoration type/vessel form	I	V	VII	VIII	total
dentate stamping + stamped impression	4	0	1	0	5
dentate stamping + stamped impression + cut lip	1	0	0	1	2
dentate stamping + stamped impression + gouge, cut-out triangle, excision	4	0	0	0	4
dentate stamping + single tool impression	5	1	1	0	7
dentate stamping + cut lip	2	0	0	0	2
dentate stamping + gouging, cut out triangle, excision	2	0	0	5	7
dentate stamping + brushing	1	0	0	1	2
totals	19	1	2	7	29

Malekolon (EAQ) results

The total ceramic assemblage from EAQ amounts to 2459 sherds, of which 61 are rim/stand sherds (Table 3, Fig. 6). An MNV of 14 was calculated for this assemblage (Table 4). These comprise seven carinated jars, four open bowls/cups and three globular pots.

Decoration is limited to four types of which notched lip (36%, n = 5) and dentate stamping (21%, n = 3) are the most common (Table 5). No combinations of decoration types were identified from this assemblage.

Finally, dentate stamping occurs only on open bowls/cups, in one case with a scalloped lip. Notched lips are present on carinated jars and globular pots and the carinated jars also have cut or scalloped lips.

Temper groups construction

Hennessey (2007) undertook the chemical analysis of the non-plastic inclusions of 43 sherds from ERA, while Hogg (2007) did the same for 18 sherds from ERC and a further 20 from EAQ, using a JEOL JXA-8600 electron microprobe analyser then housed within the Geology Department of the University of Otago (see Hennessey (2007: 92) for operating conditions employed for ERA and Hogg (2007: 42) for the same for ERC and EAQ). While the original studies only required the presence and absence of minerals to be recorded, this level of detail is insufficient for the current study. To generate data capable of drawing comparisons with temper sands within the broader region (and thus potentially identify pottery exchange), it is necessary to reinterpret the data and calculate the abundance and ratio of minerals present. In this study, new temper groups were created by reinterpreting the original microprobe photomicrographs and chemical data of Hennessey (2007: appendix 4–5) and Hogg (2007: appendix 2–3), with respect to the mineralogy, grain size and roundness of the non-plastic inclusions in each sherd.

Results

The re-interpretation of the chemical data lead to the identification of five major temper groups (Table 7, Fig. 7):

1. Calcareous (A)
2. Feldspathic-hornblendic-pyroxenic (B)
3. Hornblendic-lithic (C)
4. Pyroxenic placer (D) (divided into D1–D3 based on varying degrees of placering)
5. Feldspathic-pyroxenic non-placer (E)

The presence of trace alkali feldspar, quartz and olivine across the assemblages, characteristic of the local alkalic volcanic suite of the TLTF island chain (Wallace *et al*., 1983), suggests that the sherds are derived from this region. This interpretation is supported by the presence of the signature augite (Dickinson, 2004a: 8, 2006: 76) in all of the temper groups. Overall, there are no temper types requiring or implying transfer of pottery from outside the TLTF chain.

Comparison with the research of Dickinson (2000, 2004a, 2004b, 2006) indicates that all three of his temper groups were identified in this research: Hornblendic non-placer temper is equal to temper B in this study; Pyroxenic non-placer temper is equivalent to temper E, and Pyroxenic placer temper is equivalent to temper D and its variants. However, the two studies arrived at different conclusions as to the presence or absence of certain other temper groups in the three sites. Looking at the sites in turn:

1. ERA has six of the seven temper groups but is dominated by D1 (n = 17) and D2 (n = 16) which make up three quarters of all the ERA samples studied. Most of the remaining samples have tempers D3 (n = 4) or B (n = 3), and one sample has the rare C temper. ERA has one unique temper group, A, which was only found in two samples. Finally, Dickinson (2004b) identified one sample with a pyroxenic non-placer temper (equivalent to temper E), which was not present in this study; this likely means that at least seven tempers were in use at the site.
2. ERC has six temper groups but only two, B (n = 7) and D1 (n = 6), are present in significant numbers, making up 70% of those identified; the remaining samples are spread over D2, D3 and C, while a single example has temper E.
3. Finally, EAQ has only four temper groups and is dominated by D1 (n = 11) which makes up 60% of the samples studied. The remaining samples are largely composed of D2 (n = 5) and B (n = 3), while one sample has temper C. Like ERA, Dickinson (2004b) identified two samples with the pyroxenic non-placer tempers (equivalent to temper E), likely indicating that five temper groups were employed at the site.

In summary, the temper suites from the three assemblages are dominated by D tempers which make up the majority of samples in ERA and EAQ and half of those in ERC. However, variability occurs with regards to the presence and abundance of the three variants of this temper group. ERA and ERC contain all three of the D temper variants, while EAQ is lacking D3. Proportionally, only D1 is abundant in all three assemblages, while D2 is common in ERA and to a lesser extent EAQ.

While the D tempers suggests a significant amount of similarity in the temper being employed to manufacture pottery at the three sites, one difference is present: including the additional temper groups identified by Dickinson, ERA and ERC both contain samples with D3 temper which is lacking in EAQ, while ERA also contains the unique temper A.

Taken together, the number of temper groups (6+1) in the early assemblage of ERA when compared to the middle assemblages of ERC (6) or EAQ (4+1), provides support for Summerhayes' model (2000a, 2003), theorising a reduction in mobility as reflected in the procurement of fewer clays and tempers over time. This topic will be discussed in greater detail in the discussion section below.

Temper groups and CPCRU

This section relates the results of the newly constructed temper groups back to the results of the clay matrix analyses of the same sherds provided by Hennessey (2007) and Hogg (2007) to examine the combination of different clay sources (CPCRU) and tempers in the various sites.

Kamgot (ERA)

Ten CPCRUs were defined by Hennessey (2007: 56–64) for the early assemblages from ERA of which five (CPCRU 1, 3, 4, 5, 6) were deemed to be major groups by their presence in five or more samples. For the remainder, only one (CPCRU 8) occurred in more than one sample, while the rest were argued to be single sample outliers.

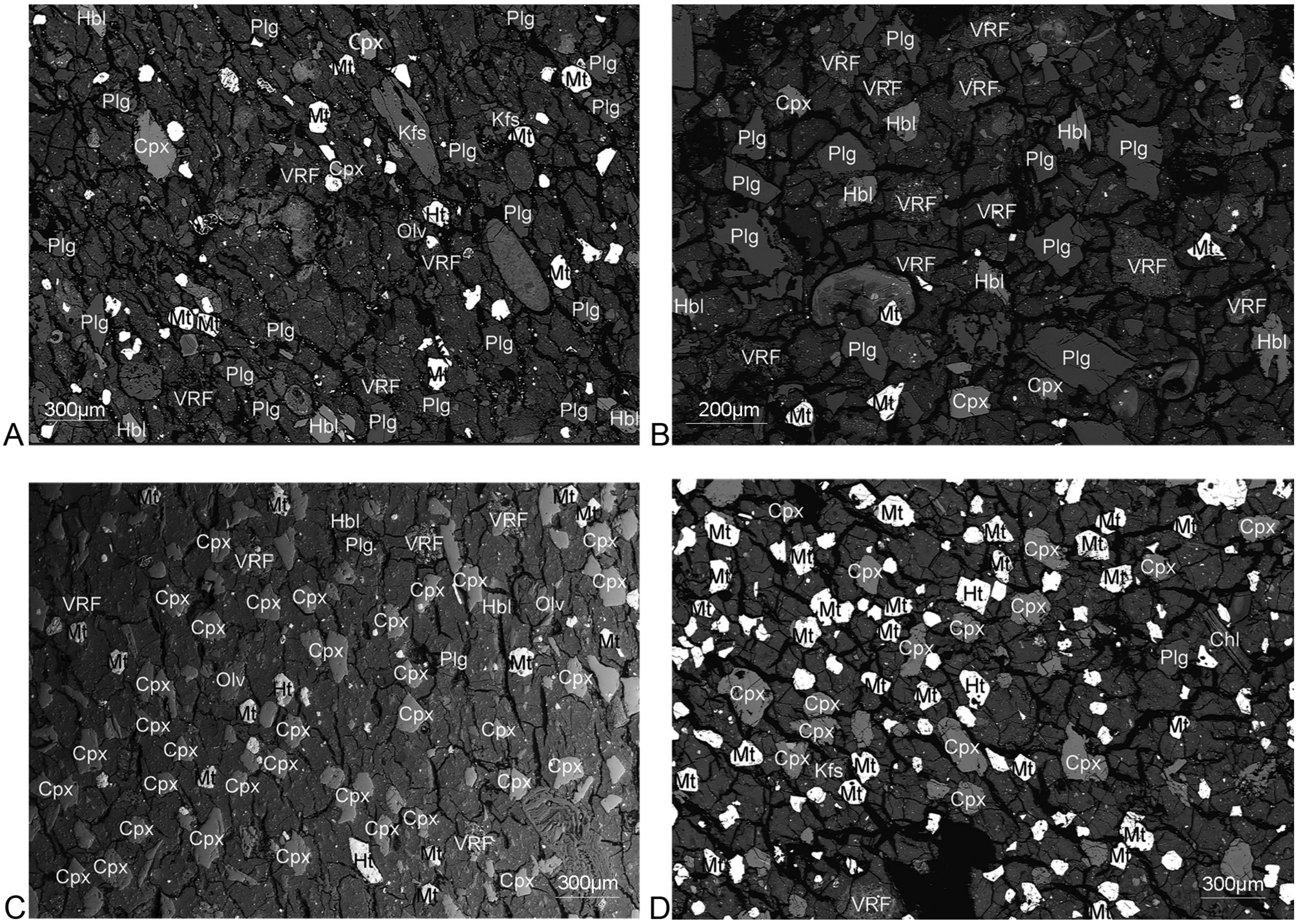

Figure 7. Microprobe photomicrographs of sherds from various temper groups. (*a*) Feldspathic-hornblendic-pyroxenic temper (temper B), sherd ERC-1926, 40×; (*b*) hornblendic-lithic temper (temper C), sherd ERA-625, 80×; (*c*) pyroxenic placer with dominant pyroxene (temper D1), sherd EAQ-167, 40×; and (*d*) pyroxenic placer with dominant iron oxides (temper D3). Abbreviations: *Chl*, chlorite; *Cpx*, clinopyroxene (augite); *Hbl*, hornblende; *Ht*, hematite; *Kfs*, alkali feldspar; *Mt*, magnetite; *Olv*, olivine; *Plg*, plagioclase; *VRF*, volcanic lithic fragments.

Table 7. New temper groups from the sites ERA, ERC, and EAQ.

temper group	temper group Code		temper description	ERA	ERC	EAQ	total	%
calcareous	A		Sands of bioclastic reef debris/reef detritus.	2 (4.7%)	0 (0.0%)	0 (0.0%)	2 (2.5%)	2.5
feldspathic-hornblendic-pyroxenic	B		Dominant plagioclase feldspar (30–45%), subordinate hornblende, pyroxene, iron-oxides and volcanic lithicfragments (10–20%). Moderately sorted, angular to sub-angular.	3 (7.0%)	7 (38.9%)	3 (15.0%)	13 (16.0%)	16.0
hornblendic-lithic	C		Dominant volcanic (50%), subordinate plagioclase feldspar (20%), minor iron–oxides (10–20%), hornblende (10%) and pyroxene (0–10%). Moderately to well sorted, sub-angular.	1 (2.3%)	1 (5.6%)	1 (5.0%)	3 (3.7%)	3.7
pyroxenic placer	D	D1	Dominant pyroxene (55–70%), minor volcanic lithic fragments, plagioclase feldspar and iron oxides (5–20%).	17 (39.5%)	6 (33.3%)	11 (55.0%)	34 (42.0%)	42.0
		D2	Dominant pyroxene (40–55%), subordinate iron oxides (30–40%), and trace volcanic lithic fragments, plagioclase, hornblende.	16 (37.2%)	1 (5.6%)	5 (25.0%)	22 (27.2%)	27.2
		D3	Dominant iron oxides (55%), subordinate pyroxene (40–45%).	4 (9.3%)	2 (11.1%)	0 (0.0%)	6 (7.4%)	7.4
feldspathic-pyroxenic non-placer	E		Dominant plagioclase feldspar (40%) and volcanic lithic fragments (30%), subordinate pyroxene (20%) and minor iron oxides (5%) Moderately sorted, sub-angular to angular.	0	1 (5.6%)	0 (0.0%)	1 (1.2%)	1.2
totals				43	18	20	81	

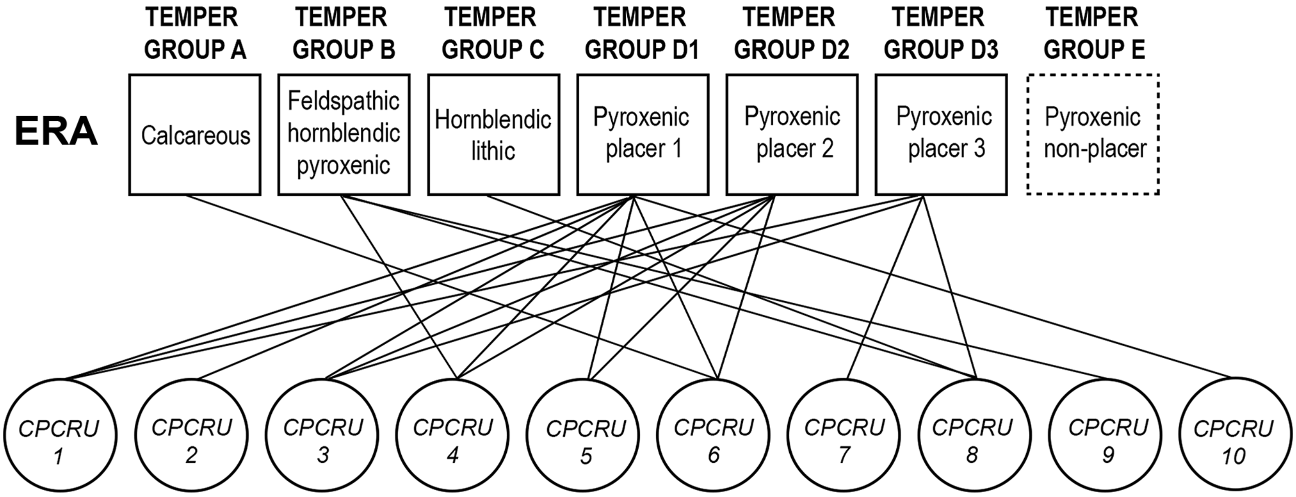

Figure 8. Pottery production model for the Early site of ERA. Temper groups A, B, C, D1, D2, and D3 found in this research, while temper E was identified by Dickinson (2004b).

Table 8. CPCRUs from site ERA by temper group.

CPCRU	A	B	C	D1	D2	D3	E	total
1	—	—	—	2	4	1	—	7
2	—	—	—	1	—	—	—	1
3	—	—	—	4	4	1	—	9
4	—	1	—	4	4	—	—	9
5	—	—	—	4	2	—	—	6
6	2	—	—	1	2	—	—	5
7	—	—	—	—	—	1	—	1
8	—	1	1	—	—	1	—	3
9	—	1	—	—	—	—	—	1
10	—	—	—	1	—	—	—	1
totals	2	3	1	17	16	4	0	43

As expected, the majority of the tempers mixed with each CPCRU are dominated by the D tempers (Table 8, Fig. 8). CPCRUs 1, 3 and 5 exclusively contain such temper sands but differ depending on the presence of temper variants D1–D3 and their proportions. CPCRU 1 and 3 both contain D1–D3 but whereas CPCRU 3 has D1 and D2 in equal abundance with D3 in one sample only, in CPCRU 1 D2 is dominant and D1 and D3 are found in lesser amounts. CPCRU 5 only contains D1 and D2 and is dominated by the former.

Like CPCRU 5, CPCRUs 4 and 6 primarily contain D1 and D2 tempers, but unlike the former they also contain unique tempers. In the case of CPCRU 4 the majority of samples contain the aforementioned tempers, while one sample has rare B temper. CPCRU 6 has two sherds with temper D2, one with D1 and two with the unique site-specific A temper.

CPCRU 8 was not considered a major grouping by Hennessey as it only contains three sherds. Interestingly, it is very varied with each sample belonging to a different temper group, including D3, the rare B temper and the only example of a C temper identified in the assemblage.

Balbalankin (ERC) and Malekolon (EAQ)

Two CPCRUs were defined by Hogg (2007: 54) for the middle assemblages of ERC and EAQ. CPCRU 1 was site-specific to ERC, while CPCRU 2 was, with the exception of one sample, specific to EAQ (Table 9 and Fig. 9). This suggests that ERC 40 with D2 temper sands may have derived from EAQ, or alternately that the sample was produced using the same clay as those from EAQ.

Lastly, it is important to reiterate that the main difference between the two assemblages relates to the tempers employed, as both sites primarily exploited a single clay source to manufacture pottery, but ERC appears to have used a broader suite of tempers to produce such wares.

Table 9. CPCRUs from sites ERC and EAQ by temper group.

site	CPCRU	A	B	C	D1	D2	D3	E	total
ERC	1	—	7	1	6	—	2	1	17
	2	—	—	—	—	1	—	—	1
EAQ	2	—	3	1	11	5	—	—	20
	totals	0	10	2	17	6	2	1	38

Reinterpretation of the temper groups associated with the clays (CPCRUs) identified in Hennessey (2007), supports the original results for ERA, where a large number of clays was used in combination with a number of temper groups. However, while EAQ shows a reduction in the number of tempers used with one clay source, as identified by Hogg (2007), ERC instead shows a different pattern, with a large number of tempers used with one or two clay sources. The Middle Lapita assemblages are thus more variable than expected, which suggests that while changes in production indeed occurred over time, they were not as universal as originally thought.

Discussion

Form and decoration

Based upon research conducted into Lapita assemblages from western New Britain, Summerhayes (2000a) argued that the dentate stamped component of Lapita ceramic assemblages can be considered a specialised component of the Lapita ceramic suite, which changed substantially over time when compared to other components. Within the western New Britain assemblages, this temporal change is reflected in a proportional decline in open bowls and stands (and vessels with attached stands) which are dominant in assemblages from early sites, and an increase in carinated jars from those derived from mid-late sites. This decline also arguably had a direct impact on the dentate stamped component, which also decreased over time. Comparison between the western New Britain assemblages and those studied in this paper from the Anir Islands allows the following points to be made.

Firstly, the results from ERA Test Pit 1 concerning vessel forms and decoration show a similar pattern to the early sites of the Arawe Islands and Mussau, where open bowls

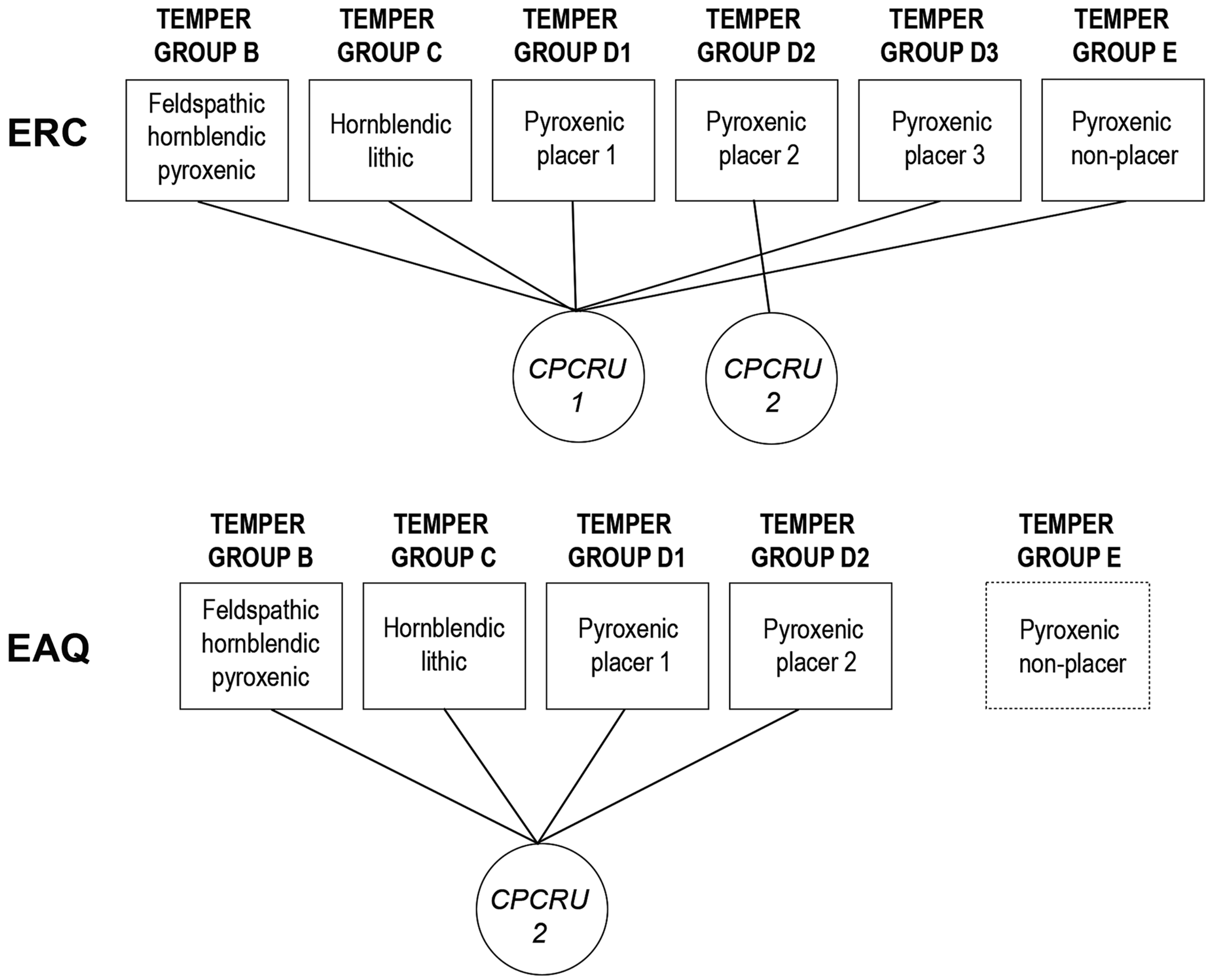

Figure 9. Pottery production model for the Middle/Late Lapita sites of ERC (top) and EAQ (below). Temper groups B, C, D1, and D2 found in EAQ in this research, while temper E was identified by Dickinson (2004b).

and stands are the most common vessel forms and dentate stamping is the dominant decoration. Comparison between the ERA Test Pit 1 results and the preliminary ERA results from Test Pits 1, 2 and 17 (Summerhayes, 2001b) indicates a considerable difference in the proportions of open bowls and carinated jars and types of decoration between the two datasets, which points to variability in vessel form and proportions of decoration type between the test pits. Despite this, both datasets show that the dominant decoration is dentate stamping and that the vessel forms from the site largely consist of open bowls/cups and pot stands.

Secondly, the results from the mid-late sites of ERC and EAQ also match those identified from mid-late sites in western New Britain and the Mussau Group, whereby carinated jars are the dominant vessel form, and dentate stamping has proportionally decreased in relation to other decoration types. Comparisons between vessel form and decoration data from ERC and EAQ presented here do not show any marked differences with data from the preliminary study discussed above. This indicates the validity of the original data.

To conclude, the results from this study complement those from Summerhayes (2000a, 2001b, 2003) and reinforce his conclusions that a marked change occurred over time with regards to the form and decoration of Lapita ceramic assemblages. While the pattern of change is apparent, the reasons for such changes is much less so. It is generally accepted that dentate stamped Lapita wares played a socially significant role within Lapita society, and that the proportional decline of such vessels over time likely related to changes occurring with regards to this particular role (Kirch, 1997: 160–161, 2017: 95–96; Spriggs, 1997: 201; Summerhayes, 2000a: 232; Chiu, 2005, 2007, 2015, 2019).

Indigenous or exotic?

A critical question of any study of pottery is where the materials for pottery production or, if traded in, the complete vessels were being sourced. Drawing upon the previous work of Dickinson (2000, 2004b, 2006) and the new temper groups defined in this research, a detailed picture of the origin of the Anir Islands samples can be drawn.

Dickinson's results showed that the temper groups identified were indigenous to the Anir Group within the TLTF island chain. This provided a baseline for comparing results for the larger assemblages analysed from the three sites in this paper. These comparisons reinforced Dickinson's results. Temper sands indigenous to the Anir Group can be delineated by focusing upon the abundance of certain diagnostic minerals within them, including plagioclase feldspars, clinopyroxenes (specifically the greenish augite), olivine and hornblende minerals.

Studying the temper groups, we argue that four identify source localities while one, temper A, is non-diagnostic, as is the case with all such tempers present within Oceanic pottery assemblages (Dickinson, 2006: 3; Dickinson *et al*., 2013: 11). The compositions of major minerals within temper groups B–E closely match those predicted by the work discussed above, whereby all groups have an abundance of clinopyroxene minerals, in this case exclusively augite, and plagioclase feldspars, primarily albite, oligoclase and andesine antiperthite, while some groups have smaller amounts of hornblende (B and C) and olivine (D1–D3). The results of the chemical analyses of the non-plastic inclusions provide no basis to suggest an exotic source for temper sands at ERA, ERC or EAQ, but do suggest some potential for the movement of materials or completed pottery between sites within the Anir Group and further afield in the TLTF chain to the Tanga Islands.

Movement of materials/complete vessels or shared temper collection localities are suggested by small numbers of samples from ERC and EAQ including one sample (EAQ 439) of temper B which has distinctively high hornblende content that makes it identical to samples from the same temper group in ERC. Additionally, the single samples of temper C in ERC and EAQ are indistinguishable in regards to composition and texture but do differ from that found in ERA because of the latter's better-sorted temper and higher density of grains. Finally, chemical analysis of the clay employed to manufacture a vessel from ERC (sample ERC 40) suggests it may have derived from EAQ or that the two sites occasionally shared the same clay collection locale. Interestingly, this latter sample is the only example of D2 temper in ERC, while EAQ has five of such samples, which tentatively supports the above result.

Pottery transfers from the Anir Island group

Movement of pottery from the Anir Group to the Tanga Group has been suggested in the past (Dickinson, 2004a, 2006; Cath-Garling, 2017). Among the 39 Tanga sherds submitted to Dickinson for petrographic analysis by Garling (2007) for her doctoral thesis, Dickinson (2004a, 2006: 78) identified six to be of Anir origin. Subsequently she argued that a number of the exotic wares identified in her research were 'vestiges from the earlier occupation of the island group during the Early-Middle Lapita period' and, that 'these early Exotic Wares probably originated from multiple communities on Anir and/or possibly some other locales within the TLTF chain of island groups' (Cath-Garling, 2017: 158).

Also noteworthy, one dentate stamped sherd (ETM 996) from Angkitkita, with Type F temper reported as being from Anir by Dickinson (2004a), has an almost identical composition to sherds of temper C from Ambitle sites EAQ (EAQ 1967) and ERC (ERC 1185) in this study, suggesting that this vessel may have been produced at one of these sites. Unfortunately, it is unclear whether the remaining five sherds examined by Dickinson are of Lapita or post-Lapita origin.

Comparison of the newly-constructed temper groups for ERC and EAQ with those identified for sites in the Tanga Islands (primarily ETM) strongly supports arguments for the movement of vessels between sites in the two island groups during the Middle Lapita period (Dickinson, 2004a, 2006; Garling, 2007; Cath-Garling, 2017). Furthermore, ERC and EAQ may have been involved in the production of some of the exotic Tanga vessels. Unfortunately, it was not possible to compare directly the pottery fabrics from the sites in question, and thus it cannot be said unequivocally that the two sites produced the exotic Tanga wares.

Population mobility and settlements

As noted above, a distinct change in pottery production occurred between the Early and Middle/Late periods in western New Britain and arguably also in the Mussau Group, which sees an overall reduction from a large number of clays being combined with a variety of fabrics to a small number of clays with a small number of fabrics. Summerhayes (2000a) argues this pattern relates to a decrease in mobility of the Lapita populations leading to a sedentary community as seen today, and not from a reduction of pottery imported from fewer production localities over time as argued for the Mussau Group (Kirch, 1990, 1997). This research follows Grainger *et al*. (2020) in viewing 'mobility' as a process that involves the small-scale movements of populations around the landscape. They suggest that the high mobility of the populations of the Early Lapita period, representing new arrivals into the region, represents an adaptive mechanism which allowed such populations to rapidly gain an understanding of their local environment, its resources and their properties. Following the end of the colonising phase, populations had successfully adapted to the unique environment of the region and had gained a thorough understanding of its associated resources, and thus became more sedentary, reflected in a greater emphasis on the procurement of materials from the immediate vicinity of their settlements. What do our results indicate about the settlements of the Anir Islands' Lapita populations?

Lapita populations during the Early Lapita period at ERA employed a very wide range of clays mixed with a variety of locally sourced temper sands to produce a number of complex vessel forms, particularly bowls and stands. The selection of clays and tempers was not conservative as seen with potting communities today that consistently use the same resources to produce pots. Reference to the work of Summerhayes (2000a) suggests that such a pattern is one of a highly mobile population that moved around the Anir Islands, and potentially even around the TLTF chain of islands, procuring sands and also likely clays to produce a range of locally-produced complex vessels; the decoration and forms of which are strikingly similar to those identified in other Early Lapita settlements of the Bismarck Archipelago, indicating a high degree of interaction between Lapita communities of the period.

By the Middle/Late Lapita periods the Lapita populations at ERC and EAQ appear to have changed to a more sedentary lifestyle which is reflected in the use of one to two likely locally sourced clays and less varied temper sands. However, while both sites show a decrease in the number of temper sands employed as compared to the earlier assemblage of ERA, the decrease is much less apparent at ERC than it is at EAQ. ERC appears to show a pattern that is in-between the two extremes set by ERA and EAQ. As in the early period, vessel forms are strikingly similar amongst the sites with similar proportions of forms and decoration types. Populations in these later sites like those that occupied ERA previously remained in contact with other populations but did not strike out as far for resources as in previous periods.

Conclusions

The data presented in this study allows for the following conclusions:

1. The results of the formal and decoration analysis on the early assemblage of ERA and the Middle/Late Lapita assemblages of ERC and EAQ closely match those originally identified by Summerhayes (2000a) in western New Britain, suggesting that such patterns are not region specific and likely relate to broad changes occurring within Lapita society with regards to the societal role played by dentate stamped pottery.
2. Results of the temper and CPCRU analysis for the three Anir Islands' sites closely match those identified by Summerhayes (2000a) in western New Britain, in showing a reduction in the number of clays and separate tempers used in the process of local pottery production between Early and Middle/Late Lapita sites. While our data support the overall model, the two sites of ERC and EAQ appear to show some variability likely existed with regards to the number of tempers employed by Middle/Late potters to produce pottery as reflected by the larger number of such tempers employed at ERC. We suggest that this change indicates a shift from highly mobile to sedentary settlements. However, it is important to note that the pattern identified in the Anir Islands' sites differs from that identified in the Mussau Group sites that contain largely exotic pottery.
3. Comparisons of tempers identified in the Ambitle sites of ERC and EAQ with the same in the Tanga Group support previous arguments (Dickinson, 2004a, 2006; Garling, 2007; Cath-Garling, 2017) for the possible movement of vessels between the Anir and Tanga Island groups, and suggests that ERC and EAQ may have been directly involved in the production of such vessels during the Middle Lapita period.
4. Significant changes occurred over time within Lapita society which can be seen in both the form and decoration of ceramic assemblages in these sites. At the same time there is also a large amount of evidence for continuing interaction and cultural continuity between dispersed Lapita communities. This is reflected in both the synchronised nature of the aforementioned changes occurring to pottery assemblages across the Bismarck Archipelago, and with regards to the argued movement of pottery within the TLTF Island chain.

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References

Ambrose, W. 1973. 3000 years of trade in New Guinea obsidian. *Australian Natural History* 17(11): 370–373.

Anson, D. 1983. *Lapita Pottery of the Bismarck Archipelago and Its Affinities*. Unpublished PhD thesis, University of Sydney.

Anson, D. 1986. Lapita pottery of the Bismarck Archipelago and its affinities. *Archaeology in Oceania* 21(3): 157–165. https://doi.org/10.1002/j.1834-4453.1986.tb00144.x

Bedford, S. 2006. *Pieces of the Vanuatu Puzzle: Archaeology of the North, South and Centre*. Terra Australis 23. Canberra: ANU Press. https://doi.org/10.22459/PVP.02.2007

Bishop, R. L, and R. L. Rands. 1982. Maya fine paste ceramics: a compositional perspective. In *Analysis of Fine Paste Ceramics. Excavations at Siebal,* ed. J. A. Sabloff, pp. 283–314. Memoirs of the Peabody Museum of Archaeology and Ethnology 15. Cambridge (Mass.): Peabody Museum of Archaeology and Ethnology.

Bishop, R. L, R. L. Rands, and G. R. Holley. 1982. Ceramic compositional analysis in archaeological perspective. *Advances in Archaeological Method and Theory* 5: 275–320. https://doi.org/10.1016/B978-0-12-003105-4.50012-1

Bronk Ramsey, C. 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51(1): 337–360. https://doi.org/10.1017/S0033822200033865

Cath-Garling, S. J. 2017. *Evolutions or Revolutions? Interaction and Transformation at the 'Transition' in Island Melanesia*. University of Otago Studies in Archaeology 27. Dunedin: Department of Anthropology and Archaeology, University of Otago.

Chiu, S. 2005. Meanings of a Lapita face: materialized social memory in ancient house societies. *Taiwan Journal of Anthropology* 3(1): 1–47.

Chiu, S. 2007. Detailed analysis of Lapita face motifs: case studies from the Reef/Santa Cruz sites and New Caledonia Lapita site 13A. In *Oceanic Explorations: Lapita and Western Pacific Settlement*, ed. S. Bedford, C. Sand, and S. P. Connaughton, pp. 241–264. Terra Australis 26. Canberra: ANU E Press. https://doi.org/10.22459/TA26.2007.15

Chiu, S. 2015. Where do we go from here? Social relatedness reflected by motif analysis. In *The Lapita Cultural Complex in Time and Space: Expansion Routes, Chronologies and Typologies*, ed. C. Sand, S. Chiu, and N. W. S. Hogg, pp. 185–206. Archeologia Pasifika 4. Noumea: Institute of Archaeology of New Caledonia and the Pacific.

Chiu, S. 2019. Measuring social distances with shared Lapita motifs: current results and challenges. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 307–334. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.15

Dickinson, W. R. 2000. Petrography of Temper Sands in Lapita Sherds from the Kamgot Site on Ambitle in the Feni Islands of the TLTF Chain Northeast of New Ireland. Petrographic Report WRD-200 (30 December 2000).

Dickinson, W. R. 2004a. Petrography of Sand Tempers in Sherds from the Tanga Islands. Petrographic Report WRD-239 (5 July 2004, revised 12 July 2004).

Dickinson, W. R. 2004b. Petrography of Sand Tempers in Lapita Sherds from the Balbalankin site on Anir (Ambitle) in the TLTF Chain off New Ireland. Petrographic Report WRD-244 (15 December 2004).

Dickinson, W. R. 2006. *Temper Sands in Prehistoric Oceanian Pottery: Geotectonics, Sedimentology, Petrography, Provenance*. Special Paper 406, Geological Society of America. Boulder (Colorado): Geological Society of America.
https://doi.org/10.1130/2006.2406

Dickinson, W. R. 2007. Discriminating among volcanic temper sands in prehistoric potsherds of Pacific Oceania using heavy minerals. In *Heavy Minerals in Use*, ed. M. A. Mange and D. T. Wright, pp. 985–1005. Developments in Sedimentology 58. Amsterdam: Elsevier.
https://doi.org/10.1016/S0070-4571(07)58039-8

Dickinson, W. R., S. Bedford, and M. Spriggs. 2013. Petrography of temper sands in 112 reconstructed Lapita pottery vessels from Teouma (Efate): archaeological implications and relations to other Vanuatu tempers. *Journal of Pacific Archaeology* 4(2): 1–20.

Garling, S. J. 2007. *Post-Lapita Evolutions or Revolutions? Interaction and Exchange in Island Melanesia: The View from the Tanga Islands*. Unpublished PhD thesis, The Australian National University, Canberra.

Grainger, A., G. R. Summerhayes, and C. Gosden. 2020. Investigating the nature of mobility patterns and interaction: ceramic production at the Late Lapita site of Amalut, Papua New Guinea. *Australian Archaeology* 87(1): 93–104.
https://doi.org/10.1080/03122417.2020.1840489

Hennessey, M. 2007. *On the Move: Mobility Pattern of the Early Phase Lapita Site at Kamgot*. Unpublished BA (Hons) thesis, University of Otago, Dunedin.

Hogg, N. W. S. 2007. *Settling Down: Mobility Patterns of three Mid-Late Lapita Sites in the Anir Group, Papua New Guinea*. Unpublished BA (Hons) thesis, University of Otago, Dunedin.

Horz, K. H., T. J. Worthington, K. Winn, and P. Stoffers. 2004. Late Quaternary tephra in the New Ireland Basin, Papua New Guinea. *Journal of Volcanology and Geothermal Research* 132(1): 73–95.
https://doi.org/10.1016/S0377-0273(03)00421-9

Hunt, T. L. 1989. *Lapita Ceramic Exchange in the Mussau Islands, Papua New Guinea*. Unpublished PhD thesis, University of Washington, Seattle.

Kirch, P. V. 1990. Specialization and exchange in the Lapita complex of Oceania (1600–500 B.C.). *Asian Perspectives* 29(2): 118–133.
http://www.jstor.org/stable/42928219

Kirch, P. V. 1997. *The Lapita Peoples: Ancestors of the Oceanic World*. Cambridge (Mass.): Blackwell Publishers Inc.

Kirch, P. V. 2017. *On the Road of the Winds: An Archaeological History of the Pacific Islands before European Contact*. Revised and expanded edition. Oakland: University of California Press.
https://doi.org/10.1525/9780520968899

Licence, P., J. Terrill, and L. Fergusson. 1987. Epithermal gold mineralisation, Ambitle Island, Papua New Guinea. In *Proceedings of the Pacific Rim Congress* 87, *Gold Coast, 26–29 August 1987*, pp. 273–278. Melbourne: The Australian Institute of Mining and Metallurgy.

Lindley, I. D. 2015. Late Quaternary geology of Ambitle volcano, Feni Island Group, Papua New Guinea. *Australian Journal of Earth Sciences* 62(5): 529–545.
https://doi.org/10.1080/08120099.2015.1076033

Poulsen, J. 1987. *Early Tongan Prehistory: The Lapita Period on Tongatapu and its Relationships*. Terra Australis 12. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.

Reimer, P. J., E. Bard, A. Bayliss, J. W. Beck, P. G. Blackwell, C. Bronk Ramsey, C. E. Buck, H. Cheng, R. L. Edwards, M. Friedrich, P. M. Grootes, T. P. Guilderson, H. Haflidason, I. Hajdas, C. Hatté, T. J. Heaton, D. L. Hoffmann, A. G. Hogg, K. A. Hughen, B. F. Kaiser, B. Kromer, S. W. Manning, M. Niu, R. W. Reimer, D. A. Richards, E. M. Scott, J. R. Southon, R. A. Staff, C. S. M. Turney, and J. van der Plicht. 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. *Radiocarbon* 55(4): 1869–1887.
https://doi.org/10.2458/azu_rc.55.16947

Spriggs, M. 1997. *The Island Melanesians*. Oxford: Blackwell Publishers Ltd.

Summerhayes, G. R. 2000a. *Lapita Interaction*. Terra Australis 15. Canberra: Department of Archaeology and Natural History and the Centre for Archaeological Research, Australian National University.

Summerhayes, G. R. 2000b. Recent archaeological investigations in the Bismarck Archipelago, Anir—New Ireland province, Papua New Guinea. *Bulletin of the Indo-Pacific Prehistory Association* 19: 167–174.

Summerhayes, G. R. 2000c. What's in a pot? In *Australian Archaeologist: Collected Papers in Honour of Jim Allen*, ed. A. J. Anderson and T. Murray, pp. 291–307. Canberra: Coombs Academic Publishing.

Summerhayes, G. R. 2001a. Defining the chronology of Lapita in the Bismarck Archipelago. In *The Archaeology of Lapita Dispersal in Oceania*, ed. G. Clark, A. J. Anderson, and T. Vunidilo, pp. 25–38. Terra Australis 17. Canberra: Pandanus, Books Research School of Pacific and Asian Studies, Australian National University.

Summerhayes, G. R. 2001b. Lapita in the far west: recent developments. *Archaeology in Oceania* 36(2): 53–63.
https://doi.org/10.1002/j.1834-4453.2001.tb00478.x

Summerhayes, G. R. 2003. Modelling differences between Lapita obsidian and pottery distribution patterns in the Bismarck Archipelago, Papua New Guinea. In *Pacific Archaeology: Assessments and Prospects (Proceedings of the International Conference for the 50th Anniversary of the First Lapita Excavation, Koné-Nouméa 2002)*, ed. C. Sand, pp. 135–158. Nouméa: Département Archéologie, Service des Musées et du Patrimoine de Nouvelle-Calédonie.

Summerhayes, G. R. 2004. The nature of prehistoric obsidian importation to Anir and the development of a 3,000 year old regional picture of obsidian exchange within the Bismarck Archipelago, Papua New Guinea. In *A Pacific Odyssey: Archaeology and Anthropology in the Western Pacific. Papers in Honour of Jim Specht*, ed. V. Attenbrow and R. Fullagar, pp. 145–156. *Records of the Australian Museum, Supplement* 29.
https://doi.org/10.3853/j.0812-7387.29.2004.1411

Summerhayes, G. R. 2007. The rise and transformations of Lapita in the Bismarck Archipelago. In *From Southeast Asia to the Pacific: Archaeological Perspectives on the Austronesian Expansion and the Lapita Cultural Complex*, ed. S. Chiu and C. Sand, pp. 141–184. Taipei: Academia Sinica.

Summerhayes, G. R. 2010. Lapita interaction—an update. In *2009 International Symposium on Austronesian Studies*, ed. G. Z. Masegseg and Hsiu-man Lin, pp. 11–40. Taitong (Taiwan): National Museum of Prehistory.

Summerhayes, G. R., and J. Allen. 2007. Lapita writ small? Revisiting the Austronesian colonisation of the Papuan south coast. In *Oceanic Explorations: Lapita and Western Pacific Settlement*, ed. S. Bedford, C. Sand, and S. P. Connaughton, pp. 97–122. Terra Australis 26. Canberra: ANU E Press.
https://doi.org/10.22459/TA26.2007.05

Summerhayes, G. R., K. Szabó, M. Leavesley, and D. Gaffney. 2019. Kamgot at the lagoon's edge: site position and resource use of an early Lapita site in Near Oceania. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 89–104. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.04

Szabó, K., and G. R. Summerhayes. 2002. Worked shell artefacts—new data from early Lapita. In *Fifty Years in the Field. Essays in Honour and Celebration of Richard Shutler Jr's Archaeological Career*, ed. S. Bedford, C. Sand, and D. Burley, pp. 91–100. New Zealand Archaeological Association Monograph 25. Dunedin: The New Zealand Archaeological Association.

Wallace, D. A., R. W. Johnson, B. W. Chappell, R. J. Arculus, M. R. Perfit, and I. H. Crick. 1983. *Cainozoic Volcanism of the Tabar, Lihir, Tanga, and Feni Islands, Papua New Guinea: Geology Whole-Rock Analyses, and Rock-Forming Mineral Compositions*. Australian Bureau of Mineral Resources Report 243. Canberra: Australian Government Publishing Service.
https://d28rz98at9flks.cloudfront.net/15154/Rep_243.pdf

White, J. P., and J. Specht. 1971. Prehistoric pottery from Ambitle Island, Papua New Guinea. *Asian Perspectives* 14: 88–94.
https://www.jstor.org/stable/42927747

Woolley, A. R. 2019. *Alkaline Rocks and Carbonatites of the World, Part 4: Antarctica, Asia and Europe (excluding the former USSR), Australasia and Oceanic Islands*. London: The Natural History Museum.
https://doi.org/10.1144/MPAR4

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The Question of Early Lapita Settlements in Remote Oceania and Reliance on Horticulture Revisited: New Evidence from Plant Microfossil Studies at Reef/Santa Cruz, south-east Solomon Islands

Carol J. Lentfer[1], Alison Crowther[1,2], and Roger C. Green†

[1] School of Social Science, The University of Queensland, St Lucia QLD 4072, Australia

[2] Department of Archaeology, Max Planck Institute for the Science of Human History, Jena, Germany

† formerly Department of Anthropology, University of Auckland, Auckland, New Zealand

Abstract. Since the earliest discoveries of Lapita sites in Remote Oceania there has been ongoing debate about the nature of Pacific island colonisation. In the 1970s, based on the archaeological material from the SE-RF-2 and SE-RF-6 sites on the Reef Islands in the SE Solomons, Roger Green proposed that early Lapita communities there must have relied on horticulture as the mainstay of subsistence. Our analyses of phytoliths and starch in sediments and on pottery has found evidence for burning, food preparation and cooking in conjunction with a suite of wild and domesticated plants indicative of horticulture. Starch and phytoliths from seeded Australimusa (syn: Callimusa) bananas as well as domesticated Eumusa (syn: Musa) bananas were recovered, as well as *Colocasia esculenta* (taro) starch, and *Metroxylon* sp. (sago palm) phytoliths. Hence, Green's early hypothesis finds support, but more analyses, together with more precise dating are needed to clarify the time taken to establish sustainable horticulture. The importation of selected plants is confirmed, with potential sources being the Bismarck region or stop-over islands along the way. This was followed by ongoing on-site breeding and/or new introductions from further human migrations into the region and establishment of trade and exchange networks.

Introduction

After a formative period marking the emergence of the 'Lapita Cultural Complex' in the Bismarck Archipelago ca 3400 cal. BP (Denham *et al*., 2012: 44; Specht *et al*., 2014; Sheppard *et al*., 2015; Sheppard, 2019; cf. Specht and Gosden, 2019: 188, where a much later start date of 3250–3150 cal. BP is considered), there was a rapid demographic expansion into Remote Oceania, reaching the Southeast Solomons, Vanuatu and New Caledonia within a few generations at most, and Fiji, Tonga and Samoa soon after (Bedford *et al*., 2019: table 1.1; Sheppard *et al*., 2015). The nature of this migration has long been debated. At one extreme, models advocate a wave of advance and strand-looping across the region with a reliance on local resources for subsistence (e.g., Groube, 1971; Anderson, 2003; and see Davidson and Leach, 2001; Sheppard, 2019). At the other, leapfrogging scenarios are envisaged, entailing initial long haul voyages from the Bismarcks more-or-less directly across to the Reef/Santa Cruz Islands by groups of migrants carrying a suite of commodities including obsidian, pottery, domestic animals and subsistence plants, intended to facilitate settlement on new islands (Sheppard and Walter, 2006; Walter and Sheppard, 2009; Sheppard, 2011, 2019; Sheppard *et al*., 2015). Given the bulk of evidence for the presence of exotic cultigens including bananas, taro and yam at sites in Vanuatu, Fiji, Samoa and

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Table 1. List of dates with details of the associated ceramic series for the Reef/Santa Cruz sites and Lapita sites of comparable age of initial settlement in Remote Oceania (extracted from Bedford *et al*., 2019: table 1.1).

code	location name	ceramic series	age cal. BP	references
SE Solomons				
Reef/Santa Cruz				
SE–RF–2	Nenumbo, Te Motu Taibä/ Ngaua, Reef Islands	Middle	3185–2639	Green, 1976; Sheppard *et al*., 2015
SE–RF–6	Ngamanie, Lomlom/Ngalo, Reef Islands	Middle	2910–2470	Green, 1976; Green and Jones, 2007
SE–SZ–8	Nanggu, Nendö/Santa Cruz	Middle	2920–2729	Green, 1976; Green *et al*., 2008; Sheppard *et al*., 2015
Vanuatu				
Malo				
MA 8–20	Batuni-urunga	Middle	3000–2800	Hedrick, n.d.
MA 8–38	Avunatari	Middle	3000–2800	Galipaud, 1998
MA 8–39	Naone	Middle	3000–2800	Hedrick, n.d.
MA 8–40	Atanoasao	Middle	3000–2800	Galipaud, 1998; Bedford and Galipaud, 2010
Efate				
No code	Teouma	Early to Late	3000–2800	Bedford *et al*., 2010; Petchey *et al*., 2014, 2015
No code	Teouma west	Early	3000–2800	Shing and Willie, 2019
New Caledonia				
North coast				
NKM001	Boirra	Early to Late	3000–2750	Galipaud, 1998
West Coast				
WK0013A	Lapita	Early to Late	3000–2750	Sand, 1998; Sand *et al*., 2019
WK0013B	Lapita	Early to Late	3000–2750	Sand, 1998
WBR001	Nessadiou	Early to Late	3000–2750	Sand *et al*., 1996
V8	Vavouto	Early to Late	2900-2750	Sand, 2010
South Coast—Île des Pins				
KV003	St Maurice-Vatcha	Early to Late	2950-2700	Sand, 1999

New Caledonia, it is now well-accepted that horticulture was a facet of early Lapita settlement (e.g., Horrocks and Bedford, 2005, 2010; Crowther, 2009a; Horrocks *et al*., 2009; Horrocks and Nunn, 2007).

However, the nature of horticultural practice and the extent to which early settlement relied on it compared with natural terrestrial and marine resources is still open to question. As recent isotope studies at Teouma, Vanuatu, have indicated (Kinaston *et al*., 2014; Lebot and Sam, 2019), this is likely to vary according to local soils and ecology, to availability as well as sustainability of local resources and to time taken to establish sustainable crops. The Nenumbo SE-RF-2 and Ngamanie SE-RF-6 Lapita sites are key localities to further investigate the importance and nature of horticulture in the Lapita settlement of Remote Oceania, especially since revised dating protocols suggest that SE-RF-2 may be one of, if not the earliest Lapita settlement in the region (Table 1; see also Sheppard *et al*., 2015; Bedford *et al*., 2019).

Site locations and background

SE-RF-2 and SE-RF-6 archaeological sites are located on raised coralline islands in the Main Reef Islands in the Te Motu Province of the Solomon Islands. They are among the first set of islands beyond the Near/Remote Oceania boundary, approximately 500 km or an estimated 5 days sailing at 4 knots/hour from San Cristobal (syn: Makira) in the main island group of the Southeast Solomons (Fig. 1 and see Irwin, 2006: 76, 2008: 21). SE-RF-2 lies on the southeast coast of Ngaua Island (syn: Te Motu Taibä) and at the time of occupation the site would have been adjacent to the beach, fronted by a shallow tidal lagoon. Due to tectonic uplift, it now lies 160 m inland from the present beach and 2.4 m above the average high tide mark (Green, 1976: 248, 1979: 51, 1986: 124). SE-RF-6 is located approximately 3 km to the north of Nenumbo on the southwest coast of Ngalo Island (syn: Lomlom) next to a shallow, mangrove-filled, tidal channel that separates Ngalo Island from Ngangaua Island. They are in close proximity to several other Lapita sites, the most significant being SE-SZ-8 which lies 50 km south on Nendö (Santa Cruz Island) and thought to be slightly younger than or contemporaneous with SE-RF-2 (Fig. 1; Table 1). The sites were initially surveyed and excavated by Roger Green in 1971 and follow-up excavations were undertaken in 1976–1977 (Green, 1979; Green and Cresswell, 1976). Excavations at the sites were conducted after systematic surface collection of artefactual material (Green, 1976: 253; Sheppard and Green, 1991: 90–99; Green and Jones, 2007: 9).

SE-RF-2 has been interpreted as being a small hamlet with two main activity areas within a total estimated area of approximately 2400 m^2. The excavated area at the time of this study was 153.5 m^2 (Fig. 2; see Sheppard and Green, 2007). The first activity area was located in the middle of the site and was associated with an obvious structure estimated to be 7 × 10 m, as shown by a large rectilinear concentration of sherds that correspond with the layout of post holes, serving perhaps as a dwelling house, a community house or a men's

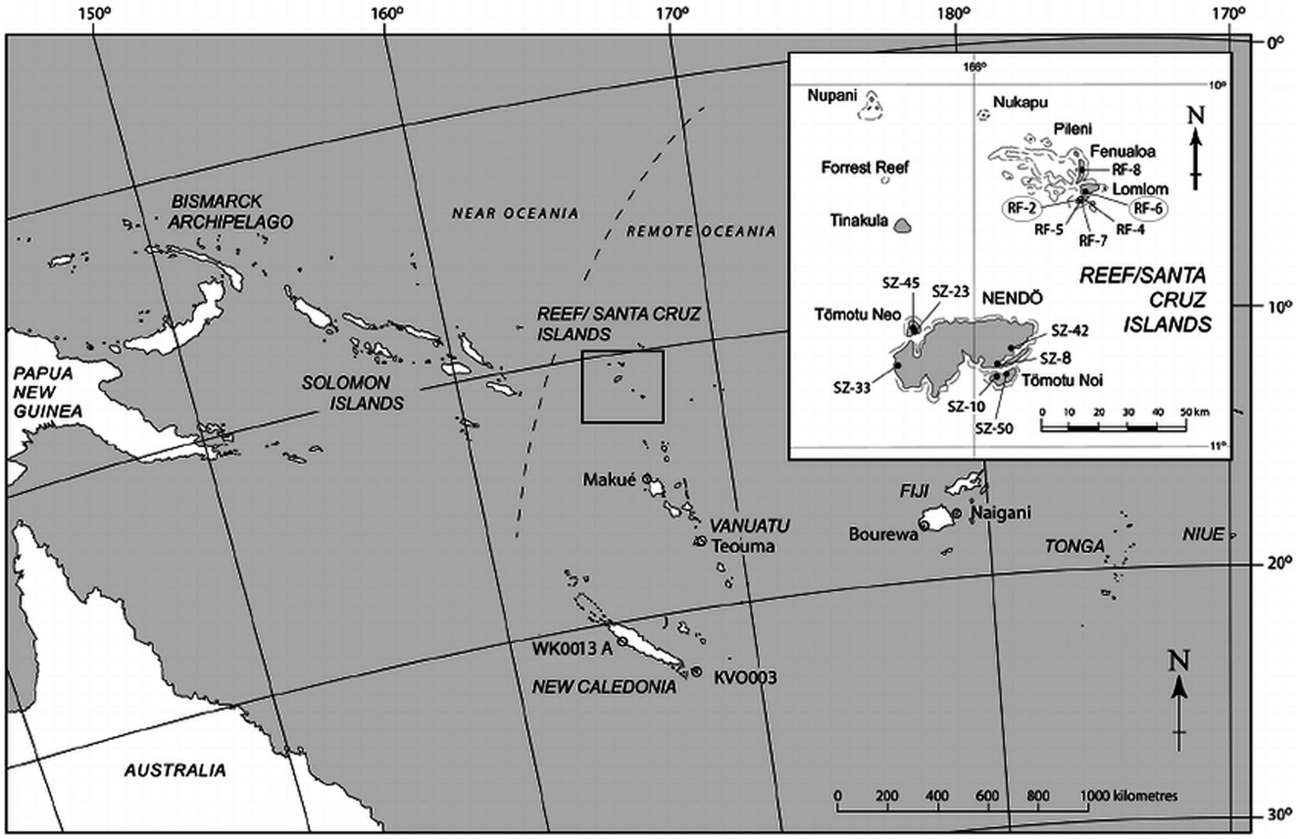

Figure 1. Map showing locations of the SE-RF-2 and SE-RF-6 archaeological sites on the Reef Islands in Remote Oceania. The location of SE-SZ-8 is marked on Santa Cruz Island (Nendö) nearby. Other sites on the Reef/Santa Cruz islands are undated but SE-SZ-23 and SE-SZ-45 also have ceramics from the Middle Lapita period. Sites marked on New Caledonia have ceramics from Early to Late Lapita (see Table 1 and Bedford *et al*., 2019). Sites in Vanuatu and New Caledonia, are potential sources of propagules for horiculture and arboriculture. Base map from Sheppard *et al*. (2015).

house, possibly with a raised floor at one end (Green and Pawley, 1999: 78–79; Sheppard and Green, 1991: 92–95, 100). The second, a complex of earth ovens and storage pits at the southern end of the site, has been interpreted as a cooking area with a series of open-sided cooking sheds (Sheppard and Green, 1991: 92–95, 100). According to Bayesian analyses of a series of radiocarbon dates on shell and charcoal (Sheppard *et al*., 2015: table 3; see Green and Jones, 2007: table 3; Sheppard and Green, 2007: 144), the site is thought to have been permanently occupied (Green, 1976: 255) and first settled between 3185 and 2639 cal. BP (95.4% CI) for a period spanning at least 50 years.

The stratigraphy of SE-RF-2 is relatively simple (Fig. 4a) with basal white coralline beach sand (Layer 3) overlain by intact cultural deposits composed of grey charcoal-stained sand (Layer 2, the Lapita occupation layer). Above this is a black garden soil (Layer 1), 25–30 cm thick, principally derived from volcanic ash deposits that most likely originated from the nearby Tinakula volcano between 2400 and 500 BP (Burnett and Fein, 1977; Jones *et al*., 2007: 99). All layers are alkaline, with pH values of 6.9–7.9 in Layer 1 increasing to 9.5 in Layer 3 (Burnett and Fein, 1977). Based on well-defined sedimentary mineralogy and geochemistry within each of the layers, Green (1986) argued for good stratigraphic integrity. However in its undisturbed context it is thought that the grey sand occupation layer would have been slightly thicker before the original upper 5–8 cm was incorporated into the garden layer. This indicates some upwards disturbance bringing cultural material to the surface. The spatial patterns exhibited by the surface sherd distribution and the subsurface features suggest that little post-depositional horizontal disturbance of the site's cultural content has occurred (Sheppard and Green, 1991) and it appears that soil-mixing from tree-fall and crab-burrowing would have been minor (Green, 1976: 251; Jones *et al*., 2007: 99).

The SE-RF-6 site, running parallel to and within view of the sea-water channel, covered a much larger area than SE-RF-2 (Fig. 3). From surface surveys and trowel test-pitting at 10 m intervals, the site was estimated to be approximately 10,800 m^2 (Green, 1979: 51; Green and Jones, 2007: 9; Sheppard and Green, 2007) of which 20 test squares, each 1 × 1 m, within a 100 m^2 portion at the eastern end, were fully excavated. Radiocarbon dates have determined that SE-RF-6 postdates SE-RF-2, perhaps spanning an occupation period of 50 to 100 years beginning sometime in the interval between 2910 and 2470 cal. BP (95.4% CI) (Table 1) (see Green and Jones, 2007; Bedford *et al*., 2019). Although hearth features were found, no well-defined structures or activity areas were identified within these limited excavations. The stratigraphy of SE-RF-6 is similar to SE-RF-2 (Fig. 4b), having white coralline beach sand and coral limestone in the basal layers, overlain by a grey sand midden layer (Layer 2) and a garden soil derived from Tinakula ashfall (Layer 1) (Green and Jones, 2007).

Cultural material found at both sites include decorated pottery sherds, oven stones, adzes made from local and imported rock, nut-cracking stones, and chert and obsidian cores and retouched flakes (Green, 1976: 259, 1978, 1991; Green *et al*., 2008). The two sites, especially SE-RF-2, provide important evidence for long distance transport of resources over a distance of more than 2000 km (Green *et

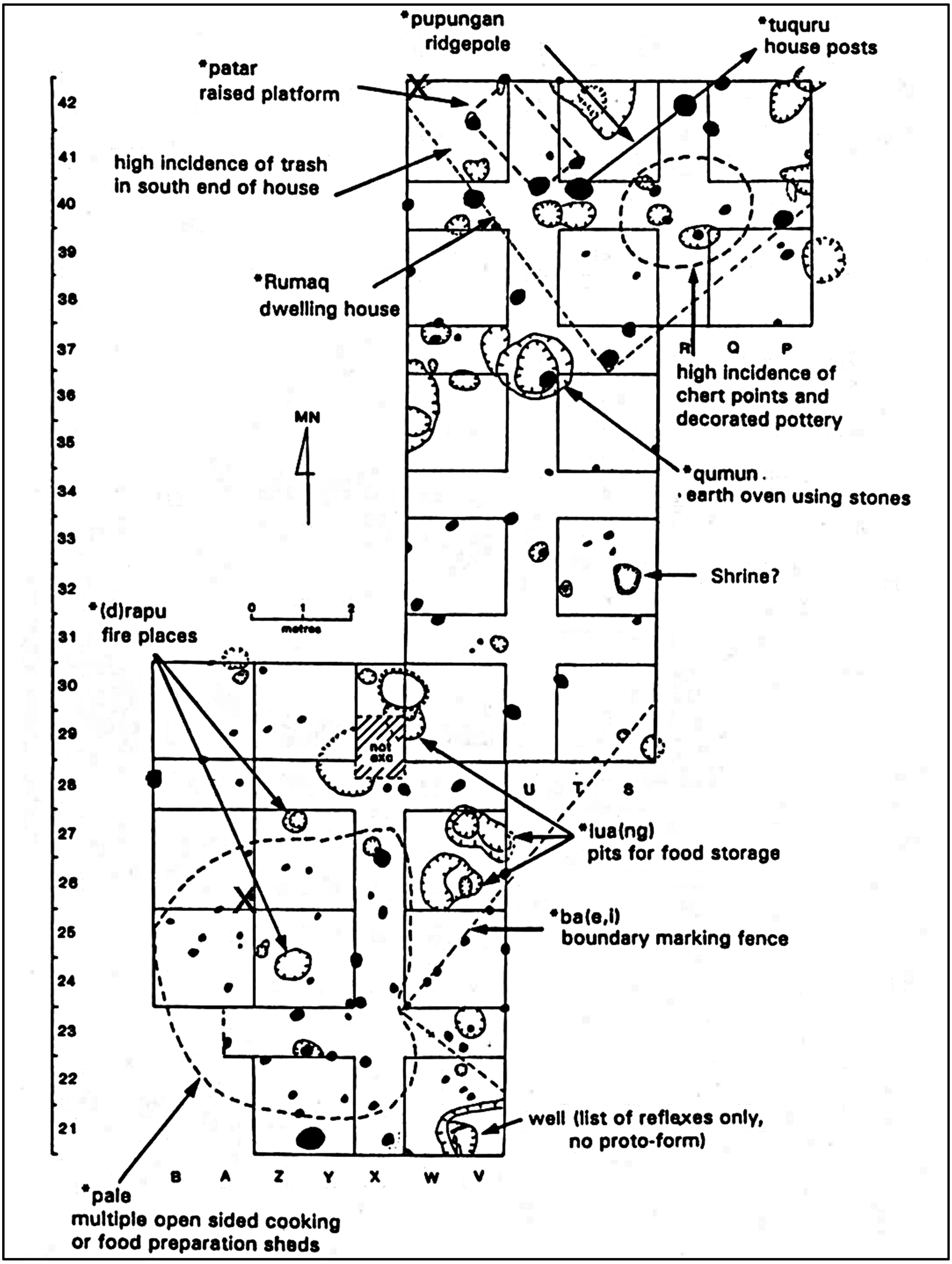

Figure 2. Site plan of SE-RF-2 (extracted from Green and Pawley, 1999). X marks sediment sampling locations.

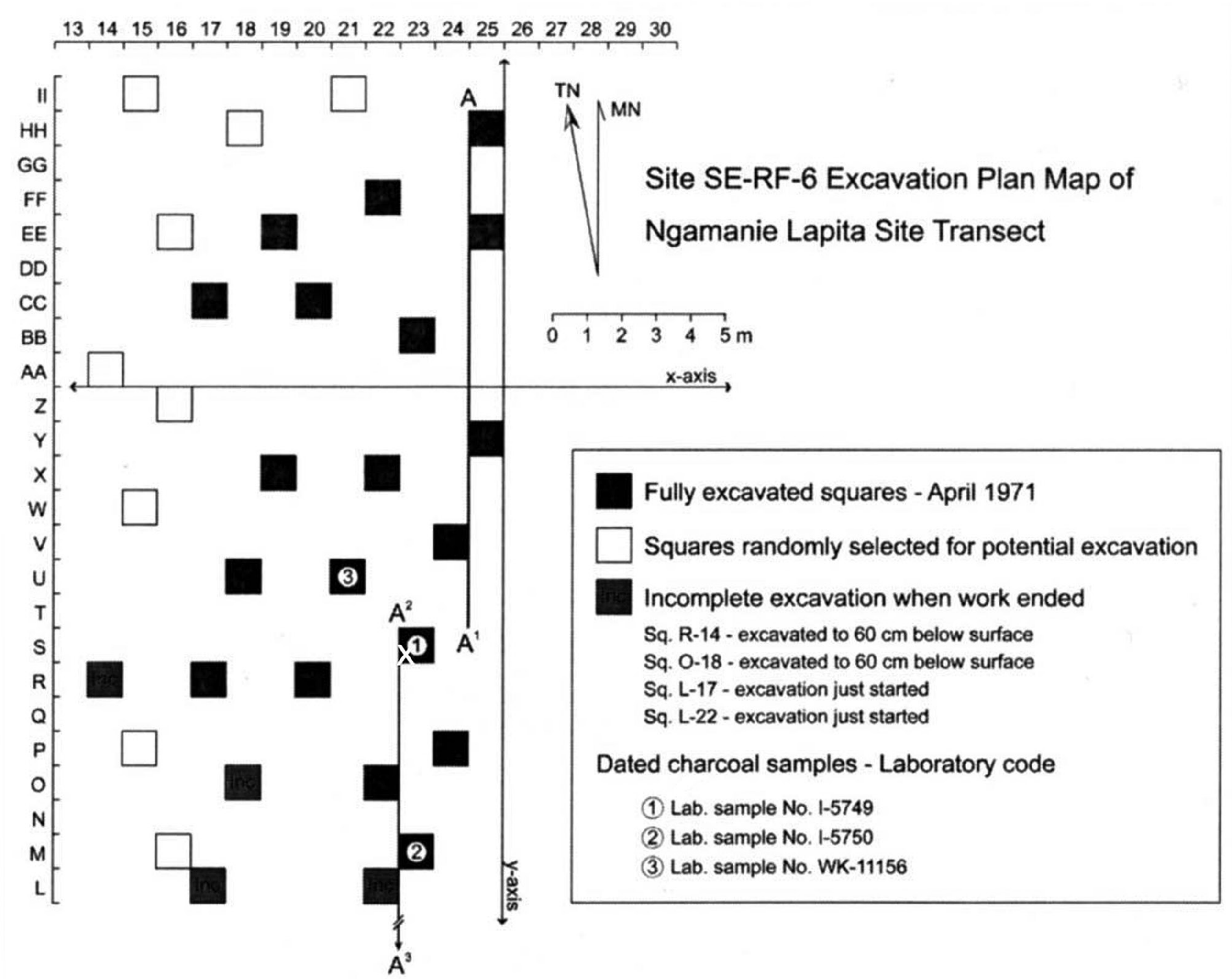

Figure 3. Section of site plan for SE-RF-6 (extracted from Green and Jones, 2007). X marks square S-23 from where the two sediments were collected.

al., 2008: 55). Ceramic styles including decorative motifs are shared with Lapita assemblages from West New Britain in the Bismarck Archipelago (Summerhayes, 2000); chert was imported from the Duff Islands and Ulawa/Malaita (100 km northeast and 350 km east of Santa Cruz respectively) (Sheppard, 1993, 1996; Walter and Sheppard, 2009); and obsidian was sourced from Willaumez Peninsula sources in the Bismarcks, Lou Island in the Admiralties, Fergusson Island in the D'Entrecasteaux Islands at the eastern tip of Papua New Guinea, and the Banks Islands in northern Vanuatu (Green, 1987; Green and Bird, 1989; Walter and Sheppard, 2009; Sheppard *et al*., 2010: 27, table 5). Together with archaeological evidence from the SE-SZ-8 site on Nendö, where an abundance of obsidian from the same sources was also found along with dentate stamped pottery and motifs most similar to SE-RF-2 (Anson, 1986; Green, 1991; Summerhayes, 2000; Green and Jones, 2007: 7; Green *et al*., 2008), this suggests that early Lapita colonists maintained close trade and/or exchange and social networks, providing important safety nets for groups as they established themselves in their new settings.

The excavated midden deposits at the two sites also included a range of tropical shoreline bivalves and gastropods indicating intensive use of lagoons, as well as evidence of on-site shell-working (Green, 1976; Szabó, 2005: 184–197; see also Szabó, 2010: table 3). Other material consisted of inshore marine invertebrates, fish bone, mostly derived from reef and lagoon species, and bones of turtle, bat, rat, whale, dugong, pig and bird. Bird remains comprised megapode, domesticated chicken, a goose-sized bird and other unidentified species (Green, 1976: 255–258; see also Storey *et al*., 2010). No plant macro-remains apart from *Pandanus* species were recovered from the site (Green, 1976: 258; Szabó, 2005). Nevertheless, the quantity of marine resources used at the site was thought to be limited and 'quite insufficient to constitute more than a minor part of the daily diet of even a small group of people from a settlement inhabited for any length of time' (Green, 1976: 258). Based on the presence of pig bone at the site (and to a lesser degree chicken), Green suggested that subsistence from the time of earliest occupation must have had a heavy reliance on horticulture. More recently, Kirch and Green (2001: 121) went on to claim that:

> when Lapita populations expanded into Remote Oceania … they transported a full roster of oceanic crops, including such staples as taro, yam, bananas and breadfruit. Indeed, the very ability to transfer such systems of horticultural production was arguably an essential aspect of the successful Lapita colonization strategy.

Subsequently, in line with ongoing debates about the nature of Lapita settlement and with the aim of testing this hypothesis with empirical evidence, Green invited the authors to undertake further investigation of the SE-RF-2 and SE-RF-6 sites, using microfossil analyses, primarily phytoliths and starch.

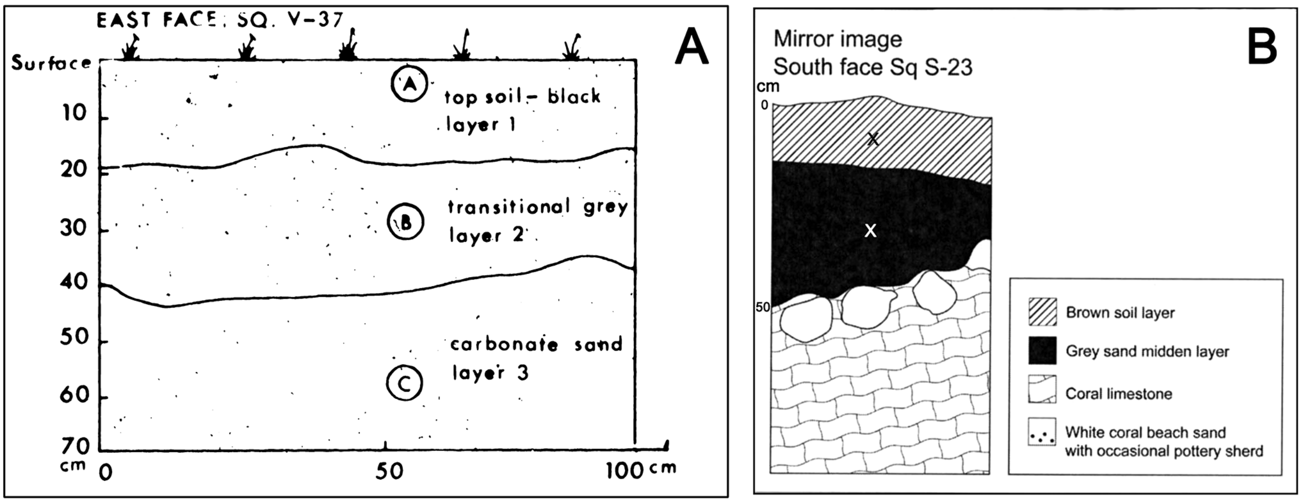

Figure 4. (*A*) Original field drawing by Doug Yen in 1971 of the stratigraphy of square V37, SE-RF-2 with locations of sediment samples used for initial soil analyses by Burnett and Fein (1975). NB stratigraphic drawings were not available for Square W42, from where the sediment samples for our analyses were collected. (*B*) Stratigraphy of square S-23, SE-RF-6, showing sediment sampling locations (extracted from Green and Jones, 2007).

Methods

Pottery

A total of 63 sherds from SE-RF-2 were selected for starch residue analysis. These comprised 36 sherds from the three main activity areas (the occupation structure, the cooking area, and the storage-pit area; a mixture of dentate-stamped, incised, and plain from each), 13 sherds from six partially-reconstructed dentate-stamped vessels, six plain rims, and eight sherds (six plain, one dentate-stamped and one incised) from cooking vessels with charred residues on their interior surfaces. Sherds with well-preserved surfaces, little weathering or edge rounding, and of suitable size and shape were targeted, preferentially from Layer 2 (the *in situ* Lapita occupation layer), which was less affected by modern cultivation activities, though some were also selected from Layer 1. Although the sherds had been lightly washed and handled during post-excavation analysis, several studies have previously demonstrated the potential for recovering use-residues from curated objects (e.g., Piperno *et al*., 2000; Fullagar *et al*., 2006).

Residues on the sherds were analysed in a multi-stage process. First, all artefact surfaces (inner, outer, broken edges) were examined directly with high magnification (× 100–1000) reflected light to locate and characterise potential *in situ* residues. Selected samples were also examined via low vacuum scanning electron microscopy (SEM) (JEOL-6460-LV; 155Pa, 15 kV accelerating voltage, 45–55 spot size). For sherds with possible starch residues (n = 20), extracts were then removed for more detailed analysis with transmitted light microscopy (× 200–1000 magnifications). For sherds without charred food crusts, residues were removed with water and pipette from a small spot (c. 1–2 cm diameter), and applied to a clean microscope slide. This process was repeated until a suitable amount of residue was removed. At least one location on the interior and exterior of each sherd was sampled by this method, and for those that had starches on either of these surfaces, the broken edges were also then sampled for comparison. Distribution patterns of starches on each surface were used to evaluate whether the microfossils were associated with vessel use (i.e. located on a used surface but absent from a non-used surface) or post-depositional, including assessing possible laboratory contaminants. Charred residues were scraped from the potsherds and processed with weak (0.125%) NaOH to break down the carbonised matrix and release entrapped starches (see Crowther, 2009b for full protocol). Prepared slides were examined as water mounts and fully scanned twice; the second time after treatment with IKI stain (to improve the detection of starches) and 5% acetic acid (to dissolve needle-fibre calcite crystals as well as other extraneous carbonates from the sediment and vessel temper) (Crowther, 2009b), both of which were applied *in situ* on the slide. Results before and after IKI and acetic acid treatment were compared. Standard morphometric characteristics were recorded for each starch granule (e.g., Torrence and Barton, 2006; Lentfer, 2009a, 2009b; Crowther, 2018).

Sediments

Three sediment samples were selected from SE-RF-2 for starch granule and phytolith analyses (Figs 2 and 4a). Samples from Layers 1 (from 0–10 cm depth) and Layer 2 (from 30–40 cm depth) were collected from the northwest corner of square W42 (Green, pers. comm. 2007) and the third from a post-hole located in square A26 in the food preparation area. The post-hole was cut into the underlying sterile sand layer, but was filled with grey sand associated with the Lapita occupation layer (Layer 2). Additionally, two sediment samples collected from Square S-23 at SE-RF-6 were selected for phytolith analysis. These were from Layer 1, the brown loam soil with modern vegetation and gardening, and Layer 2, the grey sand midden horizon at 30 cm depth (referred to in the analytical diagrams and tables as 'L25') (Figs 3 and 4b).

Starch granules were extracted from 5 g sub-samples of the SE-RF-2 sediments using heavy-liquid flotation with sodium polytungstate ($Na_6(H_2W_{12}O_{40})$) (SPT) (Therin and Lentfer, 2006). They were first treated with weak (6%) hydrogen peroxide for 30 minutes to remove organics, sieved at 300 µm to remove large sand grains, and deflocculated with warm (35°C) 5% sodium hexametaphosphate $(NaPO_3)_6$. All sediment extracts were dried and suspended in 500 µl of water from which 50 µl samples were removed per slide, which were examined as water mounts both before and after IKI staining (as above).

Phytoliths were extracted from 5 g sediment sub-samples using heavy liquid flotation with sodium polytungstate (Lentfer and Boyd 1998). Residues were mounted onto microscope slides in benzyl benzoate, examined with transmitted light microscopy (×400–600 magnification). A minimum of 100 phytoliths were counted for each sample after which slides were fully scanned and presence of previously unrecorded morphotypes were noted.

Microfossil recording and identification

Starch and phytolith morphotypes were photographed and compared with modern comparative reference material and published descriptions (e.g., Loy *et al*., 1992; Lentfer, 2003, 2009a, 2009b, 2009c; Fullagar *et al*., 2006), and classified accordingly. To differentiate Musaceae seed phytoliths from leaf phytoliths, and further, to differentiate between Musaceae sections (Eumusa syn: Musa and Australimusa syn: Callimusa) and species, maximum dimensions of craters and body length were measured for all Musaceae morphotypes with craters Body length/crater width ratios were calculated and compared with morphotypes from the modern comparative Musaceae collection (see Wilson, 1985; Ball *et al*., 2006; Lentfer, 2009c, Vrydaghs *et al*., 2009). Tukey HSD and B tests for homogeneity were also undertaken. Charcoal particles and burnt phytoliths were also recorded (see Lentfer *et al*., 2010).

Results

Starch Analysis

Twenty of the 63 sherds were observed under reflected light as having possible starch residues. Of these, 11 sherds were confirmed by transmitted light analysis as having starch: five plain sherds, one incised and five dentate-stamped. A total of 55 starch granules were recovered, most of which were from the interior (no. granules = 28) and exterior (n = 23) of the sherds rather than the broken edges (n = 4) (see Table 2). Although the degree of confidence is reduced by the small number of granules (< 3) recovered in any single sherd extract, this overall pattern is compelling and suggests that the residues in the majority of cases originate from vessel use, most likely for food preparation, storage, cooking or serving. Twenty-one of the recovered granules were morphologically 'native' (visibly undamaged), three had minor mechanical damage (e.g., cracked, split, torn or partial loss of birefringence; referred to as 'Type 1' damage in Table 2), 15 had more extensive mechanical damage resulting in complete loss of birefringence ('Type 2' damage), two were gelatinised (modified by cooking, i.e. heat and moisture), and 14 were amorphous and appeared as solubilised or dispersed deposits that stained with IKI but otherwise had no discrete form. IKI staining proved critical for detecting small and damaged starches during the analysis. No gelatinised granules or amorphous deposits were detected prior to staining. Nor were the majority of starch granules less than about 5 µm in size, which nonetheless comprised over one quarter (30.4%) of the entire morphologically-classifiable starch assemblage. These granules were otherwise difficult to detect owing to their small size and typically low birefringence. Many larger, damaged granules that had weak or no birefringence were also revealed by the stain.

In addition to the 55 starches extracted from sherd residues, 51 granules were recorded in the extracts analysed from the three SE-RF-2 sediments. Most of these were native or displayed only minor damage such as small surface pits or cracks. A single, slightly swollen granule with weak birefringence at its periphery was recovered from Layer 2 (Table 2).

The pottery and sediment starch assemblage (excluding those granules with extensive morphological alterations) was classified into 18 morphotypes (Table 3). Of these, four could be assigned to specific plant taxa with a high degree of confidence. Type 1a1 (n = 8) (Fig. 5a–c), found on four sherds (163/P2, 165/P1, 166/23 and 166/P5) and in the post-hole grey sand feature, was identified as *Colocasia esculenta* (taro) (Fig. 5d). This morphotype displayed a combination of attributes typical of storage starch granules from the corm including small size ≤8 µm (most were 3–6 µm), round (spherical) to sub-round (sub-spherical) shape and the presence of multiple flat to slightly concave facets. The facets have slightly rounded edges when viewed with long working-distance lenses, but appear sharper when examined using an oil immersion objective that enabled their differentiation from transitory starch granules of similar size that are found in the photosynthetic tissues of many plants (Fullagar *et al*., 2006: 598). Types 2a2 (n = 1), 6a (n = 6) and 6b (n = 5) (Figs 6a and 7), found only in the SE-RF-2 sediment samples, were identified as being derived from Musaceae (see Figs 6b and 8); 6a and 6b were present in all three samples and 2a2 exclusively in the grey sand of the post-hole feature (more specific descriptions and identification of these starch granules is given in a later section of this paper). Within the limits of the reference material available for comparison, and at the present stage of morphometric analysis of that material, the other 14 morphotypes could not be assigned to any specific plant taxa. However, given the range of starch granule morphotypes present in the extracted assemblages, it is very likely that several plants and plant products were represented and probably on the menu, in particular those present in the pottery residues: types 1, 1a2, 1a3, 1c, 7, 9a, 10 and 10a2. Nevertheless, until starch granules are identified, the derivation of morphotypes from edible plants cannot be assumed.

The presence of the Type 1a1 morphotype is the most significant finding from the sherd analysis, pointing to the likelihood of taro being processed and cooked on site. The morphotype occurred exclusively on either the interior or exterior surfaces of four sherds (163/P2, plain; 165/P1, plain; 166/P5, plain; 166/23, dentate stamped), and was absent from their broken edges (which would reflect post-depositional contaminants). It is probably not by coincidence that they were recovered from the purported cooking sheds and food preparation area (specifically, excavation squares ZY26-27 and WV26-27). It is very likely that 166/23 and 166/P5, with charred interior surfaces, came from pots used for cooking. The other two sherds, which were associated with pit features in the purported food preparation area, were probably from vessels used for preparation of taro and/or storage. Similarly, the occurrence of gelatinised and damaged granules on the interior and exterior surfaces of other sherds found in the two areas suggests similar types of vessel usage (Table 2).

It is notable that within the constraints of this analysis and the small amount of starch recovered, there were no discernible relationships between pot decoration and usage. This needs further investigation but it should be kept in mind that one of the primary factors contributing to the low starch yield in the sherd analysis may be the poor survival of starch in a cooking environment where granules are exposed to heat and hot water in particular. Experiments undertaken by Crowther (2009a) showed that taro starch does not remain very cohesive or sac-like when fully gelatinised from cooking and, therefore, may not have been detected or differentiated from small, amorphous deposits in the sample residues analysed. Gelatinised granules are also more susceptible

Table 2. Records of starch granule morphotypes on pottery sherds and in sediments from SE-RF-2, and comments relating to pottery use. For indeterminate starch morphotypes (indet.): *T1* = Type 1 damage, *T2* = Type 2 damage, *g* = gelatinisation, *n* = native, *a* = amorphous. For sample location: *I* = interior of sherd, *E* = exterior of sherd, *BE* = broken edge of sherd, *ch* = charred residue.

pottery sherds	sample location	1	1a1	1a2	1a3	1b	1c	2	2a1	2a2	6a	6b	7	9a	10	10a1	10a2	10b1	10b2	indeterminate	comments
135/39?	I(ch)	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1^{T1}	Use indeterminate.
	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2^{a}	
	BE	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1^{n}	
16/21	I	—	—	—	2	—	—	—	—	—	—	—	1	—	1	—	—	—	—	1^{g},1^{a}	Gelatinised starch and four native granules on
	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	interior. No starch from broken edge. Probable
	BE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	cooking or serving.
16/P1	I	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1^{n},1^{a}	Use indeterminate.
	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1^{a}	
	BE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
163/115	I	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5^{T2},1^{a}	Five damaged granules on interior and single
	E	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Type 1a3 granule on exterior. No starch from
	BE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	broken edge. Possible food storage or prepartion
163/P2	I	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2^{T2},1^{a}	Single cf. *C. esculenta* granule on exterior.
	E	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2^{T2}	Possible storage or preparation of *C. esculenta.*
	BE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
163/27	I	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1^{T2}	Use indeterminate.
	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1^{T2},1^{a}	
	BE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
165/P1	I	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Two cf. *C. esculenta* granules on interior.
	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1^{a}	Possible storage or preparation of *C. esculenta.*
	BE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1^{T2}	
166/23	I(ch)	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Three cf. *C. esculenta* granules on exterior.
	E	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1^{T1},1^{T2}	Charred residue on interior. Possible cooking
	BE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	of *C. esculenta.*
166/P1	I(ch)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1^{T2},2^{a}	Use indeterminate.
	E	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	1	—	—	—	
	BE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1^{T2}	
166/P5	I(ch)	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Single cf. *C. esculenta* granule from interior
	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3^{a}	charred residue. Possible cooking of *C.esculenta*

to enzymatic digestion and will degrade preferentially in archaeological residues (Barton and Matthews, 2006). If pottery vessels at the site were used primarily for cooking, it is probably not surprising that starch survival overall was poor and no gelatinised taro starch granules were observed. It is also notable that no calcium oxalate raphides were present in the sample residues, despite their recovery in other Pacific island contexts in association with aroid starches (e.g,. Horrocks and Barber, 2005; Horrocks and Bedford, 2005; Horrocks and Weisler, 2006). This suggests that on-site conditions may not have been conducive to their long-term preservation at SE-RF-2. Large quantities of needle-fibre calcite crystals were present on the sherds. Morphologically they are similar to calcium oxalate raphides, but can be distinguished from them because they are soluble in weak acetic acid (Crowther, 2009b).

Phytolith Analysis

The results of the phytolith analysis for SE-RF-2 and SE-RF-6 sediments are presented in Table 4. The assemblages were dominated by epidermal morphotypes (listed as 'other (indet.)') that have low diagnostic value but are characteristic of a complex of vegetation types including dicotyledonous trees, shrubs and scramblers. Diagnostic morphotypes were present but in relatively low numbers. These represented panicoid grasses and bamboo, palms including morphotypes characteristic of *Metroxylon*, *Cocos*, *Calamus* and *Licuala* species, small to medium, echinate to nodular, globular morphotypes found in several species of palms, gingers and Marantaceae, as well as morphotypes from Musaceae, Euphorbiaceae, Burseraceae, Malvaceae, Dilleniaceae, Rhizophoraceae, Fabaceae and Solanaceae. Burnt phytoliths and charcoal were also present.

Table 3. Description and counts of archaeological starch morphotypes present on sherds and sediments from the SE-RF-2 Lapita site.

starch type	count	shape(s)	hilum	vacuoles	fissures	lamellae	max. size range (µm)	comment
1	9	round (not sub-classified)	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	
1a1	8	round, sub-round and sub-elliptical with multiple facets, some with irregular margins	centric	absent	absent	absent	2.5–8	cf. *Colocasia esculenta*
1a2	2	round, sub-round and sub-elliptical, often with multiple facets and/or irregular margins	centric	absent	absent	absent	10–11	
1a3	3	round, elliptical, sub-round/polygonal with up to six facets, bell with two facets	centric	absent	absent	absent	6–9	Surfaces and margins very smooth.
1b	1	round	centric	absent	fine and shallow V- or Y-shaped 'crack'	absent	14–19	
1c	3	round, sub-round, sub-elliptical	centric	absent	absent	rare; indistinct where present	18–35	Surfaces and margins generally very smooth; cross arms perpendicular and often diffuse (not sharp) at the periphery.
2	3	elliptical (not sub-classified)	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	
2a1	1	elliptical	centric	absent	absent	absent	12–21	elongate cross-point
2a2	1	elliptical/oblong, almost elongate; surface appears wrinkled, but may be an effect of the fissure	centric	absent	longitudinal with wrinkled edges	absent	24	Margin irregular and surface slightly rough cf. Musaceae: *Musa acuminata, Musa AAA*
6a	6	sub-elongate to elongate irregular-ovate with acute hilum end, generally obtuse, rounded distal end and enlarged middle; one granule has distinctive protrusion from hilum end	highly eccentric	absent	absent	present but generally weak; most distinct toward distal end	40–55	cf. Musaceae: *Musa* cultivar AAA, *Musa acuminata* × *schizocarpa*
6b	7	elongate to very elongate elliptical, occasionally slightly curved	highly eccentric	absent	absent	generally present but weak; most distinct toward distal end	39–53	cf. Musaceae: *Musa* cultivar AAA, *Musa acuminata* × *schizocarpa*
7	1	irregular (not sub-classified)	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	
9a	2	bell with single, round-edged facet	centric	absent	absent	absent	13–37	
10	3	polygonal (not sub-classified)	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	
10a1	6	polygonal (multi-facetted) with six or seven sharp-edged (angular), slightly concave facets	centric, rarely slightly eccentric	absent	straight (transverse) or Y-shaped, usually deep	absent	11–24	
10a2	11	polygonal (multi-facetted) or sub-round with three to six flat or convex facets,	centric or slightly eccentric	absent	straight (transverse), V-, Y-, or X-shaped, fissure, usually deep	absent	10–27	
10b1	4	polygonal (multi-facetted) or sub-round with three to six flat or convex facets, generally round-edged	centric or slightly eccentric	small cavity	absent	absent	10–24	
10b2	2	polygonal (multifaceted) with five or six round-edged flat or convex facets	centric or slightly eccentric	large open cavity	absent	absent	13–21	Large cavity may be the result of damage rather than a feature of the native granule

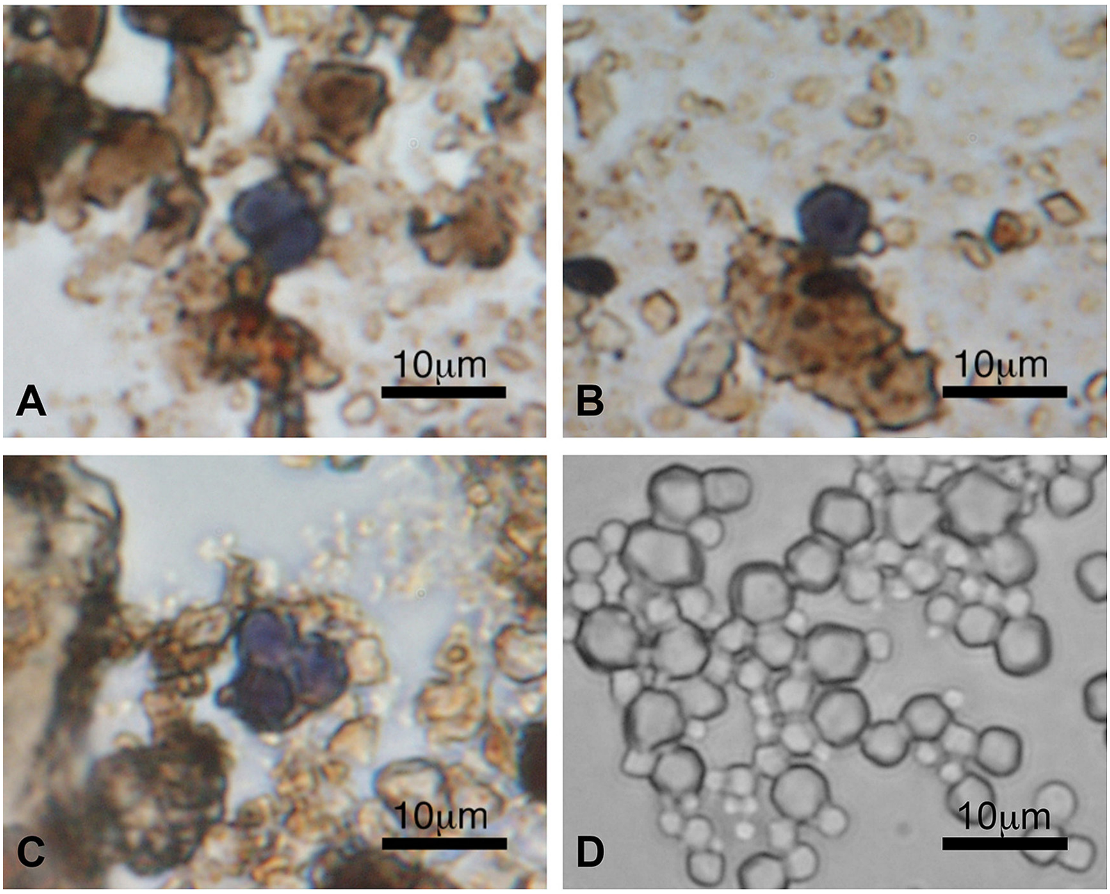

Figure 5. (*A–C*) Examples of Type 1a starch granules (stained purple with IKI) from SE-RF-2 Lapita sherds and (*D*) modern *Colocasia esculenta* starch for comparison. (*A*) Cluster of two granules from RF2/165/P1. (*B*) Isolated granule from RF2/166/P5. (*C*) Cluster of three granules from RF2/166/23.

SE-RF-2

Layer 1—black soil: This assemblage was dominated by polyhedral and elongate morphotypes. Articulated epidermal anticlinal and polygonal morphotypes, indicative of dicotyledonous vegetation, were common. Musaceae morphotypes were also relatively common, comprising > 9% of the assemblage. Palm morphotypes, possibly derived from *Cocos nucifera* and *Metroxylon* sp., and panicoid grass morphotypes were also present, but rare. Burnt phytoliths were common, mostly polyhedral morphotypes including epidermal polyhedral morphotypes found frequently in Euphorbiaceae, but also present in other species. Charcoal particles were very rare.

Layer 2—grey sand: Articulated epidermal anticlinal and polygonal morphotypes, indicative of dicotyledonous vegetation also dominated this assemblage. Musaceae morphotypes were very common comprising > 15% of the assemblage. Palm morphotypes represented > 7% of the assemblage; small echinate spheroid morphotypes similar to those found in *C. nucifera* but also present in a range of other genera such as *Licuala* and *Calamus* spp. were most common. Reniform echinate globular morphotypes commonly found in *C. nucifera* were present but larger morphotypes characteristic of *Metroxylon* sp. (Fenwick *et al*., 2011; Lentfer, 2003) were very rare. Panicoid grass morphotypes, burnt phytoliths and charcoal particles were also very rare.

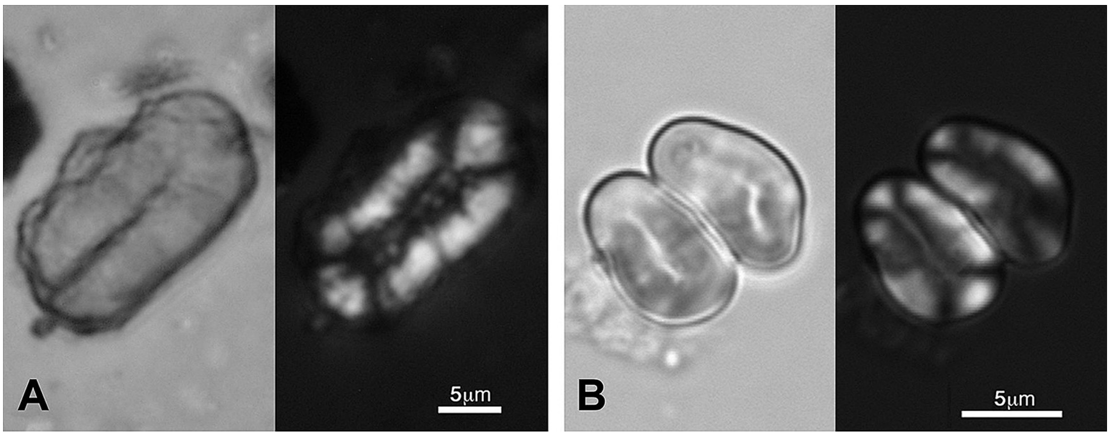

Figure 6. (*A*) Type 2a2 starch granule from SE-RF-2 Layer 2 posthole feature, and (*B*) modern *Musa acuminata* starch.

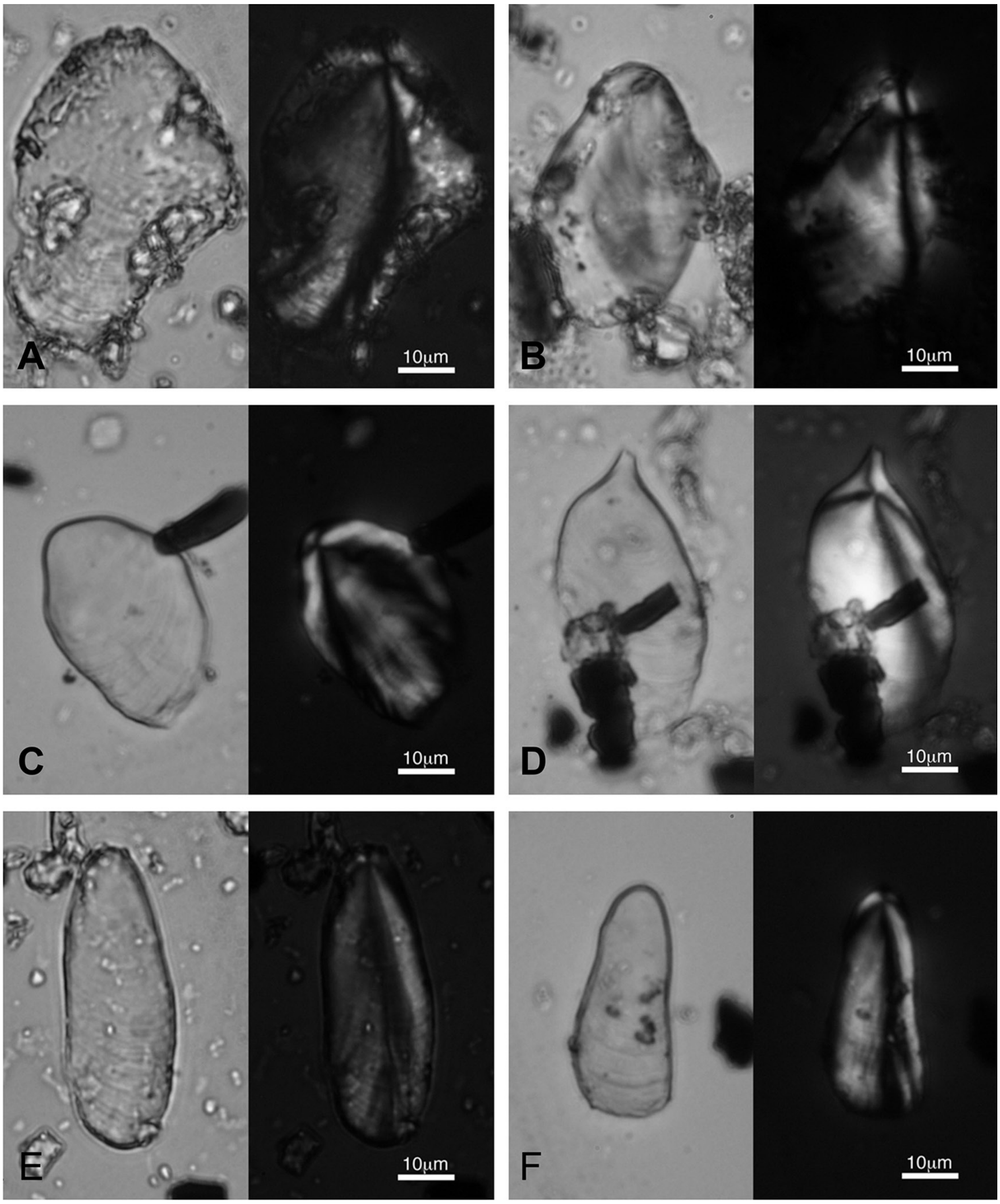

Figure 7. Examples of Type 6a (*A–D*) and 6b (*E–F*) starch granules from SE-RF-2 sediments in plain (left panel) and cross-polarised (right panel) light. (*A, E*) Layer 1; (*B*) Layer 2; (*C, D, F*) Layer 2 posthole feature.

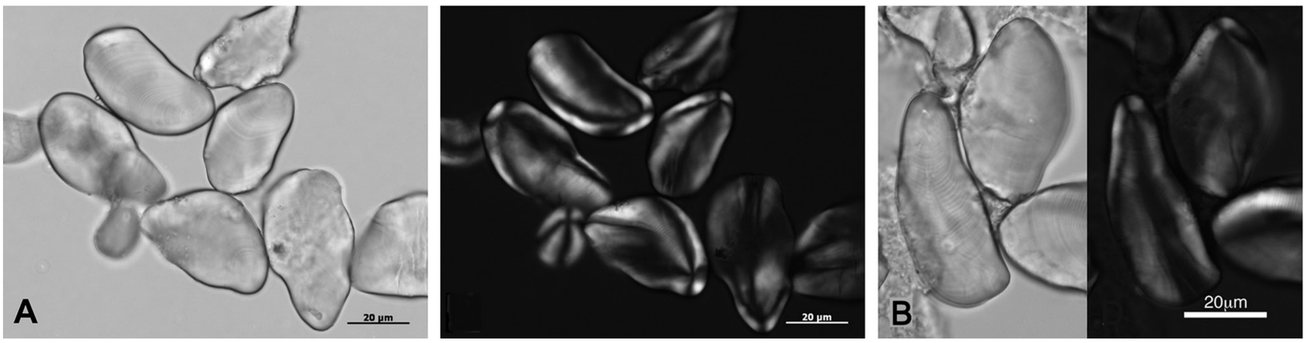

Figure 8. Modern *Musa acuminata* × *schizocarpa* starch granules in plain (left panel) and cross-polarised (right panel) light.

Table 4. Composition of phytoliths and charcoal in sediments from SE-RF-2 and SE-RF-6.

phytolith morphotypes and charcoal		% composition of phytoliths				
		SE-RF-2 Layer 1	SE-RF-2 Layer 2	SE-RF-2 Post-hole	SE-RF-6 Layer 1	SE-RF-6 Layer 2 (L25)
Musaceae		9.83	15.11	0.00	0.00	7.49
Palmae	< 10 µm	0.58	6.67	0.98	4.52	5.35
	> 10 µm	0.58	0.44	0.00	1.51	2.14
	cf. *Metroxylon* sp.	0.00	0.00	0.00	4.02	1.07
Palmae/Zingiberales		0.58	1.33	0.98	0.50	1.07
Gramineae	Bambusoid	0.00	0.00	16.67	0.00	0.00
	Bambusoid ESC	0.00	0.00	2.94	0.00	0.00
	Panicoid ESC	0.58	1.33	0.00	0.00	0.00
Euphorbiaceae	cf. *Macaranga* sp.	0.58	0.00	0.00	1.51	1.07
Burseraceae	cf. *Canarium indicum*	0.00	0.00	3.92	0.00	0.00
Malvaceae	cf. *Hibiscus tiliaceus*	0.00	0.00	1.96	0.00	0.00
Dilleniaceae	cf. *Dillenia* sp.	0.00	0.00	0.98	0.00	0.00
Rhizophoraceae	cf. *Rhizophora* sp.	0.00	0.00	1.96	0.00	0.00
Solanaceae	cf. *Solanum torvum*	0.00	0.00	0.98	0.00	0.00
Fabaceae	cf. *Mucuna* sp.	1.16	0.00	0.98	1.01	0.00
gl/nod (indet.)		0.58	1.78	1.96	1.01	1.07
other (indet.)		85.55	68.89	62.75	85.93	73.80
burnt phytoliths		5.78	1.78	0.00	6.53	0.53
ratio (charcoal particles : phytoliths)		0.03	0.01	0.00	0.15	0.29
total phytolith count		173	225	102	199	187

Grey sand from the post-hole feature: This sample had the most diverse assemblage of diagnostic phytoliths with at least seven plant families represented. Also, it was the only sample with Bambusoid morphotypes (Fig. 9a). Notably, the culm morphotypes were most common, comprising > 16% of the assemblage, suggesting they were derived from a bamboo post used in construction of the cooking house. By contrast, epidermal short cells from leaves were rare. Palm morphotypes were also present but very rare and Musaceae morphotypes were absent. Morphotypes found in other trees and shrubs were also present including phytoliths from the wood, leaves and nutshell of *Canarium* (Burseraceae). Burnt phytoliths and charcoal particles were absent.

SE-RF-6

Layer 1—brown soil: The phytolith assemblage was dominated by polygonal, elongate and epidermal morphotypes. These included Fabaceae morphotypes, one cf. *Mucuna* sp., a vine commonly found in regrowth forest (Lentfer, 2003; Peekel, 1984). Articulated epidermal silica skeletons were common. Diagnostic palm morphotypes were also relatively common, representing > 9% of the assemblage including globular echinate leaf morphotypes that occur in a range of palms (cf. SE-RF-2 Layer 2) as well as other morphotypes more typical of *Metroxylon* (Fig. 9b). Fruit morphotypes from *Metroxylon* sp. (cf. *M sagu*, Fig. 9c) were also present. Diagnostic grass and Musaceae morphotypes were absent. Burnt phytoliths were very common, and similar to SE-RF-2 Layer 1 comprised epidermal polyhedral morphotypes (cf. Euphorbiaceae). Charcoal particles were common.

Layer 2 (L25)—grey sand: The phytolith assemblage was dominated by polygonal, elongate and epidermal morphotypes. Euphorbiaceae cf. *Macaranga* sp. were present. Over 7% of the diagnostic morphotypes were derived from Musaceae and > 8% from palms. Similar to SE-RF-6, Layer 1, leaf morphotypes characteristic of *Metroxylon* and diagnostic fruit morphotypes were present. Grass morphotypes were absent. Burnt phytoliths were relatively rare but charcoal particles very common.

Musaceae starch

Type 6a starches, shown in Fig. 7a–d, are large (50–55 µm), irregular-ovate granules with a highly eccentric, acute hilum end, a generally obtuse, rounded distal end and an enlarged middle. These granules have tightly packed lamellae that are most visible at the distal end. One granule belonging to this type, found in the post-hole sample, has a very distinctive, long, thin protrusion or 'peak' from the hilum end (Fig. 7d). This morphotype occurs in the fruit pulp of the triploid *Musa acuminata* (AAA) Cavendish cultivar (Fullagar *et al*., 2006: fig. 6a–b). Morphotypes of this type have not been found in Australimusa bananas but similar morphotypes with lesser 'peaks' have been found in the fruit of *M. acuminata* ssp. *banksii* and *M. acuminata* × *schizocarpa* suggesting that this is a feature unique to the Eumusa section, possibly specific to *Musa acuminata* ssp. *banksii* and its derivatives. Aside from the peaked granule in the Layer 2 post hole, Type 6a starches match closely with *M. acuminata x schizocarpa* (Fig. 8) but also occur in the fruit, corms and more rarely leaves and inflorescence of *M. acuminata* ssp. *banksii* as well as AA, AAA and AB cultivars.

Type 6b (Fig. 7e–f) comprises large (39–53 µm), elongate ovate/oblong granules with highly eccentric hila and distinct, tightly packed lamellae that are most visible at the distal end. Similar morphotypes have been recorded in various Musaceae, including *M. acuminata*, *M. acuminata* × *schizocarpa* (Fig. 8c)*, M. acuminata* var. *cerifera* (a Malaysian variety), *M. peekelii* (which is endemic to the New Guinea region) and *M. maclayi* (which occurs wild from New Guinea to the Solomon Islands) (Argent, 1976; Daniells *et al*., 2001). Similar forms also occur in other economic taxa such as *Dioscorea alata* and *D. pentaphylla* (Fullagar *et al*., 2006; Loy *et al*., 1992). Many of these possibilities can be eliminated on the basis of granule morphology, assemblage composition or geographical distribution. For example, none of these taxa, with the exception of *M. acuminata* and *M. acuminata x schizocarpa*, produce both Type 6a and 6b starches. *Dioscorea alata* starch granules are further differentiated from the SE-RF-2 starches by their typically

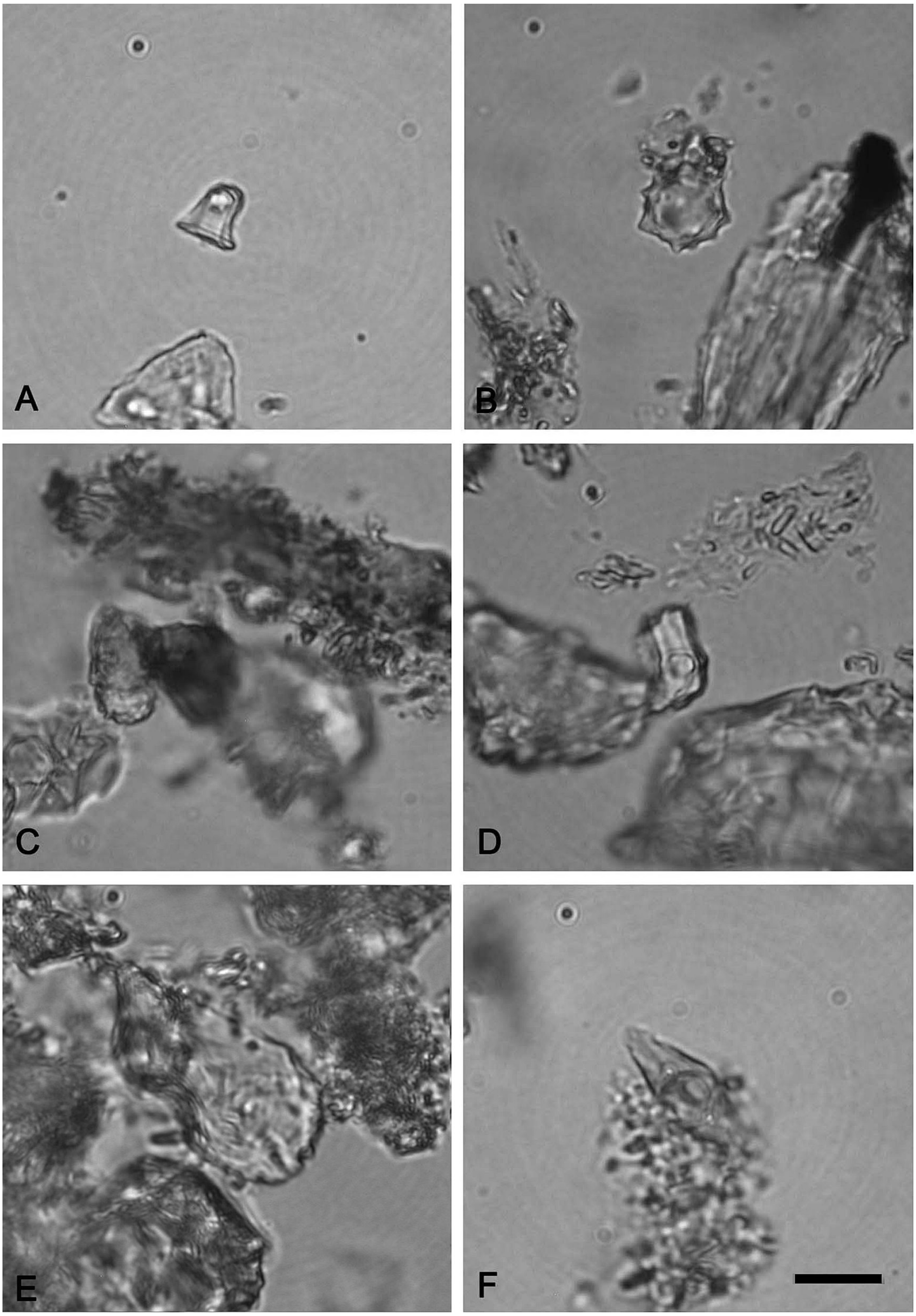

Figure 9. (*A*) Bambusoid epidermal short cell from the post hole sample at SE-RF-2. (*B, C*) Echinate globular phytolith and irregular globular phytolith cf. *Metroxylon sagu* from SE-RF-6 Layer 1. (*D, E*) Volcaniform leaf morphotype and tabular seed morphotype cf. the Australimusa species *Musa maclayi* from Layer 2, SE-RF-2. (*F*) Boat-shaped volcaniform morphotype from Layer 2, SE-RF-2—the same morphotype was found in leaves from a triploid AAA banana (accession number ENB24) collected from East New Britain (Lentfer, 2003b). Scale bar = 10 µm.

truncated distal margin, which is absent from the Type 6b granules. Likewise, the distinctive 'sculpted' hilum end commonly present on larger *D. pentaphylla* starches (i.e. those that occur in the same size range as Type 6b) is also absent from the archaeological granules. Very few starch granules in general were observed in the reference materials from the Australimusa *M. maclayi*, but elongate granules similar to Type 6b were present in the inflorescence, albeit only rarely. The majority of granules from this taxon were < 30 µm in size and of a simple ovate form that is not represented in the SE-RF-2 assemblages.

Type 2a2 is a medium-sized (24 µm), sub-elongate ovate granule with a longitudinal fissure and wrinkled surface (Fig. 6a). Similar, but less wrinkled granules have been observed

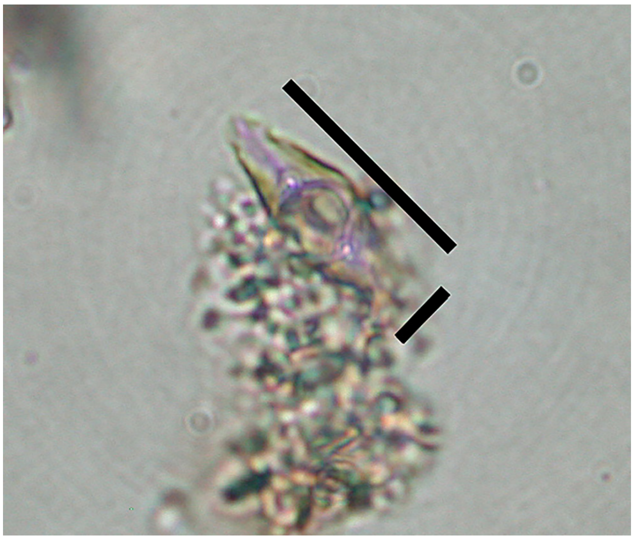

Figure 10. The ratio of maximum body length to maximum crater width of phytoliths were calculated and used for statistical analyses.

in the seed of some *Heliconia* spp., but this exact morphotype has also been found in the leaves and pseudostem of an unidentified subspecies of *M. acuminata* from Flores Indonesia (Fig. 6b), and the fruit of an AAA cultivar. It is therefore, most likely that the 2a2 granule is derived from the *M. acuminata* spectrum rather than *Heliconia*, especially given the presence of other distinctive Musaceae starch and phytolith morphotypes in the sediment samples.

Musaceae phytoliths

Musaceae phytoliths were found in Layers 1 and 2 at SE-RF-2 and Layer 2 (L25) at SE-RF-6 but none were recorded from SE-RF-6 Layer 1. The assemblages consist of a variety of Musaceae phytoliths including globular, polyhedral and volcaniform morphotypes with echinate, nodular or tuberculate decoration and craters, and other morphotypes without craters. Rigorous comparison with modern reference material shows strong similarity between a leaf morphotype from the Australimusa species *M. maclayi* and one of the archaeological morphotypes from Layer 2, SE-RF-2 (Fig. 9d), and again from the same layer, between a boat-shaped phytolith and a Eumusa AAA cultivar (Fig. 9f). Furthermore, some tabular and polyhedral morphotypes from Layer 2 of SE-RF-2 are derived from seeds and are diagnostic to the Australimusa Section bananas (Fig. 9e). Interestingly, no seed morphotypes were found in Layer 1 of SE-RF-2. For Layer 2 (L25) of SE-RF-6 a nodular globular morphotype is possibly derived from Australimusa seeds, and also, an echinate irregular globular morphotype might be from seeded Eumusa bananas, but a stronger similarity with *Metroxylon* fruit phytoliths suggests that this is a more likely derivation. Other than that, the majority of morphotypes with craters, particularly globular and volcaniform morphotypes, are more difficult to differentiate (Lentfer, 2009c) but it should also be noted that *Ensete glaucum* is unlikely to be represented at either site. It has distinctive seed phytoliths (Lentfer, 2003, 2009c; cf. Vrydaghs *et al*., 2009) that were not present in the assemblages. Also, *Ensete* phytoliths are

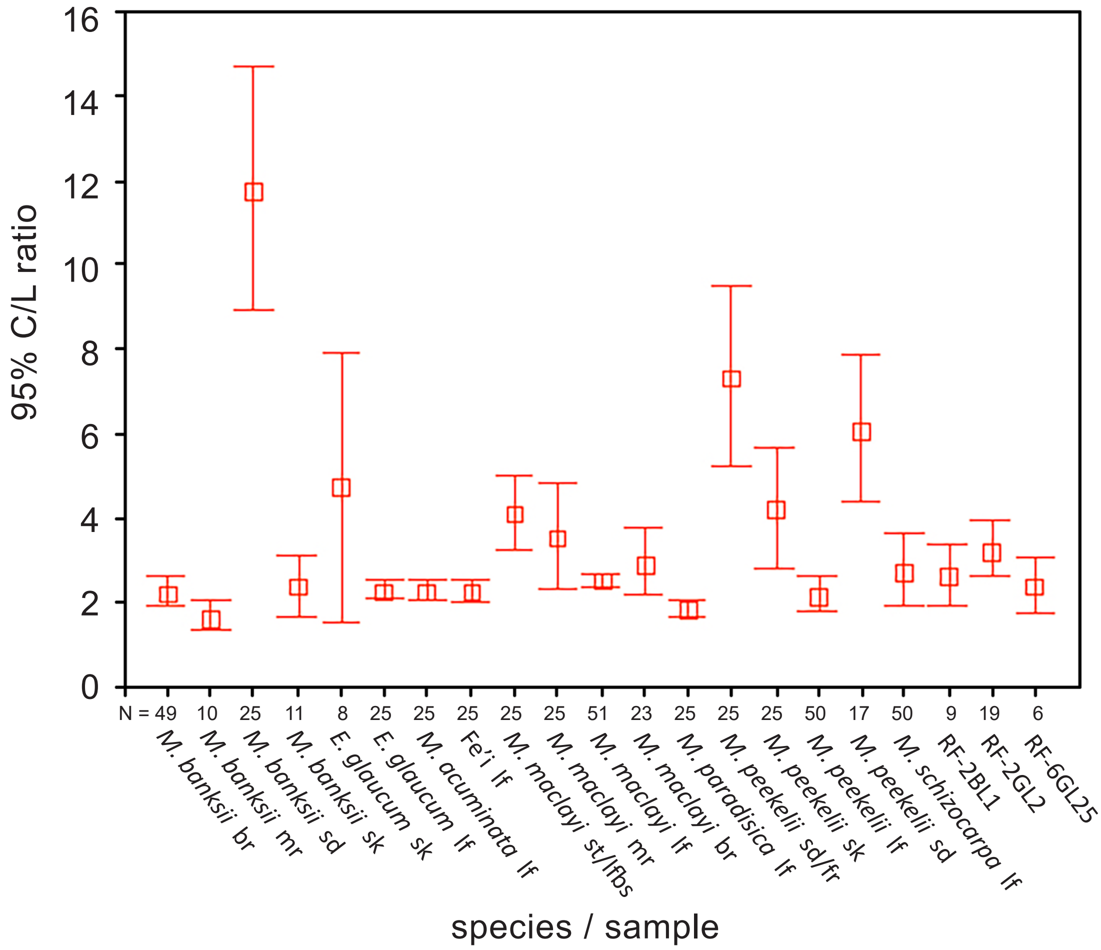

Figure 11. Error bars of body length/crater width ratios (L/C ratio) of archaeological and modern *Musa* and *Ensete* phytolith morphotypes show that the phytoliths with craters in the SE-RF-2 and SE-RF-6 assemblages were probably derived from plant parts other than seeds of either *Eumusa* bananas or *Australimusa* bananas. (See also the Tukey HSD homogeneity tests, Table 5, based on phytoliths with craters). (*lf* = leaf, *br* = bract, *bs* = base, *sd* = seed, *st* = stem, *sk* = skin, *fr* = fruit, *mr* = midrib). Numbers of phytoliths in each sample are indicated below horizantal axis.

Table 5. Results for the Tukey HSD and B tests for homogeneity using body length/crater width ratios of modern and archaeological *Musa* and *Ensete* phytoliths. Means for groups in homogeneous subsets are displayed.

			subset for alpha = 0.05		
species/sample		N	1	2	3
Tukey HSD[a]					
Musa banksii	midrib	10	1.7009	—	—
M. paradisica	leaf	25	1.8834	—	—
M. peekelii	leaf	50	2.2030	—	—
M. banksii	bract	49	2.2553	—	—
Fe'i	leaf	25	2.2872	—	—
M. acuminata	leaf	25	2.2975	—	—
Ensete glaucum	leaf	25	2.3367	—	—
M. banksii	skin	11	2.4054	—	—
RF-6GL25	—	6	2.4083	—	—
M. maclayi	leaf	51	2.5328	—	—
RF-2BL 1	—	9	2.6659	—	—
M. schizocarpa	leaf	50	2.7818	—	—
M. maclayi	bract	23	2.9615	—	—
RF-2GL2	—	19	3.2830	3.2830	—
M. maclayi	midrib	25	3.5750	3.5750	—
M. maclayi	stem/leaf base	25	4.1430	4.1430	—
M. peekelii	skin	25	4.2419	4.2419	4.2419
E. glaucum	skin	8	4.7604	4.7604	4.7604
M. peekelii	seed	17	—	6.1248	6.1248
M. peekelii	seed/fruit	25	—	—	7.3475
M. banksii	seed	25	—	—	—
significance			0.071	0.145	0.060
Tukey B[a]					
M. banksii	midrib	10	1.7009	—	—
M. paradisica	leaf	25	1.8834	—	—
M. peekelii	leaf	50	2.2030	—	—
M. banksii	bract	49	2.2553	—	—
Fe'i	leaf	25	2.2872	—	—
M. acuminata	leaf	25	2.2975	—	—
E. glaucum	leaf	25	2.3367	—	—
M. banksii	skin	11	2.4054	—	—
RF-6GL25	—	6	2.4083	—	—
M. maclayi	leaf	51	2.5328	—	—
RF-2BL 1	—	9	2.6659	—	—
M. schizocarpa	leaf	50	2.7818	—	—
M. maclayi	bract	23	2.9615	—	—
RF-2GL2	—	19	3.2830	—	—
M. maclayi	midrib	25	3.5750	3.5750	—
M. maclayi	stem/leaf base	25	4.1430	4.1430	—
M. peekelii	skin	25	4.2419	4.2419	—
E. glaucum	skin	8	4.7604	4.7604	4.7604
M. peekelii	seed	17	—	6.1248	6.1248
M. peekelii	seed/fruit	25	—	—	7.3475
M. banksii	seed	25	—	—	—

[a] Uses *harmonic mean sample size* = 17.667

characterised by short nodular ornamentation and irregular rims. Such traits were not seen in the archaeological material that is characterised by phytoliths with regular crater rims and a dominance of tuberculate ornamentation.

The statistical analysis of the ratio of maximum body length: maximum crater width (Figs 10 and 11; Table 5) is significant, pointing to derivation mostly from banana plant parts other than seeds. This analysis, however, was not sufficient to identify the *Musa* banana species and cultivars that were growing at the sites, perhaps not surprising given the strong similarity between Eumusa and Australimusa morphotypes and the previous work along these lines (Wilson, 1985). Nevertheless, the tests for homogeneity using the same criteria (Table 5) proved to be very useful by determining degree of similarity between the archaeological Musaceae assemblages and modern Musaceae morphotypes. There is a clinal variation in the homogeneity scores, showing a greater similarity between the SE-RF-2 Layer 1 and the Layer 2 (L25) of SE-RF-6 rather than the SE-RF-2 Layer 2, an interesting outcome given the relative chronology of the two sites. The tests also show the closest relationship between SE-RF-2 Layer 2, the oldest layer sampled, and Australimusa morphotypes. Furthermore, the Layer 2 (L25) assemblage from SE-RF-6 has a closer relationship with species and

Table 6. Phylogeny of wild and cultivated bananas (genus *Musa*) found in the Bismarcks, eastern lowland PNG, Bougainville and the western Solomon Islands chain. (Data adapted from Argent, 1976; Daniells *et al*., 2001, 2016; Sardos *et al*., 2018).

section	*Eumusa* (syn: *Musa*)			*Australimusa* (syn: *Callimusa*)	hybrids *Eumusa*		*Eumusa* × *Australimusa*
species	*M. acuminata* ssp. *banksii*	*M. balbisiana*	*M. schizocarpa*	*M. maclayi* ssp. *namatani*, M. *maclayi* ssp. *maclayi*, *M. maclayi* ssp. *ailuluai*, *M. peekelii* ssp. *peekelii*. *M. peekelii* ssp. *angustigemma*, *M. bukensis*	*M. acuminata* × *M. balbisiana*	*M. acuminata* × *M. schizocarpa*	
wild genotypes	AA	BB	SS	TT (unspecified for individual species)	?	AS	?
diploid cultivars	AA	?	—	Fe'i (TT)	AB	AS	AT
triploid cultivars	AAA	?	—	?	AAB, ABB	AAS?	AAT
tetraploid cultivars	AAAA	—	—	?	AABB	?	ABBT, 4x/Ax/BxT

cultivars from both Australimusa and Eumusa bananas, suggesting higher diversity. Finally, the homogeneity tests showed no relationship between seed morphotypes from the Eumusa bananas and any of the archaeological horizons. This is in accordance with the morphological identification of the Musaceae phytoliths for the entire microfossil assemblage, where no positive identifications were obtained for Eumusa seed morphotypes.

Discussion

Green and Pawley (1999: 33) stated that:

> the great advantage of prehistoric archaeology over comparative ethnology and historical linguistics is that it can locate particular assemblages of structural and portable artefacts more precisely in space and time.

We consider that this study, which provides evidence for the presence of imported crop plants in the early phase of occupation of the Reef/Santa Cruz islands, supports this view even though starch and phytoliths may not have been among the list of portable artefacts Green and Pawley were referring to at that time. Nevertheless, when associated with imported plants and whether or not they are referred to as 'artefacts' or 'ecofacts', they are crucial in the context of this study. Indeed, there is very strong support for a well-developed subsistence economy with a sound horticultural base in the early phase of settlement on the Reef Islands, as originally hypothesised by Green. The array of plants identified from phytoliths and starch feature edible and otherwise useful palms and gingers, bananas, taro, *Canarium* sp. and bamboo important for subsistence. There is also evidence of burning, and plants typical of clearance and regrowth, e.g., grass, Euphorbiaceae plants, *Mucuna* sp. and a variety of palms.

The biogeographic distribution of endemic plants on the Santa Cruz Islands, which are phytogeographically more similar to Vanuatu than the main Solomons chain of islands (Mueller-Dombois and Fosberg, 1998: 22), makes for more certainty of some plants being from introductions of plant cultivars by way of human vectors. For example, it is well accepted that bananas, both Australimusa and Eumusa types, have natural distributions limited to Near Oceania and westwards (Table 6; also see Simmonds, 1959, 1962). As such it can be assumed that all bananas in Remote Oceania would have been imports. Moreover, our evidence from both the starch and phytolith assemblages for a mixed array of bananas, including probable wild-seeded or partly domesticated Australimusa bananas as well as Eumusa seedless hybrids (i.e. domesticated bananas) in the oldest layer at SE-RF-2 gives support for a well-planned horticultural portfolio suggesting thoughtful selection and collection during the early phase of Lapita dispersal and occupation of Remote Oceania. The presence of *M. maclayi* is in itself interesting and raises questions about the direction of sea travel and exploration. Although it is endemic to southeast PNG and the Bismarcks along with other Australimusa and Eumusa species, its distribution extends to the main Solomon Island chain in Near Oceania (Sauer, 1993: 198), outside the natural range of wild Eumusa species and also where it is one of only two Australimusa species and by far the most common. Therefore, this raises the possibility of it being collected from several different sources including mainland southeast PNG and nearby offshore islands or anywhere along the western Solomon island chain, prior to or during the occupation of the Reef/Santa Cruz Islands. Similar exploratory stop-offs could also explain the presence of Fergusson Island obsidian recovered from SE-RF-2 (Green and Bird, 1989). The presence of hybridised and domesticated Eumusa bananas also opens similar possibilities for stop-offs and collection, but in this instance if they weren't sourced from the Bismarcks along with the preponderance of Talasea obsidian at SE-RF-2, collection would be restricted to mainland New Guinea and its closest nearby islands.

Importantly, the relatively high percentage of Musaceae phytoliths in the younger Layer 1 of SE-RF-2 but the absence of Musaceae seed types, and furthermore, the greater similarity between that layer and the Layer 2 (L25) of SE-RF-6, indicates continuity spanning the occupation period of the sites with the implication that horticultural practices involved on-site cross-breeding of selected cultivars, and/or ongoing introductions of domesticated cultivars from further afield. Such practices may have contributed to the development and dispersal of the modern Australimusa Fe'i and Eumusa plantain bananas that now prevail in the broader region of Remote Oceania (Argent, 1976; Lebot *et al*., 1993; Perrier *et al*., 2011; Simmonds, 1959) especially given the geographic context of the Reef/Santa Cruz Islands and their potential role as a stepping off point to more remote islands.

The status of *C. esculenta* taro is probably similar to bananas. Although taro was tentatively identified from starch granules on stone tools from Kilu Cave in the main Solomons chain and dated to between ca 28,700 years BP and 20,100 years BP (Loy *et al*., 1992), the species may not have occurred naturally on the Reef/Santa Cruz Islands. Furthermore, the fact that taro starch found at SE-RF-2 was associated with pottery most likely used for cooking and serving, suggests that taro was a component of the diet that would have required cultivation for its sustainable production. This would weigh heavily in favour of it being another imported, high-yielding domesticate. The origins of Pacific Island taro being from a narrow genetic base (Kreike *et al*., 2004; Lebot *et al*., 2004; Sardos *et al*., 2012) and the centre of Aroid diversity and domestication being in the South-east Asian and New Guinea region, provide further support for its likely domesticated status (Lebot *et al*., 2010; Matthews, 1990).

Metroxylon species (sago palms), although endemic to the Solomon Islands, Vanuatu, Fiji and possibly further east as far as Tahiti, are likely to be another domesticated import (e.g., Höft, 1992; Bintoro *et al*., 2018; Ehara, 2018), but probably became more important much later in the occupation sequence, since the evidence from phytoliths suggest a notable emergence of sago (cf. *Metroxylon sagu*) at the younger site of SE-RF-6 after 2910 cal. BP.

Unfortunately, in the absence of macro-remains and extensive comparative studies of phytolith and starch morphotypes, the status of other plants identified in the microfossil assemblages is less certain. *Canarium harveyi,* for example, is endemic to the Solomons, as are bamboo and several ginger and palm species including the pan-tropical coconut, which very likely had a natural distribution (Yen, 1974, 2009; Harries and Clement, 2014; Lebot and Sam, 2019; Wickler, 2001: 234; see also Gunn *et al*., 2011). This lack of clarity, however, does not detract from these being important horticultural elements and the potential for them arriving on the Reef/Santa Cruz islands via human transport. Nor does it detract from the possibility of them being selected, collected and grown on-site with bananas and taro, or even selectively bred and modified to improve flavor or other qualities and increase yield (e.g., Yen, 1973, 1974, 1985, 2009; Hather, 1992; Lebot,1999; Lebot *et al*., 2004; Lebot and Sam, 2019).

Conclusion

The results of this study are evidence for the presence and dispersal of domesticated crop plants in the early settlement of the Reef/Santa Cruz islands and are in accordance with similar studies of Lapita settlements in Vanuatu, Fiji, New Caledonia and Samoa that have also yielded evidence for the presence of cultigens. Moreover, the changes in the horticultural assemblage at the two study sites, particularly the disappearance of seeded bananas, have implications not only for plant domestication processes being an important facet of Lapita culture during the early phase of its appearance in Remote Oceania, but also for the exchange of plant products across the broader region of Oceania throughout the period of occupation.

The presence of *M. maclayi* together with Fergusson Island obsidian in the early phase of occupation may shed some light on the nature and course of early voyaging routes, especially with regard to exploratory stop-offs en-route and for the development of early trade networks. The study is limited however, not only by the small sample size, particularly the small number of sediments examined, but also by the small number of available dates and lack of chronological precision. Therefore, while we can be assured that horticulture was indeed an important element in the early settlement of SE-RF-2 and later, SE-RF-6, the issues pertaining to the strand-looper concept and the degree to which initial settlement relied on local terrestrial and marine resources vs horticultural produce cannot be fully resolved. However, while it makes good sense that it would take considerable time for any sustainable horticultural regime to be established (Lebot and Sam, 2019: 404), the small amount of marine remains recovered from the archaeological excavations at SE-RF-2 and the presence of at least two key plant domesticates points more towards a short rather than a long, drawn out period with reliance on wild resources. As such, the rapid establishment of a viable cropping system would suggest either well-planned voyages with an extensive array of essential commodities on-board at the outset, or obtained through exploration and collection en-route. Also, proximity to other well-established settlements and/or access to early exchange routes need to be considered. All of these options are implicit in Bedford’s (2019: 236) comment that:

> in Remote Oceania, people became highly mobile, exploring, colonising and interacting at a whole series of regionally based levels and different directions over several generations with continuing input from populations from the west.

Probably all are applicable in one way or another to the Reef/Santa Cruz islands. For now, the evidence presented by our analyses of the SE-RF-2 and SE-RF-6 sites finds due level of support for Green’s hypothesis that transported landscapes were instrumental for the successful colonisation and establishment of the Lapita tradition in Remote Oceania. Nevertheless, a much more definitive understanding of settlement processes and time taken for establishment is dependent on additional studies incorporating systematic sampling procedures and more precise dating, with a special focus on identifying and dating subsistence plants, associated garden plants and other ecological changes related to horticultural development.

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References

Anderson, A. J. 2003. Unchartered waters: colonization of Remote Oceania. In *Colonization of Unfamiliar Landscapes: The Archaeology of Adaptation*, ed. M. Rockman and J. Steele, pp. 169–189. London: Routledge.

Anson, D. 1986. Lapita pottery in the Bismarck Archipelago and its affinities. *Archaeology in Oceania* 21(3): 157–165. https://doi.org/10.1002/j.1834-4453.1986.tb00144.x

Argent, G. C. G. 1976. The wild bananas of Papua New Guinea. *Notes from the Royal Botanic Garden, Edinburgh* 35: 77–114.

Ball, T., L. Vrydaghs, I. Houwe, J. Manwaring, and E. Langhe. 2006. Differentiating banana phytoliths: wild and edible Musa acuminata and Musa balbisiana. *Journal of Archaeological Science* 33(9): 1228–1236. https://doi.org/10.1016/j.jas.2005.12.010

Barton, H., and P. Matthews. 2006. Taphonomy. In *Ancient Starch Research*, ed. R. Torrence and H. Barton, pp. 75–94. Walnut Creek, California: Left Coast Press.
https://doi.org/10.4324/9781315434896

Bedford, S. 2019. Lapita pottery from the small islands of north-east Malakula, Vanuatu: a brief overview and implications. In *Debating Lapita: Distribution, Chronology, Society and Subsistence,* ed. S. Bedford and M. Spriggs, pp. 225–240. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.11

Bedford, S., and J.-C. Galipaud. 2010. Chain of islands: Lapita in the north of Vanuatu. In *Lapita: Ancêtres Océaniens/Oceanic ancestors*, ed. C. Sand and S. Bedford, pp. 122–137. Paris: Museé du quai Branly-Jacques Chirac and Somogy Éditions d'art.

Bedford, S., M. Spriggs, D. V. Burley, C. Sand, P. J. Sheppard, and G. R. Summerhayes. 2019. Debating Lapita: distribution, chronology, society and subsistence. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 5–36. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.01

Bintoro, M. H., M. I. Nurulhag, A. J. Pratama, F. Ahmad, and L. Ayulia. 2018. Growing area of sago palm and its environment. In *Sago Palm Multiple Contributions to Food Security and Sustainable Livelihoods*, ed. H. Ehara, Y. Toyoda, and D. V. Johnson, pp. 17–30. Springer.
https://doi.org/10.1007/978-981-10-5269-9_2

Burnett, W. C., and C. D. Fein. 1977. Geological report on soil samples from Lapita site SE-RF-2,, Solomon Islands cultural history project. *Oceanic Prehistory Records* 4: 1–22.

Crowther, A. 2009a. *Investigating Lapita Subsistence and Pottery Use Through Microscopic Residues on Ceramics: Methodological Issues, Feasibility and Potential*. Unpublished PhD thesis. The University of Queensland, St Lucia.

Crowther, A. 2009b. Reviewing raphides: issues with the identification and interpretation of calcium oxalate crystals in microfossil assemblages. In *New Directions in Archaeological Science*, ed. A. Fairbairn, S. O'Connor, and B. Marwick, pp. 105–118. Terra Australis 28. Canberra: ANU E Press.
https://doi.org/10.22459/TA28.02.2009.08

Crowther, A. 2018. Starch granule analysis. In *The SAS Encyclopedia of Archaeological Sciences*, ed. S. L. López Varela. Hoboken (NJ): Wiley Blackwell.
https://doi.org/10.1002/9781119188230.saseas0550

Daniells, J., C. Jenny, D. Karamura, and K. Tomekpe. 2001. *Musalogue: A Catalogue of Musa Germplasm. Diversity in the Genus Musa*. Montpellier: International Network for the Improvement of Banana and Plantain.

Daniells, J. W., G. Sachter-Smith, and M. Taylor. 2016. Bananas adrift in time—a case study in the Solomons. *Acta Horticulturae* 1114: 27–32.
https://doi.org/10.17660/ActaHortic.2016.1114.4

Davidson, J., and F. Leach. 2001. The strandlooper concept and economic naivety. In *The Archaeology of Lapita Dispersal in Oceania*, ed. G. Clark, A. Anderson, and T. Vunidilo, pp. 115–123. Terra Australis 17. Canberra: Pandanus Books, Research School of Pacific and Asian Studies, Australian National University.

Denham, T., C. Bronk Ramsey, and J. Specht. 2012. Dating the appearance of Lapita pottery in the Bismarck Archipelago and its dispersal to Remote Oceania. *Archaeology in Oceania* 47(1): 39–46.
https://doi.org/10.1002/j.1834-4453.2012.tb00113.x

Ehara, H. 2018. Genetic variation and agronomic features of *Metroxylon* palms in Asia and Pacific. In *Sago Palm*, ed. H. Ehara, Y. Toyoda, and D. Johnson, pp. 45–59. Singapore: Springer.
https://doi.org/10.1007/978-981-10-5269-9_4

Fenwick, R. H., C. J. Lentfer, and M. I. Weisler. 2011. Palm reading: a pilot study to discriminate phytoliths of four Arecaceae (Palmae) taxa. *Journal of Archaeological Science* 38(9): 2190–2199.
https://doi.org/10.1016/j.jas.2011.03.016

Fullagar, R. L. K., J. Field, T. Denham, and C. J. Lentfer. 2006. Early and mid Holocene tool-use and processing of taro (*Colocasia esculenta*), yam (*Dioscorea* sp.) and other plants at Kuk Swamp in the highlands of Papua New Guinea. *Journal of Archaeological Science* 33(5): 595–614.
https://doi.org/10.1016/j.jas.2005.07.020

Galipaud, J.-C. 1998. *The Lapita site of Atanoasao Malo, Vanuatu*. Port Vila: ORSTOM.

Green, R. C. 1976. Lapita sites in the Santa Cruz Group. In *Southeast Solomon Islands Cultural History: A Preliminary Survey*, ed. R. C. Green and M. Cresswell, pp. 245–265. Bulletin 11. Wellington: The Royal Society of New Zealand.

Green, R. C. 1978. *New Sites with Lapita Pottery and their Implications for an Understanding of the Settlement of the Western Pacific*. Auckland: Department of Anthropology, University of Auckland.

Green, R. C. 1979. Lapita. In *The Prehistory of Polynesia*, ed. J. Jennings, pp. 27–60. Cambridge (Mass.): Harvard University Press.
https://doi.org/10.4159/harvard.9780674181267.c3

Green, R. C. 1986. Lapita fishing: the evidence of site SE-RF-2 from the main Reef Islands, Santa Cruz Group, Solomons. In *Traditional Fishing in the Pacific: Ethnographical and Archaeological Papers from the 15th Pacific Science Congress*, ed. A. J. Anderson, pp. 119–135. Honolulu: Department of Anthropology, Bernice P. Bishop Museum.

Green, R. C. 1987. Obsidian results from the Lapita sites of the Reef/Santa Cruz Islands. In *Archaeometry: Further Australasian Studies*, ed. W. Ambrose and J. M. J. Mummery, pp. 239–249. Canberra: Department of Prehistory, Australian National University.

Green, R. C. 1991. A reappraisal of the dating for some Lapita sites in the Reef/Santa Cruz Group of the southeast Solomons. *Journal of the Polynesian Society* 100(2): 197–208.

Green, R. C., and R. Bird. 1989. Fergusson island obsidian from the d'Entrecasteaux Group in a Lapita site of the Reef Santa Cruz Group. *New Zealand Journal of Archaeology* 11: 87–99.

Green, R. C., and M. Cresswell. 1976. *Southeast Solomon Islands Cultural History: A Preliminary Survey*. Wellington: The Royal Society of New Zealand.

Green, R. C., and M. Jones. 2007. The absolute age of SE-RF-6 (Ngamanie) and its relation to SE-RF-2 (Nenumbo): two decorated Lapita sites in the southeast Solomons. *New Zealand Journal of Archaeology* 9: 5–18.

Green, R. C., M. Jones, and P. J. Sheppard. 2008. The reconstructed environment and absolute dating of SE-RF-8 Lapita site on Nendo, Santa Cruz, Solomon Islands. *Archaeology in Oceania* 43: 49–61.
https://doi.org/10.1002/j.1834-4453.2008.tb00030.x

Green, R. C., and A. Pawley. 1999. Early Oceanic architectural forms and settlement patterns: linguistic, archaeological and ethnological perspectives. In *Archaeology and Language III: Artefacts, Languages and Texts*, ed. R. Blench and M. Spriggs, pp. 31–39. London: Routledge.
https://doi.org/10.4324/9780203202906

Groube, L. M. 1971. Tonga, Lapita pottery, and Polynesian origins. *Journal of the Polynesian Society* 80(1): 278–316.

Gunn, B. F., L. Baudouin, and K. M. Olsen. 2011. Independent origins of cultivated coconut (*Cocos nucifera* L.) in the Old World tropics. *PLoS ONE* 6(6): e21143.
https://doi.org/10.1371/journal.pone.0021143

Harries, C. H., and C. R. Clement. 2014. Long-distance dispersal of the coconut palm by migration within the coral atoll ecosystem. *Annals of Botany* 113(4): 565–570.
https://doi.org/10.1093/aob/mct293

Hather, J. G. 1992. The archaeobotany of subsistence in the Pacific world. *Archaeology in Oceania* 24(1): 70–81.
https://doi.org/10.1080/00438243.1992.9980194

Hedrick, J. D. n.d. *Archaeological Investigation of Malo Prehistory: Lapita Settlement Strategy in the Northern New Hebrides*. Unpublished draft PhD thesis, University of Pennsylvania, Philadelphia.

Höft, R. 1992. *Plants of New Guinea and Solomon Islands. Dictionary of the Genera and Families of Flowering Plants and Ferns*. Papua New Guinea: Wau Institute.

Horrocks, M., and I. Barber. 2005. Microfossils of introduced starch cultigens from an early wetland ditch in New Zealand. *Archaeology in Oceania* 40(3): 106–114.
https://doi.org/10.1002/j.1834-4453.2005.tb00596.x

Horrocks, M., and S. Bedford. 2005. Microfossil analysis of Lapita deposits in Vanuatu reveal introduced Araceae. *Archaeology in Oceania* 40(2): 67–74.
https://doi.org/10.1002/j.1834-4453.2005.tb00587.x

Horrocks, M., and S. Bedford. 2010. Introduced *Dioscorea* spp. starch in Lapita and later deposits, Vao Island, Vanuatu. *New Zealand Journal of Botany* 48(3): 179–183.
https://doi.org/10.1080/0028825X.2010.502238

Horrocks, M., S. Bedford, and M. Spriggs. 2009. A short note on banana (*Musa*) phytoliths in Lapita, immediately post-Lapita and modern period archaeological deposits from Vanuatu. *Journal of Archaeological Science* 36(9): 2048–2054.
https://doi.org/10.1016/j.jas.2009.05.024

Horrocks, M., and P. D. Nunn. 2007. Evidence for introduced taro (*Colocasia esculenta*) and lesser yam (*Dioscorea esculenta*) in Lapita-era (c. 3050–2500 cal. yr BP) deposits from Bourewa, southwest Viti Levu Island, Fiji. *Journal of Archaeological Science* 34(5): 739–748.
https://doi.org/10.1016/j.jas.2006.07.011

Horrocks, M., and M. I. Weisler. 2006. Analysis of plant microfossils in archaeological deposits from two remote archipelagos: the Marshall Islands, eastern Micronesia, and the Pitcairn Group, southeast Polynesia. *Pacific Science* 60(2): 261–280.
https://doi.org/10.1353/psc.2006.0004

Irwin, G. J. 2006. Voyaging and settlement. In *Voyages of the Ancestors*, ed. K. R. Howe, *Waka Moana,* pp. 56–91. Auckland: David Bateman.

Irwin, G. J. 2008. Pacific seascapes, canoe performance, and a review of Lapita voyaging with regard to theories of migration. *Asian Perspectives* 47(1): 12–27.
https://doi.org/10.1353/asi.2008.0002

Jones, M., F. Petchey, R. C. Green, P. J. Sheppard, and M. Phelan. 2007. The marine delta-R for Nenumbo (Solomon Islands): a case study in calculating reservoir offsets from paired sample data. *Radiocarbon* 49(1): 95–102.
https://doi.org/10.1017/S0033822200041928

Kinaston, R., H. R. Buckley, F. Valentin, S. Bedford, M. Spriggs, S. Hawkins, and E. Herrscher. 2014. Lapita diet in Remote Oceania: new stable isotope evidence from the 3000-year-old Teouma site, Efate Island, Vanuatu. *PLoS ONE* 9(3): e90376.
https://doi.org/10.1371/journal.pone.0090376

Kirch, P. V., and R. C. Green. 2001. *Hawaiki: Ancestral Polynesia*. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511613678

Kreike, C., H. J. van Eck, and V. Lebot. 2004. Genetic diversity of taro, *Colocasia esculenta* (L.) Schott, in Southeast Asia and the Pacific. *Theoretical and Applied Genetics* 109: 761–768.
https://doi.org/10.1007/s00122-004-1691-z

Lebot, V. 1999. Biomolecular evidence for plant domestication in Sahul. *Genetic Resources and Crop Evolution* 46: 619–628.
https://doi.org/10.1023/A:1008748504038

Lebot, V., M. Aradhya, R. Manshardt, and B. A. Meilleur. 1993. Genetic relationships among cultivated bananas and plantains from Asia and the Pacific. *Euphytica* 67(3): 163–175.
https://doi.org/10.1007/BF00040618

Lebot, V., S. Hartati, N. T. Hue, N. H. Nghia, T. Opkpul, J. Pardales, T. K. Prana, N. Thongjiem, C. M. Krieke, H. Vanheck, T. C. Yap, and A. Ivancic. 2010. Characterizing taro using isozymes and agro-morphologic descriptors. In *The Global Diversity of Taro: Ethnobotany and Conservation*, ed. R. V. Ramanatha, P. J. Matthews, P. B. Eyzaguirre, and D. Hunter, pp. 39–55. Italy: Bioversity International.

Lebot, V., M. S. Prana, N. Kreike, H. van Heck, J. Pardales, T. Okpul, T. Gendua, M. Thongjiem, H. Hue, N. Viet, and T. C. Yap. 2004. Characterisation of taro (*Colocaisa esculenta* (L.) Schott) genetic resources in southeast Asia and Oceania. *Genetic Resources and Crop Evolution* 51: 381–392.
https://doi.org/10.1023/B:GRES.0000023453.30948.4d

Lebot, V., and C. Sam. 2019. Green desert or 'all you can eat'? How diverse and edible was the flora of Vanuatu before human introductions? In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 403–414. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.19

Lentfer, C. J. 2003. *Plants, People and Landscapes in Prehistoric Papua New Guinea. A Compendium of Phytolith (and Starch) Analyses*. Unpublished PhD thesis, Southern Cross University, Lismore (NSW).

Lentfer, C. J. 2009a. Building a comparative starch reference collection for Indonesia and its application to palaeoenvironmental and archaeological research. In *Archaeological Science Under A Microscope: Studies in residue and ancient DNA analysis in honour of Tom Loy*, ed. M. Haslam, G. Robertson, A. Crowther, S. Nugent, and L. Kirkwood, pp. 80–101. Terra Australis 30. Canberra: ANU Press.
https://doi.org/10.22459/TA30.07.2009.07

Lentfer, C. J. 2009b. Going bananas in Papua New Guinea: a preliminary study of starch granule morphotypes in Musaceae fruit. *Ethnobotany Research and Applications* 7: 217–238.
https://doi.org/10.17348/era.7.0.217-238

Lentfer, C. J. 2009c. Tracing domestication and cultivation of bananas from phytoliths: an update from Papua New Guinea. *Ethnobotany Research and Applications* 7: 247–270.
https://doi.org/10.17348/era.7.0.247-270

Lentfer, C. J. and W. E. Boyd. 1998. A comparison of three methods for the extraction of phyoliths from sediments. *Journal of Archaeological Science* 25: 1159–1183.
https://doi.org/10.1006/jasc.1998.0286

Lentfer, C. J., C. Pavlides, and J. Specht. 2010. Natural and human impacts in a 35 000-yr vegetation history in central New Britain, Papua New Guinea. *Quaternary Science Reviews* 29(27–28): 3750–3767.
https://doi.org/10.1016/j.quascirev.2010.08.009

Loy, T. H., M. Spriggs, and S. Wickler. 1992. Direct evidence for human use of plants 28,000 years ago: starch residues on stone artefacts from the northern Solomon Islands. *Antiquity* 66(253): 898–912.
https://doi.org/10.1017/S0003598X00044811

Matthews, P. J. 1990. *The Origins, Dispersal and Domestication of Taro*. Unpublished PhD thesis, Australian National University, Canberra.

Mueller-Dombois, D., and F. R. Fosberg. 1998. *Vegetation of the Tropical Pacific Islands*. New York: Springer-Verlag.
https://doi.org/10.1007/978-1-4419-8686-3

Peekel, P. G. 1984. *Flora of the Bismarck Archipelago for Naturalists*. Lae: Office of Forests, Division of Botany.

Perrier, X., E. De Langhe, M. Donohue, C. J. Lentfer, L. Vrydaghs, F. Bakry, F. Carreel, I. Hippolyte, J-P. Horry, C. Jenny, V. Lebot, A.-M. Risterucci, K. Tomekpe, H. Doutrelepont, T. Ball, J. Manwaring, P. de Maret, and T. Denham. 2011. Multidisciplinary perspectives on banana (*Musa* spp.) domestication. *Proceedings of the National Academy of Sciences of the United States of America* 108(28): 11311–11318.
https://doi.org/10.1073/pnas.1102001108

Petchey, F., M. Spriggs, S. Bedford, and F. Valentin. 2015. The chronology of occupation at Teouma, Vanuatu: use of a modified chronometric hygiene protocol and Bayesian modeling to evaluate midden remains. *Journal of Archaeological Science: Reports* 4: 95–105.
https://doi.org/10.1016/j.jasrep.2015.08.024

Petchey, F., M. Spriggs, S. Bedford, F. Valentin, and H. R. Buckley. 2014. Radiocarbon dating of burials from the Teouma Lapita cemetery, Efate, Vanuatu. *Journal of Archaeological Science* 50: 227–242.
https://doi.org/10.1016/j.jas.2014.07.002

Piperno, D., A. Ranere, I. Holst, and P. Hansell. 2000. Starch grains reveal early crop horticulture in the Panamanian tropical forest. *Nature* 407(6808): 894–897.
https://doi.org/10.1038/35038055

Sand, C. 1998. Archaeological report on localities WKO013A and WKO013B at the site of Lapita (Koné, New Caledonia). *Journal of the Polynesian Society* 107(1): 7–34.
https://www-jstor-org/stable/20706768

Sand, C. 1999. The beginning of Southern Melanesian Prehistory: The St Maurice-Vatcha Lapita site, New Caledonia. *Journal of Field Archaeology* 26(3): 307–323.
https://doi.org/10.1179/jfa.1999.26.3.307

Sand, C. 2010. *Lapita Calédonien: Archéologie d'un premier peuplement Insulaire Océanien*. Collection Travaux et Documents Océanistes 2. Société des Océanistes, Paris.
https://doi.org/10.4000/books.sdo.1128

Sand, C., J. Bolé, and A. Ouetcho. 1996. *Le Début du Peuplement Austronésien de la Nouvelle-Calédonie: Donnés Archéologiques Récentes*. Noumea: Département Archéologie, Service Territorial des Musées et du Patrimoine.

Sand, C., S. Domergue, L. Lagarde, J. Bole, A.-J. Ouetcho, and D. Bare. 2019. A new assessment of site WKO013A of Xapeta'a (Lapita), New Caledonia. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 205–224. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.10

Sardos, J., P. Christelová, J. Čížková, J. Paofa, G. L. Sachter-Smith, S. B. Janssens, G. Rauka, M. Ruas, J. W. Daniells, J. Doležel, and N. Roux. 2018. Collection of new diversity of wild and cultivated bananas (Musa spp.) in the Autonomous Region of Bougainville, Papua New Guinea. *Genetic Resources and Crop Evolution* 65: 2267–2286.
https://doi.org/10.1007/s10722-018-0690-x

Sardos, J., J. L. Noyer, R. Malapa, S. Bouchet, and V. Lebot. 2012. Genetic diversity of taro (*Colocasia esculenta* (L.) Schott) in Vanuatu (Oceania): an appraisal of the distribution of allelic diversity (DAD) with SSR markers. *Genetic Resources and Crop Evolution* 59: 805–820.
https://doi.org/10.1007/s10722-011-9720-7

Sauer, J. D. 1993. *Historical Geography of Crop Plants: A select roster*. Boca Raton: CRC Press.

Sheppard, P. J. 1993. Lapita lithics: trade/exchange and technology. A view from the Reefs/Santa Cruz. *Archaeology in Oceania* 28(3): 121–137.
https://doi.org/10.1002/j.1834-4453.1993.tb00303.x

Sheppard, P. J. 1996. Hard rock: archaeological implications of chert sourcing in Near and Remote Oceania. In *Oceanic Culture History: Essays in Honour of Roger Green*, ed. J. Davidson, G. J. Irwin, F. Leach, A. Pawley, and D. Brown, pp. 99–115. Dunedin: New Zealand Journal of Archaeology.

Sheppard, P. J. 2011. Lapita colonization across the Near/Remote Oceania boundary. *Current Anthropology* 52: 799–840.
https://doi.org/10.1086/662201

Sheppard, P. J. 2019. Early Lapita colonisation of Remote Oceania: an update on the leapfrog hypothesis. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 135–153. Terra Australi*s* 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.07

Sheppard, P. J., S. Chiu, and R. Walter. 2015. Re-dating Lapita movement into Remote Oceania. *Journal of Pacific Archaeology* 6(1): 26–36.

Sheppard, P. J., and R. C. Green. 1991. Spatial analysis of the Nenumbo (SE-RF-2) Lapita site, Solomon Islands. *Archaeology in Oceania* 26(3): 89–101.
https://doi.org/10.1002/j.1834-4453.1991.tb00272.x

Sheppard, P. J., and R. C. Green. 2007. Sample size and the Reef/Santa Cruz Lapita sequence. In *Oceanic Explorations: Lapita and Western Pacific Settlement*, ed. S. Bedford, C. Sand, and S. P. Connaughton, pp. 141–149. Terra Australis 26. Canberra: ANU E Press.
https://doi.org/10.22459/TA26.2007.07

Sheppard, P. J., B. Trichereau, and C. Milicich. 2010. Pacific obsidian sourcing by portable XRF. *Archaeology in Oceania* 45(1): 21–30.
https://doi.org/10.1002/j.1834-4453.2010.tb00074.x

Sheppard, P. J., and R. Walter. 2006. A revised model of Solomon Islands culture history. *Journal of the Polynesian Society* 115(1): 47–76.
https://www-jstor-org/stable/i20707316

Shing, R., and E. Willie. 2019. Connecting with Lapita in Vanuatu: Festivals, sporting events and contemporary themes. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 471–482. Terra Australi*s* 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.22

Simmonds, N. W. 1959. *Bananas*. London: Longman.

Simmonds, N. W. 1962. *The Evoluton of Bananas*. London: Longman.

Specht, J., T. Denham, J. R. Goff, and J. E. Terrell. 2014. Deconstructing the Lapita Cultural Complex in the Bismarck Archipelago. *Journal of Archaeological Research* 22: 89–140.
https://doi.org/10.1007/s10814-013-9070-4

Specht, J., and C. Gosden. 2019. New dates for the Makekur (FOH) Lapita pottery site, Arawe Islands, New Britain, Papua New Guinea. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 169–202. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.09

Storey, A., M. Spriggs, S. Bedford, S. Hawkins, J. H. Robins, L. Huynen, and E. Matisoo-Smith. 2010. Mitochondrial DNA from 3000-year old chickens at the Teouma site, Vanuatu. *Journal of Archaeological Science* 37(10): 2459–2468.
https://doi.org/10.1016/j.jas.2010.05.006

Summerhayes, G. R. 2000. *Lapita Interaction*. Terra Australis 15. Canberra: Department of Archaeology and Natural History and the Centre for Archaeological Research, Australian National University.

Szabó, K. 2005. *Techniques and Practice: Shell-working in the Western Pacific and Island Southeast Asia*. Unpublished PhD thesis, Australian National University, Canberra.

Szabó, K. 2010. Shell artefacts and shell-working within the Lapita Cultural Complex. *Journal of Pacific Archaeology* 1(2): 115–127.

Therin, M., and C. J. Lentfer. 2006. A protocol for extraction of starch from sediments. In *Ancient Starch Research*, ed. R. Torrence and H. Barton, pp. 159–161. Walnut Creek, California: Left Coast Press.
https://doi.org/10.4324/9781315434896

Torrence, R., and H. Barton. 2006. *Ancient Starch Research*. Walnut Creek, California: Left Coast Press.

Vrydaghs, L., T. Ball, H. Volkaert, I. van den Houwe, J. Manwaring, and E. De Langhe. 2009. Differentiating the volcaniform phytoliths of bananas: *Musa acuminata*. *Ethnobotany Research and Applications* 7: 239–246.
https://doi.org/10.17348/era.7.0.239-246

Walter, R., and P. Sheppard. 2009. A review of Solomon Island archaeology. In *Lapita: Ancestors and Descendants*, ed. P. J. Sheppard, T. Thomas, and G. R. Summerhayes, pp. 35–72. New Zealand Archaeological Association Monograph 28. Auckland: New Zealand Archaeological Association.

Wickler, S. 2001. *The Prehistory of Buka: A Stepping Stone Island in the Northern Solomons*. Terra Australis 16. Canberra: Department of Archaeology and Natural History and Centre for Archaeological Research, Australia Natural University.

Wilson, S. M. 1985. Phytolith analysis at Kuk; an early agricultural site in Papua New Guinea. *Archaeology in Oceania* 20(3): 90–97.
https://doi.org/10.1002/j.1834-4453.1985.tb0015x

Yen, D. E. 1973. The origins of Oceanic agriculture. *Archaeology and Physical Anthropology in Oceania* 8(1): 68–88.
https://www-jstor-org/stable/i40017132

Yen, D. E. 1974. Arboriculture in the subsistence of Santa Cruz, Solomon Islands. *Economic Botany* 28: 237–243.
https://doi.org/10.1007/BF02861424

Yen, D. E. 1985. Wild plants and domestication in Pacific islands. In *Recent Advances in Indo-Pacific Prehistory*, ed. V. N. Misra and P. Bellwood, pp. 315–329. New Delhi: Oxford and IBH Publishing.

Yen, D. E. 2009. Ethnobotany in the Southeast Solomon Islands Cultural History Project. In *Lapita: Ancestors and Descendants*, ed. P. J. Sheppard, T. Thomas, and G. R. Summerhayes, pp. 247–284. New Zealand Archaeological Association Monograph 28. Auckland: New Zealand Archaeological Association.

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Negotiating Social Identity through Material Practices with Stone

Pip Rath[1] and Nina Kononenko[2,3]

[1] Independent scholar, Australia

[2] School of Philosophical and Historical Inquiry, University of Sydney NSW 2006, Australia

[3] Geosciences and Archaeology, Australian Museum, Sydney NSW 2010, Australia

Abstract. Dazzling, highly retouched obsidian stemmed objects comprised part of the material world of people in West New Britain and beyond in Papua New Guinea sometime between 6000 and 3000 years ago. Geochemical characterisation studies of the region's obsidian sources indicate that the source of Kutau-Bao dominated to the point where stemmed artefacts made from its obsidian have been found in abundance on nearby Garua Island where another obsidian source, Baki, is located. Furthermore, stemmed artefacts made from Baki obsidian are not found anywhere else except on Garua Island. Studies suggest the nature of production involved centralised knowledge and practices with specialist knappers located on Garua Island. We explore two different approaches in order to look at how such organisation was accomplished. Firstly, we conducted replication experiments to identify characteristic debitage of aspects of stemmed artefact making. Then, the debitage attributes identified were used to examine excavated material from three sites, one near the Kutau-Bao source and two on Garua Island to try to understand the practices employed at the two sources. Our results suggest that Garua Island was a special place where knappers came and used the Baki source to learn, practise and hone their skills for making these dazzling artefacts.

Introduction

Two forms of large, elaborately retouched, stemmed obsidian artefacts that were made prior to 6000 BP and ended by 3000 BP in West New Britain, Papua New Guinea, have long caught the attention of researchers in the area (Casey, 1939; Araho *et al*., 2002; Rath and Torrence, 2003; Specht, 2005; Torrence, 2004a, 2005, 2011; Petrie and Torrence, 2008; Torrence *et al*., 2009, 2013a, 2013b). The reduction sequences for the two forms have been identified and described (Araho, 1996; Araho *et al.*, 2002: 66, fig. 7; Fullagar, 1993a, 1993b; Rath and Torrence, 2003: 121, fig. 3). The two forms were made on different kinds of blanks, one on a blade (Type 1), the other on a specialised flake called kombewa (Type 2) (Araho *et al*., 2002). The processes for the two forms encompassed complex, staged sequences, requiring different sets of skills, knowledge and decisions at various stages. The Type 1 blade form was made generally on a large blade with a triangular or trapezoidal cross section on which a relatively small retouched stem was bifacially formed, more often than not at the bulbar end of the blade. The Type 2 form was made on a kombewa flake by splitting a nodule to create a bulbar surface. A flake was then removed from the ventral side of the split nodule by a blow struck across the bulbar surface. The resulting kombewa blank preserves the bulbar surface on both sides of the flake. The flake blank was retouched to form a stem, the position and form of which varied. The stems on both forms were pronounced with well-defined shoulders or waists. In contrast to Type 1 artefacts, Type 2 forms varied widely in size, and this has been interpreted as reflecting the use of the larger ones for ceremonial purposes and the smaller ones for more mundane activities (Araho *et al*., 2002; Torrence, 2004a). Research on the manufacturing sequences shows that the makers of the large Type 1 and 2 forms would have required training, practice and great skill. In this paper we focus of the large, elaborate forms of both types.

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Corresponding author: Pip Rath prath@bigpond.net.au
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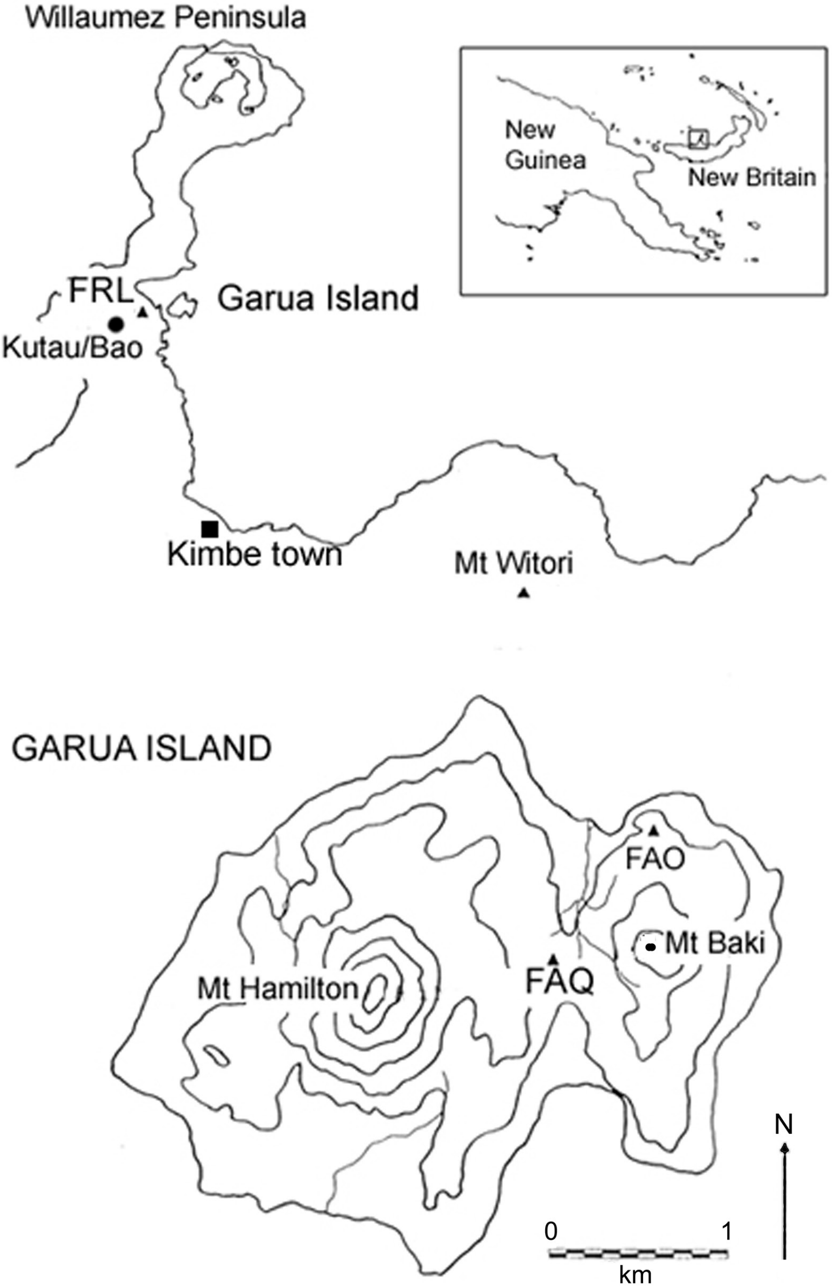

Figure 1. Map of West New Britain, showing location of excavated sites and the Kutau-Bao and Baki obsidian sources.

Over the past two decades detailed programmes of geochemical characterisation of obsidian outcrops and artefacts using PIXE-PIGME, neutron activation (NAA) and pXRF have identified four sources in West New Britain: Kutau-Bao, Gulu and Mopir, all on mainland West New Britain and Baki on Garua Island (Fig. 1; Bird *et al.*, 1997; Torrence and Summerhayes, 1997; Torrence *et al.*, 2013a). Studies of the obsidian from the sources indicate that each produced obsidian with excellent flaking properties. Although the Baki and Gulu sources are not as abundant as Kutau-Bao and Mopir, the widespread distribution of outcrops would have made it difficult for small local groups to monopolise access to obsidian (Torrence, 2004b: 117).

Stemmed obsidian artefacts have been found throughout Papua New Guinea (Torrence *et al.*, 2013a: 279, fig. 1). The characterisation studies of stemmed artefacts from quarries at the four sources indicated that the overwhelming majority derived from the local raw material (Araho *et al.*, 2002: 74, table 2; Torrence *et al.*, 2013a). However, with the exception of one artefact collected from the south coast of New Britain (Torrence *et al.*, 2013a: table 1, item 16), those stemmed artefacts found away from the source areas were all made using Kutau-Bao obsidian. Additionally, Kutau-Bao obsidian dominates archaeological assemblages in the region during the early-middle Holocene. This complex picture of the choice of the sources, their exploitation and distribution of their products, is further complicated by the nature of production of stemmed artefacts on Garua Island where the Baki source is located (Rath and Torrence, 2003). As anticipated, studies have shown people on Garua Island used the local Baki source to produce the two forms of stemmed artefacts, but the studies also revealed that Kutau-Bao obsidian was transported to Garua Island in the form of prepared cores and sometimes as pre-formed blade blanks. There, knappers struck blades and kombewa flakes from the imported cores and carefully added retouch to form the distinctive shoulders and stems. At one locality, site FAP, both Kutau-Bao and Baki blade stems were retouched.

These studies revealed complex, staged production processes with material being passed among different hands and locations, creating and maintaining identities and social links between raw material owners, blank producers and stem specialists. The production sequences for the two forms of stemmed tools provided numerous opportunities for producers to follow different paths. However, the finished Type 1 artefacts made on Garua Island from both Baki and Kutau-Bao obsidian were strikingly consistent in shape and size, varying so slightly that it was highly unlikely people could have visually distinguished artefacts from one or other of the sources. Rath and Torrence (2003: 126) argued that 'either the producers conformed to particular standards, and/or the knowledge and skill were controlled in few hands.' They suggested that people with the specific skills required to shape the shoulders and stems were located on Garua Island, and possibly only on Garua Island. They concluded that it was unlikely the source of obsidian was significant; rather, the artefacts probably gained their value through the complex staging process.

Some puzzling features of the manufacturing process using Baki obsidian do not fit neatly into that explanation. Given the striking visual similarity of the final forms of the Type 1 artefacts made on Garua Island, it is surprising that the Baki stemmed artefacts have been found only on the island and nowhere else, and did not circulate in the same way as those made from Kutau-Bao obsidian. Additionally, Baki obsidian is not distributed evenly across Garua Island. It is more common at the sites near the source outcrops on the northeastern side of the island, than on the western side closer to the mainland and the Kutau-Bao outcrops, where Kutau-Bao obsidian dominates sites. These small details raise some important questions. How did people prevent Baki forms from leaving the island? Why were Baki forms so similar to Kutau-Bao forms, thereby increasing the risk of Baki forms being transported from the island in either error or intentionally? Why was Baki obsidian, the local readily available source, only worked at some sites on the island?

The deliberate nature of production on Garua Island and the restricted movement of stemmed objects made from Baki, Gulu and Mopir obsidian 'indicates centralisation of knowledge and practice …possibly the result of deliberate ownership or control' (Torrence *et al*., 2013a: 305). But how were such feats of organisation accomplished? One answer may lie in the creation and maintenance of socially sanctioned groups with which people identified and were perceived as belonging to through their active engagement in the production processes. The restricted nature of production suggests the deliberate creation of social groups such as owners of obsidian outcrops, sponsors of production, specialist craft workers and consumers who owned and exchanged the large stemmed artefacts (Torrence *et al*., 2013a: 301). Social groups could have assisted in controlling and centralising knowledge and practices. As Diaz-Andreu and Lucy (2005: 11) argue, belonging to different groups matters as they help define who people were, who they were not, what they could do, where they could go and a myriad of other things. A less explored explanation is that the production process was a co-operative venture. Burton's (1984) ethnographic work on the quarrying activities of the Tungei people in the New Guinea highlands showed that collective endeavour and shared experience can produce successful, great co-operative works without the need for central places or central persons. We believe that understanding the stemmed tool production processes on Garua Island and in particular the role of specialists can shed some light on the feats of organisation identified by Torrence *et al*. (2013a).

Methodology: replication studies informing on archaeological assemblages

Garua Island is unique in that it has been identified as a place where specialist knappers employed complex staging processes for the manufacture of the shoulders and stems on obsidian artefacts created from both the local Baki on-island source and obsidian imported from the mainland Kutau-Bao source (Fig. 1). Underlying the conclusion that the stemmed artefacts gained their value through the manufacturing process is the assumption that specialists shaping the shoulders and stems whether from Baki or Kutau-Bao obsidian had a core of shared beliefs, knowledge and skills. We test this proposition by comparing diagnostic morphologies of debitage identified and resulting from shoulder and stem making during replication experiments and a sample of excavated material from three sites: FRL, FAO and FAQ. These sites were chosen because:

1. The excavated assemblages are dated to the same time period as the presence of stemmed tools in the region.
2. Their excavated assemblages appear to consist of manufacturing debris relating to the stemmed tools; and
3. Their location, with site FRL on the mainland near a Kutau-Bao obsidian outcrop and sites FAQ and FAO on Garua Island. Given the uneven distribution of Baki obsidian at locations on Garua, FAO was chosen as it is near a Baki outcrop and FAQ because it is nearer the centre of the Island and further away from the obsidian outcrops (Fig. 1). Since less experienced knappers are likely to have consumed more obsidian than skilled workers, it is likely they would have been located closer to obsidian sources (Arnold, 2012; Finlay, 2008).

Replication studies of obsidian stemmed tools on Easter Island/Rapa Nui (Bollt *et al*., 2006) and in West New Britain (Kononenko *et al*., 2015) have demonstrated that shaping of the shoulders on the stemmed tools is one of the most demanding stages in the sequence of manufacturing the artefacts and one that specialist knappers would have been responsible for in order to produce uniform artefacts.

The design of our replication experiments was informed by preliminary techno-morphological analyses of the archaeological obsidian stemmed tools and debitage which showed that numerous stages of production were required (Araho *et al*., 2002; Rath and Torrence, 2003). The replication experiments aimed at assessing the actions, time and skill requirements for the manufacture of Type 2 stemmed tools. The experimental tools were made in 2005 with obsidian from the same geological sources as the prehistoric tools (Kutau-Bao and Baki) by N. Kononenko during fieldwork in West New Britain, and by K. Akerman in Sydney (Fig. 2). In our experiments, we did not attempt to produce blades from prepared large blade cores. For the purpose of this study we assumed the flakes removed from Type 1 blade blanks to create the distinctive shoulders would have similar attributes to those removed from kombewa blanks. Our assumption was based on our detailed examination of Type 1 artefacts (e.g., Rath and Torrence, 2003). Fruitful discussions between Akerman, Rath and Kononenko over the years have identified how making both types of the stemmed artefacts translated into the characteristics exhibited on the debitage.

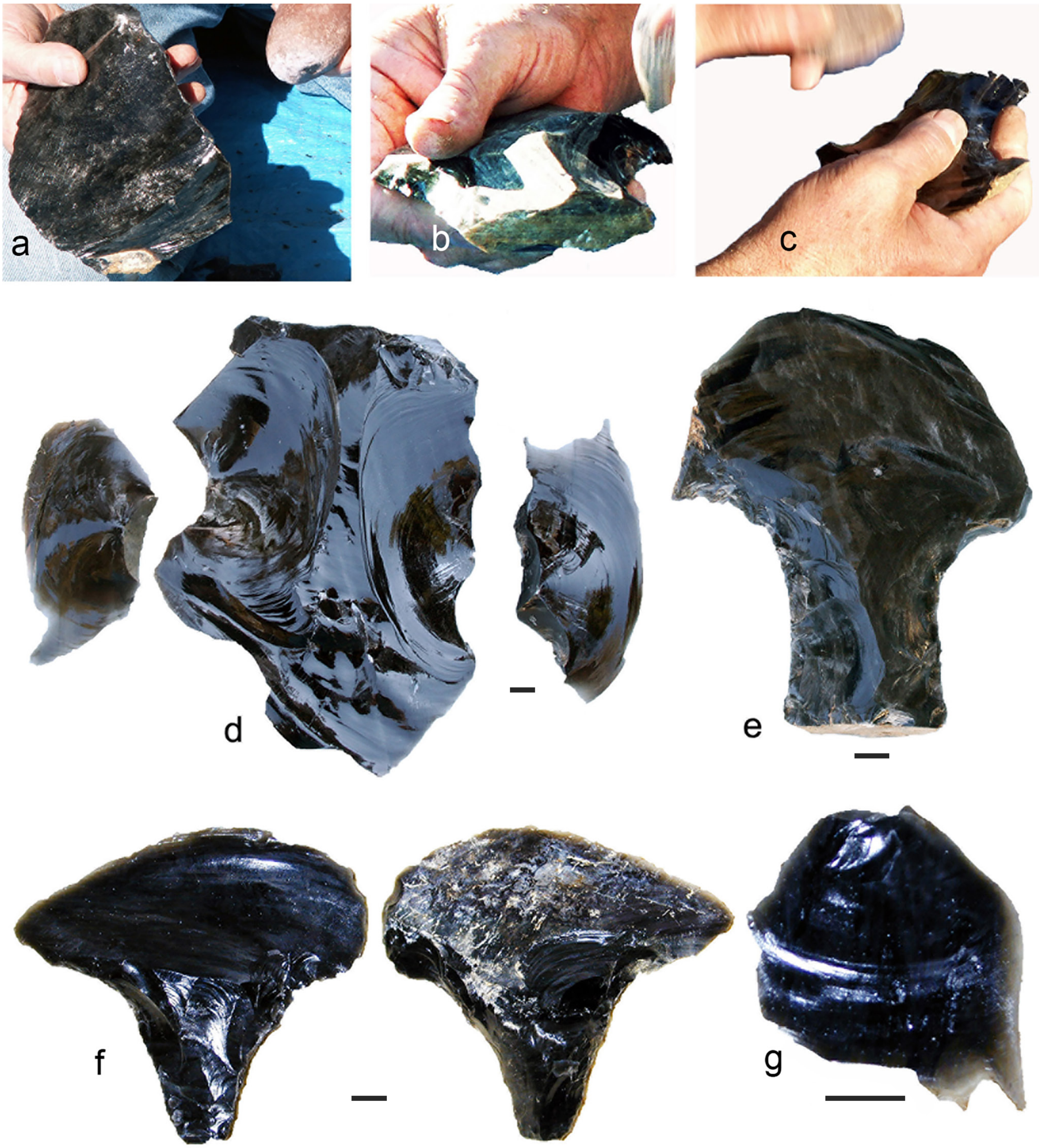

Figure 2. Experimental replication of stemmed tools: (*a*) massive blank knapped from the core; (*b, c*) percussive shaping the stem; (*d*) flakes and blank with notches from percussive strokes; (*e, f*) finished stemmed tools with unretouched edges; and (*g*) negative of flake from flaking the stem. Scale 1 cm.

The replica Type 2 stemmed tools were knapped using hard hammer percussion. In the first stage of manufacture, a roughly circular, or elongate thick blank with a large bulb of percussion was struck from a core (Fig. 2a,d). According to Akerman's observations, the platform preparation for striking the Type 2 blanks from cores was not always carefully carried out, in contrast to the platforms for the Type 1 blanks which were better prepared. Although not always strictly a kombewa flake, the detached blank resembled many stemmed tools in terms of its bilateral symmetry and longitudinal cross section. The ventral and dorsal surfaces of the blank intersected to form a relatively thick and sturdy distal edge (Fig. 2f).

Next, a combination of invasive and steep bifacial percussion was applied to the flake to create the two notches (shoulders) that delineate the stem and create its roughly triangular cross section (Fig. 2b,c). Examination of stemmed artefacts made on blades and kombewa flakes indicates that the creation of the shoulders involved detaching flakes with prominent bulbs of percussion. These flakes leave a deep concave scar on the blank form facilitating the creation of the shape of the shoulder. (Fig. 2d). The replication studies show that striking continually at the edge of the blank to create a shoulder requires many blows which increase the risk of generating cracks and ultimately breakage before the shoulder is completed. A more efficient method requiring less

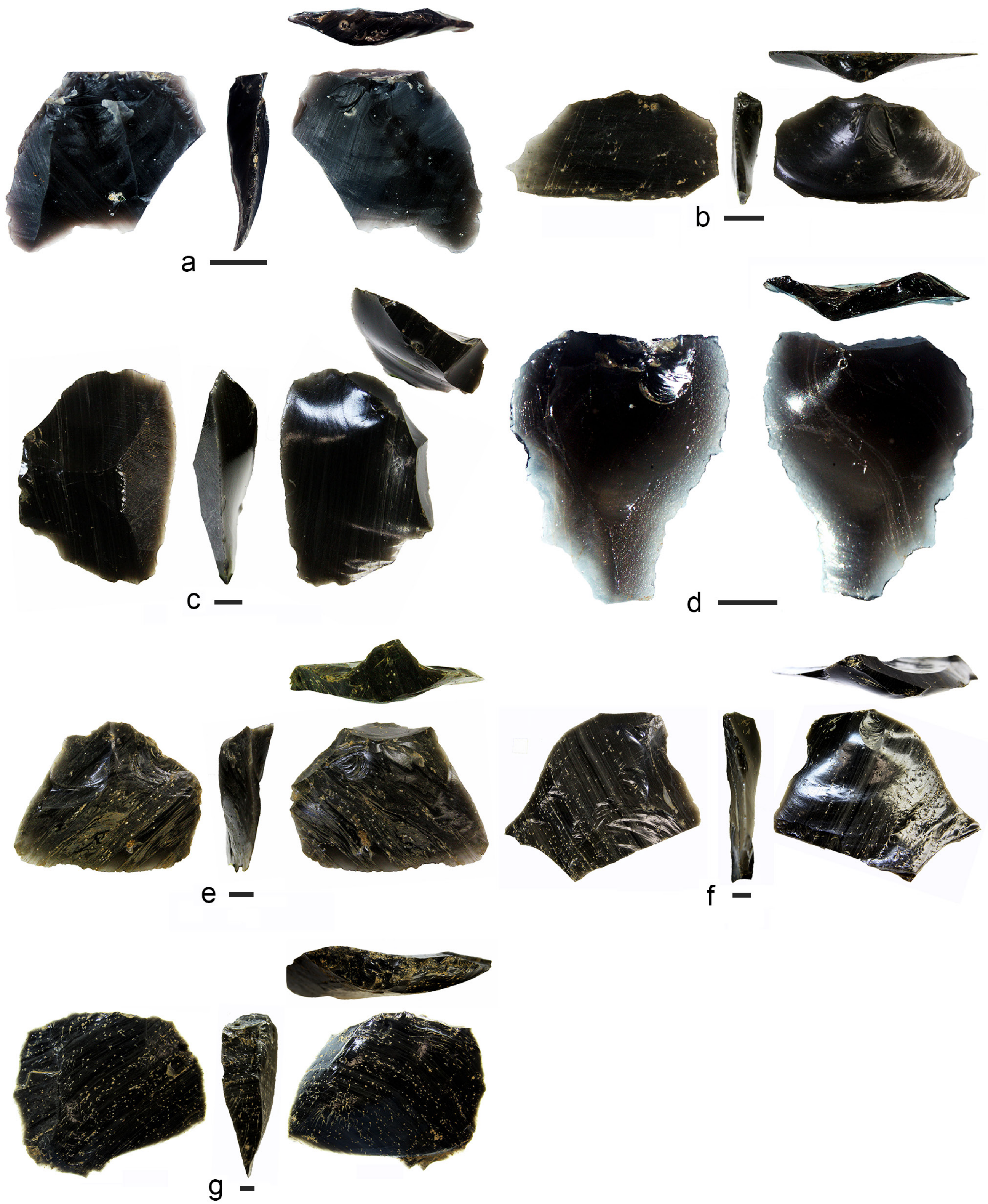

Figure 3. Flakes from excavated sites showing characteristic attributes: (*a)* FAO 1000/1010 Level 5 spit 1; (*b*) FRL NEb 12; (*c*) FRL NEb 12; (*d*) FAO 1000/1010 Level 5 Spit 1; (*e*) FRL NEb 12; (*f*) FRL SEa 12; and (*g*) FRL SEc 12. Scale 1 cm.

blows is to strike the blank further away from the edge which detaches flakes with thick platforms and pronounced bulbs of percussion (Figs 2d,g and 3). It is likely that shoulders were created unifacially from the flattest surface to begin with and then rotated to knap the other side. As more flakes are removed to make the shoulders, the platforms of those flakes will become facetted (three or more flake scars) or winged (Fig. 3d,g; Inizan *et al.*, 1992: 80, fig. 32.6; Titmus, 1985: 251–252).

As flaking continues around the shoulder in order to produce a prominent waist, the number of dorsal scars increases on those flakes removed during the later stages of the process (Titmus, 1985: 251; Andrefsky, 1998: 106; Holdaway and Stern, 2004: 146, fig. 3.30.1). Additionally, the direction of the scars on the dorsal surface of flakes detached increasingly will be at different angles to the ventral surface. (Fig. 3; Holdaway and Stern, 2004: 146, fig. 3.31.1).

The longitudinal profile (cross-section) of flakes may also

Figure 4. Stemmed tools from sites FRL, FAP and FAO: (*a*) FRL016, broken stemmed tool; (*b*) FAP400, broken stem; (*c*) FAP417; (*d*) FAO1731, broken stem; (*e*) FAP267, dorsal and ventral faces of the tool with pecked stem (Type 2); and (*f*) FRL0150, dorsal and ventral faces of the tool made on a blade (Type 1). Scale 1 cm.

give a guide as to whether they were removed during the shoulder making process. In view of the pronounced bulbs, these flakes may exhibit two types of profiles:

1. The first is where the relatively thin body of the flake curves back at the distal end towards the prominent bulb (Fig. 3a,c) and is referred to in this paper as S-shaped.
2. The second type of profile has a thin straight body after the prominent bulb (Fig. 3b,e) and is referred to in this paper as C-shaped. Although prominent bulbs are generally the result of hammer percussion, the thin body of the flake provides the shoulder flakes with their recognisable characteristic.

In summary, the replication experiment provides support for hypotheses that multiple stages of production and considerable amounts of time, energy and skill inputs are all required to make a stemmed tool. Freshly flaked obsidian is sharp, so dulling a potential handle reduces risks of injury and damage to a haft or handle. Additional to flaking, hammer-dressing of the stem (Fig. 4e) also requires extra time, care, skill, and perhaps practice. The manufacture of each experimental stemmed tool took from 1.5 to 3 hours (Kononenko *et al*., 2015) but experienced and skilled prehistoric knappers probably required much less time. The working edges of the experimental tools were not retouched, similarly to the archaeological artefacts (Fig. 4).

The observations made during the replication experiments provide a number of diagnostic attributes summarised as follows:

1 The thickness of the bulbs of percussion (metric)
2 The thickness of striking platforms (metric)
3 Whether the platform is flat, facetted or winged (non-metric)
4 Number of dorsal scars (non-metric)
5 Direction of the dorsal scars (non-metric)
6 The longitudinal profile of the flakes (non-metric)

The methodology used in recording these attributes is set out in Appendix 1.

The archaeological sample and analyses

The assemblages come from excavations carried out in 1988 at FRL (Specht *et al*., 1988); 1993 at FAO (Torrence and Summerhayes, 1997; Parr *et al*., 2001; Lentfer and Torrence, 2007; Kononenko, 2011); and 1992 at FAQ (Torrence and Summerhayes, 1997; Rath and Torrence, 2003). These sites yielded a large number of flakes, some blade-like material and undiagnostic debris from knapping activities thought to be associated with the manufacture of stemmed artefacts (Torrence and Boyd, 1996). FRL is located down-slope from Kutau-Bao obsidian sources at Bitokara on the eastern side of the Willaumez Peninsula mainland overlooking Garua Island (Fig. 1). The sample came from Layer 4 which is described as being densely packed with obsidian flakes often in nested groups 'of 10–20 pieces of all sizes as though left in a group. The deposit is a flaking floor in situ' (Specht, excavation notes). FAO is located near the crest of a small but prominent hill on the north-east point of Garua Island overlooking a narrow beach, close to outcrops of Baki obsidian (Fig. 1). The assemblage from this site was recovered from square 1000/1010, which is described as being a large dump of obsidian waste (Torrence, 1993; Parr *et al*., 2001: 14, fig. 5). Unlike the other two sites, FAQ is not located near the coast or close to obsidian outcrops. The site is located on the lower of two natural terraces which form distinctive shoulders on the slopes of Mt Hamilton and were probably the result of uplift. Five test pits were excavated, in two of which the excavators recovered large quantities of waste resulting from the manufacture of obsidian tools. They noted that the 'existence of so much obsidian debitage at a reasonable distance from an obsidian source is surprising' (Torrence and Webb, 1992).

There were 1123 whole and proximal flakes at FRL, 2538 at FAO and 918 at FAQ. Given the large size of the assemblages, a sample of whole and proximal flakes from each site was chosen. The choice of pieces was influenced by the replication studies and in particular the platform characteristics. Accordingly, the whole and proximal flakes were sorted into three groups of platform types—facetted, winged and other. A sample from each platform group was then chosen from each site. The aim was to get approximately 200 flakes from each site. The study sample comprised of 238 flakes from FRL, 214 from FAO and 190 from FAQ.

Over several years, flakes from each of the three sites were sourced using PIXE-PIGME (2003/2004), NAA (2006) and pXRF (2011) techniques. The results from the different geochemical methods were consistent. It was anticipated that obsidian at FRL and FAO would reflect their proximity to Kutau-Bao and Baki outcrops respectively (Torrence and Summerhayes, 1997; Torrence *et al*., 2013a), but FAQ was not near either Kutau-Bao or Baki sources. A small sample of 20 pieces from this site had previously been tested using PIXE-PIGME with 14 pieces assigned to Baki and 6 pieces to Kutau-Bao (Torrence and Summerhayes, 1997: 78, table 3). Given that the site offered an opportunity to investigate stemmed tool practices where both obsidian sources may have been used at the same time, P. Rath analysed a much larger sample (153 pieces) (P. Rath, unpublished data). All the flakes selected from FRL were from Kutau-Bao sources. The flakes selected from FAO included a small amount of Kutau-Bao obsidian (9 out of 108—8.3%), while at FAQ, 73.9% of the flakes tested were from Kutau-Bao sources with Baki accounting for the remaining 26.1%.

When the characterisation data is considered in conjunction with the amount of cortical material at each site, a picture emerges of sites at different stages of stemmed production and perhaps of the location of specialists. The presence or absence of cortex on an artefact is a general indication of the whether an artefact belongs to an early or late stage of flaking a core. Only 3.4% of excavated material at FRL is cortical. This suggests that Kutau-Bao obsidian was tested, and cores prepared at outcrops before being moved downhill to FRL, where the stemmed artefacts were made. In contrast, at FAO nearly 1 in 4 pieces (22.5%) were cortical, indicating there was less testing and core preparation at the Baki outcrops than at the Kutau-Bao source. Instead, these activities appear to have taken place at FAO along with the other stages of stemmed tool making. At FAQ, 13.5% of material is cortical. Previous research established that Kutau-Bao obsidian was transported in the form of prepared cores and sometimes as blade blanks (Rath and Torrence, 2003). In the circumstances, it is likely the cortical material at FAQ is largely Baki obsidian.

Araho (1996: 121) noted that it is extremely difficult to rejuvenate a prepared core that is damaged. Any imperfection in the core means that, in most instances, the core must be abandoned (Crabtree, 1968: 452). Given the difficulty in rejuvenating cores, it would seem prudent for knappers to be located close to fresh sources of obsidian in the case of knapping mistakes or imperfections in the raw material. The differences in the amounts of cortical material and locations near obsidian outcrops indicates activities at the sites differed. Knappers at FRL and FAQ appear to be involved in processes at later stages of stemmed tool making than at FAO. Using pre-prepared cores at these two sites may indicate the presence of specialists who were involved in the difficult later stages of creating shoulders and stems on blade and kombewa flake blanks. FAQ is not situated near to obsidian source outcrops, in contrast to FRL and FAO, so the knappers at FAQ were arguably specialists with the knowledge and skills to form the shoulders and stems on prepared blades and kombewa flakes.

Results

Bulb and platform thickness

The pronounced shoulders on the stemmed artefacts required the careful removal of a large volume of the blade or flake blank. Prominent bulbs of percussion are a characteristic of flakes detached to create the shoulders of stemmed artefacts (Fig. 3).

Comparison of the coefficient of variation in thickness of the bulbs of percussion from each of the sites (Table 1) shows there was a greater emphasis on controlling bulb thickness at FAQ than at FAO and FRL, which suggests that skilled

Table 1. Comparison of mean thickness of bulb and platform of whole and proximal flake.

	FRL	FAO	FAQ
sample size for each site	238	214	190
mean bulb thickness (mm)	4.21	4.72	3.31
SD	3.32	2.92	1.74
CV%	78.8	61.83	52.64
FAQ/FAO $t = (-)5.79$ $p < 0.00001$			
FAQ/FRL $t = (-)3.36$ $p = 0.00042$			
FAO/FRL $t = 1.73$ $p = 0.042$			
mean platform thickness (mm)	3.44	3.72	2.57
SD	3.17	2.85	1.75
CV%	92.34	76.5	68.3
FAQ/FAO $t = (-)4.83$ $p < 0.00001$			
FAQ/FRL $t = (-)3.39$ $p = 0.00039$			
FAO/FRL $t = 0.99$ $p = 0.16$			
mean ratio of platform to bulb thickness (mm)	0.78	0.78	0.77
SD	0.33	0.32	0.33
CV%	42.3	40.6	42.9
FAQ/FAO $t = (-)0.21$ $p = 0.42$			
FAQ/FRL $t = (-)0.38$ $p = 0.35$			
FAO/FRL $t = (-)0.18$ $p = 0.43$			

knappers of shoulders and stems were located at this site. However, if we follow the recommendation of Allen *et al.* (1997: 35) for interpreting the coefficients of variation for stone tool production, the values at each site are on the high side. The data therefore reflect a high degree of variability in bulb thickness at each site. Based on *t*-tests the difference in the means of bulb thickness for FAQ and FAO, FAQ and FRL and FAO and FRL is statistically significant (Table 1).

Next, we compared the thickness of the striking platforms of the flakes from three sites. As Table 1 shows, the platform thickness of the flakes is highly variable at each of the sites.

Interestingly, *t*-tests results indicate the differences in means between FAQ and FAO and between FAQ and FRL are statistically significant. However, the difference between the means at FRL and FAO is not statistically significant. This once again suggests that knapping activities at FAQ were more focused on a particular task.

Ratio of platform thickness to bulb thickness

The replication studies indicated that the most efficient way to create the shoulder was to detach flakes with thick platforms and bulbs. This suggests knappers would aim to control for both the thickness of the bulb and the platform. Consequently, we investigated the ratio of platform thickness to bulb thickness. The results indicate a relative degree of control in removing the volume required to create the shoulder. Although the coefficients of variation (Table 1) are still on the high side, the same level of control is achieved irrespective of the source of obsidian. Moreover, differences between the ratio of platform thickness to bulb thickness are not statistically significant between the sites, which is interesting given that at FAO the presence of cortical material suggests early stages of flaking. The data point to a shared skill in controlling the dimensions of flakes required to make the shoulder.

Platform characteristics

During the replication experiments it was noted that as more flakes are removed to make the shoulders, the platforms of later flakes become facetted (three or more flakes scars) or winged (Fig. 3d,g). As Table 2 shows, the results point to variability in these attributes between the sites. At FRL only 35.4% of flakes were either facetted or winged compared to 43.3% at FAQ and 48.6% at FAO. At FAQ the percentage of winged and facetted flakes was similar (21.9% and 21.4% respectively), while at FAO facetted platforms accounted for 1 in 3 (33%). The results suggest that both FAQ and FAO knappers were involved in the later stages of reduction activities, although not necessarily using the same knapping strategies.

Table 2. Percentage of flakes by platform characteristics.

platform type	flat %	facetted %	winged %	other %
FRL	36.3	21.2	14.2	28.3
FAO	20.3	32.4	16.2	31.1
FAQ	30.5	21.4	21.9	26.2

Rotation of the blade and kombewa blanks to make the shoulder

The replication experiments indicated that in order to proceed around the shoulder, the blade blank or kombewa flake blank often was rotated in the hand. This rotation was likely to produce negative scars on the dorsal surface of flakes detached with varying degrees of direction from that of the ventral surface. In the case of flakes removed when the blank was turned over to bifacially retouch the shoulder, dorsal scars on some of the detached flakes would be greater than 90 degrees to the direction of the ventral face. As the measurement of the degree of rotation from the line of the direction of the ventral face is not easy to standardise, we opted for recording the degree in four broad categories: zero where the dorsal scars were in the same direction as the ventral face; less than 90 degrees, between 91 and 179 degrees and 180 where the dorsal scars ran in the opposite direction to the ventral face.

Table 3. Direction of dorsal scars to ventral face.

degrees of rotation	FRL %	FAO %	FAQ %
none	37.3	43.0	37.4
< 90°	39.0	35.2	33.1
91–179°	14.0	8.3	19.3
> 180°	9.7	13.5	10.2

As Table 3 shows, the majority of flakes at each site were rotated less than 90 degrees. However, nearly 30% of flakes at FAQ were rotated more than 90 degrees in contrast to FRL (23.7%) and FAO (21.8%). This may indicate that knappers at FAQ were more engaged in activities relating to bifacially shaping shoulders than at the other sites, once again alluding to the presence of specialists located at FAQ.

Number of dorsal scars

As knapping of a core or prepared blank progresses, scars on the dorsal surface of a detached flake will increase. The replication experiments indicate that progressive flaking around the blanks to create the shoulders and stem is likely to result in increased numbers of dorsal scars on flakes. In recording the number of dorsal scars, we have tried to eliminate 'clutter' (Andrefsky, 1998: 106) by counting only those scars believed to be made before the flake was detached. The results as set out in Table 4 are varied. We had thought there might be some correlation between the amount of rotation as discussed above and the number of scars, that is, the more rotation, the more scars. To some extent that is the case. FAQ which has almost 30% of flakes analysed with 90 degrees or more rotation, has 76% of flakes with three or more scars. FRL, with 23.7% with 90 degrees or more rotation, has 70.7% of flakes with three or more scars. Whereas FAO, where Baki obsidian was used, has 21.8% with greater than 90 degrees rotation but only 61.1% with three or more scars.

FAO, however, is unusual in that it has 1.6 times as many flakes with only one scar compared to FRL and three times as many as FAQ. Additionally, more than 30% of flakes at FAO have five or more scars, meaning more than half of the flakes fall into these two categories alone. If a broad correlation between degree of rotation and the number of dorsal scars holds, then the results at FAO do not seem to fit with the site being the location of specialists involved in shoulder making.

Table 4. Number of dorsal scars.

number of scars	FRL %	FAO %	FAQ %
1	10.3	25.5	7.8
2	19.0	13.4	16.1
3	27.7	16.9	30.0
4	20.1	11.6	26.1
5+	22.9	32.6	20.0

Longitudinal cross-section

The final attribute examined was the longitudinal cross section of whole flakes. Pronounced bulb of percussion flakes are part of the shoulder making. Our observations indicate that while the bulbs are large, the body of the flake is generally thin (Fig. 3), creating distinctive longitudinal cross-sections. If specialists knappers were working at one or more of the locations, we might expect to see these types of flakes in significant proportions. Table 5 shows that more than 50% of the sample flakes at each site have flakes fitting the 'S' or 'C' flake profiles considered to be a characteristic attribute of flakes resulting from knapping the shoulders. Interestingly, almost 70% of the flakes at FAO fit into the two categories, compared to FRL with 54.3% and FAQ, 52.6%. This seems to suggest that knappers using Baki obsidian at FAO were concentrating on achieving the 'S' and 'C' shaped flakes.

Table 5. Longitudinal cross-section of whole flakes.

whole flake cross-section	S %	C %	W %	other %
FRL	27.7	26.6	2.7	43.0
FAO	41.6	26.8	0.7	30.9
FAQ	32.8	19.8	7.8	39.6

The results for all attributes examined show a high degree of variability. Such variability seems incompatible with the consistency of skill we would have expected to observe if expert knappers were making the shoulders on the blade and kombewa blanks. The results certainly appear at odds to the standardised final products of Type 1 blades made from both sources (Rath and Torrence, 2003). Interestingly, the results for FRL, where only Kutau-Bao obsidian was used, show marginally more variability that the sites on Garua Island.

Of the three sites, FAQ alludes to the presence of skilled knappers. The knappers at this location needed to be more skilled given they did not have ready recourse to obsidian in the case of mistakes. Nor were they learning to prepare cores and blanks as the Kutau-Bao obsidian was imported already prepared. The presence of Baki obsidian at this site may have been used to practise on, before tackling the task of making stemmed objects from Kutau-Bao material.

The different distribution of Baki and Kutau-Bao obsidian across Garua Island implies some form of segregation of groups of knappers on the island. Apprentices used Baki obsidian near its outcrops (FAO), while more proficient knappers at FAQ using Kutau-Bao were located away from readily available obsidian outcrops from each source. Delimiting the spaces for knapping in this way may have enhanced the difference in social identities between novices and specialists (Torrence, 2011: 36).

Discussion and conclusion

Skill and how to identify it in lithic assemblages has been the subject of a considerable body of research (e.g., Pelegrin, 1990; Pigeot, 1990; Bamforth and Finlay, 2008; Bamforth and Hicks, 2008; Bleed, 2008; Ferguson, 2008; Finlay, 2008; Olausson, 2008; Darmark, 2010; Geribàs *et al*., 2010; Nonaka *et al*., 2010; Arnold, 2012; Damlien, 2015). There is general agreement on the need to consider a combination of attributes to identify skill and to avoid relying on a single attribute as a marker (Finlay, 2008: 86; Damlien, 2015: 131). On that note the only attribute that shows a level of control consistent with a tightly constrained practice is the ratio of platform thickness to bulb thickness. Based on the combination of attributes examined, however, the results present a high level of variation in the composition of the assemblages inconsistent with the observed uniformity of the shape and size of the Type 1 artefacts made from both Kutau-Bao and Baki obsidian on Garua Island.

One major factor that could account for the variability is the nature of the activities at the three sites. There is no reason to believe that the activities at the sites were confined to making stemmed tools. As Torrence (2011: 30) notes, '[a]lthough certainly a significant artefact type, outside the quarries where they were made, stemmed tools comprise only a tiny proportion of the overall lithic assemblages.' Accordingly, it is likely that the assemblages at the three sites comprise both stemmed artefact debitage and that from other, different knapping episodes, complicating our understanding of variability. However, we believe our methodology, using the suite of morphological attributes derived from the experimental work, assists in identifying stemmed tool debitage relating to shoulder production from other flaking activities. This means that the variability identified by those attributes is a feature of stemmed tool production.

We argue that the variability observed is a key factor in explaining what was happening on Garua Island. We propose that the variability is accounted for by the presence of knappers at all levels of skill from apprentices to experts working side by side. Unless specialists worked in discrete areas away from others less skilled and apprentices, debitage from skilled knapping will be difficult to identify. The results from FAO suggest it was a unique location where novices sat with specialists learning how to make the stemmed artefacts from the earliest stages to the finished product. The early stages are evidenced by the large quantity of cortical material at the site compared to the other two, as well as the fact that just over 1 in 4 flakes have only 1 dorsal scar in contrast to FRL (1 in 10) and FAQ (just under 1 in 10). On the other hand, the later stages of production, as suggested by the greater percentage of facetted platforms and longitudinal cross sections characteristic of notching flakes at this site compared to the other two, indicates knappers at FAO were practising detaching flakes to make shoulders.

Further support that Baki obsidian played a special role in teaching apprentices comes from a small sample of stemmed blades that were made from both Baki and Kutau-Bao obsidian sources. As Rath and Torrence (2003: 121) noted that most of these artefacts were trapezoidal or triangular in cross-section. However, this desired cross section was achieved surprisingly frequently without careful preparation of ridges down the face of the core suggesting the outcome was more important than the method (Rath and Torrence, 2003: 121). Many Type 1 blade blanks have flake rather than blade scars dominating their dorsal surfaces (referred to as irregular blades). The Baki blades (Table 6) are generally more irregular in cross section compared with Kutau-Bao blades, which are either trapezoidal or triangular in cross section. Retouch was observed on the stems of the blades. All the Kutau-Bao stems have bifacial retouch, while six of the Baki stems have only direct retouch (retouch on the dorsal surface initiated from the ventral face), and six of the stems bifacially retouched.

Achieving the desired cross section by way of irregular knapping and then retouching to form the shoulder and stem, we argue, are examples of novices grasping the principles required to produce the Type 1 stemmed objects without having skills to match. Instead of rejecting the irregular blanks as imperfect, imperfection appears to have been tolerated as an act of tutelage (Robb, 2007).

Our study points to co-operative tool making and learning whereby the knowledge of how to make the two types of stemmed artefacts was shared rather than controlled in the hands of specialists. This conclusion has a number of implications. Firstly, the striking visual similarity between finished Type 1 artefacts from both sources may be accounted for by open interaction and mutual evaluation (Arnold, 2012: 279). As Burton (1984: 234) noted of the Tungei quarrying practices '[b]ecause openness and comradeship were placed at a premium during a quarrying expedition, men did not hide their axes as they would their shell valuables … They were left in the open for others to see freely'. Secondly, the lack of movement of Baki stemmed artefacts away from the island may simply be because none of the finished artefacts whether made from imported Kutau-Bao obsidian or the local Baki obsidian was transported away from the island. Perhaps the nature of the production on Garua Island was a shared experience of learning and not of making artefacts for exchange. Finally, the co-operative nature of tool making on Garua Island would not have precluded people identifying and belonging to groups such as specialists, learners, or owners of obsidian sources. These groups may have included their participants in other social roles and links involved in the creation and maintenance of societies in West New Britain between 6000 and 3000 BP.

Our study suggests that the methodology used to examine a sample of debitage from the three sites provides a useful tool for further research of stemmed tool production assemblages. It also reminds us that variability has its own story to tell.

Table 6. Obsidian sources, blade cross-section and position of retouch.

source	Baki		Kutau-Bao	
	position of retouch		position of retouch	
cross section	direct	bifacial	direct	bifacial
trapezoidal	1	3	0	6
triangular	2	0	0	3
irregular	4	3	0	2
totals	7	6	0	11

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References

Allen, J., S. Holdaway, and R. Fullagar. 1997. Identifying specialisation, production and exchange in the archaeological record: the case of shell bead manufacture on Motupore Island, Papua. *Archaeology in Oceania* 32(1): 13–38. https://doi.org/10.1002/j.1834-4453.1997.tb00367.x

Andrefsky, W. 1998. *Lithics: Macroscopic Approaches to Analysis*. Cambridge: Cambridge University Press.

Araho, N. 1996. *Obsidian Stemmed Tools from West New Britain Papua New Guinea*. Unpublished MPhil thesis, University of Sydney.

Araho, N., R. Torrence, and J. P. White. 2002. Valuable and useful: mid-Holocene stemmed obsidian artefacts from West New Britain, Papua New Guinea. *Proceedings of the Prehistoric Society* 68: 61–81. https://doi.org/10.1017/S0079497X00001444

Arnold, J. E. 2012. Detecting apprentices and innovators in the archaeological record. *Journal of Archaeological Method and Theory* 19(2): 269–305. https://doi.org/10.1007/s10816-011-9108-1

Bamforth, D. B., and N. Finlay. 2008. Introduction: archaeological approaches to lithic production skill and craft learning. *Journal of Archaeological Method and Theory* 15(1): 1–27. https://doi.org/10.1007/s10816-007-9043-3

Bamforth, D. B., and K. Hicks. 2008. Production skill and Paleoindian workgroup organization in the Medicine Creek Drainage, Southwestern Nebraska. *Journal of Archaeological Method and Theory* 15(1): 132–153.
https://doi.org/10.1007/s10816-007-9045-1

Bird, R., R. Torrence, G. R. Summerhayes, and G. Bailey. 1997. New Britain obsidian sources. *Archaeology in Oceania* 32(1): 61–67.
https://doi.org/10.1002/j.1834-4453.1997.tb00371.x

Bleed, P. 2008. Skill matters. *Journal of Archaeological Method and Theory* 15(1): 154–166.
https://doi.org/10.1007/s10816-007-9046-0

Bollt, R., J. E. Clark, P. R. Fisher, and K. Yoshida. 2006. An experiment in the replication and classification of Easter Island *mata'a*. *Rapa Nui Journal* 20: 125–133.

Burton, J. 1984. Quarrying in a tribal society. *World Archaeology* 16(2): 234–247.
https://doi.org/10.1080/00438243.1984.9979930

Casey, D. A. 1939. Some prehistoric artefacts from the Territory of New Guinea. *Memoirs of the National Museum of Victoria* 11: 143–150.
https://doi.org/10.24199/j.mmv.1939.11.05

Crabtree, D. 1968. Mesoamerican polyhedral cores and prismatic blades. *American Antiquity* 33(4): 446–478.
https://doi.org/10.2307/278596

Damlien, H. 2015. Striking a difference? The effect of knapping techniques on blade attributes. *Journal of Archaeological Science* 63: 122–135.
https://doi.org/10.1016/j.jas.2015.08.020

Darmark, K. 2010. Measuring skill in the production of biface flaked points: a multivariate approach using the flip-test. *Journal of Archaeological Science* 37(11): 2308–2315.
https://doi.org/10.1016/j.jas.2010.04.004

Diaz-Andreu, M., and S. Lucy 2005. Introduction. In *The Archaeology of Identity: Approaches to Gender, Age, Status, Ethnicity and Religion*, ed. M. Diaz-Andreu, S. Lucy, S. Babic, and D. Edwards, pp. 1–13. London: Routledge.

Ferguson, J. R. 2008. The when, where, and how of novices in craft production. *Journal of Archaeological Method and Theory* 15(1): 51–67.
https://doi.org/10.1007/s10816-007-9047-z

Finlay, N. 2008. Blank concerns: issues of skill and consistency in the replication of Scottish later Mesolithic blades. *Journal of Archaeological Method and Theory* 15(1): 68–90.
https://doi.org/10.1007/s10816-007-9048-y

Fullagar, R. 1993a. Taphonomy and tool-use: a role for phytoliths in usewear and residue analysis. In *Archaeometry: Current Australasian Research*, ed. B. L. Fankhauser and J. R. Bird, pp. 21–27. Occasional Papers in Prehistory 22. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.

Fullagar, R. 1993b. Flaked stone tools and plant food production: a preliminary report on obsidian tools from Talasea, West New Britain, PNG. In *Traces et Fonction: les gestes retrouvés*, ed. P. Anderson, S. Beyries, M. Otte, and H. Plisson, pp. 331–337. Liége: Éditions ERAUL.

Geribàs, N., M. Mosquera, and J. M. Vergàs. 2010. What novice knappers have to learn to become expert stone toolmakers. *Journal of Archaeological Science* 37(11): 2857–2870.
https://doi.org/10.1016/j.jas.2010.06.026

Holdaway, S., and N. Stern. 2004. *A Record in Stone: The Study of Australia's Flaked Stone Artefacts.* Canberra: Aboriginal Studies Press.

Inizan, M. L., H. Roche, and J. Tixier. 1992. *The Technology of Knapped Stone*. Meudon: CREP.

Kononenko, N. 2011. Experimental and archaeological studies of use-wear and residues on obsidian artefacts from Papua New Guinea. *Technical Reports of the Australian Museum Online* 21: 1–244.
https://doi.org/10.3853/j.1835-4211.21.2011.1559

Kononenko, N., R. Torrence, and J. P. White. 2015. Unexpected uses for obsidian: experimental replication and usewear/residue analyses of chopping tools. *Journal of Archaeological Science* 54: 254–269.
https://doi.org/10.1016/j.jas.2014.11.010

Lentfer, C., and R. Torrence. 2007. Holocene volcanic activity, vegetation succession, and ancient human land use: unraveling the interactions on Garua Island, Papua New Guinea. *Review of Palaeobotany and Palynology* 143: 83–105.
https://doi.org/10.1016/revpalbo.2006.06.007

Nonaka, T., B. Bril, and R. Rein. 2010. How do stone knappers predict and control the outcome of flaking? Implications for understanding early stone tool technology. *Journal of Human Evolution* 59(2): 155–167.
https://doi.org/10.1016/j.jhevol.2010.04.006

Olausson, D. J. 2008. Does practice make perfect? Craft expertise as a factor in aggrandizer strategies. *Journal of Archaeological Method and Theory* 15(1): 28–50.
https://doi.org/10.1007/s10816-007-9049-x

Parr, J. F., C. J. Lentfer, and W. E. Boyd. 2001. Spatial patterning of a Lapita landscape at an archaeological site in the West New Britain Province, Papua New Guinea. *Domodomo* 13(2): 7–18.

Pelegrin, J. 1990. Prehistoric lithic technology: some aspects of research. *Archaeological Review of Cambridge* 9(1): 116–125.

Petrie, C., and R. Torrence. 2008. Assessing the effects of volcanic disasters on human settlement in the Willaumez Peninsula, Papua New Guinea: a Bayesian approach to radiocarbon calibration. *The Holocene* 18(5): 729–744.
https://doi.org/10.1177/0959683608091793

Pigeot, N. 1990. Technical and social actors: flintknapping specialists at Magdalenian Etiolles. *Archaeological Review of Cambridge* 9(1): 126–141.

Rath, P., and R. Torrence. 2003. Producing value: stemmed tools from Garua Island, Papua New Guinea. *Australian Archaeology* 57: 119–127.
https://doi.org/10.1080/03122417.2003.11681770

Robb, J. 2007. *The Early Mediterranean Village: Agency, Material Culture, and Social Change in Neolithic Italy*. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511499647

Specht, J. 2005. Obsidian stemmed tools in New Britain: aspects of their role and value in mid Holocene Papua New Guinea. In *Many Exchanges: Archaeology, History, Community and the Work of Isabel McBryde,* ed. I. Macfarlane, R. Paton, and M.-J. Mountain, pp. 373–392. Aboriginal History Monograph 11. Canberra: Aboriginal History Inc.

Specht, J., R. Fullagar, R. Torrence, and N. Baker. 1988. Prehistoric obsidian exchange in Melanesia: a view from the Talasea sources. *Australian Archaeology* 27: 3–16.
https://doi.org/10.1080/03122417.1988.12093158

Titmus, G. L. 1985. Some aspects of stone tool notching. In *Stone Tool Analysis: Essays in Honor of Don E. Crabtree*, ed. M. G. Plew, J. C. Woods, and M. G. Pavesic, pp. 243–263. Albuquerque: University of New Mexico Press.

Torrence, R. 1993. *Archaeological Research on Garua Island, West New Britain Province, PNG. June–July 1993*. Unpublished report submitted to various government agencies in Papua New Guinea.
https://media.australian.museum/media/dd/Uploads/Documents/21423/Torrence+1993.5d43be5.pdf

Torrence, R. 2004a. Pre-Lapita valuables in island Melanesia. In *A Pacific Odyssey: Archaeology and Anthropology in the Western Pacific,* ed. V. Attenbrow and R. Fullagar. *Records of the Australian Museum, Supplement* 29: 163–172.
https://doi.org/10.3853/j.0812-7387.29.2004.1413

Torrence, R. 2004b. Now you see it, now you don't: changing obsidian source use in the Willaumez Peninsula, Papua New Guinea. In *Explaining Social Change: Studies in Honour of Colin Renfrew,* ed. J. Cherry, C. Scarre, and S. Shennan, pp. 115–125. Cambridge: McDonald Institute for Archaeological Research.

Torrence, R. 2005. Valued stone: how so? In *Many Exchanges: Archaeology, History, Community and the Work of Isabel McBryde,* ed. I. Macfarlane, R. Paton, and M.-J. Mountain, pp. 357–372. Aboriginal History Monograph 11. Canberra: Aboriginal History Inc.

Torrence, R. 2011. Finding the right question: learning from stone tools on the Willaumez Peninsula, Papua New Guinea. *Archaeology in Oceania* 46(2): 29–41. https://doi.org/10.1002/j.1834-4453.2011.tb00097.x

Torrence, R., and W. Boyd. 1996. *Archaeological Fieldwork on Garua Island, West New Britain, PNG, June–August 1996*. Unpublished report submitted to various government agencies in Papua New Guinea. https://media.australian.museum/media/dd/Uploads/Documents/21426/Torrence+and+Boyd+1997.c44ad03.pdf

Torrence, R., and G. R. Summerhayes. 1997. Sociality and the short distance trader: intra-regional obsidian exchange in the Willaumez Peninsula region, Papua New Guinea. *Archaeology in Oceania* 32(1): 74–84. https://doi.org/10.1002/j.1834-4453.1997.tb00373.x

Torrence, R., P. Swadling, N. Kononenko, W. Ambrose, P. Rath, and M. D. Glascock 2009. Mid-Holocene social interaction in Melanesia: new evidence from hammer-dressed obsidian stemmed tools. *Asian Perspectives* 48(1): 119–148. https://doi.org/10.1353/asi.0.0014

Torrence, R., S. Kelloway, and P. White. 2013a. Stemmed tools, social interaction, and voyaging in Early–Mid Holocene Papua New Guinea. *Journal of Island and Coastal Archaeology* 8(2): 278–310. https://doi.org/10.1080/15564894.2012.761300

Torrence, R., and J. Webb 1992. *Report on Archaeological Research on Garua Island, West New Britain Province, PNG. July–August 1992*. Unpublished report submitted to various government agencies in Papua New Guinea. https://australian-museum-prd.s3.amazonaws.com/media/dd/Uploads/Documents/21428/Torrence%20and%20Webb%201992.c1e1c26.pdf

Torrence, R., P. White, and N. Kononenko. 2013b. Meaningful stones: obsidian stemmed tools from Barema, New Britain, Papua New Guinea. *Australian Archaeology* 77: 1–8. https://doi.org/10.1080/03122417.2013.11681974

Appendix 1

Methodology for recording attributes

1 The thickness of the bulb of percussion was measured perpendicular to the line length of the flake at the thickest part of the bulb. The line length was taken as the straight-line distance from the proximal end to the distal end of the flake; this straight line is perpendicular to the striking platform. Measurements are in millimetres.

2 Thickness of the striking platform was measured as a distance from the ventral to dorsal surface perpendicular to the line through the width of the platform. Measurements are in millimetres.

3 Whether the platform is flat, facetted or winged (non-metric). Facetted platforms are those with two or more flakes. Identification of flat and wing platforms was based on observations; see Fig. 3. Titmus (1985: 251–252) describes the winged platform as follows: 'viewed with the platform towards oneself and the dorsal side of the flake up. It will have the appearance of a bird in flight coming head-on with its wings up-raised.'

4 Dorsal scars were counted using a 5-value ordinal scale to record the relative number of previous flake removals because it is almost impossible to replicate the number of actual counts of dorsal scars consistently. The ordinal scale assigned a value of '1' to flakes with a single dorsal scar and in those cases where there was some dorsal cortex remaining. The value '2' was assigned to those flakes with 2 dorsal scars, while '3'was assigned to those flakes with 3 dorsal scars, and so on. The value '5+' was given to those flakes with more than 4 previous flake removals. One of the difficulties in counting the number of dorsal scars is that the surface may have what is termed 'clutter' (Andrefsky, 1998: 106) where there are scars resulting from removal of flakes or blades after an artefact was detached from the core. An effort was made to try and avoid such 'clutter.'

5 The direction of scars was recorded with the proximal end of the flake up with the dorsal surface facing the recorder. An imaginary line length was drawn down the dorsal face with another line perpendicular to the line length. In a clockwise direction from the top, the quadrants are labelled 0–90°, 91–180°, 181–270°, and 271–360°. The direction of the scars was then recorded as '0' where the direction was the same direction as the striking force that removed the flake being examined; < 90 where scars were initiated from quadrant 1; 91–180 where scars were initiated from quadrant 2, and 180+ where scars were initiated from quadrants 3 and 4. The number of scars in each of the categories was recorded.

6 Longitudinal profile of flake was recorded by observation, see Fig. 3 in text. Flakes were orientated with the platform at the top and the bulb of percussion to the left. In the 'S' profile, the distal end curves back to the bulb of percussion; in the 'C' profile, the distal end is straight, and the bulb profile is shaped like a wedge.

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Narrow Margins: Standardised Manufacturing of Obsidian Stemmed Tools as Evidence for Craft Specialisation and Social Networks in Mid-Holocene New Britain

Paul Dickinson

School of Archaeology and Ancient History,
University of Leicester, Leicester, LE1 7RH, United Kingdom

Abstract. Geochemical studies have shown that between ca 6000 and 3400 cal. BP, distinctive stemmed tools were produced at obsidian sources on New Britain and transported widely throughout the island and the Archipelago, implying extensive social networks linking communities across the region. Technological studies at the sources on Willaumez Peninsula of New Britain have suggested specialisation in the production of the two major types of stemmed tools, with implications for the nature of society at that time.

The present study extends this previous work through morphological and use-wear analyses of the stems of 148 obsidian Type 1 tools. It proposes that a group of skilled artisans worked together to systematically produce standardised obsidian blades, particularly with regards their stems that were designed to be hafted. It further argues that these artisans were organised in some kind of formal workshop that produced stemmed tools as valued items of social significance. These tools entered an array of exchange networks across the Archipelago and beyond. These networks are likely to have facilitated the later spread of the Lapita cultural complex across this island world.

Introduction

A key issue for understanding the history of settlement of New Guinea and its neighbouring islands is the nature of society prior to the emergence of the Lapita cultural complex in the Bismarck Archipelago of Papua New Guinea, that has been described as a period of major changes during which the world was 'turned upside down' through significant cultural changes introduced by the Lapita pottery makers (Spriggs, 1997: 67). This picture, however, arguably reflects the sparse archaeological evidence for the pre-Lapita peoples apart from an abundance of lithic artefacts, especially of obsidian. Geochemical studies of the provenance of these obsidian artefacts show that from the late Pleistocene onwards, and particularly during the mid-Holocene period, obsidian from the New Britain sources was distributed through extensive networks across the islands of the Bismarck Sea (Torrence and Swadling, 2008: 610–613; Summerhayes, 2009).

The movement of obsidian within these networks was not limited to raw materials, but included two types of stemmed tools, Types 1 and 2 (Araho *et al*., 2002), produced primarily on obsidian from the Kutau/Bao source on Willaumez Peninsula of New Britain (Torrence *et al*., 2013). The design of both types is particularly complex, and production would have required a high degree of skill (Araho *et al*., 2002: 76). During the mid-Holocene obsidian artefacts, prepared cores, and blade blanks were transported from the Kutau/Bao source to nearby Garua Island (Figs 1, 2), contrary to expectation as Garua has its own source of raw material of comparable high quality (Torrence and Summerhayes, 1997; Rath and Torrence, 2003: 121). Analysis of the manufacturing stages suggests that this involved transferring unfinished tools from the original producer to another person, presumably a specialist, for completion (Rath and Torrence, 2003: 126). This pattern of transfer and logistical movement suggests that the value attributed to some stemmed tools was

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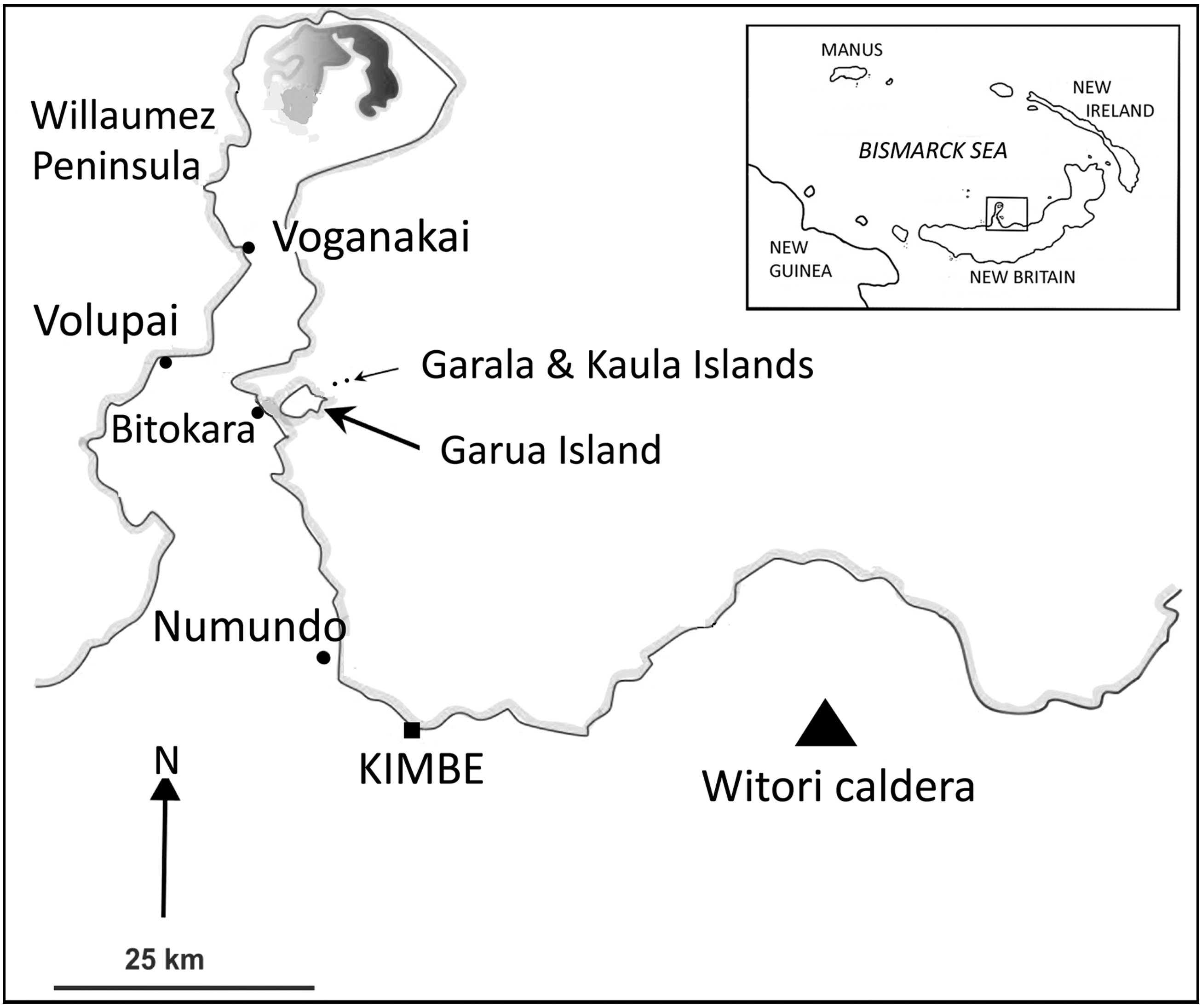

Figure 1. Willaumez Peninsula and Garua Island showing principle locations mentioned in the text (after Summerhayes *et al*., 2010).

derived, at least in part, from the source of their raw materials (Kutau/Bao) and the social processes and negotiations that were required to achieve their completion (the recruitment of a specialist).

The volcanic history of the Willaumez Peninsula and Garua Island has provided a clear and well-dated stratigraphy of airfall tephra layers, each labelled by reference to the volcanic episode that produced it and interleaved with contrasting darker brown palaeosols. The eruptions relevant to this study are those of the Witori volcano (W-K events), about 60 km from Garua Island (Machida *et al*., 1996). Excavation has shown that manufacture of Type 1 stemmed tools started before the W-K1 eruption (6160–5750 cal. BP) and ceased soon after the W-K2 eruption (3480–3150 cal. BP) (Araho *et al*., 2002: 62; Petrie and Torrence, 2008: table 5).

Type 1 tools vary between 10 to 20 cm long and 4 to 5 cm in width; some large ones at 30 cm long and up to 10 cm wide would appear to be larger than required for practical utility (Araho *et al*., 2002: 76; Torrence, 2003: 293–296). They were formed on prismatic blades with up to four arrises and are characterised by a distinct, narrow stem at the proximal end formed by hard-hammer percussion and bifacial retouch reduction on what is exceptionally brittle raw material (e.g., Fig. 3). In many examples this fragility is exacerbated by the weak design of the junction between the stem and the blade and stems often broke off (Araho *et al*., 2002: 63–65, 76).

Only a few Type 1 tools have been described and analysed. Fullagar (1993: 22–25) examined one artefact and concluded from phytolith evidence that the stem had been hafted. Kealhofer *et al*. (1999: 534) in their integrated use-wear and residue study analysed three blades and also found evidence for hafting. Araho's study investigated 19 complete artefacts of Type 1 and several broken stems (Araho *et al*., 2002: 64). Kononenko examined five stemmed points and concluded that at least three had been used with wooden hafts (Kononenko, 2011: tables 12, 13). She also suggested that site FAO on Garua Island included an area used specifically as a knapping workshop. A further six tools were included in Kononenko's (2012: 15–17, table 1) study of tattooing and skin working tools each of which carried use-wear evidence of wooden hafts. This paper extends these previous studies through an exploration of standardisation and specialisation in the production of Type 1 tools, and analyses of their morphology and use-wear associated with their hafting.

Specialisation, standardisation and value

How past peoples produced things is generally accepted as a basis for an understanding of how they organised and lived their lives as individuals, as societies and in terms of relationships between communities (Costin, 1998: 10). Allen *et al*. (1997: 14, 36) argue that archaeologists often take the degree of specialisation evident in an artefact

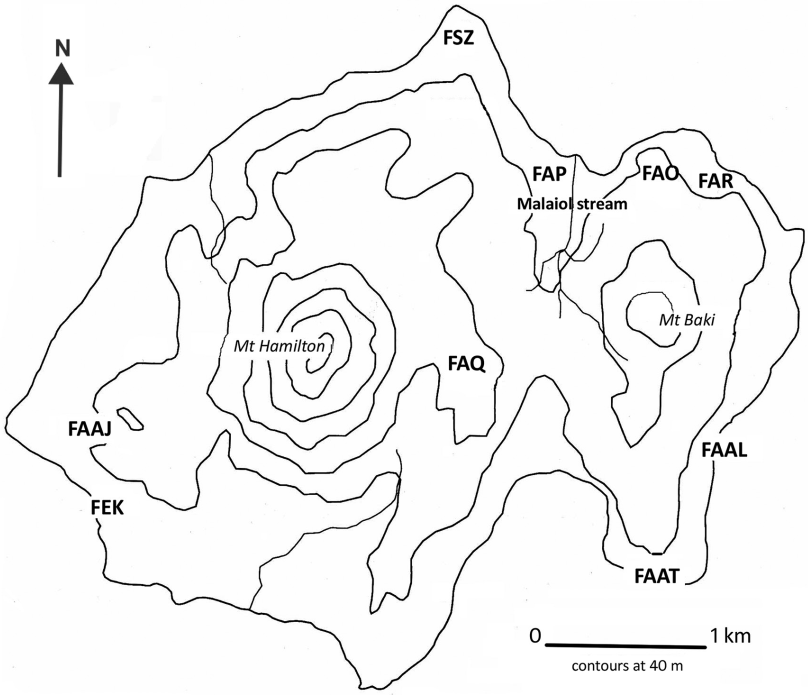

Figure 2. Garua and Kaula Islands showing sites included in the study (Torrence, 1998).

assemblage as an 'uneasy' proxy for the extent of social differentiation that existed in the society that made them. While village level part-time specialisation does not inevitably infer entrenched social stratification, nevertheless, some level of craft specialisation appears to be common to stratified societies and is frequently linked to organisation of production and standardisation of output (Clark, 1979: 10–11; Costin, 1998: 12).

Specialisation involves people producing things for other people and this implies the existence of some form of distribution network of producers and consumers. The investment of time and effort required to transfer things through those networks also implies that what is moved has some form of value. Renfrew (1986: 158–166) argued that value is a social construct with which something can be endowed through its rarity, exoticism, ownership history, and the networks within which it circulated. Not only objects moved through these networks. Social networks are polysemic conduits through which people, intangibles, information and indices of prestige or status move and are exchanged, sometimes simultaneously (Aswani and Sheppard, 2003: S53–S54).

Standardisation, which can be regarded as a systemisation of specialisation, shares the same implicit connection with exchange, value and the networks of people that engage in it (Costin, 2000: 397). It is reasonable to argue for a rough correlation between the extent of product standardisation evident in a community and the geographical spread and social complexity of the networks engaged with it. This is supported by a number of archaeological case studies that show changes in societies occurring relatively contemporaneously with increases in specialisation, the degree of artefact standardisation and the complexity of their social networks (Renfrew, 1974: 85; Frieman, 2012: 458; Kardulias, 2014: 116).

Specialisation is a prerequisite for standardisation of production through a tendency for the output of craft specialists to become more homogeneous over time. Both style and dimension become less variable, and products show markedly less artisan individuality and considerably more consistency of form. While specialisation does not automatically imply the existence of standardisation, standardisation does suggest specialisation. The archaeological record enables us to identify the degree of standardisation of an artefact type relative to other similar types from the same society and period (Blackman *et al*., 1993: 61).

Figure 3. Araho's Type 1 stemmed tool (FEK M015).

The evidence for identifying product specialisation can be divided into two broad categories (Costin, 1991: 18, 32):

1. Direct evidence lies in the production features, manufacturing debris, tools and raw material waste that are common at archaeological sites (e.g., kilns, lithic debitage, pottery wasters and slag).
2. Indirect evidence includes the recognition of relatively large numbers of virtually identical and standardised artefacts as well as evidence for high artisan skill levels and an element of production efficiency.

While the evidence of manufacturing detritus may mark production sites, it is debatable whether these provide specific evidence of specialisation or simply of domestic manufacture over an extended period of occupation. Torrence (1986: 157), for example, challenged arguments that the quantity of obsidian waste and debitage at Mallia, Knossos and Phylakopi demonstrated that these were sites of full-time, specialist production of obsidian blades. She showed that in each case the weight and number of obsidian pieces produced were insufficient to substantiate this claim. She also maintained that a more effective method to infer specialist production would be to analyse the extent of standardisation in the production output (Torrence, 1986: 159).

The established procedure for measuring standardisation within an assemblage is to statistically determine the coefficients of variation of item dimensions and proportions (Allen *et al*., 1997: 30–31; Bamforth and Finlay, 2008: 5). Torrence (1986: 159–161) analysed the degree of standardisation evident in obsidian blades produced at Teotihuacan, Phylakopi and Knossos by using the coefficients of variation (Cv) of blade width and thickness. She concluded that lower values for Cv signified a greater degree of manufacturing standardisation and pointed to a greater degree of specialism at Teotihuacan than at either Phylakopi or Knossos. I have adopted this approach in the present study.

Materials and methods

The initial sample of 148 Type 1 blades selected for this study was composed of artefacts recovered during fieldwork by the Australian Museum at 18 sites spread over c. 70 km^2. Each artefact is identified by the three- or four-letter archaeological site-code allocated by the Papua New Guinea National Museum and Art Gallery, together with a sequential catalogue number; for example, FAP 123 = general catalogue number; FEK M015 = use-wear/residue catalogue number. The archaeological sites from which the sample was drawn

Table 1. Sites on Willaumez Peninsula and Garua Island from which the study samples of Type 1 tools were obtained. Sources: Specht, 1981; Torrence, 1993, 1995, 2004; Torrence and Webb, 1992; Torrence and Boyd, 1996, 1997; Torrence *et al*., 1999, 2000; Araho *et al*., 2002; Specht and Torrence, 2007; Petrie and Torrence, 2008. Radiocarbon dates are 2-sigma ranges.

site code	Type 1 artefacts	location	fieldwork date	archaeological context	notes
FAP	72	Garua Island	1989, 1991, 1992, 1996, 1997	Gully exposure; 1 excavated below reworked W-K1 tephra. 71 surface finds	Quarry cut by Malaiol stream. Pre-W-K1: 6280–5930 cal. BP (NZA 1570)
FAO	1	Garua Island	1995	Excavated, below W-K2 tephra	W-K1 palaeosol: 3990–3640 cal. BP (NZA 2901)
FEK	9	Garua Island	1993, 1997	Surface finds	Mudflats sealed by slope-wash
FAQ	2	Garua Island	1989, 1992, 1993, 1995, 1996	Excavated, below W-K2 tephra	W-K1 palaeosol: 4080–3690 cal. BP (NZA 2850)
FSZ	2	Garua Island	1993	Excavated, 1 above and 1 beneath W-K2 tephra	W-K2 palaeosol: 3070–2750 cal. BP (NZA 6099)
FAR	15	Garua Island	1992	Excavated, 5 stratified; 10 surface finds	Eroding from stream gully
FAAJ	2	Garua Island	1997	1 below W-K2 tephra; 1 surface find	Gully wall. W-K2 palaeosol: 2680–2000 cal. BP (Beta-102971)
FAAL	1	Garua Island	1996, 1997	Surface find	Beach outwash fan
FAAT	1	Garua Island	1997	Surface find	Beach outwash fan
FAW	1	Kaula Island	1996	Surface find	
FRL	28	Willaumez Peninsula	1988	Excavated. 21 in W-K1 palaeosol; 7 below reworked W-K1 tephra	Bitokara Mission
FDW	1	Willaumez Peninsula	1981	Surface find	Bitokara Mission
FDY	1	Willaumez Peninsula	1973	Surface find	Bitokara Mission
FQT	1	Willaumez Peninsula	1988	Surface find	Lambe Gully, Bitokara Mission
FDM	1	Willaumez Peninsula	1991	Surface find	Near Voganakai village
FAY	2	Willaumez Peninsula	1989	Surface finds	Near Voganakai village
FDC	7	Willaumez Peninsula	1991	Surface finds	Near Volupai village
FAAH	1	Willaumez Peninsula isthmus	1996, 1997, 1999	Deposit below W-K1 tephra	Numundo Plantation. Pre-dates 6100–5750 cal. BP

Table 2. Summary of frequencies of classified stem types.

stem type	N
Type A	43
Type B	10
Type C	19
Type D	24
Type E	13
total	109

are shown as a named location on the Willaumez Peninsula map (Fig. 1) or as a site code on the map of Garua Island (Fig. 2). Table 1 shows the number of artefacts from each site; of the 148 artefacts in the sample, only 41 (28%) were stratified in palaeosols below the W-K2 tephra. Excavation at site FRL revealed a sequence of flaking floors, while site FAP is described as a site for extraction and manufacturing activity (Specht *et al*., 1988: 6–10; Torrence, 1992: 113–115). The remaining 107 items were surface finds.

Each artefact stem section was classified by shape and its dimensions recorded (Tables 2, 3), followed by microscopic examination under high-magnification for use-wear including hafting wear. Stem dimensions were measured to the nearest millimetre and are expressed as ratios using length, maximum width and maximum thickness of each artefact that had sufficient identifiable stem to be measured. Incomplete stems were measured for width and thickness only. Measurement of width and thickness can be considered reasonably objective in that the gauge spanned the physical perimeters of the artefact, but the measurement of length was more challenging as a decision had to be made as to where the stem ended and the blade commenced. To be considered complete, a stem was required to have both a proximal end that included either the original platform or, where the platform had been retouched away, had that retouch in place; and a distal end that had either some portion of blade attached, or an identifiable inflection point at the neck/stem junction. Some damaged stems were typologically classifiable, but could not be measured; consequently, there are some minor differences between the overall numbers of stems in Table 2 and the numbers of stem measurements in Tables 3 to 6. A statistical analysis using Levene's test for the equality of variances was undertaken to establish whether any typological group of stems showed dimensional or proportional uniformity consistent with standardised manufacture.

Table 3. Dimensions and statistical analyses of stem types A to E.

stem dimension	N	min	max	mean (μ)	SD (σ)	Cv%
TYPE A						
length	40	42	75	58.28	7.62	13.08
width	41	25	43	34.73	4.05	11.68
thickness	41	8	15	11.90	1.83	15.24
TYPE B						
length	9	37	85	49.89	14.76	29.58
width	9	15	70	36.11	16.95	44.47
thickness	9	7	22	14.56	4.06	27.93
TYPE C						
length	14	22	54	37.64	12.30	32.66
width	16	14	37	24.13	7.08	29.34
thickness	16	9	18	13.70	3.20	23.37
TYPE D						
length	21	22	74	45.14	12.77	28.29
width	21	24	51	33.91	7.50	22.11
thickness	21	9	20	13.86	2.80	20.19
TYPE E						
length	7	20	92	57.00	26.80	47.00
width	10	26	64	42.40	12.57	29.65
thickness	10	9	26	15.7	4.95	31.50

Table 4. Dimensions and statistical analysis of all stem types including Type A, stem Types B–E only.

stem dimensions	N	min	max	mean (μ)	SD (σ)	Cv%
With Type A						
length	91	20	92	50.87	14.66	28.83
width	97	14	70	33.72	9.37	27.79
thickness	97	7	25	13.25	3.17	23.92
Without Type A						
length	49	22	92	45.90	16.14	35.18
width	56	14	70	33.28	11.88	35.69
thickness	56	7	25	14.33	3.54	24.69

The use-wear analysis was carried out at the University of Leicester and The Australian Museum, Sydney. These laboratories have a similar level of equipment and software to support them: in Sydney, an Olympus BX60M binocular incident light microscope with an Olympus DP72 colour digital camera and one Orient SM1 stereoscopic microscope; and in Leicester; a Zeiss Axioscop2 MAT binocular incident light microscope with a Zeiss Axiocam MRc 5 colour digital camera and one Zeiss Stemi 2000-C stereoscopic microscope.

The study of hafting wear was conducted using reference material from Dr Nina Kononenko's experimental work on the hafting of obsidian tools (Kononenko, 2011: 19, 37). This was supplemented by examination of the Australian Museum's ethnographic collection of obsidian blades from Manus Province, PNG that were originally hafted but have lost their hafts. These blades had been hafted using a fibrous binding material together with a putty made from the Parinarium nut, *Atuna racemosa* Raf. (Chrysobalanaceae). When macerated into a thick paste, the large oily cotyledon of *A. racemosa* dries to form a tough and inflexible matrix traditionally used in the Pacific Islands as an adhesive and caulking substance (Prance, 2004: 472–474). Araho *et al*. (2002: 70; also, Nevermann, 1934: 187, in translation) describe this method as used in recent times on Manus Island for the hafting of obsidian tools.

Results

Stem morphology: typology

Although each Type 1 stemmed tool was made an obsidian prismatic blade with a stem knapped on its proximal end, these artefacts are not a uniform group. There are clear differences in design between artefacts in the sample. This is particularly so regarding the stems, which are the part of the tool that received the greatest application of craft skills. It was immediately clear from the initial examination of the sample that the form of the stem was likely to be the most promising location for evidence of specialisation and standardised manufacturing processes.

Rath and Torrence (2003: 120, 122) previously classified their sample of Type 1 stems by shape as ovate, leaf, pear and rectangular, and according the extent and invasiveness of retouch applied to them. The present study did not adopt

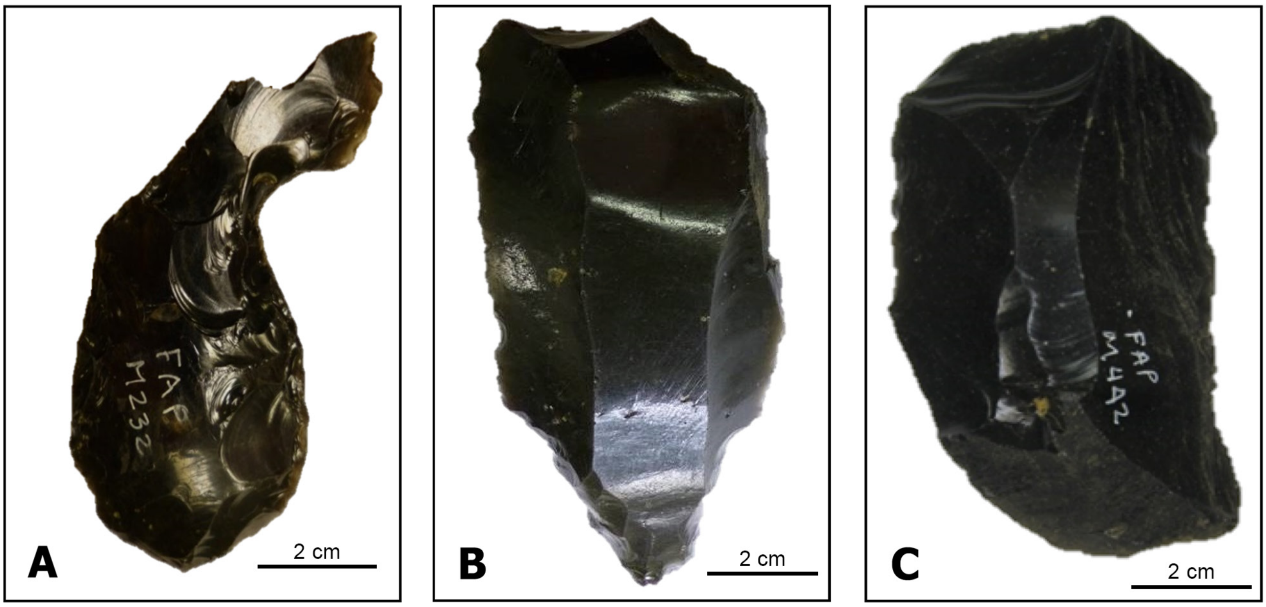

Figure 4. Stem types: (*A*) Type A (FAP M232); (*B*) Type B (FAP 542); and (*C*) Type C (FAP M442)

that typology because the sample contained a wider range of stem shapes than those of Rath and Torrence and because the objective to use microwear evidence for hafting to explore the possibility that some stems had been intended for attachment to specific types of haft or shaft, or to facilitate different modes of haft attachment. Some shapes used in the earlier typology such as 'pear' and 'leaf,' while visually distinctive, probably had almost identical hafting potential.

Overall, the sample contains 109 stems or identifiable stem sections (39 blades have no identifiable stem sections) and, after considering marked differences in the ways that stems had been shaped, these were organised into a typology of five distinct forms A to E (Table 2):

1. Type A stems are intensively bifacially retouched pear-shaped stems (Fig. 4A). At the stem/blade junction invasive retouch has reshaped each side of the tool in a distinctly arched design, leaving a very narrow and fragile-looking neck connecting blade and stem. Of 43 examples in the assemblage, 32 have the blade missing entirely or have only a small section of blade attached to the neck. Most Type A stems have broken across or adjacent to this spindly neck. Three examples with relatively large sections of blade attached appear to have stems that are particularly crude and incomplete.
2. Type B stems have no neck between blade and stem. They have a broad triangular plan created by tapering the proximal end of the blade with retouch along the blade edges (Fig. 4B). The design is less delicate and requires much less retouch than Type A. The lack of a narrow neck at the junction of blade and stem makes the stem-blade intersection significantly more robust, and the 10 robust and less intensively retouched Type B stems all have some blade sections attached.
3. Type C stems are bifacially retouched over most of the surface and are carefully shaped to have a distinct hook or curve at the proximal end (Fig. 4C).
4. Type D stems are characterised by a distinctly rectangular profile. The line of the stem shoulder at the stem-blade junction is much less curved than in Type A stems and runs more perpendicular to the long axis of the blade (Fig. 5). The stem itself is retouched on the margins of both faces leaving an axial panel of original obsidian surface along the centre. The proximal corners of the stem are also generally right-angled.
5. Type E stems have minimal bifacial retouch that slightly tapers to a generally curved proximal end (Fig. 6).

Figure 5. Type D stem (FAP M416).

Table 5. Summary of coefficients of variation (Cv) in stem width and thickness measurements.

stem type	N	width (Cv%)	thickness (Cv%)
Type A	41	11.68	15.24
Type B	9	44.47	27.93
Type C	16	29.34	23.37
Type D	21	22.11	20.19
Type E	10	29.65	31.50
all stems	97	27.79	23.92
stems—no Type A	56	35.69	24.69

Stem morphology: standardisation and the Type A stems

The relative proportions of any artefact are a constituent of its design. The data shows that there is less variability in length, width, and thickness in Type A stems than in each of the other stem types (Table 3). Comparisons of the Cv for the three dimensions between the Type A stems and each of the other stem types, as well as with the sample as a whole (Tables 3 vs 4), show that the dimensional variations within Type A are markedly smaller compared to each of the other types and to the complete sample set. This consistency is even more marked if we compare Type A stems (Table 3) with the other stem types as a group (Table 5).

It is not only in absolute dimensions that Type A stems are distinctive. While the sizes of individual stems vary within-type, their relative dimensions remain very consistent. Analysis of the ratio of width to thickness (the two least subjective measurements—see above), shows that with a Cv of 17.01% the proportions of the Type A stems are markedly less variable than for all of the stems together (30.68%) and for non-Type A stems as a group (37.6%) (Table 6). At 17.01% the Cv for this ratio of the Type A stems approaches Eerkens' (2000) proposal of 15% as a best possible consistency expectation for stone tool manufacture. With a Cv of > 30% for the same ratio, the non-Type A stem types show no meaningful degree of standardisation.

The application of Levene's statistical test for equality of variances (Table 7) shows that this homogeneity of variance in Type A stems is unlikely to have occurred randomly. For all stems taken together, the variation in each of the measured dimensions, length, width and thickness, as well as the aggregated variation across all dimensions, have a p value that is less than 0.05 (with <0.05 as statistically significant). However, when the values for the Type A stems are excluded from the test, the variances have p values > 0.05. Consistency in the dimensions of the stems only becomes statistically significant when the Type A stems are included in the sample. The most parsimonious explanation is that only Type A stems have a statistically significant homogeneity of variation in their lengths, widths, and thicknesses.

The statistical evidence corroborates the proposition that the blades with Type A stems were made to a standardised design. From this one can infer that they were the output of a specialist or group of specialists who worked in sufficiently close physical and temporal proximity that they could work empirically to very close design parameters with very narrow margins of variation.

Creating a series of almost identical stone tools with such tightly defined dimensions and proportions must have required considerable skill and discipline, with intensive training and practice before knappers could consistently produce accurate and detailed work with hard-hammer percussion on such brittle material (Araho *et al*., 2002: 64, 67–68). The overall interpretation is one of occupational

Table 6. Ratios of stem width: stem thickness.

ratio of width: thickness	N	min	max	mean	SD	Cv%
all stems	97	1.06	5.83	2.66	8.16	30.68
Type A only	41	2.13	4.11	3.00	5.1	17.01
stems—no Type A	56	1.06	5.83	2.41	9.07	37.60

Figure 6. Type E stem (FRL 1004).

Table 7. Levene's test for homogeneity of variation (*p*) applied to stem dimensions.

dimension	Levene's test *p* =
length: all stems	0.002311
length: all stems (no Type A)	0.09836
width: all stems	0.000111
width: all stems (no Type A)	0.0791
thickness: all stems	0.004401
thickness: all stems (no Type A)	0.6662
all dimensions	0.000004598
all dimensions (no Type A)	0.2294

specialisation operating from a workshop production centre on Garua Island that was gathering raw material from surrounding sources to produce a standardised product.

Use-wear: searching for hafting wear

The experimental tools and the ethnographic examples showed similar patterns of hafting wear:

1. contiguous flake and feather scars along the tool edge
2. contiguous micro-scarring on the edges of earlier retouch scars or ridges on the tool surface
3. transverse striae, particularly at the hafting margin
4. patches of short, dense rough-bottomed striae running parallel to the direction of working action
5. polish on arrises and ridges well-away from the working edge of the tool
6. a marked difference in surface texture between the unhafted and formerly hafted areas of the artefact.

There is a further micro-wear characteristic, 'bright spots', that is particularly associated with hafting. Bright spots are exceptionally smooth, highly reflective, micro-wear surface features on flint and chert tools (Keeley, 1982: 804). Rots (2002: 63–66) found that they occurred on surfaces in direct contact with the hafting material such as edges, the tool butt, and around the area of the tool close to where it emerges from the haft. They were particularly prevalent on elevated areas such as ridges and the bulb of percussion and were chiefly present when the tools were hafted with a hard material in direct contact with the stone surface. Additionally, bright spots were produced during the process of de-hafting tools that had been hafted using a resin matrix (Rots, 2002: 63–69). Her experimental work established that, when used in conjunction with other evidence of hafting and use-wear traces, bright spots are a clear indicator of hafting on flint tools. Consequently, I maintain that, when found in conjunction with other complementary micro-wear evidence, bright spots on the stem and proximal areas of the blade of an obsidian tool are also diagnostic indications that the tool was formally hafted; and that the contact area between the haft, any hafting matrix and the surface of the tool had been subjected to an element of pressure. Finding sufficient evidence of such complementary micro-wear for hafting depends on at least part of the stem and/or some of the proximal section of the blade being present. One or other of these elements was missing from 26 artefacts; these were omitted from the study, leaving a sample of 122.

Table 8. Analysis of evidence for potential hafting for all stems combined.

hafting potential	no. of items
possible	17
probable	13
certain	44
no evidence	18
total stems available for microscopy	92
damaged, degraded or missing relevant sections of tool	56
total	148

Obsidian is liable to mechanical damage through abrasion and degradation of the surface because of hydration and fungal attack (Patel *et al*., 1998: 1047). Hydration causes the obsidian to become pitted and progressively less translucent (Lofgren, 1971: 115–117; Anovitz *et al*., 2008: 1169). The absence of translucency does not necessarily prevent use-wear identification as striae and surface polish can be identified, but surface pitting physically removes micro-wear traces. The complex chemical reactions engendered by fungi often cause opaque crystals to grow on the surface of the stone. Fungi also secrete organic acids that etch tiny pits over the obsidian surface. These can become filled with dirt that can be almost impossible to remove, thus obscuring large areas of the artefact surface. (Adeyemi and Gadd, 2005: 273, 277).

Of the 122 tools suitable for examination, 30 had surface degradation in key locations that prevented hafting traces being observed. This left 92 examples with the potential for identifying hafting wear. Of these, 18 artefacts had sections of the tool present where hafting wear could be expected and were free of surface contamination, but none showed signs of hafting. The remaining 74 examples exhibited varying degrees of likely hafting traces. These were graded according to density of wear on each artefact and the extent of different combinations of the key variables listed above. There are three groups of likely hafting: Possible, Probable and Certain (Table 8).

Each of the 17 artefacts graded as 'Possible' has possible hafting wear of limited extent or partially obscured, or the

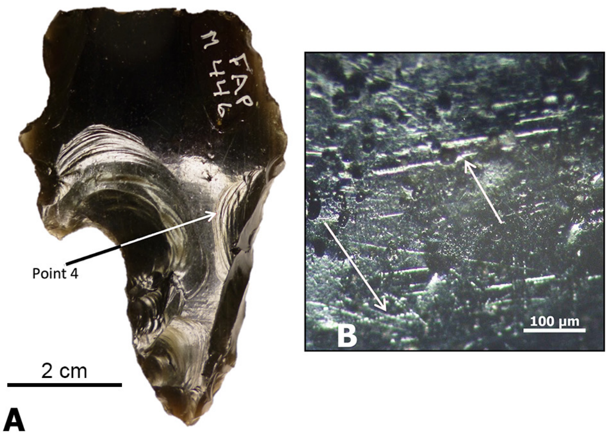

Figure 7. FAP 446: (*A*) ventral face, Point 4; and (*B*) Point 4 ×100; white arrows indicate scatter of transverse intermittent striae at hafting line.

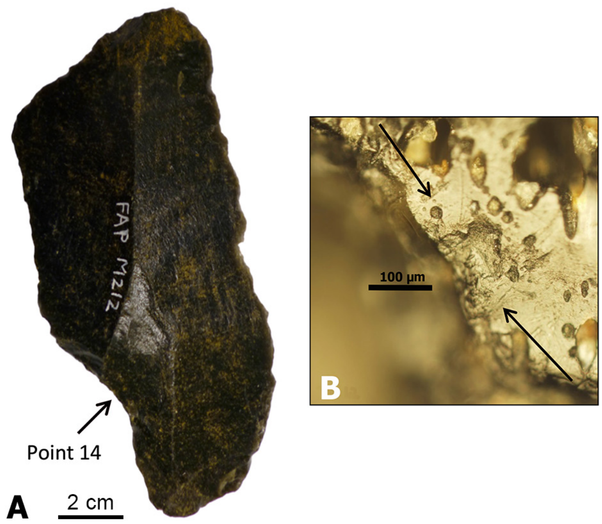

Figure 8. FAP 212: (*A*) dorsal face, Point 14; and (*B*) Point 14 ×200; black arrows indicate a rounded edge with short striae from hafting.

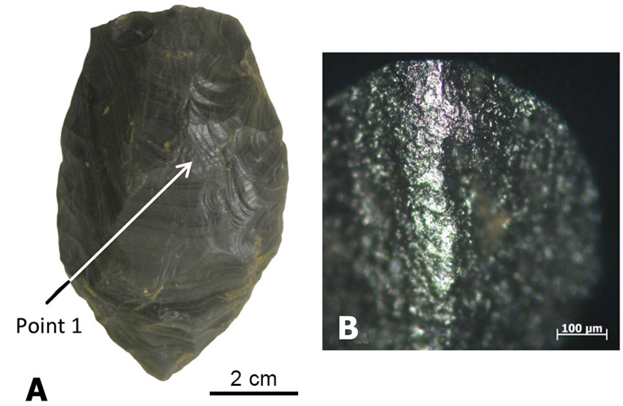

Figure 9. FAP 481: (*A*) dorsal face, Point; and (*B*) Point 1 ×100; line of well-developed polish on elevated edge of scar.

artefact is so damaged and incomplete that correlation between several wear locations is not possible. FAP 446 (Fig. 7A,B), for example, exhibits a distinct though scattered band of transverse intermittent striae across the edge of the area that would have been embedded in a haft. FAP 212 (Fig. 8A,B) has a very rounded area of edge on the dorsal face of the distal stem end of the stem that also has short transverse striae running across the smooth surface. FAP 481 (Fig. 9A,B) is a bladeless Type A stem with a line of polish running axially along the elevated edge of a retouch scar, though this is inconclusive evidence for hafting.

The 13 artefacts graded as 'Probable' exhibit more extensive evidence, typically of more than one type of key variable and at several locations. FAP 429 (Fig. 11A–C) has deep transverse striae at the junction of the blade and stem as well as well-rounded edge polish at the distal end of the stem's ventral face. Similarly, FRL 183 (Fig. 10D–F) has two areas of transverse striae close to the stem/blade junction. The dorsal face of FEK 109 (Fig. 12A–C) has two areas of transverse striae at points where a haft edge would pass over the dorsal face at the stem/blade junction. FRL 428 (Fig. 13A–C) has hafting evidence on both the dorsal and ventral faces of the same edge with the ventral face also exhibiting dense transverse striae and distinct edge rounding.

Of the 44 artefacts assessed as 'Certain', several exhibit bright spots on elevated areas of the stem. FAP 261 (Fig. 14A–D) is a bladeless Type A stem with dense transverse striae visible on the edge of the broken neck of the stem and

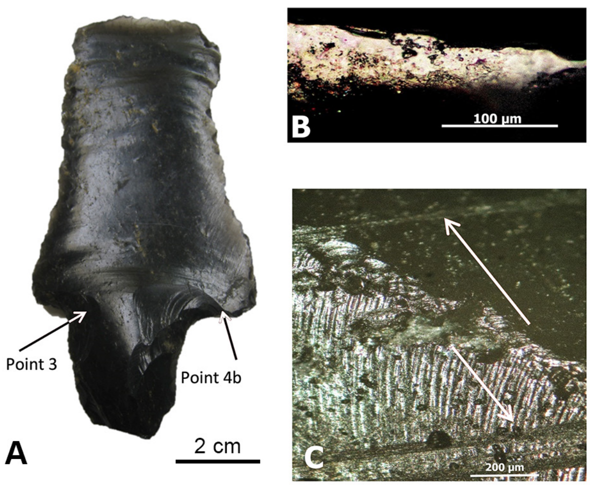

Figure 10. FAP 429: (*A*) ventral face, Points 3 and 4b; (*B*) Point 3 ×500; rounded polish spot on edge; and (*C*) Point 4b × 50 with parallel lines of transverse striae at hafting line, indicated by white arrows.

Table 9. Breakdown of evidence for potential hafting by stem type.

stem type	hafting potential	N	totals
A	certain	20	
A	probable	5	
A	possible	6	
A	total with hafting evidence	31	
A	surface degraded	8	
A	no evidence	4	
	Type A total		43
B	certain	5	
B	probable	1	
B	possible	0	
B	total with hafting evidence	6	
B	surface degraded	2	
B	no evidence	4	
	Type B total		12
C	certain	3	
C	probable	4	
C	possible	5	
C	total with hafting evidence	12	
C	surface degraded	6	
C	no evidence	1	
	Type C total		19
D	certain	11	
D	probable	1	
D	possible	0	
D	total with hafting evidence	12	
D	surface degraded	8	
D	no evidence	4	
	Type D total		24
E	certain	3	
E	probable	1	
E	possible	6	
E	total with hafting evidence	10	
E	surface degraded	0	
E	no evidence	4	
	Type E total		14
unclassified	with hafting evidence	2	
unclassified	surface degraded	6	
unclassified	no evidence	1	
stem missing	hafting evidence on blade	1	
stem missing	n/a 26		
	unclassified total		36
all tools	total		148

a bright spot close to the proximal tip of the stem. FAP 705 (Fig. 15A–D) has dense transverse striae at the hafting line, developed polish on the ventral stem edge and a bright spot on the edge close to the stem/blade junction. FAP 255 (Fig. 16A–D) exhibits the distinctive contiguous feather scars that are typical of hafting wear on its ventral edge, a band of transverse striae across the ventral stem and a well-developed polish patch on the top of the dorsal arris in the centre of the stem. FDY 001 (Fig. 17A–C), an almost complete tool has bright spots on the dorsal face around the area of the hafting margin. The clear bright spot on Type A stem FAP 400 (Fig. 18A–D) is convincing evidence of hafting because of its location and its association with a band of transverse striae running across the widest part of the stem.

The summary of hafting wear evidence provided in Table 9 shows that of the 92 artefacts with potential to exhibit

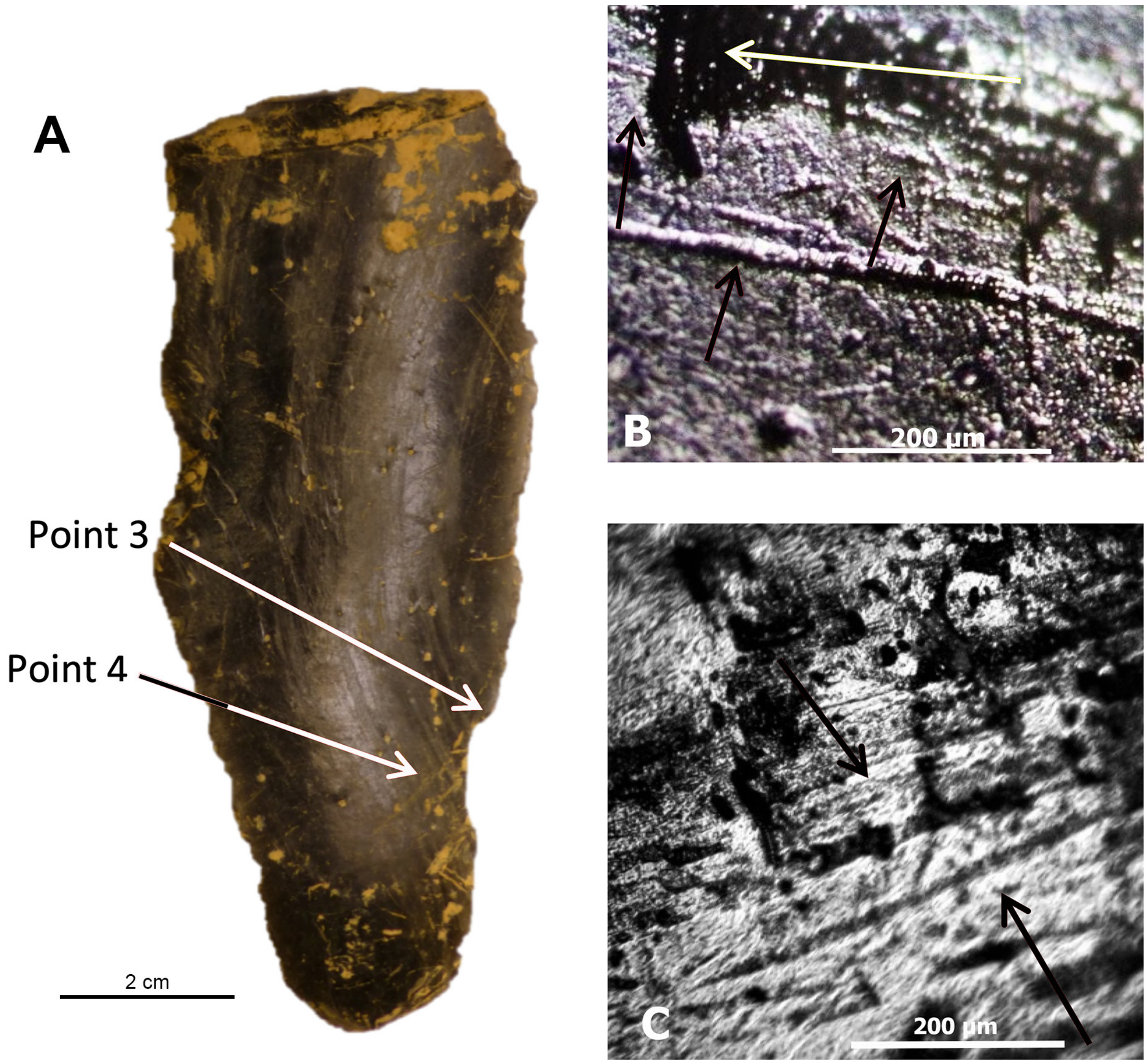

Figure 11. FRL 183: (*A*) ventral face, Points 3 and 4; and (*B*) Point 3 ×200 with scatter of transverse rough-bottomed striae indicated by black arrows. These are on a slightly different alignment to the dense crescent row striae, indicated by a white arrow, which overlies them. (*C*) Point 4 of FRL 183 ×100 with dense transverse rough-bottomed striae indicated by black arrows.

hafting traces, 74 (80%) provided some evidence of hafting for at least some part of their use-lives. A notably high proportion (31/43, 72%) of Type A stems were hafted. Of the remaining 12 tools, four stems had no traces of hafting wear while eight were too degraded for hafting traces to be identified. Although 75% of the 43 Type A stems are broken at roughly the same place, across the neck of the stem, it is clear from the use-wear evidence that these tools must have been broken after they were hafted. They are not manufacturing failures or discards and must be considered components of composite tools that were broken either during use or by mishap.

The strong correlation between some of the use-wear identified on the sample blades and that seen on the ethnographic collection artefacts used as reference for this study suggests that similar methods may have been used to attach the sample blades to hafts. Several of the stemmed tools in this study have distinct traces of an orange-red residue on their stems or proximal areas of their blades that resisted attempts at cleaning (Fig. 18D). Kononenko *et al*. (2010: 20–21) describe similar residues on irregular stemmed flakes from a post-W-K2 tephra on Boduna Island near Garua Island.

The likelihood is that in the mid-Holocene, Parinarium nut mastic was used to cement Type 1 stemmed tools into their hafts, and Rots' (2002) results imply that the use of such an adhesive could have been instrumental in the formation of bright spots on some stems. No analyses have yet been undertaken on Type 1 stemmed tools to identify their residues, but the success of gas chromatography analysis of plant mastics on middle-Palaeolithic lithics (Degano *et al*., 2019) opens promising possibilities for future research on the New Britain stemmed tools.

Discussion

The function of Type 1 stemmed tools is unclear, as use-wear on the blades does not shed much light on the matter. Most Type A stems in the sample have no blades or only small sections of blade attached. Of the eleven examples with blade sections present, only seven exhibited any helpful use-wear, though this showed no consistent pattern of use: some had signs of use with plants for slicing, whittling and in three cases for scraping; Kononenko (2011: 54) found a similar range of actions. It is likely that these elaborate, hafted blades were occasionally used as general implements, especially after breakage.

There is no convincing evidence that Type 1 tools were used as weapons for hunting or fighting or other activities

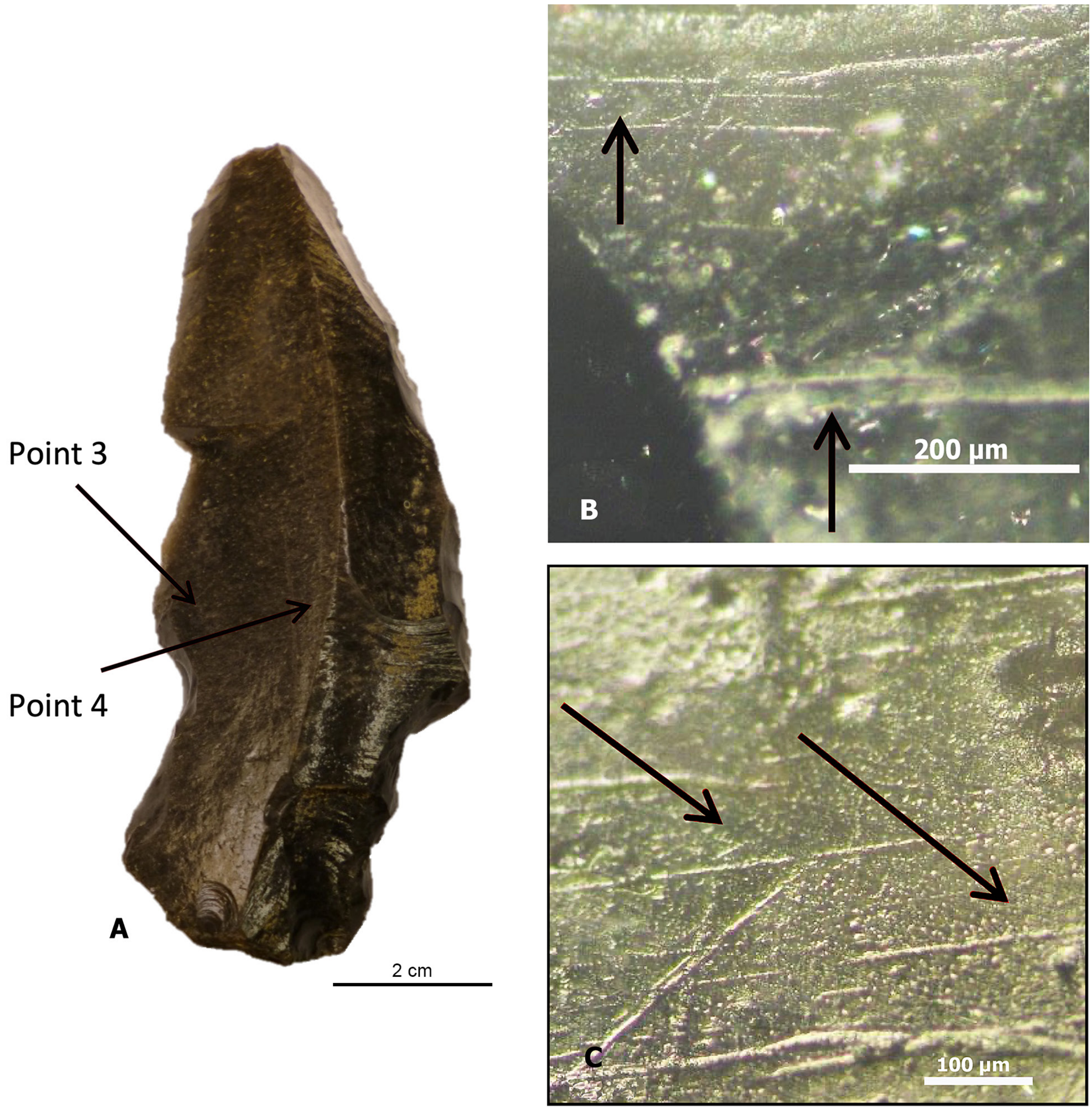

Figure 12. FEK 109: (*A*) dorsal face; Points 3 and 4; (*B*) Point 3 ×100 with transverse rough-bottomed striae indicated by black arrows; and (*C*) Point 4 ×100 with scatter of transverse striae indicated by black arrows.

involving flesh. In the absence of large mammals such as pigs during the mid-Holocene, it is unlikely they were used for hunting. It is possible that they were used as spear heads or knives as fighting weapons. They would undoubtedly have been highly effective, though the tendency of the tool to break at stem/blade junction makes this unlikely. While the blade could have been designed to break off in a wound and thus be more effective in a fight, the protagonist would have needed a backup weapon to avoid being left defenceless once the blade broke away. This seems a risky strategy!

There is no obvious reason why the stems were so carefully and elaborately designed and crafted, though they were so susceptible to breakage. It must have been possible for such proficient artisans to design a standardised and reliable tool system that was robust, effective, and easily replaceable without the necessity to shape the complex internally curved shoulders (Bleed, 1986: 743). If craft specialists derived social or economic benefit from producing these tools for others to acquire, then perhaps designing a more robust Type A stem would have led to a reduction in the demand for replacements and a diminution in the role and importance of the craftsmen. What is mystifying is that these stems would have been buried in the hafts of the composite tools and not normally seen. It is likely that the process of knapping the stem was important to the producers by demonstrating their skills and this brought them both respect and social status.

The intensity of retouch, symmetry and dimensional consistency of the Type A stems, together with the risk of failure inherent in the design, differentiates them from the other stems in the research sample. Most (31/43, 72%) of the Type A tools show some evidence of hafting wear. By comparison with the other stem types that also have hafting micro-wear, the amount of work and skill applied to knapping Type A stems exceeds what was necessary to achieve a competent, practical and robust hafting joint.

Type A stemmed blades appear to have been specifically designed components of a composite tool such as a spear or

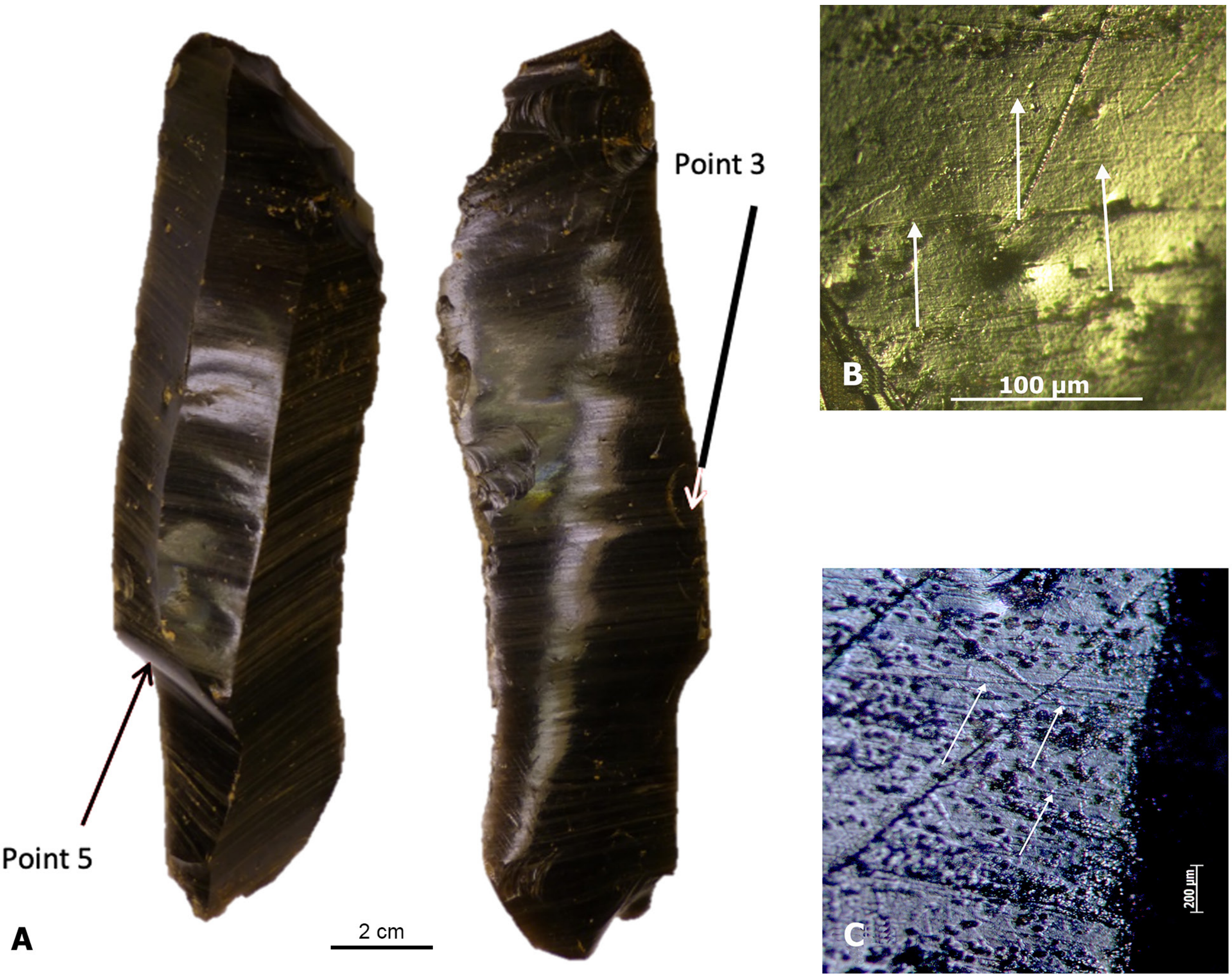

Figure 13. FRL 428: (*A*) dorsal and ventral faces, Points 3 and 5; (*B*) Point 5 ×100 with transverse striae indicated by white arrows; and (*C*) Point 3 ×200, white arrows indicate edge rounding and moderate dense transverse striae.

knife using a method of hafting that is likely to have bound the stem tightly to the shaft or handle. If during use the blades broke from the stems, they would probably have been discarded wherever they fell. The owner then had a useless possession and, as its power and effectiveness had been destroyed, it was impotent as a social signal and needed to be replaced. If a moderately similar blade, however crudely knapped, would suffice as a replacement then, as obsidian was available in abundance, this work could have been done almost anywhere by any passably skilled knapper and the broken stems extracted from the hafts would have been randomly scattered. However, to restore the symbolic capital inherent in its ownership, the owner needed to replace the broken blade with one made at the Garua Island workshop. The archaeological evidence shows that the broken Type A stems were not widely dispersed on discard. Site FAP on the north side of Garua Island yielded 70% (30/43) of Type A stems, and a further 23% (10/43) were picked up at site FAR just a few hundred metres from FAP. Similar patterns of discard of worn or damaged stone tools at raw material resource sites are reported and discussed in other parts of the world (Keeley, 1982: 804; Gramly, 1980: 826, 829; Stevenson, 1985: 67).

The evidence for a workshop raises questions about the social structure that underpinned it. Standardisation of output enables a systemisation of process that then allows stages of production to be differentiated. People can work more quickly and accurately on tasks that they frequently repeat. Apprentices can concentrate on the less intricate stages of process, leaving the more experienced and expert artisans to do the finer and riskier work (Torrence, 1986: 44–45). Any form of apprenticeship for skilled knappers infers a structured and stratified relationship between novice and expert. Bamforth and Finlay (2008: 9–11) emphasise the importance of a learning process in which novices may spend years working for an experienced master craft worker who demonstrates, supervises and controls their activities. This enables production to be organised and safeguarded craft knowledge to be carefully handed on. The expertise required to make the Type A stems within the proposed Garua workshop strongly suggests that some element of social control managed the quality and consistency of output.

A Type A stem produced on Garua Island must have been valued over and above its utility value, where it came from and who made it. This is consistent with the relative accumulations of the most standardised stem type, Type A, at sites FAP and FAR and with the observation that almost all of these are broken at the neck of the stem, where the artefact projects from the supporting hafting matrix. This pattern of broken stem disposal reinforces the hypothesis that these stems are the product of a standardised manufacturing process. These distinctive tools both identified their origins by style and performed as connecting actants in components of social and exchange network establishment and maintenance.

Fullagar's (1993: 23, 25) study of one Type 1 stemmed tool (FRL 150) for both use-wear and residues, recorded a differential distribution of phytolith types between the blade of the tool and the stem. Bowdery's (2001: 235) analysis of phytoliths and starch grains recovered from this artefact

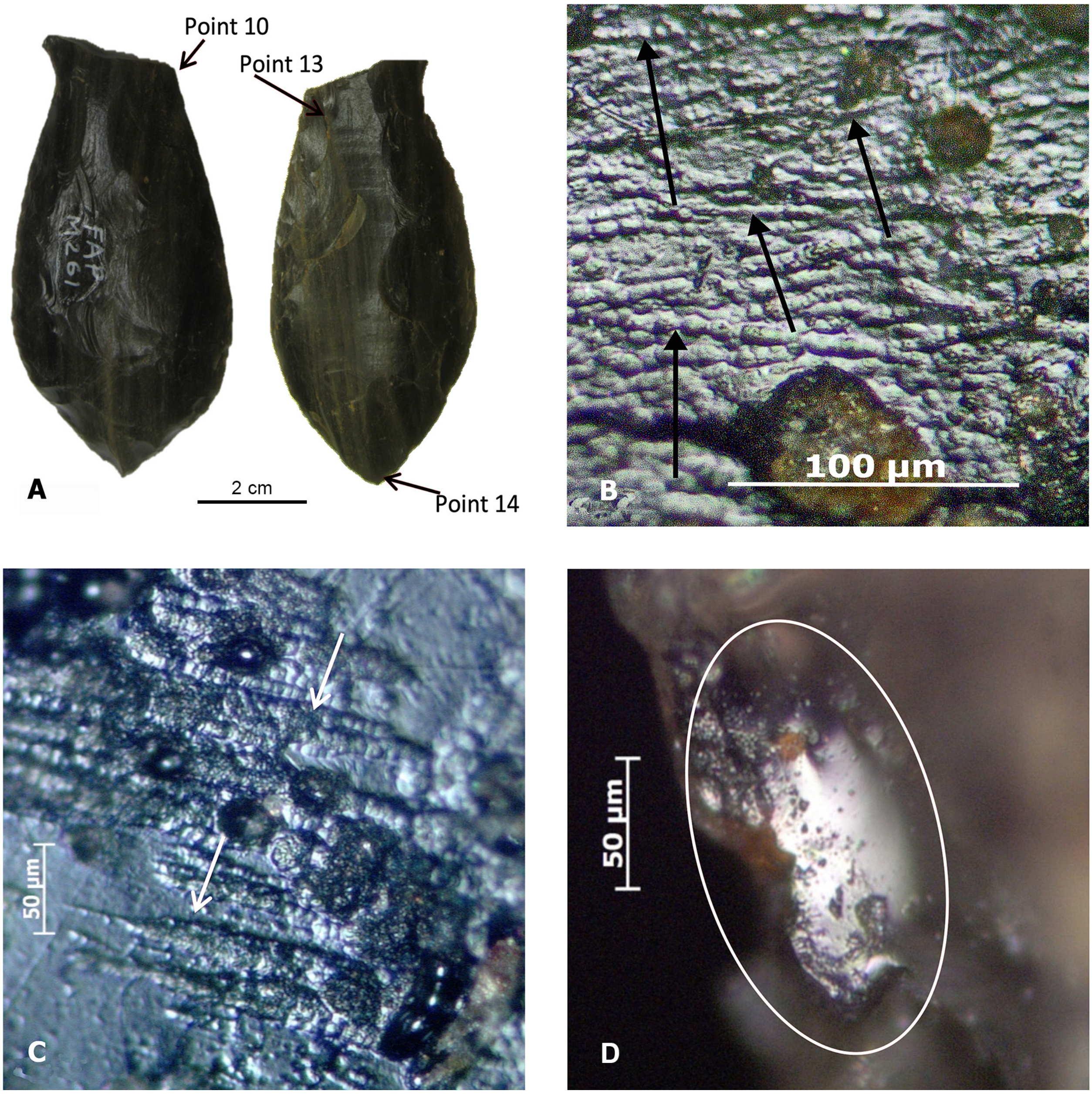

Figure 14. FAP 261: (*A*) Type A stem, dorsal and ventral faces, Points 10, 13 and 14; (*B*) Point 10 ×200 with black arrows indicating dense transverse striae across neck of stem; (*C*) Point 13 ×200, with white arrows indicating a dense patch of very short striae; and (*D*) Point 14 ×200, the white oval indicates a 'bright spot.'

both verified that this blade had been hafted using some form of plant materials and linked the hafting adhesive used on the Type 1 blades to that used on ethnographic examples of obsidian tools. Although hafts have not been preserved, it is reasonable to suggest that the amount and quality of work that went into making the blade and its stem would have been reflected in the refinement and craft skill applied to the haft. Hafts are frequently the most important and valued part of any composite tool. Exceptional blades are likely to have been attached to particularly well-constructed hafts that were distinguished by ownership personalisation (Keeley, 1982: 800, 808). As complete composite tools they meet the criteria of Binford (1962: 222), Renfrew (1986: 167) and Spielmann (2002: 199–200) for 'special' objects to be durable, visually distinctive, and with evidence of exceptional skill levels. The overall investment of skill and expertise into these artefacts would have been consistent with their social worth being significantly greater than their utility value.

Conclusions

This study extends our understanding of the roles that Type 1 stemmed tools played in mid-Holocene West New Britain. The evidence indicates that, for a period, a group of accomplished workers became specialist producers of a class of standardised stemmed blades into each of which they invested considerable time, expertise, learned skill and personal dexterity. The likelihood is that production of these exceptional artefacts was carried out in an organised workshop. This investment infers that these objects had a social role and a value that was additional to and distinctive from any utility value that they may have had. The evidence of this study and of other researchers is that prior to the Lapita cultural complex there was a web of social networks in the Bismarck Archipelago centred on the New Britain obsidian sources within which special valued objects were transported and exchanged.

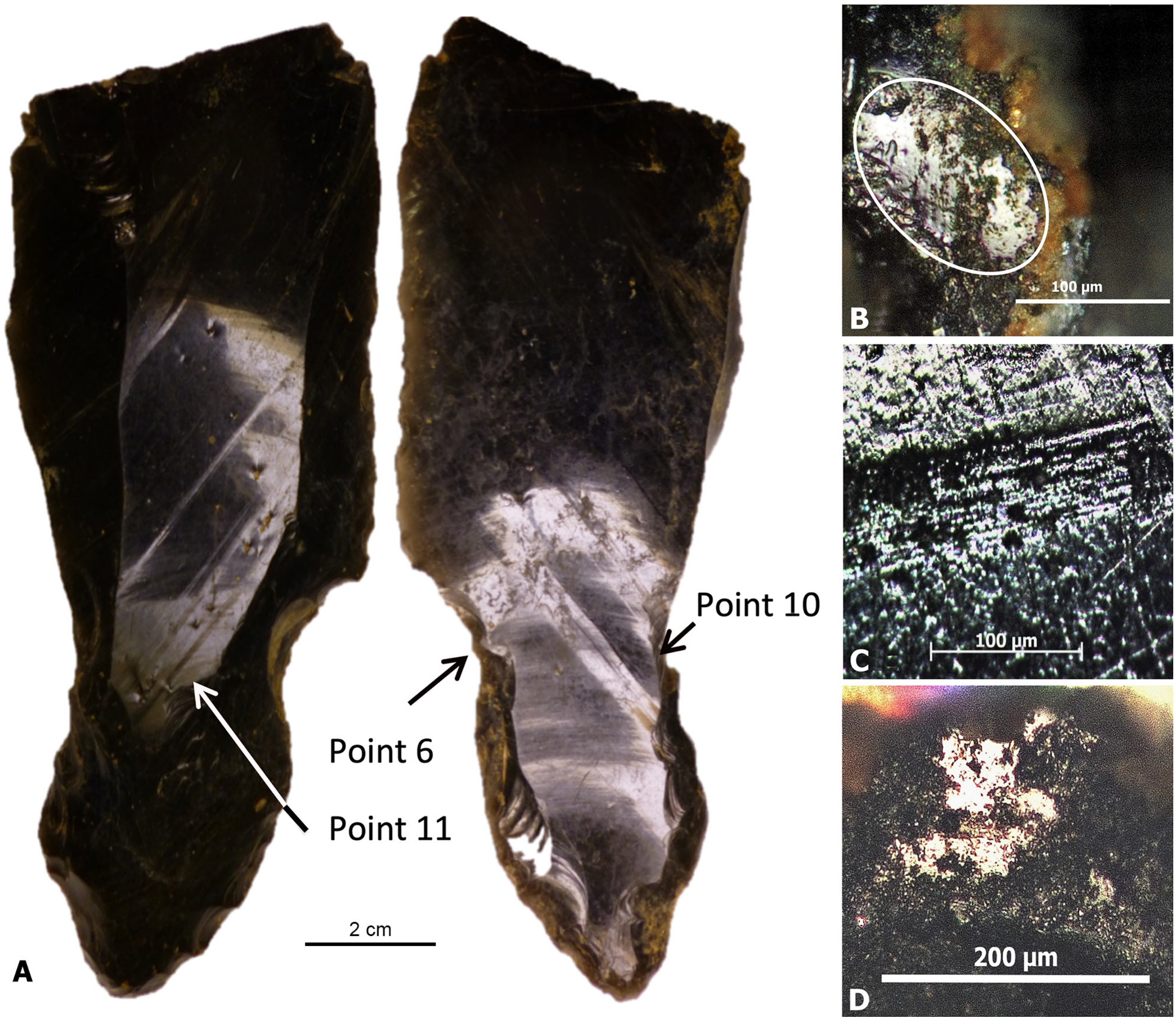

Figure 15. FAP 705: (*A*) Type A stem, dorsal and ventral faces, Points 6, 10 and 11; (*B*) Point 6 ×200 with developed polish patch on edge indicted by white oval; (*C*) Point 11 ×100 with dense transverse rough-bottomed striae at hafting line; and (*D*) Point 10 ×100 showing 'bright spot' on edge.

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References

Adeyemi, A. O., and G. M. Gadd. 2005. Fungal degradation of calcium, lead and silicon-bearing minerals. *BioMetals* 18(2): 269–281.
https://doi.org/10.1007/s10534-005-1539-2

Allen, J., S. Holdaway, and R. Fullagar. 1997. Identifying specialisation, production and exchange in the archaeological record: the case of shell bead manufacture on Motupore Island, Papua. *Archaeology in Oceania* 32(1): 13–38.
https://doi.org/10.1002/j.1834-4453.1997.tb00367.x

Anovitz, L. M., D. R. Cole, and M. Fayek. 2008. Mechanisms of rhyolitic glass hydration below the glass transition. *American Mineralogist* 93: 1166–1178.
https://doi.org/10.2138/am.2008.2516

Araho, N., R. Torrence, and J. P. White. 2002. Valuable and useful: mid-Holocene stemmed obsidian artefacts from West New Britain, Papua New Guinea. *Proceedings of the Prehistoric Society* 68: 61–81.
https://doi.org/10.1017/S0079497X00001444

Aswani, S., and P. Sheppard. 2003. The archaeology and ethnohistory of exchange in precolonial and colonial Roviana. *Current Anthropology* 44 (Supplement, December): S51–S78.
https://doi.org/10.1086/377667

Bamforth, D., and N. Finlay. 2008. Introduction: archaeological approaches to lithic production skill and craft learning. *Journal of Archaeological Method and Theory* 15(1): 1–27.
https://doi.org/10.1007/s10816-007-9043-3

Binford, L. R. 1962. Archaeology as anthropology. *American Antiquity* 28(2): 217–225.
https://doi.org/10.2307/278380

Blackman, M. J., G. J. Stein, and P. B. Vandiver. 1993. The standardization hypothesis and ceramic mass production: technological, compositional, and metric indexes of craft specialization at Tell Leilan, Syria. *American Antiquity* 58(1): 60–80.
https://doi.org/10.2307/281454

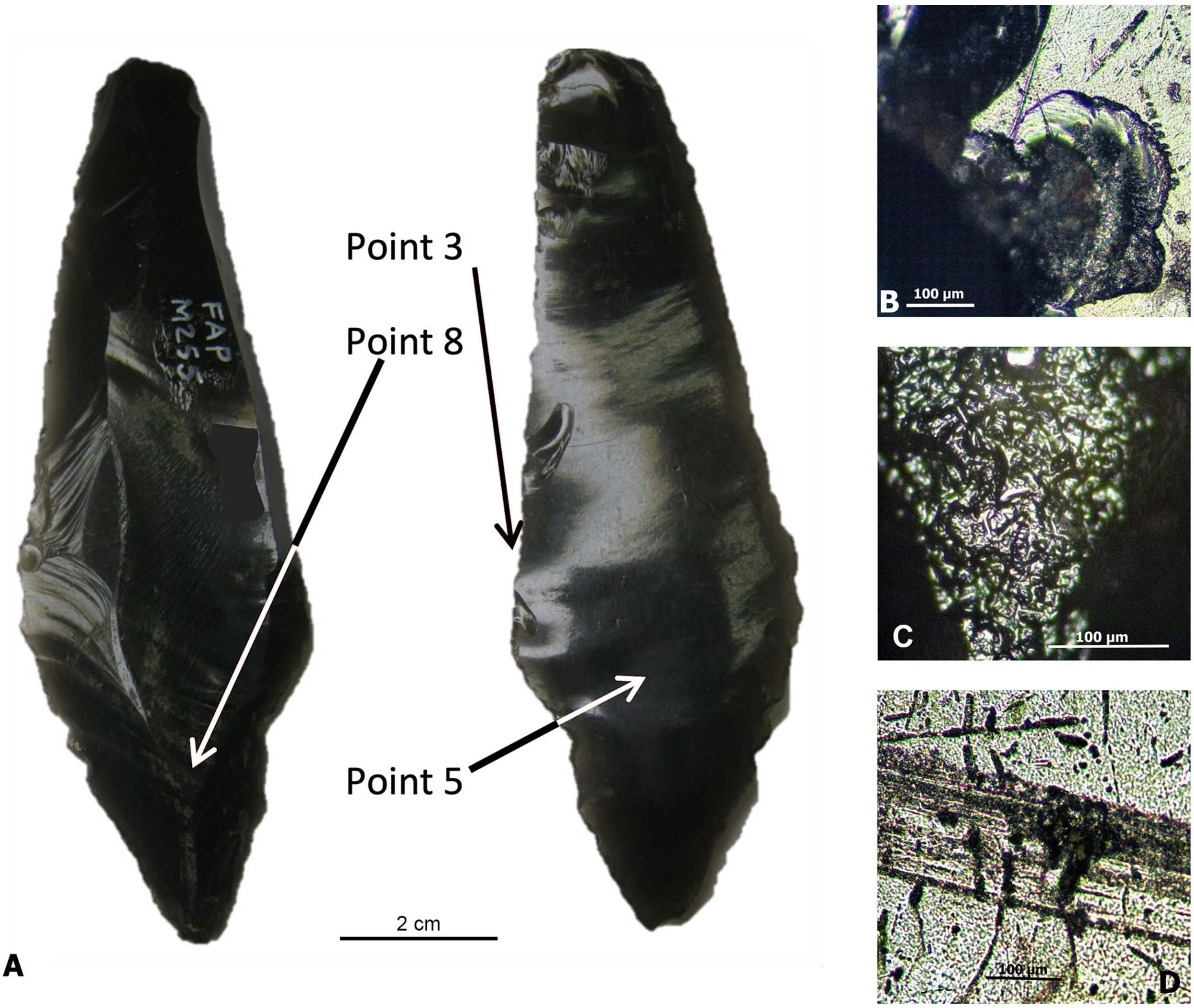

Figure 16. FAP 255: (*A*) dorsal and ventral faces, Points 3, 5 and 8; (*B*) Point 3 ×100 with feather scars on edge; (*C*) Point 8 ×200; well-developed polish patch; (*D*) Point 5 ×100 with transverse rough-bottomed striae.

Bleed, P. 1986. The optimal design of hunting weapons: maintainability or reliability. *American Antiquity* 51(4): 737–747.
https://doi.org/10.2307/280862

Bowdery, D. 2001. Phytolith and starch data from an obsidian tool excavated at Bitokara, West New Britain Province, Papua New Guinea: a 3400 year old hafting technique? In *Phytoliths: Applications in Earth Sciences and Human History*, ed. J. J. Meunier and F. Colin, pp. 225–237. Lisse: A. A. Balkema.
https://doi.org/10.1201/NOE9058093455.ch17

Clark, G. 1979. Archaeology and human diversity. *Annual Review of Anthropology* 8: 1–20.
https://doi.org/10.1146/annurev.an.08.100179.000245

Costin, C. L. 1991. Craft specialization: issues in defining, documenting, and explaining the organisation of production. *Archaeological Method and Theory* 3: 1–56.

Costin, C. L. 1998. Introduction: craft and social identity. *Archeological Papers of the American Anthropological Association* 8(1): 3–16.
https://doi.org/10.1525/ap3a.1998.8.1.3

Costin, C. L. 2000. The use of ethnoarchaeology for the archaeological study of ceramic production. *Journal of Archaeological Method and Theory* 7(4): 377–403.
https://doi.org/10.1023/A:1026523023550

Degano, I., S. Soriano, P. Villa, L. Pollarolo, J. J. Lucejko, Z. Jacobs, K. Douka, S. Vitagliano, and C. Tozzi. 2019. Hafting of Middle Paleolithic tools in Latium (central Italy): new data from Fossellone and Sant'Agostino caves. *PLoS ONE* 14(6): 1–29.
https://doi.org/10.1371/journal.pone.0213473

Eerkens, J. 2000. Practice makes within 5% of perfect: visual perception, motor skills, and memory in artifact variation. *Current Anthropology* 41(4): 663–668.
https://doi.org/10.1086/317394

Frieman, C. 2012. Flint daggers, copper daggers, and technological innovation in late neolithic Scandinavia. *European Journal of Archaeology* 15(3): 440–464.
https://doi.org/10.1179/1461957112Y.0000000014

Fullagar, R. L. K. 1993. Taphonomy and tool use: a role for phytoliths in use-wear and residue analysis. In *Archaeometry: Current Australian Research*, ed. B. L. Frankhauser and J. R. Bird, pp. 21–27. Occasional Papers in Prehistory 22. Canberra: Department of Prehistory, Australian National University.

Gramly, R. M. 1980. Raw material source areas and 'curated' tool assemblages. *American Antiquity* 45(4): 823–833.
https://doi.org/10.2307/280152

Kardulias, P. N. 2014. Archaeology and the study of globalization in the past. *Journal of Globalization* Studies 5(1): 110–121.

Kealhofer, L., R. Torrence, and R. Fullagar. 1999. Integrating phytoliths within use-wear/residue studies of stone tools. *Journal of Archaeological Science* 26(5): 527–546.
https://doi.org/10.1006/jasc.1998.0332

Keeley, L. H. 1982. Hafting and retooling: effects on the archaeological record. *American Antiquity* 47(4): 798–809.
https://doi.org/10.2307/280285

Kononenko, N. 2011. Experimental and archaeological studies of use-wear and residues on obsidian artefacts from Papua New Guinea. *Technical Reports of the Australian Museum Online* 21: 1–244.
https://doi.org/10.3853/j.1835-4211.21.2011.1559

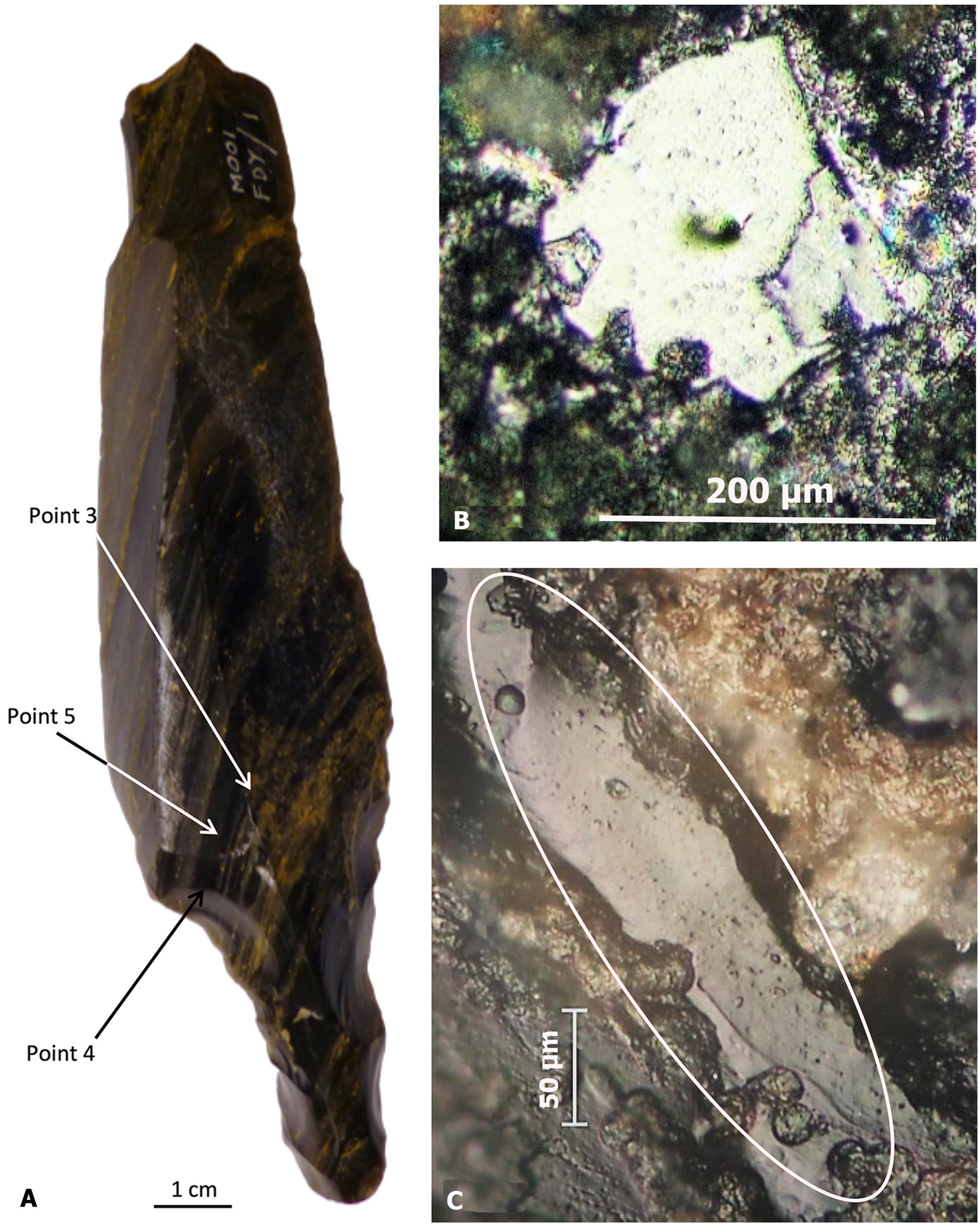

Figure 17. FDY 001: (*A*) dorsal face; Points 3, 4 and 5; (*B*) Point 3 ×100 'bright spot'; and (*C*) Point 4 ×500 with 'bright spot' indicated by white oval.

Kononenko, N. 2012. Middle and late Holocene skin-working tools in Melanesia: tattooing and scarification? *Archaeology in Oceania* 47(1): 14–28.
https://doi.org/10.1002/j.1834-4453.2012.tb00111.x

Kononenko, N., J. Specht, and R. Torrence. 2010. Persistent traditions in the face of natural disasters: stemmed and waisted stone tools in late Holocene New Britain, Papua New Guinea. *Australian Archaeology* 70: 17–28.
https://doi.org/10.1080/03122417.2010.11681908

Lofgren, G. 1971. Experimentally produced devitrification textures in natural rhyolitic glass. *Geological Society of America Bulletin* 82: 111–124.
https://doi.org/10.1130/0016-7606(1971)82[111:EPDTIN]2.0.CO;2

Machida, H., R. Blong, J. Specht, H. Moriwaki, R. Torrence, Y. Hayakawa, B. Talai, D. Lolok, and C. F. Pain. 1996. Holocene explosive eruptions of Witori and Dakataua caldera volcanoes in West New Britain, Papua New Guinea. *Quaternary International* 34–36: 65–78.
https://doi.org/10.1016/1040-6182(95)00070-4

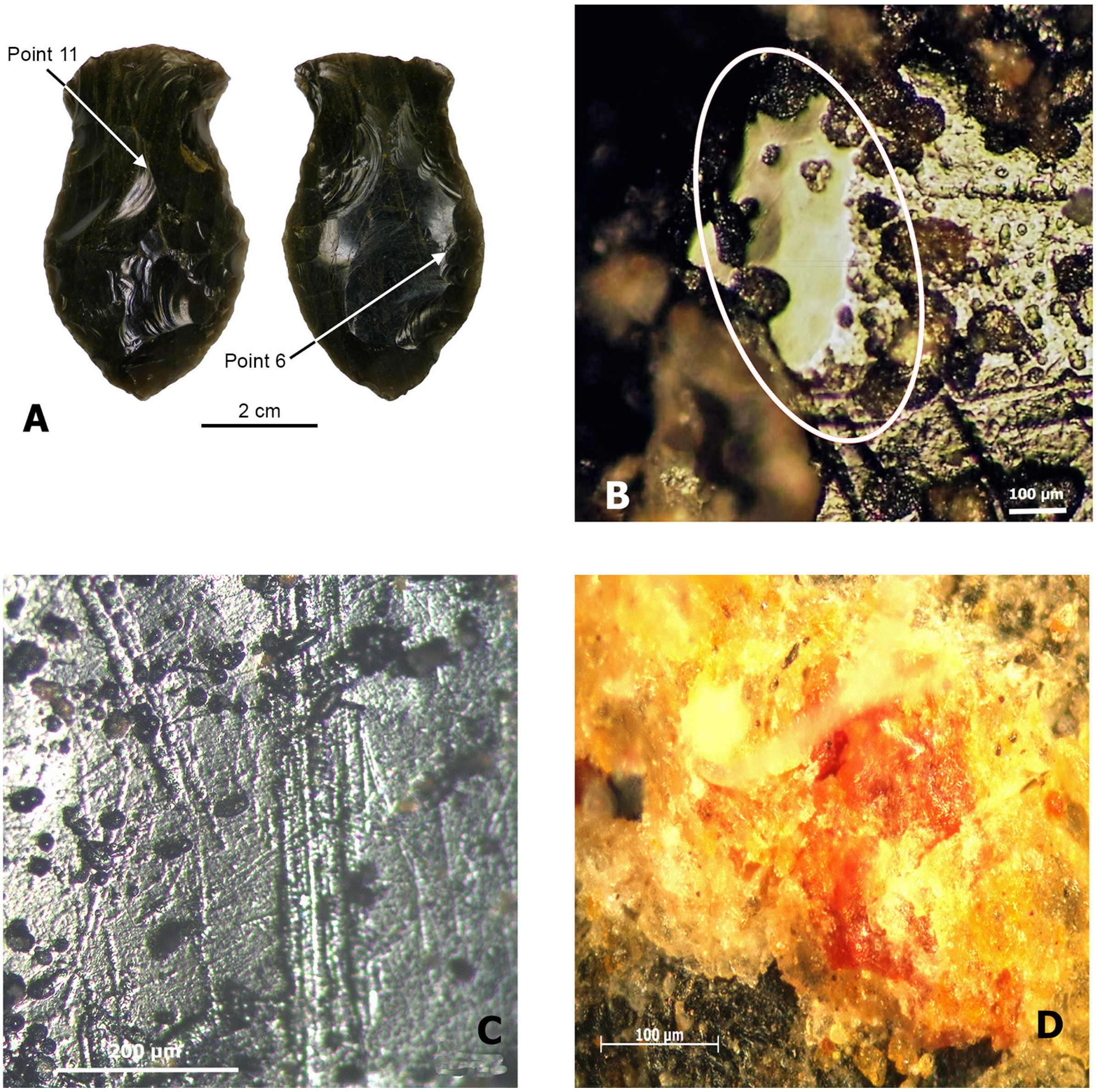

Figure 18. FAP 400: (*A*) dorsal and ventral faces; (B) Point 11 ×200, with 'bright spot' indicated by white oval; (*C*) Point 6 showing transverse rough-bottomed striae. FDM 002: (*D*) Point 4 ×200 showing orange and red residues on stem.

Nevermann, H. 1934. *The Admiralty Islands*, translated by J. Dennison (2013), ed. J. Dennison and G. R. Summerhayes. University of Otago Working Papers in Anthropology No. 1. Dunedin: Department of Anthropology and Archaeology, University of Otago. Originally published in 1934 as *Die Admiralitäts-Inseln.* Ergebnisse der Südsee-Expedition, 1908–1910. II. Ethnographie: A. Melanesien Band 3. Hamburg: Friederichsen, de Gruyter and Co.

Patel, S. B., R. E. M. Hedges, and J. A. Kilner. 1998. Surface analysis of archaeological obsidian by SIMS. *Journal of Archaeological Science* 25(10): 1047–1054. https://doi.org/10.1006/jasc.1998.0327

Petrie, C. A., and R. Torrence. 2008. Assessing the effects of volcanic disasters on human settlement in the Willaumez Peninsula, Papua New Guinea: a Bayesian approach to radiocarbon calibration. *The Holocene* 18(5): 729–744. https://doi.org/10.1177/0959683608091793

Prance, G. T. 2004. The uses of *Atuna racemosa* Raf. (Chrysobalanaceae) in Samoa. *Economic Botany* 58(3): 470–475. https://doi.org/10.1663/0013-0001(2004)058[0470:TUOARR]2.0.CO;2

Rath, P., and R. Torrence. 2003. Producing value: stemmed tools from Garua Island, Papua New Guinea. *Australian Archaeology* 57: 119–127. https://doi.org/10.1080/03122417.2003.11681770

Renfrew, C. 1974. Beyond a subsistence economy: the evolution of social organization in prehistoric Europe. *Bulletin of the American Schools of Oriental Research, Supplementary Studies* 20: 69–95.

Renfrew, C. 1986. Varna and the emergence of wealth in prehistoric Europe. In *The Social Life of Things: Commodities in Cultural Perspective,* ed. A. Appadurai, pp. 141–168. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511819582.007

Rots, V. 2002. Bright spots and the question of hafting. *Anthropologica et Praehistorica* 113: 61–71.

Specht, J. 1981. Obsidian sources at Talasea, West New Britain, Papua New Guinea. *Journal of the Polynesian Society* 90(3): 337–356. https://doi.org/10.1002/j.1834-4453.1981.tb00027.x

Specht, J., R. Fullagar, R. Torrence, and N. Baker. 1988. Prehistoric obsidian exchange in Melanesia: a perspective from the Talasea sources. *Australian Archaeology* 27: 3–16. https://doi.org/10.1080/03122417.1988.12093158

Specht, J., and R. Torrence. 2007. Archaeological Studies of the Middle and Late Holocene, Papua New Guinea. Part IV. Pottery sites of the Talasea area, Papua New Guinea. *Technical Reports of the Australian Museum Online* 20: 131–196. https://doi.org/10.3853/j.1835-4211.20.2007.1476

Spielmann, K. A. 2002. Feasting, craft specialization, and the ritual mode of production in small-scale societies. *American Anthropologist* 104(1): 195–207.
https://doi.org/10.1525/aa.2002.104.1.195

Spriggs, M. 1997. *The Island Melanesians*. Oxford: Blackwell Publishers.

Stevenson, M. G. 1985. The formation of artifact assemblages at workshop/habitation sites: models from Peace Point in Northern Alberta. *American Antiquity* 50(1): 63–81.
https://doi.org/10.2307/280634

Summerhayes, G. R. 2009. Obsidian network patterns in Melanesia—sources, characterisation and distribution. *Bulletin of the Indo-Pacific Prehistory Association* 29: 110–124.
https://doi.org/10.7152/bippa.v29i0.9484

Torrence, R. 1986. *Production and Exchange of Stone Tools. Prehistoric Obsidian in the Aegean* Cambridge: Cambridge University Press.

Torrence, R. 1992. What is Lapita about obsidian? A view from the Talasea sources. In *Poterie, Lapita et Peuplement. Actes du Colloque Lapita Nouméa Janvier 1992*, ed. J.-C. Galipaud, pp. 111–126. Noumea: ORSTOM.

Torrence, R. 1993. *Archaeological Research on Garua Island, West New Britain Province, PNG. June–July 1993*. Unpublished report submitted to the West New Britain Provincial Government, the National Research Institute of Papua New Guinea, and the National Museum and Art Gallery of Papua New Guinea.

Torrence, R. 1995. Archaeological and Ethobotanical Fieldwork in West New Britain Province, PNG: June–July 1995. Unpublished report to West New Britain Provincial Government, National Research Institute of Papua New Guinea, and National Museum and Art Gallery of Papua New Guinea.

Torrence, R. 2003. 'Like everywhere you've never been': archaeological fables from Papua New Guinea. In *Theory, Method, and Practice in Modern Archaeology*, ed. R. J. Jeske and D. K. Charles, pp. 287–300. Westport (Connecticut): Praeger.

Torrence, R. 2004. Pre-Lapita valuables in Island Melanesia. *Records of the Australian Museum, Supplement* 29: 162–172.
https://doi.org/10.3853/j.0812-7387.29.2004.1413

Torrence, R., and W. Boyd. 1996. *Archaeological Fieldwork on Garua Island, West New Britain, PNG: June–August 1996*. Unpublished report to West New Britain Provincial Government, National Research Institute of Papua New Guinea, and National Museum and Art Gallery of Papua New Guinea.

Torrence, R., and W. Boyd. 1997. *Archaeological Fieldwork in West New Britain, PNG: July–August 1997*. Unpublished report to West New Britain Provincial Government, National Research Institute of Papua New Guinea, and National Museum and Art Gallery of Papua New Guinea.

Torrence, R., C. Pavlides, P. Jackson, and J. Webb. 2000. *Volcanic disasters and cultural discontinuities in Holocene time, in West New Britain, Papua New Guinea*. In *The Archaeology of Geological Catastrophes*, ed. W. G. McGuire, D. R. Griffiths., P. L. Hancock, and I. S. Stewart, pp. 225–244. Special Publication 171. London: The Geological Society of London.
https://doi.org/10.1144/GSL.SP.2000.171.01.18

Torrence, R., J. Specht, and W. Boyd. 1999. *Archaeological fieldwork on Numundo and Garu plantations, West New Britain, PNG: July 1999*. Unpublished report to West New Britain Provincial Government, National Research Institute of Papua New Guinea, and National Museum and Art Gallery of Papua New Guinea.

Torrence, R., and G. R. Summerhayes. 1997. Sociality and the short distance trader: intra-regional obsidian exchange in the Willaumez Peninsula region, Papua New Guinea. *Archaeology in Oceania* 32(1): 74–84.
https://doi.org/10.1002/j.1834-4453.1997.tb00373.x

Torrence, R., and P. Swadling. 2008. Social networks and the spread of Lapita. *Antiquity* 82: 600–616.
https://doi.org/10.1017/S0003598X00097258

Torrence, R., and J. Webb. 1992. *Report on Archaeological Research on Garua Island, West New Britain Province, PNG, July–August 1992*. Unpublished report to West New Britain Provincial Government, National Research Institute of Papua New Guinea, and National Museum and Art Gallery of Papua New Guinea.

Torrence, R., P. White, and N. Kononenko. 2013. Meaningful stones: obsidian stemmed tools from Barema, New Britain, Papua New Guinea. *Australian Archaeology* 77: 1–8.
https://doi.org/10.1080/03122417.2013.11681974

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Modelling Prehistoric Social Interaction in the South-western Pacific: a View from the Obsidian Sources in Northern Vanuatu

Christian Reepmeyer

Centre of Excellence for Australian Biodiversity and Heritage, College of Arts, Society and Education,
James Cook University, Cairns Queensland 4811, Australia

Abstract. This paper investigates the history of social interaction within communities in the Vanuatu Archipelago and between Vanuatu and other regions in the Western Pacific as reflected by variations in lithic raw material sources and technology of stone artefacts. Past research determined an apparent contradiction between long-distance transportation of obsidian, indicating high value, and the under-utilisation of the raw material at the place of discard, indicating low value. The paper concludes that because previous hypotheses depend too much on the notion of the scarcity of resources in their evaluation of the concept of value, they are insufficient to explain the pattern of spatial and temporal distribution of lithic artefacts. Rather than focusing on the intrinsic value of obsidian raw material for individuals or communities, it is more useful to view it as a marker of group identity in a complex system connecting discrete populations in mitigating risk in unpredictable new environments. These new environments included pre-established populations, which might be hostile to new arrivals. The necessity for this complex system quickly disappeared once the colonisers arrived in regions uninhabited by prior populations.

Introduction

Obsidian has been a focus of archaeological research in the Pacific for its unique geochemical attributes that allow identification of distance and directionality in raw material transport, which enables interpretations about its importance as an item embodying cultural meaning (Sheppard, 1993; Torrence, 2005). During the period when Lapita pottery was made some 3000 years ago, obsidian travelled long distances from source locations in West New Britain, Papua New Guinea, as far East as Fiji and West to Sabah in Malaysia (Sheppard, 2011). This long-distance transportation of obsidian over several thousand kilometres has raised questions why people selected obsidian from particular sources, and how this transport might have been organised.

The appearance of Lapita pottery in Remote Oceania (the islands to the south and east of the main Solomon Islands chain) has been associated with a migration of groups out of the Bismarck Archipelago Papua New Guinea region (Kirch, 1997; Spriggs, 1997). These groups have been described as potentially small and highly mobile initially leaving only a small footprint of human occupation; primarily, but not exclusively, on small off-shore islands (Bedford and Sprigg, 2008). The small size and low number of initial groups have been hypothesised to be prime cause explaining subtle difference in the archaeological record of Lapita sites (Bedford, 2019), and this differentiation has been associated with the emergence of 'localised ethnic identities' (Green and Kirch, 1997: 30). The detailed process of this population movement is unclear (Sheppard, 2011), as are likely reasons for it. Different explanations have been proposed, summarised as push and pull factors (Lilley, 2000), such as demographic pressures (Bellwood, 2011), environmental disasters (Grattan and Torrence, 2007), and the search for pristine environments with abundant food resources (Lilley, 2019). Each of these reasons might have played a part at some stage in the process, but the archaeological record is unlikely to preserve clear evidence for them (Kirch, 1997: 253; see also Anthony, 1990).

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Corresponding author: Christian Reepmeyer Christian.Reepmeyer@jcu.edu.au
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Before the appearance of Lapita pottery in the Bismarck Archipelago, the main obsidian technology on New Britain comprised the production of complex stemmed obsidian tools, some of which have associated with high social value connected with prestige and status (Araho *et al*., 2002; Torrence, 2005). In contrast, Lapita pottery sites mark a substantial shift to a simple technology of small and medium sized flakes produced by direct percussion, bipolar hammering or crushing, only a few of the artefacts display retouch or use-wear (Torrence, 1992; Sheppard, 1993; Kononenko *et al*., 2010).

The combination of distance and social organisation has been used to explain the social value of obsidian and to define Lapita as a hierarchical society in which obsidian as a prestige object allowed actors to acquire social status and power (Kirch, 1997; cf. Earle and Spriggs, 2015). However, the lack of an elaborate lithic technology and of evidence for resource optimisation presents a conundrum as this pattern does not fit into common models of distribution of long-distance transported raw materials with high value (Torrence, 2005). The dominant interpretation of the role of obsidian in Lapita societies currently is that it was transported for its social value connecting populations to a founding 'homeland' (Green, 1987: 246; Kirch, 1988: 113; Sheppard, 2011). These interpretations have also been applied to artefact assemblages from Vanuatu (Reepmeyer *et al*., 2011; Galipaud *et al*., 2014; Constantine *et al*., 2015).

In this paper, I go a step further and propose that obsidian transportation did not define hierarchical status of individuals or connect people to their point of origin, but rather it was used as a marker of group identity in a complex system connecting discrete populations in the mitigation of risk in unpredictable new environments. Initially, these new environments included pre-established populations which might have been hostile to new arrivals. The need for marking identity disappeared quickly once the colonisers arrived in uninhabited regions.

This paper examines these assumptions and tests the validity of economic models in defining obsidian transportation through a combination of geochemical data and basic measurements of obsidian artefacts within the methodological framework outlined by Torrence (1986) and Hodder (1978). Summarising previously published works, it argues that although the obsidian artefacts show a clear trend of down-the-line movement, this by itself cannot explain the necessity to transport the raw material. The paper proposes that the correlation of changes in identity marking and intensities of interaction within environmental constraints is more productive in understanding the organisation of obsidian transport.

Background and some theoretical considerations

Values of obsidian

The function of obsidian artefacts in past societies in the Pacific has seen a wide range of interpretations. Use-wear/residue studies have pointed out the exceptional sharp edges of the material and identified a wide range of functions for these tools: processing of siliceous soft wood, non-siliceous soft and hard wood, non-woody plants and soft elastic skin, including possible tattooing and scarification (Kononenko *et al*., 2010; Kononenko, 2012; Torrence *et al*., 2018). Mundane functions of obsidian have been emphasised as obsidian discard occur mainly in domestic contexts (Torrence, 2005). Low value of obsidian has also been suggested because of the small amount of energy required for expedient reduction and curation of the raw material (Fredericksen, 1994; Hanslip, 2001). Unfortunately, functional approaches alone do not explain long-distance transportation of obsidian or the choice by communities to import obsidian from one source only (Torrence *et al*., 1996; Torrence and Summerhayes, 1997); more so as use-wear studies of other raw materials such as chert and quartz display the same aforementioned functions, with the main difference being a shorter use-life for obsidian artefacts (Kononenko *et al*., 2010).

It has been suggested that the Lapita complex represents a system of trading goods between communities (Terrell, 1989: 625) with obsidian being a very visual part of the archaeological record. Viewing obsidian as a traded commodity, however, implies that these objects were specifically made for this purpose and were exchanged between people who did not necessarily share the same cultural or economic background (Gregory, 1982; Graeber, 2001). Consequently, it would be expected that a close emotional bond between transactors did not always exist. As a shared identity is presumed not to be essential for trade, individuals could have categorised the value of these objects within the sphere of subsistence (Appadurai, 1986; Earle, 1997). Would short use-life and focus on only one source imply obsidian as a luxury item for the accumulation of wealth? Variations in burial practices at the Teouma cemetery in Vanuatu possibly reflect different social positions of individuals (Valentin *et al*., 2011), but there is no evidence for the accumulation of obsidian by individuals (Constantine *et al*., 2015).

Rather than viewing the value of obsidian as a luxury item, its value might have derived from its physical attributes such as its distinctive glassy appearance, translucency, consistent colour, and its rarity and association with discrete places (Torrence, 2005; McBryde, 1997). The association of obsidian with discrete places, particularly for colonising groups, is reflected in the interpretation of obsidian as a 'lifeline' back to a homeland (Kirch, 1988). Similarly, Specht (2002) argued that such seemingly non-utilitarian behaviour shows that communities consciously attempted to replicate the ancestral societies. In these views, the geographical extension of the Lapita exchange network defined the value of obsidian and emphasised its scarcity and the energy invested in its transport. The transactors in this network shared social institutions and cultural backgrounds, and the exchange of prestige items and valuables contributed to the accumulation of social status in hierarchical communities in a unified exchange system (Green and Kirch, 1997; Green, 2003).

The argument of obsidian representing a 'lifeline' between colonising groups and the 'homeland' was further developed by considering the transport of obsidian separately from its utilisation at its final destination (Sheppard, 1993). The discard of Kutau/Bao obsidian in Lapita sites of the Reef Santa Cruz, Solomon Islands occurred in a non-utilitarian way, and it is argued that the obsidian artefacts were moving through changing spheres of value. The value of obsidian was defined through its role as a material symbol of exchange and not the item of exchange itself (see, for example, Gregory, 1982; Graeber, 2001). Therefore, its value was not measured by its utility, energy investment or scarcity, but derived from its capacity to make social relationships visible (Preucel and Hodder, 1996).

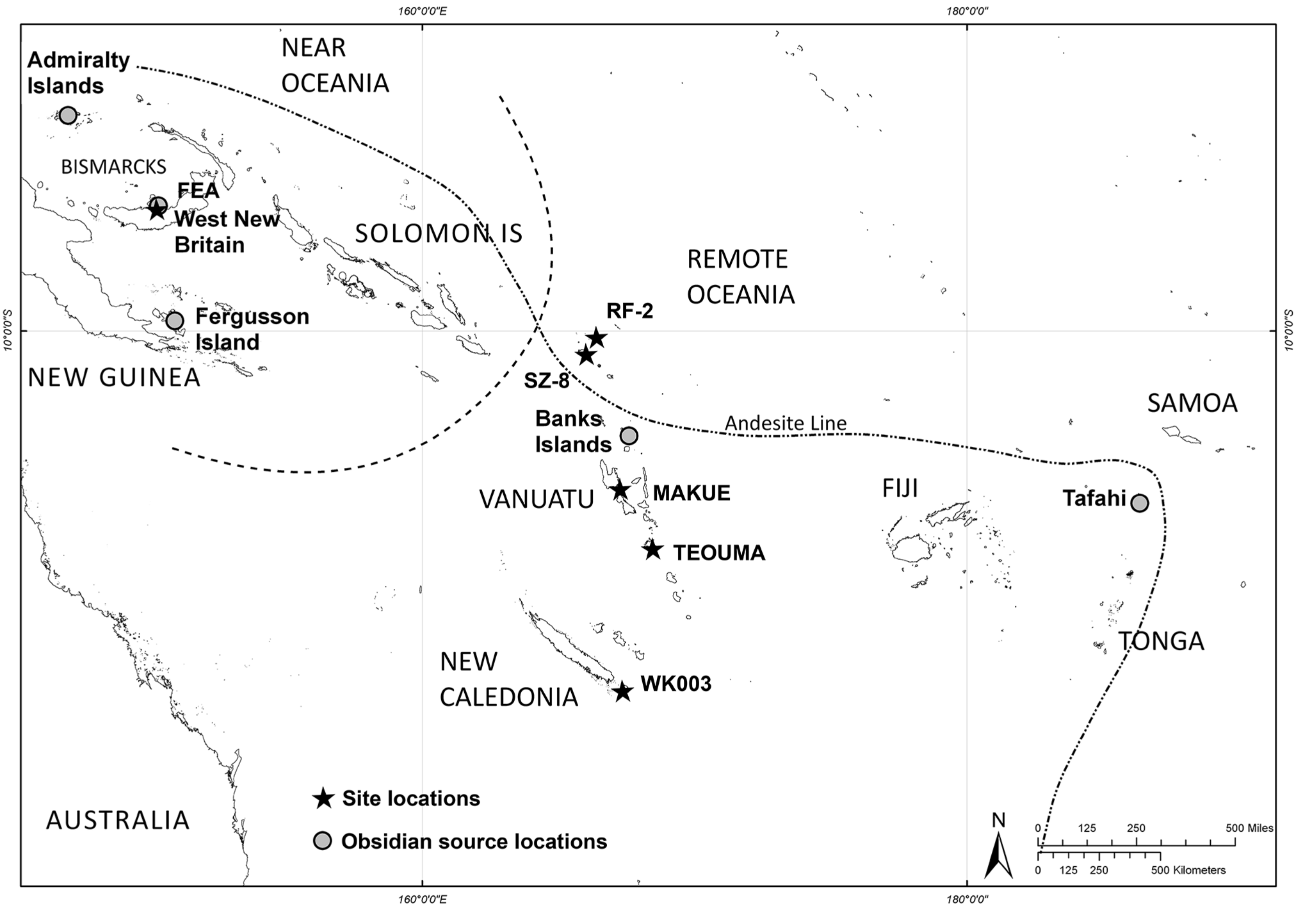

Figure 1. Map of the Western Pacific Islands showing the location of sites discussed in the paper. The division between Near and Remote Oceania lies between the Solomon Islands and sites RF2 and SZ8. The andesite line marks the extent of the island arc geological feature in the Western Pacific.

Incorporating risk

Small groups of highly mobile people are susceptible to risks when engaging with new and unpredictable environments. Risk research is a wide field incorporating risk assessment, risk perception, decision analysis and behavioural responses (Cashdan, 1985: 455, 1990). In archaeological and anthropological applications, the term 'risk' covers several definitions: *effects of stochastic variation in the outcome associated with some behaviour* (Torrence, 1989; Winterhalder, 1986); *the probability of loss* (Wiessner, 1982); and *unpredictable resource variability* (Bamforth and Bleed, 1997).

The important concept of 'uncertainty' is linked to an actor's lack of knowledge about their environment in a situation. Uncertainty, therefore, focuses on a situation in which the actor makes decisions without full knowledge of the underlying probabilities (Cashdan, 1990). This is in contrast to risk, which describes the more objective state in which an individual makes a decision in full knowledge of the probabilities of variation (Clark, 1990). 'Coping with risk' modelling has found wide application, and responses to risk in human societies may include:

1. mobility, either residential or logistical mobility (Winterhalder, 1996)
2. storage, either food stuffs or social obligations (Halstead and O'Shea, 1982)
3. resource intensification (Bird and O'Connell, 2006)
4. resource diversification (Winterhalder, 1996)
5. group foraging (Bliege Bird *et al.*, 2002)
6. technological adaptation and innovation (Torrence, 1989), and
7. exchange, including information and objects (Cashdan, 1985, 1990).

Information exchange based on identity markers as a strategy to mitigate risk has recently been argued by Veth *et al.* (2011) in the context of the colonisation of the Australian continent. Here, in situations of small, highly mobile social groups, there is a high probability that encounters occurred that involved unfamiliar actors. In these contexts, markers of group identity might have mitigated antagonistic encounters and facilitated information exchange.

Sourcing obsidian artefacts in the Western Pacific

Five major obsidian source regions exist in the Western Pacific (Fig. 1): the Admiralty Islands and New Britain in the Bismarck Archipelago, Fergusson Islands of southeast Papua New Guinea, the Banks Islands of Vanuatu, and Tafahi in northern Tonga (Ambrose, 1976; Reepmeyer, 2008; Summerhayes, 2009; Summerhayes *et al.*, 2014). The Bismarck Archipelago obsidian deposits have a long history of research, with multiple sources in the Admiralty Islands (Pam Lin and Pam Mandian, Lou, Hahie, Lepong) and West New Britain (Kutau/Bao, Gulu, Baki, Hamilton and Mopir). Less research has been done of the sources of Fergusson Islands (Igwageta, Iaupolo, Fagalulu, Sanaroa, Aiasuna, Lomonai), the Banks Islands (Vanua Lava and Gaua) in Vanuatu and Tafahi in Tonga.

Kutau/Bao obsidian had its widest distribution during the Lapita period at ca 3100–3000 cal. BP when it was transported about 3500 km eastwards into Remote Oceania, where small numbers of pieces have been found in Lapita sites in Reef/Santa Cruz islands of the southeast Solomons, Tikopia and Vanuatu (Bird *et al*., 1981; Reepmeyer *et al*., 2011), New Caledonia (Sand and Sheppard, 2000) and Fiji (Ross-Sheppard *et al*., 2013). Large quantities of Kutau/Bao obsidian artefacts in Remote Oceania are limited to the Reef/Santa Cruz sites in the Solomon Islands (Sheppard, 1993). From the thousands of artefacts found at those sites, only 12 were sourced to Vanua Lava, 11 to the Lou in the Admiralty Islands and one piece to West Fergusson (Green, 1987; Green and Bird, 1989). Admiralty Island obsidian artefacts are very rare in Remote Oceania, and on Tikopia in the Solomon Islands it is only present in the earliest deposits (Kirch and Yen, 1982; Kirch, 1986; Spriggs *et al*., 2010; McCoy *et al*., 2020), and only one piece has been confirmed in Vanuatu (Ambrose, 1976; Reepmeyer *et al*., 2011: 218).

Until the excavation of the sites in northern and central Vanuatu only small quantities of obsidian were found beyond the Reef/Santa Cruz Islands (Galipaud and Swete-Kelly, 2007; Reepmeyer *et al*., 2011). Transportation of Banks Islands obsidian started with the earliest colonisation of northern and central Vanuatu (Galipaud and Swete-Kelly, 2007; Reepmeyer *et al*., 2011), and similarly in eastern Fiji, where late Lapita sites received obsidian from the Tafahi source in Tonga around 2700–2600 cal. BP (Reepmeyer *et al*., 2012).

Long-distance transportation of obsidian ceased after the Lapita period with the exception of Tikopia, where Admiralty Islands obsidian replaced Kutau/Bao obsidian in the late Lapita—post-Lapita phase around 2500 cal. BP (Kirch and Yen, 1982; Kirch, 1986; Spriggs *et al*., 2010; McCoy *et al*., 2020). Central Vanuatu did not receive any Bismarck Archipelago obsidian, and only a few pieces from the Banks Islands' sources reached neighbouring islands, indicating a low level of inter-island contacts. Around 1000 cal. BP Banks Islands obsidian was more frequent on neighbouring islands, reflecting increased in inter-island contacts (Reepmeyer, 2008), and around the same time Tongan obsidian reached Polynesian outliers to the west (McCoy *et al*., 2020).

Case study: Northern Vanuatu obsidian distribution patterns

Vanuatu (Fig. 1) is located at a critical crossroad for the colonisation of the Pacific Ocean (Bedford and Spriggs, 2008). It is the first archipelago south of Solomon Islands in the Western Pacific that was, crucially, uninhabited until the Lapita period at the end of the second Millennium cal. BP, and it acted as an important stepping-stone for colonising populations migrating East to Western Polynesia and South to New Caledonia (Bedford *et al*., 2019). The early archaeology of Vanuatu has seen significant advancements recently which showed that Lapita colonisation started in Vanuatu around 3000 cal. BP, was only very short-lived and underwent rapid changes, with new ceramic typologies appearing at around 2800–2700 cal. BP (Bedford *et al*., 2019).

Materials and methods

Sites included in this study

The interpretations presented in this study are based on the combination of geochemical (for methods, see Ambrose *et al*., 2009) and technological analysis (Andrefsky, 2005). The technological dataset covered 2441 artefacts drawn from recent excavations and legacy collections; sites from Vanuatu totalled 1990 artefacts (Table 1). The legacy collections included assemblages from the Torres Islands (Galipaud, 1998), Tikopia (held at the Bishop Museum, Hawaii; Kirch and Yen, 1982), and Pakea Island in the Banks Islands (held at the Australian National University, Canberra; Ward, 1979). The more recently excavated assemblages from Vanuatu covered sites on Mota Lava (Bedford and Spriggs, 2008) and Ambek on Vanua Lava (Reepmeyer, 2008) in the Banks Islands; Makue on Aore Island (Galipaud and Swete-Kelly, 2007; Galipaud *et al*., 2014); and Teouma on Efate Island (Reepmeyer, 2010; Reepmeyer *et al*., 2011). These data were compared to published data from the FEA site on Boduna Island, close to the Kutau/Bao source (Specht and Summerhayes, 2007), SZ-8 on Nanggu and RF-2 on Nenumbo in the Reef/Santa Cruz Islands (Sheppard, 1993) and KVO003 site (St Maurice/Vatcha) on the Île des Pins, New Caledonia (Sand and Sheppard, 2000).

Ambek, Vanua Lava Island

The village of Ambek is located on the western side of Vanua Lava close the Bemon River, which is a secondary source of Vanua Lava obsidian (Reepmeyer, 2008). Two 1×1 m test pits were dug to analyse the stratigraphy of the area. Test pit 1 was excavated in the village area near a local house above the river inside a dense concentration of surface obsidian artefacts and test pit 2 in close vicinity of the Bemon River. Both sites were excavated to 70 cm under surface and revealed dense obsidian artefact concentrations in the topmost 30 cm in a dark grey-brown silty sand. The artefact-bearing layers were dated to 374±30 BP (charcoal; Wk-19647) and 390±31 BP (charred nutshell; Wk-19648) respectively (Bedford and Spriggs, 2008).

Lequesdewen, Mota Lava Island

Several surface concentrations of ceramics and obsidian occur on a reef deposit uplifted to 5–8 m above current sea level and at approximately 200 m from the western shoreline of Mota Lava Island. The site is within the current village and the spoil heaps of material dug up by the local population include pottery fragments and large amounts of shell. A 1×1 m test pit in the centre of a raised area revealed cultural deposits overlying a sterile beach at 90 cm below surface. Bedford and Spriggs (2014) identified the site as Lapita-age in several additional sondages.

Saywoume, Mota Lava Island

Situated approximately 700 m inland from the western shore of the island are several surface concentrations of ceramic fragments and a thin scatter of obsidian flakes. The area is a recent garden with several small mounds of shell, basalt fragments (fire-cracked rocks) and eroded pottery, most probably a result of gardening activities. Excavation of one mound revealed a stratigraphy of 70 cm with cultural materials. Two marine shell samples date the site to 1862±41 BP (Wk-21683) and 2078±35 BP (Wk-21684) (Reepmeyer, 2010).

Table 1. Summary of sites with basic statistics of the obsidian samples (in mm and g) used in the study; *na* = not available, $\bar{x}$ = mean; σ = standard deviation.

		West New Britain obsidian								Banks Islands obsidian								source / literature
site		weight		length		width		thickness		weight		length		width		thickness		
	N	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	
Papua New Guinea, Bismarcks																		
Boduna Island, FEA	963	3.5	*na*	*na*	*na*	*na*	*na*	*na*	*na*	—	—	—	—	—	—	—	—	Specht, 2002; Specht & Summerhayes, 2007
Solomons, Reef / Santa Cruz																		
Nanggu, SZ-8	329	2.4	3.1	19.6	12.4	18.6	7.8	5.6	2.7	—	—	—	—	—	—	—	—	Sheppard, 1993
Nenumbo, RF-2	625	1.9	2.9	18.6	7.0	17.3	7.2	5.2	3.1	—	—	—	—	—	—	—	—	Sheppard, 1993
Tikopia sites	451	—	—	—	—	—	—	—	—	1.0	1.8	15.1	5.1	13.7	5.3	4.5	1.8	new data
Vanuatu																		
Aore Island, Makue	61(20)	0.9	*na*	16.6	*na*	*na*	*na*	3.7	*na*	1.8	*na*	20.2	*na*	*na*	*na*	5.1	*na*	Galipaud & Swete-Kelly, 2007
Efate, Teouma	48(6)	1.1	1.1	16.1	6.1	14.2	5.8	5.1	2.6	2.4	1.3	22.6	6.2	17.0	3.8	7.0	2.0	Reepmeyer, 2010; new data
Vanua Lava, Ambek	454	—	—	—	—	—	—	—	—	2.1	2.6	18.8	6.4	16.1	6.1	5.9	2.8	new data
Pakea Island, Pakea	851	—	—	—	—	—	—	—	—	1.7	*na*	*na*	*na*	*na*	*na*	*na*	*na*	Ward, 1979
Mota Lava, Lequesdewen (early)	34	—	—	—	—	—	—	—	—	1.3	2.1	15.7	6.5	13.7	6.6	5.4	3.4	new data
Mota Lava sites (late)	223	—	—	—	—	—	—	—	—	1.7	2.0	17.9	6.5	13.5	5.5	5.3	2.5	new data
Torres Islands sites	319	—	—	—	—	—	—	—	—	1.4	1.8	16.4	5.5	14.2	5.1	5.4	2.6	new data
New Caledonia																		
St Maurice/Vatcha, KV0003	4	0.3	0.3	14.5	7.5	9.3	5.2	2.0	1.4	—	—	—	—	—	—	—	—	Sand & Sheppard, 2000

Pakea, Pakea Island

Graeme Ward's (1979) excavations on Pakea Island in 1973–1974 revealed a stratigraphy of episodic habitation from the early third millennium BP until about 1000 BP. The initial occupation (layer III) dated to between 3100 BP and 2400 BP is separated from the later deposits by a sterile beach deposit. Reoccupation occurred in Layer II between 2400 BP and 2000 BP and probably ended around 1000–800 BP. Based on this gap in dates and differences in the appearance and structure of the sediment, Ward (1979) assumed an occupation hiatus of about 500–600 years, after which habitation of the site was continuous until the final abandonment of the site sometime after 1000 AD.

Teouma, Efate Island

Details of the lithic assemblage of the Teouma site have been published in Reepmeyer *et al*. (2011) and Constantine *et al*. (2015). The cemetery site was excavated from 2004 to 2016 and is dated to 3000–2700 cal. BP (Bedford and Spriggs, 2014; Petchey *et al*., 2014). The analysed obsidian was only found in the earliest midden deposits or associated with burial fill.

Torres Islands

The Torres Islands are the northernmost island group of Vanuatu. Surface surveys on Tegua and Toga Islands by Galipaud (1998) located several archaeological sites with occupation records covering approximately 2500 years. Eight obsidian artefacts found on the surface of one site on Tegua were associated with non-obsidian flakes and mainly plainware and Mangaasi style pottery (Galipaud, 1998: 161–163). Excavations revealed a series of grey-brown and dark brown sandy soils that were interrupted in several test pits by a 10–20 cm layer of white sand that probably represents a tropical cyclone deposit. Above this was a 20–40 cm thick layer of dark brown humus. Obsidian artefacts, sherds and shells were found throughout the stratigraphy but were more common at about 30 cm below surface. The white sand deposits were mostly sterile and at about 75 cm below surface sealed grey silty sand containing much cultural material, especially pottery fragments and faunal remains. This series of sands and dark sandy-soils continued to approximately 110 cm below surface and overlay the sterile pre-occupation sediments. Two charcoal samples from levels predating sterile white sand produced dates of 2450±40 BP and 2460±40 BP (Galipaud, 1998: 167).

Tikopia sites

The largest quantity of Banks Islands obsidian found outside Vanautu was recovered on Tikopia where excavations revealed three habitation phases (Kirch and Yen, 1982). Recent re-dating of the sites has increased the chronological precision of the cultural sequence (Kirch and Swift, 2017). The colonisation phase (Kiki) started around 3000 cal. BP and was associated with a small amount of Lapita pottery. The post-Lapita Sinapupu phase possibly started as early as 2000 cal. BP or as late as 1600 cal. BP, and the Tuakamali phase lasted from ca 750 cal. BP until European contact. The obsidian assemblage available for re-analysis consisted of only 576 artefacts as 13 were destroyed for previous petrographic analysis using thin sections and 50 were not present in the accessible Bishop Museum collection. The sample analysed totalled 451 pieces (Table 1).

The obsidian samples and regression curves

The present study includes summary data about the mean weights, lengths, widths and thicknesses of the obsidian samples (Table 1). To facilitate inter-site comparisons, Specht (2002) used mean artefact weight as a proxy for the relative abundance of obsidian at sites. This has been argued to be a more robust assessment of raw material transportation as artefact numbers are notoriously skewed by post-depositional breakage, particularly of brittle raw materials such as obsidian (Hiscock, 2002).

Previous studies of obsidian distribution in the Pacific employed Renfrew's (1975) 'modes of exchange' to assess the likely nature of exchange systems: direct access, down-the-line, and central place distribution. In this scheme, communities that could have direct access to the source of raw material constitute the 'supply zone', beyond which is the 'contact zone' where populations cannot access the source of raw material directly but need intermediaries to acquire the raw material, and this is reflected in exponential fall-off of the quantities of goods. Differences in the shape of fall-off curves can be described as linear attenuation for direct access in the 'supply zone'. Outside of the supply zone, down-the-line exchange is identified through an exponential fall-off in the 'contact zone'. Central places are adding discrete peaks of higher artefact abundances in the 'contact zone'.

To assess the likely modes of exchange this study uses the shape of regression curves of mean artefact weights against distance from the source area, as best-fit regression curves investigate the relationships between independent variables. Most applied is linear regression, where a series of datapoints are used to predict unknown parameters in a population (SPSS, 2006). Non-linear regression curves use successive approximations where data is modelled based on specific calculations, which take only parts of the population into account. These can be exponential, logarithmic or polynomial calculations, and commonly result in better curve fittings.

Results

If we assume that there is a change in the mode of transportation, for example establishing a 'contact zone' where abundances change significantly, linear regression curves will show lower correlation coefficients than non-linear regression curves. A test for this assumption is to calculate both linear and non-linear regression curves for the dataset (Fig. 2A). Best-fit regression curve estimates for Kutau/Bao obsidian show highest correlation with a cubic curve ($r^2 = 0.970$). The shape of the curve with two points of inversion lends support to the down-the-line model. The best-fit estimate displays a sharp drop in mean weights in Vanuatu sites compared to the Reef/Santa Cruz sites and support this hypothesis. The significantly smaller quantities of obsidian artefacts found in Vanuatu and the decrease in mean weight of artefacts support the hypothesis that Kutau/Bao obsidian in Vanuatu did not originate directly from the source, but through down-the-line transfer through the Reef/Santa Cruz sites as intermediaries. This further indicates that a multi-staged transport system might have been an essential part of the colonising strategy of Lapita dispersal.

the distribution of Banks Islands obsidian, the spatial pattern appears to be different. Sites at or near the Banks Islands' obsidian source did not contain evidence for the earliest colonisation phase (Fig. 2B). Therefore, distribution patterns must be inferred from the measurement of artefacts found at distance from the source. There are no strong indicators for down-the-line exchange or resource maximisation techniques at any site throughout the distribution area. On the contrary, especially during the initial colonisation phase and directly post-Lapita, all measured physical attributes show increasing values (Table 1). The spatial distribution does not correlate easily with Renfrew's modes of exchange, as there are no distinctive fall-off patterns. One possible explanation for these random patterns is 'embedded procurement' (Binford, 1979; Torrence *et al*., 1996), whereby people with high settlement mobility obtained raw material in the course of other activities not related to raw material procurement.

In the post-Lapita period this pattern does not change. The Banks Islands' sites continue to show a mixed pattern, whereas elsewhere mean weight decreases with distance from the source. This is particularly evident in the Torres Islands and Tikopia. However, best-fit curves do not reveal significant difference between the linear and polynomial regression curves, which implies that raw material distribution is best explained with direct access.

Assessing the value of obsidian

Hodder (1974, 1978) advanced Renfrew's mathematical exchange models in several publications focussing of identifying equifinality. He used a regression formula that describes the form and steepness of the fall-off curve:

$\text{Log } Y = a - bX\alpha + e$

Here, 'a' represents Y when X = 0; 'b' describes the reverse proportionality of X and Y; and 'e' is the 'standard error of the estimate' (Hodder and Orton, 1976). Torrence (1986) successfully applied this formula in her analysis of the production and distribution of obsidian in the Mediterranean. In the regression analysis, α can be correlated with the value of certain items; for example, low values of α (0.1–0.6) show that items were distributed only over short distances, whereas high values (0.9–2.5), would indicate prestige items.

Relating the steepness of the regression curve for Kutau/Bao obsidian outside of the supply zone with Hodder's equation (Table 2) for mean weight and mean maximum length of artefacts, low values of α have the highest correlation. The most significant correlations ($\delta < 0.01$) are between $0.4 < \alpha < 0.6$. Interestingly, mean maximum length shows a high correlation with $\alpha = 0$ (both significance at $\delta < 0.01$). In general, low values for α imply that obsidian was not a highly valued commodity and cannot be identified as a prestige good. The correlation of curve steepness with α-values is even more pronounced for Banks Islands obsidian (Table 2). In the correlation of distance-decay characteristics α-values of zero score highest and are the only ones statistically significant in the evaluation of nearly all attributes. Additionally, if other values score high in the correlation matrix ($p > 0.99$), then they usually have low α-values (< 0.6).

Discussion

What makes obsidian special? Torrence (2005) posed this question in her important paper on understanding the value of obsidian and its distribution in the Western Pacific. She argued that it is not only the association of obsidian with 'distant people, places and times' that can explain its wide distribution obsidian, but also its physical attributes of brilliance, translucency and colour that are important factors in making it a desirable raw material. Other qualities are its scarcity in terms of natural occurrence and its sharpness.

It has previously been argued that early Lapita sites in the Reef/Santa Cruz Islands, which are at a significant distance from the Kutau/Bao obsidian source, received obsidian through direct contact with the Lapita 'homeland' (Sheppard, 1993, 2011; Halsey, 1995). The results of the present study support that position. It has also been suggested that sites in Vanuatu did not receive Kutau/Bao obsidian directly from the supply zone but were indirectly connected to it through the Solomon Islands (Reepmeyer *et al*., 2011; Constantine *et al*., 2015). The present study supports those conclusions, but it also shows that obsidian distribution in the Western Pacific did not follow simple economic models of resource acquisition. We can detect some forms of distance decay and resource optimisation processes in the abundances of

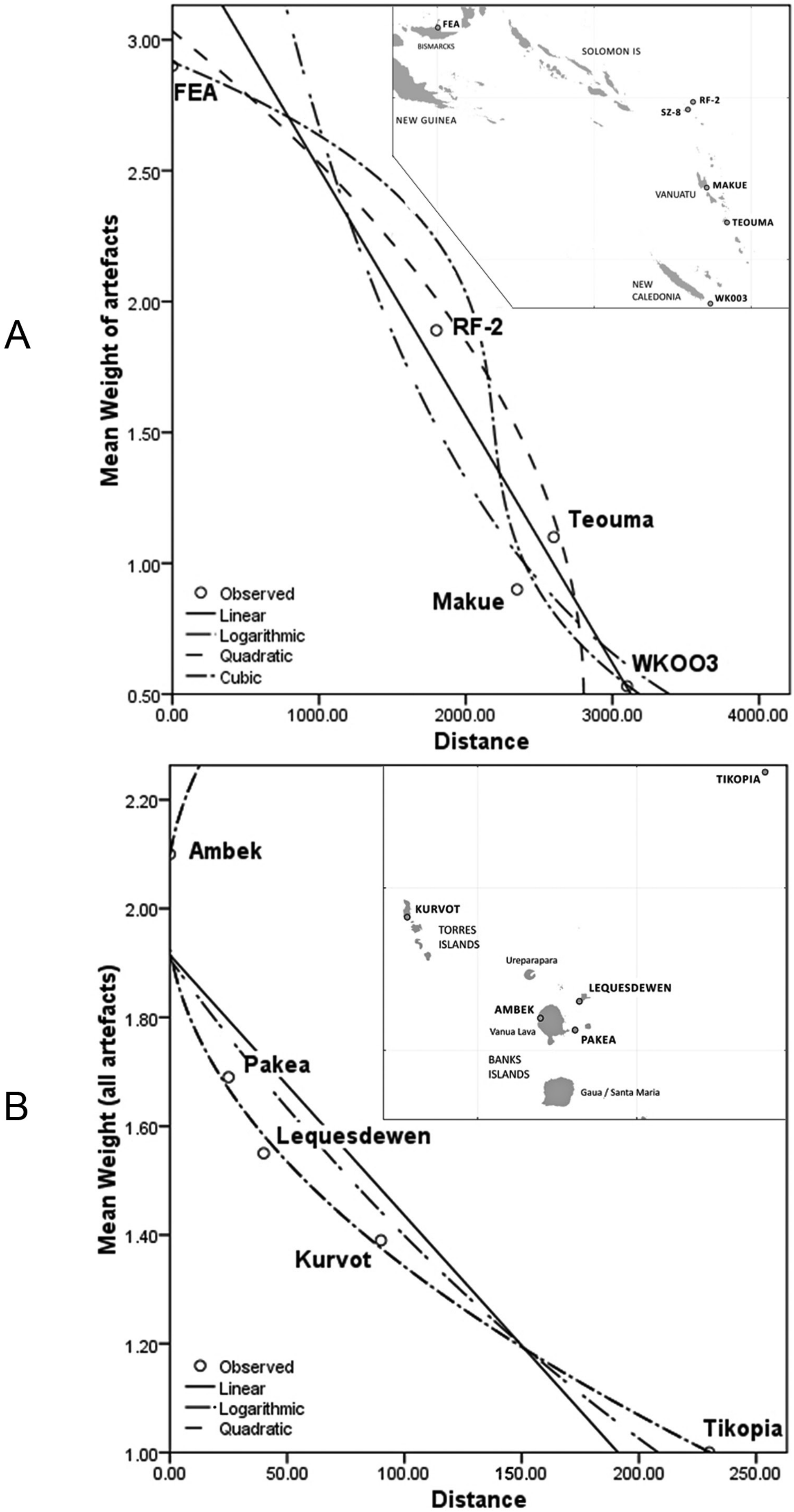

Figure 2. Best-fit estimation regression curves for mean weights (g) and lengths (mm) of West New Britain (*A*) and Banks Islands (*B*) obsidian artefacts against distance from the source.

Table 2. Pearson's correlation coefficient—summary statistics for selected variables for Kutau/Bao (New Britain) and Banks Island obsidian.

value for α	correlation and significance	West New Britain obsidian		Northern Vanuatu obsidian	
		mean weight (log Y) N = 4	mean length (log Y) N = 4	mean weight (log Y) N = 5	mean length (log Y) N = 4
linear					
α = 0	Pearson Correlation	0.977*	0.999**	0.992**	0.999**
		0.023	0.001	0.001	0.001
exponential					
α = 0.1	Pearson Correlation	0.946	0.907	0.874	0.897
	Sig. (2-tailed)	0.054	0.093	0.063	0.103
α = 0.2	Pearson Correlation	0.958*	0.934	0.946*	0.949
	Sig. (2-tailed)	0.042	0.066	0.015	0.051
α = 0.3	Pearson Correlation	0.965*	0.956*	0.985**	0.981*
	Sig. (2-tailed)	0.035	0.044	0.002	0.019
α = 0.4	Pearson Correlation	0.968*	0.973*	0.998**	0.995**
	Sig. (2-tailed)	0.042	0.027	0.000	0.005
α = 0.5	Pearson Correlation	0.967*	0.986*	0.996**	0.998**
	Sig. (2-tailed)	0.033	0.014	0.000	0.002
α = 0.6	Pearson Correlation	0.963*	0.994**	0.984**	0.992**
	Sig. (2-tailed)	0.037	0.006	0.002	0.008
α = 0.7	Pearson Correlation	0.956*	0.998**	0.969**	0.980*
	Sig. (2-tailed)	0.044	0.002	0.007	0.020
α = 0.8	Pearson Correlation	0.947	0.999**	0.952*	0.966*
	Sig. (2-tailed)	0.053	0.001	0.013	0.034
α = 0.9	Pearson Correlation	0.936	0.998**	0.935*	0.951*
	Sig. (2-tailed)	0.064	0.002	0.020	0.049
α = 1	Pearson Correlation	0.924	0.994**	0.920*	0.935
	Sig. (2-tailed)	0.076	0.006	0.027	0.065
α = 1.5	Pearson Correlation	0.858	0.955*	0.858	0.869
	Sig. (2-tailed)	0.142	0.045	0.063	0.131
α = 2	Pearson Correlation	0.800	0.910	0.820	0.824
	Sig. (2-tailed)	0.200	0.090	0.089	0.176

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

obsidian between Reef/Santa Cruz sites and sites in Vanuatu, with obsidian artefacts becoming significantly smaller the further Lapita people penetrated the western Pacific; but the discard of most artefacts was not connected to increased use.

Purely functional approaches to the transportation of obsidian, whether for its sharp edges or as an item for special functions such as tattooing, do not unambiguously explain the discard of small, hardly used artefacts. Singular artefacts, for example the retouched artefacts in New Caledonia and Fiji, might indicate that the symbolic importance of obsidian in ritual behaviours was a factor in transportation over such distances. On the other hand, these sites also have very few artefacts, which follows the pattern of discard in Vanuatu. At the cemetery site of Teouma only a limited number of artefacts occurred with the burials, and most were found in the midden adjacent to the site (Constantine *et al*., 2015: table 2). The lack of economising behaviour of obsidian utilisation led Earle and Spriggs (2015: 521) to propose that obsidian did not contain social meaning as the created artefacts are 'small and minimally modified flakes would have been unsuited to carry social meaning.' Unfortunately, this approach does not explain the transport of obsidian raw material over thousands of kilometres.

Contrary to these interpretations, I advocate the idea that the value of this raw material derived from the idea of a common origin. Rather than re-creating social worlds (Kirch, 1988; Specht, 2002), the founding Lapita communities in Remote Oceania used obsidian to mark group affiliation in unknown territory where the risk of meeting unfamiliar actors was high and might include antagonistic encounters. This interpretation echoes Chiu's (2007) view of the highly decorated Lapita pottery as also signalling group membership. Chiu argued that specific designs (primarily face motifs) were symbols that facilitated participation in social networks. Relationships created and reinforced through these symbols could, independently of ancestry, enhance engagement with distant communities while colonising new lands (Terrell and Welsch, 1997).

This hypothesis is based on three indicators. First, it is unclear from the archaeological record whether an exchange system for Kutau/Bao obsidian existed at all in Remote Oceania. Sheppard (2011) proposed that the distribution of obsidian could have resulted from direct access and an heirloom effect whereby the obsidian accompanied the colonists on their voyages. Second, if re-creation of social worlds was the main objective of obsidian transportation, it is hard to explain the breakdown of long-distance transport into Remote Oceania at the end of Lapita. Third, it is unlikely that a secondary migration (Posth *et al*., 2018; Spriggs and Reich, 2019) caused this breakdown, as obsidian exchange in the Bismarck Archipelago was apparently not impacted by social disruptions which might have occurred in contact situations (Summerhayes, 2009).

What then was the difference between the Solomon

Islands and Vanuatu that caused the import of obsidian to cease after people migrated further south? At the core of Sheppard's (2011) 'leap frogging' model of early Lapita migration through the Solomon Islands is the hypothesis that the early migrants targeted uninhabited islands with pristine resources and, therefore, they most likely by-passed already populated islands in the main Solomon Island chain. Here, the hypothesis of obsidian as a marker of group identity provides support, as the need for the group identity marker stopped once uninhabited islands were found.

The distribution of Banks Islands obsidian, on the other hand, differs significantly from that of Kutau/Bao obsidian. In the earliest period, its distribution followed irregular trend curves with no indication of distant decay, indicating likely direct access to sources. As a raw material, Banks Islands obsidian was most likely not in as much demand as Kutau/Bao obsidian, as its distribution also points to changing patterns of raw material association (Reepmeyer *et al*., 2011). Banks Islands obsidian never travelled long distances so we cannot assume that the social role of Kutau/Bao obsidian was replaced by Banks Islands' obsidian. The Banks Islands' obsidian reached the Reef/Santa Cruz islands, but only in small numbers. On Tikopia the use of Banks Islands' obsidian only increased significantly after 1000 BP, and there is a clear pattern of distance decay. This increase did not spatially extend the area of distribution or result in the development of more complex exchange networks, as the results show that acquisition of Banks Islands' obsidian was by direct access.

Formal exchange systems for the distribution of obsidian were not detected in either the Lapita or post-Lapita phase. If socio-political transformations in these periods resulted from changes in prestige-good exchange systems which included obsidian (Friedman, 1981; Spriggs, 1997: 156), then we must be cautious as it has been suggested above that an exchange network might not have existed. Intensification of a short-distance exchange network did not directly supersede long-distance transportation of obsidian, but instead there was a long hiatus of limited inter-island communication. However, contra Earle's and Spriggs' (2015) notion that obsidian transportation had no meaning, I argue that the meaning, and thus the usefulness of obsidian disappeared with the establishment of larger populations on islands where communication and interaction were maintained through means other than obsidian as a marker of group identity and where independent regional trajectories of cultural development became prevalent.

Conclusions

The transportation of obsidian from West New Britain and local sources in northern Vanuatu had its widest spatial extension in Remote Oceania during the initial colonisation phase. The Reef/Santa Cruz sites appear to have been within the supply zone for Kutau/Bao obsidian, and so maintained contact with the homeland. Colonisation sites further from the New Britain source, such as Makue and Teouma in Vanuatu, were probably not connected directly to the homeland, but most likely received Kutau/Bao obsidian through the Reef Santa Cruz sites as intermediaries. In contrast, the physical attributes of Banks Islands obsidian artefacts do not unambiguously support one specific mode of exchange, and access to the raw material probably included 'embedded procurement' at the sources.

The statistical analysis fall-off curves allowed assessment of the social value of obsidian in Renfrew's framework of modes of exchange and exploration of motives for the transportation of raw material over such long distances. Obsidian most likely had low economic value, so its contextualisation in an economic framework is not sufficient to understand the archaeological distribution patterns. We must consider alternative ascriptions of value for the Lapita phase, for example the importance of symbols of group affiliation. In risk management, we should not underestimate the importance of easy identification of group affiliation in unpredictable situations when colonising new territories.

The use of symbols of communication did not persisted throughout the long period of low-level interaction after Lapita in which different groups on separate islands developed their own expressions of cultural identity. These communication networks did not result in the development of more complex exchange networks—at least not for obsidian—as the study identified direct access as the mode of distribution for Banks Islands obsidian in later times.

In a theoretical framework of risk minimisation in which interaction intensifies when unpredictable environments increase uncertainty, obsidian as a symbol of group identity might have constituted an easy medium for communication.

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References

Ambrose, W. R. 1976. Obsidian and its prehistoric distribution in Melanesia. In *Ancient Chinese Bronzes and South East Asian Metal and Other Archaeological Artifacts*, ed. N. Barnard, pp. 351–378. Melbourne: National Gallery of Victoria.

Ambrose, W. R., C. Allen, S. O'Connor, M. Spriggs, N. V. Oliveira, and C. Reepmeyer. 2009. Possible obsidian sources for artefacts from Timor: narrowing the options using chemical data. *Journal of Archaeological Science* 36(3): 607–615.
https://doi.org/10.1016/j.jas.2008.09.022

Andrefsky, W. 2005. *Lithics: Macroscopic Approaches to Analysis. Cambridge Manuals in Archaeology*. 2nd edn. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511810244

Anthony, D. W. 1990. Migrations in archeology: the baby and the bathwater. *American Anthropologist* 92(4): 895–914.
https://doi.org/10.1525/aa.1990.92.4.02a00030

Appadurai, A. 1986. Introduction: commodities and the politics of value. In *The Social Life of Things*, ed. A. Appadurai, pp. 3–63. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511819582.003

Araho, N., R. Torrence, and J. P. White. 2002. Valuable and useful: mid-Holocene stemmed obsidian artefacts from West New Britain, Papua New Guinea. *Proceedings of the Prehistoric Society* 68: 61–81.
https://doi.org/10.1017/S0079497X00001444

Bamforth, D. B., and P. Bleed. 1997. Technology, flaked stone technology and risk. In *Rediscovering Darwin: Evolutionary Theory and Archaeological Explanation*, ed. C. M. Barton and G. A. Clark, pp. 109–139. Washington DC: American Anthropological Association.
https://doi.org/10.1525/ap3a.1997.7.1.109

Bedford, S. 2019. Lapita pottery from the small islands of north-east Malakula, Vanuatu: a brief overview and implications. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 225–240. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.11

Bedford, S., and M. Spriggs. 2008. Northern Vanuatu as a Pacific crossroads. The archaeology of discovery, interaction, and the emergence of the ethnographic present. *Asian Perspectives* 47(1): 95–120.
https://doi.org/10.1353/asi.2008.0003

Bedford, S., and M. Spriggs. 2014. The archaeology of Vanuatu: 3,000 years of history across islands of ash and coral. In *The Oxford Handbook of Prehistoric Oceania*, ed. E. Cochrane and T. Hunt, pp. 1–17. Oxford: Oxford University Press.
https://doi.org/10.1093/oxfordhb/9780199925070.013.015

Bedford, S., M. Spriggs, D. V. Burley, C. Sand, P. J. Sheppard, and G. R. Summerhayes. 2019. Debating Lapita: distribution, chronology, society and subsistence. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 5–36. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.01

Bellwood, P. 2011. Holocene population history in the Pacific region as a model for worldwide food producer dispersals. *Current Anthropology* 52 (Supplement 4): S363–S377.
https://doi.org/10.1086/658181

Binford, L. R. 1979. Organization and formation processes: looking at curated technologies. *Journal of Anthropological Research* 35: 255–273.
https://doi.org/10.1086/jar.35.3.3629902

Bird, J. R., P. Duerden, W. R. Ambrose, and B. F. Leach. 1981. Pacific obsidian catalogue. In *Lithic Resources of the Pacific Region*, ed. B. F. Leach, pp. 31–43. Oxford: BAR.

Bird, D. W., and J. F. O'Connell. 2006. Behavioral ecology and archaeology. *Journal of Archaeological Research* 14(2): 143–188.
https://doi.org/10.1007/s10814-006-9003-6

Bliege Bird, R., D. W. Bird, E. A. Smith, and G. C. Kushnick. 2002. Risk and reciprocity in Meriam food sharing. *Evolution and Human Behavior* 23(4): 297–321.
https://doi.org/10.1016/S1090-5138(02)00098-3

Cashdan, E. 1985. Coping with risk: reciprocity among the Basarwa of northern Botswana. *Man* 20(3): 454–474.
https://doi.org/10.2307/2802441

Cashdan, E. 1990. Information, costs and customary prices. In *Risk and Uncertainty in Tribal and Peasant Economies*, ed. E. Cashdan, pp. 259–278. Boulder: Westview Press.

Chiu, S. 2007. Detailed analysis of Lapita face motifs: case studies from Reef/Santa Cruz Lapita sites and New Caledonia Lapita site 13A. In *Oceanic Explorations: Lapita and Western Pacific Settlement*, ed. S. Bedford, C. Sand, and S. P. Connaughton, pp. 241–264. Terra Australis 26. Canberra: ANU E Press.
https://doi.org/10.22459/TA26.2007.15

Clark, C. W. 1990. Uncertainty in economics. In *Risk and Uncertainty in Tribal and Peasant Economies*, ed. E. Cashdan, pp. 1–16. Boulder: Westview Press.

Constantine, A., C. Reepmeyer, S. Bedford, M. Spriggs, and M. Ravn. 2015. Obsidian distribution from a Lapita cemetery sheds light on its value to past societies. *Archaeology in Oceania* 50(2): 111–116.
https://doi.org/10.1002/arco.5064

Earle, T. K. 1997. Exchange in Oceania: search for evolutionary explanations. In *Prehistoric Long-Distance Interaction in Oceania: An Interdisciplinary Approach*, ed. M. I. Weisler, pp. 224–237. New Zealand Archaeological Association Monograph 21. Auckland: New Zealand Archaeological Association.

Earle, T. K., and M. Spriggs. 2015. Political economy in prehistory: a Marxist approach to Pacific sequences. *Current Anthropology* 56(4): 515–544.
https://doi.org/10.1086/682284

Fredericksen, C. F. K. 1994. *Patterns in Glass: Obsidian and Economic Specialisation in the Admiralty Islands*. Unpublished PhD thesis, Australian National University, Canberra.

Friedman, J. 1981. Notes on structure and history in Oceania. *Folk* 23: 275–295.

Galipaud, J.-C. 1998. Recherches archéologiques aux Îles Torres. *Journal de la Société des Océanistes* 107(2): 159–168.
https://doi.org/10.3406/jso.1998.2055

Galipaud, J.-C., C. Reepmeyer, R. Torrence, S. J. Kelloway, and J. P. White. 2014. Long-distance connections in Vanuatu: new obsidian characterisations for the Makue site, Aore Island. *Archaeology in Oceania* 49(2): 110–116.
https://doi.org/10.1002/arco.5030

Galipaud, J.-C., and M. C. Swete-Kelly. 2007. Makue (Aore Island, Santo, Vanuatu): a new Lapita site in the ambit of New Britain obsidian distribution. In *Oceanic Explorations: Lapita and Western Pacific Settlement*, ed. S. Bedford, C. Sand, and S. P. Connaughton, pp. 151–162. Terra Australis 26. Canberra: ANU E Press.
https://doi.org/10.22459/TA26.2007.08

Graeber, D. 2001. *Toward An Anthropological Theory of Value: The False Coin of Our Own Dreams*. New York: Palgrave.
https://doi.org/10.1057/9780312299064

Grattan, J., and R. Torrence, eds. 2007. *Living Under the Shadow: Cultural Impacts of Volcanic Eruptions*. Walnut Creek (California): Left Coast Press.

Green, R. C. 1987. Obsidian results from the Lapita sites of the Reef/Santa Cruz Islands. In *Archaeometry: Further Australasian Studies*, ed. W. R. Ambrose and J. M. J. Mummery, pp. 239–249. Canberra: Department of Prehistory, Australian National University and National Gallery of Australia.

Green, R. C. 2003. The Lapita horizon and traditions—signature for one set of Oceanic migrations. In *Pacific Archaeology: Assessments and Prospects. Proceedings of the International Conference for the 50th Anniversary of the First Lapita Excavation, Koné-Nouméa 2002*, ed. C. Sand, pp. 95–120. Les Cahiers de l'Archéologie en Nouvelle-Calédonie 15. Noumea: Service des Musées et du Patrimoine de Nouvelle-Calédonie.

Green, R. C., and J. R. Bird. 1989. Fergusson Island obsidian from the d'Entrecasteaux Group in a Lapita site of the Reef Santa Cruz group. *New Zealand Journal of Archaeology* 11: 87–99.

Green, R. C., and P. V. Kirch. 1997. Lapita exchange systems and their Polynesian transformations: seeking explanatory models. In *Prehistoric Long-Distance Interaction in Oceania: an Interdisciplinary Approach*, ed. M. I. Weisler, pp. 19–37. New Zealand Archaeological Association Monograph 21. Auckland: New Zealand Archaeological Association.

Gregory, C. A. 1982. *Gifts and Commodities*. London: Academic Press.

Halsey, A. 1995. *Obsidian Resource Maximisation. A Comparison of Two Lapita Assemblages*. Unpublished BA (Hons) thesis, La Trobe University, Melbourne.

Halstead, P., and J. O'Shea. 1982. A friend in need is a friend indeed: social storage and the origins of social ranking. In *Ranking, Resource and Exchange*, ed. C. Renfrew and S. Shennan, pp. 92–99. Cambridge: Cambridge University Press.

Hanslip, M. D. 2001. *Expedient Technologies? Obsidian Artefacts in Island Melanesia*. Unpublished PhD thesis, Australian National University, Canberra.

Hiscock, P. 2002. Quantifying the size of artefact assemblages. *Journal of Archaeological Science* 29(3): 251–258.
https://doi.org/10.1006/jasc.2001.0705

Hodder, I. 1974. Regression analysis of some trade and marketing patterns. *World Archaeology* 6(2): 172–189.
https://doi.org/10.1080/00438243.1974.9979600

Hodder, I. 1978. Some effects of distance on patterns of human interaction. In *The Spatial Organisation of Culture*, ed. I. Hodder, pp. 155–178. Norwich: Duckworth.

Hodder, I., and C. Orton. 1976. *Spatial Analysis in Archaeology*. Cambridge: Cambridge University Press.

Kirch, P. V. 1986. Exchange systems and inter-island contact in the transformation of an island society: the Tikopia case. In *Island Societies: Archaeological Approaches to Evolution and Transformation*, ed. P. V. Kirch, pp. 33–41. Cambridge: Cambridge University Press.

Kirch, P. V. 1988. Long-distance exchange and island colonization: the Lapita case. *Norwegian Archaeological Review* 21(2): 103–117.
https://doi.org/10.1080/00293652.1988.9965475

Kirch, P. V. 1997. *The Lapita Peoples: Ancestors of the Oceanic World*. Cambridge (Mass.): Blackwell Publishers.

Kirch, P. V., and J. A. Swift. 2017. New AMS radiocarbon dates and a re-evaluation of the cultural sequence of Tikopia Island, southeast Solomon Islands. *Journal of the Polynesian Society* 126(3): 313–336.
https://doi.org/10.15286/jps.126.3.313-336

Kirch, P. V., and D. E. Yen. 1982. *Tikopia: The Prehistory and Ecology of a Polynesian Outlier*. Bernice P. Bishop Museum Bulletin 238. Honolulu: Bishop Museum Press.

Kononenko, N. A. 2012. Middle and late Holocene skin-working tools in Melanesia: tattooing and scarification? *Archaeology in Oceania* 47(1): 14–28.
https://doi.org/10.1002/j.1834-4453.2012.tb00111.x

Kononenko, N. A., S. Bedford, and C. Reepmeyer. 2010. Functional analysis of late Holocene flaked and pebble stone artefacts from Vanuatu, southwest Pacific. *Archaeology in Oceania* 45(1): 13–20.
https://doi.org/10.1002/j.1834-4453.2010.tb00073.x

Lilley, I. 2000. Migration and ethnicity in the evolution of Lapita and post-Lapita maritime societies in northwest Melanesia. In *East of Wallace's Line: Studies of Past and Present Maritime Cultures of the Indo-Pacific Region*, ed. S. O'Connor and P. M. Veth., pp. 177–195. Rotterdam: A. A. Balkema.

Lilley, I. 2019. Lapita: the Australian connection. In *Debating Lapita: Distribution, Chronology, Society and Subsistence*, ed. S. Bedford and M. Spriggs, pp. 105–114. Terra Australis 52. Canberra: ANU Press.
https://doi.org/10.22459/TA52.2019.05

McBryde, I. 1997. 'The landscape is a series of stories.' Grindstones, quarries and exchange in Aboriginal Australia: a Lake Eyre case study. In *Siliceous Rocks and Culture*, ed. A. Ramos-Millan and M. A. Bustillo, pp. 587–606. Granada: Universidad de Granada.

McCoy, M. D., C. Cervera, M. A. Mulrooney, A. McAlister, and P. V. Kirch. 2020. Obsidian and volcanic glass artifact evidence for long-distance voyaging to the Polynesian outlier island of Tikopia. *Quaternary Research* 98: 49–57.
https://doi.org/10.1017/qua.2020.38

Petchey, F., M. Spriggs, S. Bedford, F. Valentin, and H. Buckley. 2014. Radiocarbon dating of burials from the Teouma Laptita cemetery, Efate, Vanuatu. *Journal of Archaeological Science* 50: 227–242.
https://doi.org/10.1016/j.jas.2014.07.002

Posth, C., K. Nägele, H. Colleran, F. Valentin, S. Bedford, K. W. Kami, R. Shing, H. Buckley, R. Kinaston, M. Walworth, G. R. Clark, C. Reepmeyer, J. Flexner, T. Maric, J. Moser, J. Gresky, L. Kiko, K. J. Robson, K. Auckland, S. J. Oppenheimer, A. V. S. Hill, A. J. Mentzer, J. Zech, F. Petchey, P. Roberts, C. Jeong, R. D. Gray, J. Krause, and A. Powell. 2018. Language continuity despite population replacement in Remote Oceania. *Nature Ecology and Evolution* 2(4): 731–740.
https://doi.org/10.1038/s41559-018-0498-2

Preucel, R. W., and I. Hodder. 1996. The production of value. In *Contemporary Archaeology in Theory: A Reader*, ed. R. W. Preucel and I. Hodder, pp. 99–113. Oxford: Blackwell Publishers.

Reepmeyer, C. 2008. Characterising volcanic glass sources in the Banks Islands, Vanuatu. *Archaeology in Oceania* 43(2): 120–127.
https://doi.org/10.1002/j.1834-4453.2009.tb00038.x

Reepmeyer, C. 2010. *Obsidian Sources and Distribution Systems Emanating from Gaua and Vanua Lava on the Banks Islands of Vanuatu*. Unpublished PhD thesis, Australian National University, Canberra.

Reepmeyer, C., M. Spriggs, S. Bedford, and W. R. Ambrose. 2011. Provenance and technology of lithic artefacts from the Teouma Lapita site, Vanuatu. *Asian Perspectives* 49(1): 205–225.
https://doi.org/10.1353/asi.2010.0004

Reepmeyer, C., G. R. Clark, and P. J. Sheppard. 2012. Obsidian source use in Tongan prehistory: new results and implications. *Journal of Island and Coastal Archaeology* 7(2): 255–271.
https://doi.org/10.1080/15564894.2011.611858

Renfrew, A. C. 1975. Trade as action at a distance: questions of integration and communication. In *Ancient Civilization and Trade*, ed. J. A. Sabloff and C. C. Lamberg-Karlovsky, pp. 3–59. Albuquerque: University of New Mexico Press.

Ross-Sheppard, C., C. Sand, J. Balenaivalu, and D. V. Burley. 2013. Kutau/Bao obsidian—extending its eastern distribution into the Fijian northeast. *Journal of Pacific Archaeology* 4(2): 79–83.

Sand, C., and P. J. Sheppard. 2000. Long distance prehistoric obsidian imports in New Caledonia: characteristics and meaning. *Comptes-rendus de l'Académie des Sciences de Paris. Sciences de la Terre et des Planètes* 331: 235–243.
https://doi.org/10.1016/S1251-8050(00)01411-7

Sheppard, P. J. 1993. Lapita lithics: trade/exchange and technology. A view from the Reefs/Santa Cruz. *Archaeology in Oceania* 28(3): 121–137.
https://doi.org/10.1002/j.1834-4453.1993.tb00303.x

Sheppard, P. J. 2011. Lapita colonization across the Near/Remote Oceania boundary. *Current Anthropology* 52(6): 799–840.
https://doi.org/10.1086/662201

Specht, J. 2002. Obsidian, colonising and exchange. In *Fifty Years in the Field: Essays in Honour and Celebration of Richard Shutler Jr`s Archaeological Career*, ed. S. Bedford, C. Sand, and D. Burley, pp. 37–49. New Zealand Archaeological Association Monograph 25. Auckland: New Zealand Archaeological Association.

Specht, J., and G. Summerhayes. 2007. *The Boduna Island (FEA) Lapita Site, Papua New Guinea. Archaeological Studies of the Middle and Late Holocene, Papua New Guinea.* Part II. *Technical Reports of the Australian Museum Online* 20: 51–103.
https://doi.org/10.3853/j.1835-4211.20.2007.1474

Spriggs, M. 1997. *The Island Melanesians*. Oxford: Blackwell Publishers.

Spriggs, M., J. R. Bird, and W. R. Ambrose. 2010. A reanalysis of the Tikopia obsidians. *Archaeology in Oceania* 45(1): 31–38.
https://doi.org/10.1002/j.1834-4453.2010.tb00075.x

Spriggs, M., and D. Reich. 2019. An ancient DNA Pacific journey: a case study of collaboration between archaeologists and geneticists. *World Archaeology* 51(4): 620–639.
https://doi.org/10.1080/00438243.2019.1733069

SPSS. 2006. *SPSS for Windows.* Chicago: SPSS Inc.

Summerhayes, G. R. 2009. Obsidian network patterns in Melanesia—sources, characterisation and distribution. *Indo-Pacific Prehistory Association Bulletin* 29: 109–124.
https://doi.org/10.7152/bippa.v29i0.9484

Summerhayes, G. R., J. Kennedy, E. Matisoo-Smith, H. Mandui, W. Ambrose, C. Allen, C. Reepmeyer, R. Torrence, and F. Wadra. 2014. Lepong: a new obsidian source in the Admiralty Islands, Papua New Guinea. *Geoarchaeology* 29(3): 238–248.
https://doi.org/10.1002/gea.21475

Terrell, J. E. 1989. Commentary: what Lapita is and what Lapita isn't. *Antiquity* 63(240): 623–626.
https://doi.org/10.1017/S0003598X00076584

Terrell, J. E., and R. L. Welsch. 1997. Lapita and the temporal geography of prehistory. *Antiquity* 71(273): 548–572.
https://doi.org/10.1017/S0003598X0008532X

Torrence, R. 1986. *Production and Exchange of Stone Tools: Prehistoric Obsidian in the Aegean*. Cambridge: Cambridge University Press.

Torrence, R. 1989. Retooling: towards a behavioral theory of stone tools. In *Time, Energy and Stone Tools*, ed. R. Torrence, pp. 57–66. Cambridge: Cambridge University Press.

Torrence, R. 1992. What is Lapita about obsidian? A view from the Talasea sources. In *Poterie, Lapita et Peuplement: Actes du Colloque Lapita, Nouméa, Nouvelle-Calédonie*, ed. J.-C. Galipaud, pp. 111–126. Noumea: ORSTOM.

Torrence, R. 2005. Valued stone—how so? In *Many Exchanges: Archaeology, History, Community and the Work of Isabel McBryde*, ed. I. Macfarlane, M.-J. Mountain, and R. Paton, pp. 357–372. Aboriginal History Monograph 11. Canberra: Aboriginal History.

Torrence, R., N. Kononenko, P. Sheppard, M. S. Allen, S. Bedford, P. V. Kirch, and M. Spriggs. 2018. Tattooing tools and the Lapita cultural complex. *Archaeology in Oceania* 53(1): 58–73. https://doi.org/10.1002/arco.5139

Torrence, R., J. Specht, R. Fullagar, and G. R. Summerhayes. 1996. Which obsidian is worth it? In *Oceanic Culture History: Essays in Honour of Roger Green*, ed. J. Davidson, G. Irwin, F. Leach, A. Pawley, and D. Brown, pp. 211–224. Dunedin: New Zealand Journal of Archaeology.

Torrence, R., and G. R. Summerhayes. 1997. Sociality and the short distance trader: intra-regional obsidian exchange in the Willaumez region, Papua New Guinea. *Archaeology in Oceania* 32(1): 74–84. https://doi.org/10.1002/j.1834-4453.1997.tb00373.x

Valentin, F., M. Spriggs, S. Bedford, and H. R. Buckley. 2011. Vanuatu mortuary practices over three millennia: Lapita to the early European contact period. *Journal of Pacific Archaeology* 2(2): 49–65.

Veth, P., N. Stern, J. McDonald, J. Balme, and I. Davidson. 2011. The role of information exchange in the colonisation of Sahul. In *Information and Its Role in Hunter-Gatherer Bands*, ed. R. Whallon, W. A. Lovis, and R. K. Hitchcock, pp. 203–220. Los Angeles: Cotsen Institute of Archaeology Press. https://doi.org/10.2307/j.ctvdmwwz4.13

Ward, G. 1979. *Prehistoric Settlement and Economy in a Tropical Small Island Environment: The Banks Islands, Insular Melanesia*. Unpublished PhD thesis, Australian National University, Canberra.

Wiessner, P. 1982. Risk, reciprocity and social influences on !Kung San. In *Politics and History in Band Societies*, ed. E. Leacock and R. Lee, pp. 61–84. Cambridge: Cambridge University Press.

Winterhalder, B. 1986. Diet choice, risk, and food sharing in a stochastic environment. *Journal of Anthropological Archaeology* 5(4): 369–392. https://doi.org/10.1016/0278-4165(86)90017-6

Winterhalder, B. 1996. Social foraging and the behavioral ecology of intragroup resource transfers. *Evolutionary Anthropology* 5(2): 46–57. https://doi.org/10.1002/(SICI)1520-6505(1996)5:2<46::AID-EVAN4>3.0.CO;2-U

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The Cylindrical Stone Adzes of Borneo

Huw Barton

School of Archaeology and Ancient History,
University of Leicester, LE1 7RH, United Kingdom

Abstract. This paper provides a descriptive review of a class of stone tools from the interior highlands of Borneo that are formally defined in this paper as 'cylindrical stone adzes.' The implements discussed are all housed in the archives of the Sarawak Museum in Kuching, Malaysia. They form part of an ethnographic and archaeological collection that was largely compiled by Tom Harrisson during his tenure as Curator of the Sarawak Museum from 1947 to 1966. These tools have been described and discussed in previous publications and I add detail to these descriptions that includes a technological and functional assessment. The results of this study show that these tools are a type of hafted stone adze used to process the starchy pith of sago palms. These tools were not in use during the historic period and may have been abandoned within the early first millennium AD, associated with a decline in the role of sago as a food staple.

Introduction

This paper provides a review and discussion of a category of stone tools unique to the highland interior of Borneo that have been variously classified as specialised tools for processing sago (Collings, 1949; Harrisson, 1951a, 1951b), or as tools for cracking hard-shelled nuts (Sellato, 1996). Amongst the indigenous communities of the Borneo highlands, these implements are frequently classified as *batu perahit*, 'thunderstones' or 'dragon's teeth' (Janowski and Barton, 2012): items that have not existed in the living memory of these communities, but have now re-entered the human realm, imbued with supernatural agency and referred to by the Kelabit and Lundayeh people as *lalud,* or life force (Janowski and Barton, 2012; Janowski, 2020). As an object with a living history, some of these tools have been all of these things at one time, or, in their current role, one thing in all times. As museum objects they rarely see the light of day and live on catalogued into obscurity. It seems fitting then, in this volume, to tackle the complexity of these object biographies and to bring these items into full publication for the first time.

The tools discussed here were collected in the field by Tom Harrisson (the original curator of the Sarawak Museum from 1947 to 1966) or sent to the museum on his request (Harrisson, 1951a). At the time of their collection, locals who discovered them had no knowledge of their age or function and regarded them as items created by spirits or natural forces in past times (Janowski and Barton, 2012; Janowski, 2020). These tools are polished, tapered cylinders of stone with a smooth concavity or cup at one end, and a flat, rounded or ridged decoration on the butt (Fig. 1A–D). They vary in size up to 184 mm and 178 mm in total length (Fig. 1A,B). All tools are relatively consistent in their girth (c. 36 mm), ranging between 39 to 54 mm at the cup end. A feature of the entire assemblage is the consistency of their cylindrical shape and their smooth exterior finish (Fig. 1A,B). Most of the tools are fashioned from quartzite, a raw material known to outcrop on the fringes of the upland regions (Harrisson, 1949: 134). A few are made from igneous stone, outcrops of which occur on the southern extremes of the highland region. All pieces in the study sample are well made, with many hours in their initial shaping and final smoothing. They are so well done, that it is not possible to determine what the initial tool blanks were. Did they begin their journey as tools from elongate pebbles? Hand-hewn from larger blocks of stone? That part of their lives remains a mystery.

Keywords: Borneo; stone adzes; swamp sago; hill sago; usewear studies; residue studies

Corresponding author: Huw Barton hjb15@leicester.ac.uk

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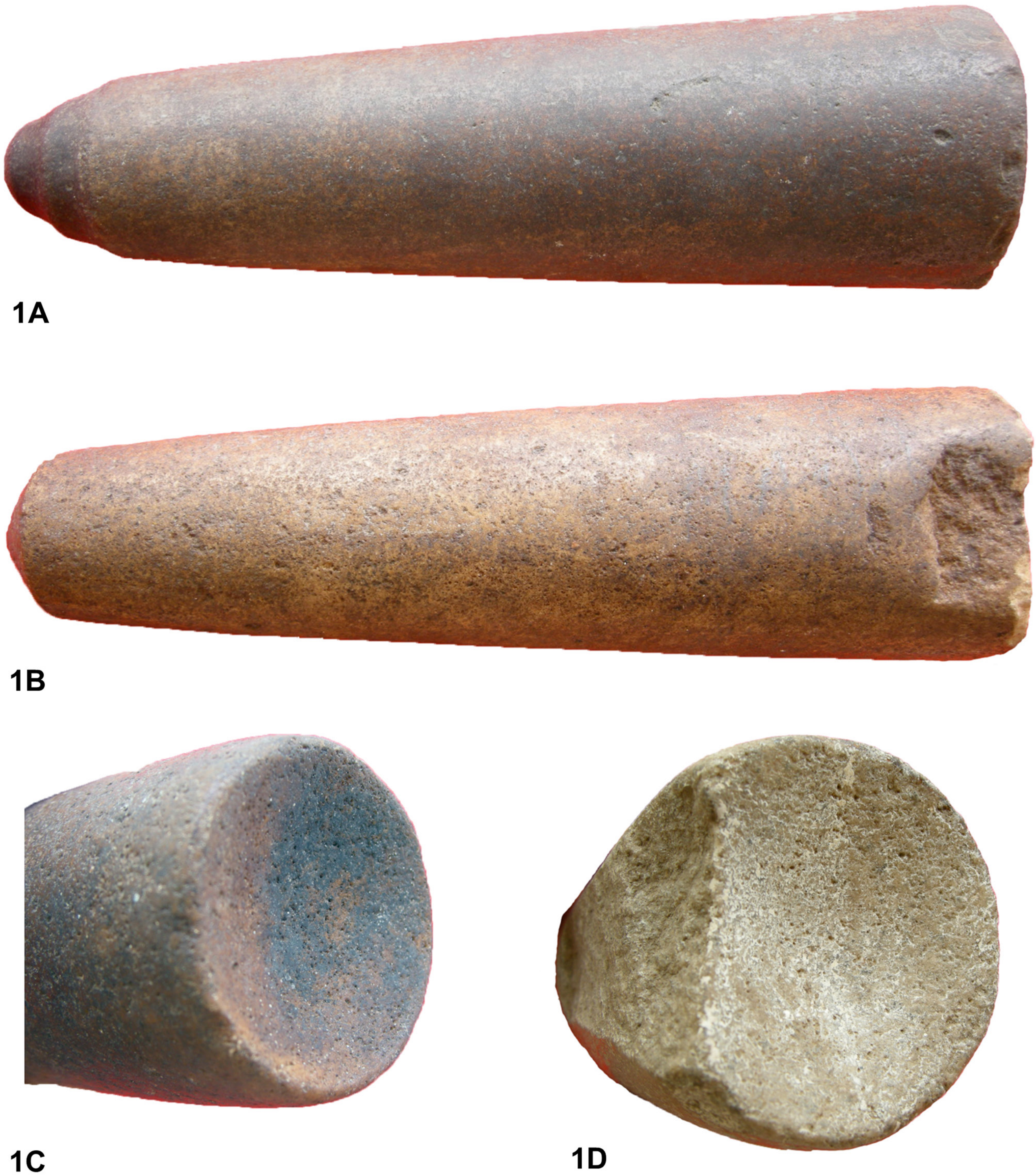

Figure 1. (*A*) #3193. Cylindrical adze (quartzite), from Belawit, Sarawak. Minor edge damage on cutting edge. This specimen has an elaborately shaped butt with tapered grooves. The cylinder is symmetrical and highly polished. Length 184 mm. (*B*) # 3155. Cylindrical adze (quartzite), from Pa' Mada, Sarawak. Typical edge damage on cutting edge. The cylinder is symmetrical and highly polished. Butt is shaped into a short cone. Length 178 mm. (*C*) #3159. Cutting edge (cup) of a cylindrical adze (quartzite), from Pa' Dalih, Sarawak. The cutting edge shows few signs of wear. Blackened area is soot, probably from storage in the longhouse above the hearth. Length 161 mm. (*D*) #3174. Cutting edge (cup) of a cylindrical adze (quartzite), from Pa' Bawang, Kalimantan. There is flaking damage around the perimeter of the cutting edge, with one large flake removal running down ⅓ length of shaft. Butt of this tool has an elaborate finish with tapered grooves and is more weathered and worn than #3193. Length 172 mm.

Distribution of cylindrical sago adzes in Borneo

The study sample (Table 1) was primarily recovered from the interior uplands of Sarawak and Kalimantan, c. 900 to 1000 m a.s.l. (Fig. 2). The vegetation of the uplands is predominantly lower montane tropical rainforest draped over steep, mountainous ridges that rise above 3000 m a.s.l. Between these ridges lie layered palaeo-river terraces, wide riverine plains and swamps. The plains and riparian areas of the study region are home to a number of agricultural longhouse communities, primarily the Kelabit and Lundayeh, and until recently, smaller communities of hunter-gatherer Penan. The Kelabit and Lundayeh are closely related communities, both speakers of Apo Duat, a sub-group of the Austronesian family. They share many cultural similarities including sedentary living in longhouses, cultivation of wet rice (*sawah*) and dry rice using slash and burn cultivation on hill slopes, the erection of stone monuments, and the holding of prestige feasts (Sellato, 2016).

Museum records and local informants state that most of the study sample, commonly recorded as sago pounders, were isolated finds nearby current or old villages. Tools were discovered by locals from streams and stream banks during any activity that moved earth, such as making or maintaining padi fields and gardens or digging postholes. As a type of polished stone tool, they occur in a relatively high frequency in the Sarawak Museum collections, outnumbering polished stone adzes by thirty to one (Harrisson, 1951a: 534). They were originally identified as sago pounders, used in the processing of wild sago palms (Collings, 1949; Harrisson,

Table 1. Location data of cylindrical sago adzes in the Sarawak Museum (SM) found in Sarawak State, Malaysia and Kalimantan Province, Indonesia; *n.d.* = no data.

SM reg. no.	region	geography	collection location	ethnic group
50/138	n.d.	n.d.	n.d.	n.d.
59/97	n.d.	n.d.	n.d.	n.d.
64/239	Sarawak	n.d.	n.d.	n.d.
59/98	Sarawak	n.d.	n.d.	n.d.
50.182	Sarawak	n.d.	n.d.	n.d.
3195	Sarawak	n.d.	n.d.	n.d.
3200	Sarawak	Coastal lowlands	Lawas	Lunbawang
3178	Kalimantan	Interior highlands	Belawit	Lundayeh
3191	Kalimantan	Interior highlands	Belawit	Lundayeh
3193	Kalimantan	Interior highlands	Belawit	Lundayeh
3174	Kalimantan	Interior highlands	Pa’ Bawang	Lundayeh
50.200	Kalimantan	Interior highlands	Pa’ Bawang	Lundayeh
50.202	Kalimantan	Interior highlands	Pa’ Bawang	Lundayeh
50.231	Kalimantan	Interior highlands	Pa’ Bawang	Lundayeh
3170	Kalimantan	Interior highlands	Pa’ Bawang	Lundayeh
50.184	Sarawak	Interior highlands	Ba’ Kelalan	Lundayeh
3196	Sarawak	Interior highlands	Ba’ Kelalan	Lundayeh
3198	Sarawak	Interior highlands	Ba’ Kelalan	Lundayeh
50.186	Sarawak	Interior highlands	Ba’ Kelalan	Lundayeh
3180	Sarawak	Interior highlands	Belawit	Lundayeh
3197	Sarawak	Interior highlands	Upper Trusan R.	Lundayeh
50.213	Sarawak	Interior lowlands	Pa’ Tengoa	Lundayeh
50.542	Sarawak	Interior highlands	Kelabit highlands	Kelabit
50.544	Sarawak	Interior highlands	Kelabit highlands	Kelabit
50.545	Sarawak	Interior highlands	Kelabit highlands	Kelabit
65/376	Sarawak	Interior highlands	Bario	Kelabit
64/230	Sarawak	Interior highlands	Bario	Kelabit
64/229	Sarawak	Interior highlands	Bario	Kelabit
64/226	Sarawak	Interior highlands	Bario	Kelabit
3166	Sarawak	Interior highlands	Batu Patong	Kelabit
50.208	Sarawak	Interior highlands	Pa’ Bengar	Kelabit
PDH07	Sarawak	Interior highlands	Pa’ Dalih	Kelabit
3159	Sarawak	Interior highlands	Pa’ Dalih	Kelabit
3164	Sarawak	Interior highlands	Pa’ Dalih	Kelabit
3154	Sarawak	Interior highlands	Pa’ Mada	Kelabit
3156	Sarawak	Interior highlands	Pa’ Mada	Kelabit
65/258	Sarawak	Interior highlands	Pa’ Tik	Kelabit
50.173	Sarawak	Interior highlands	Pa’ Trap	Kelabit
50.214	Sarawak	Interior highlands	Pa’ Umor	Kelabit
50.215	Sarawak	Interior highlands	Pa’ Umor	Kelabit
50.216	Sarawak	Interior highlands	Pa’ Umor	Kelabit
50.219	Sarawak	Interior highlands	Pa’ Umor	Kelabit
50.220	Sarawak	Interior highlands	Pa’ Umor	Kelabit
3155	Sarawak	Interior highlands	Pa’ Mada	Kelabit
50.230	Sarawak	Interior highlands	Remudu	Kelabit
50.543	Sarawak	Interior highlands	Upper Baram R.	Kelabit
65/260	Sarawak	Interior lowlands	Long Lellang	Kelabit

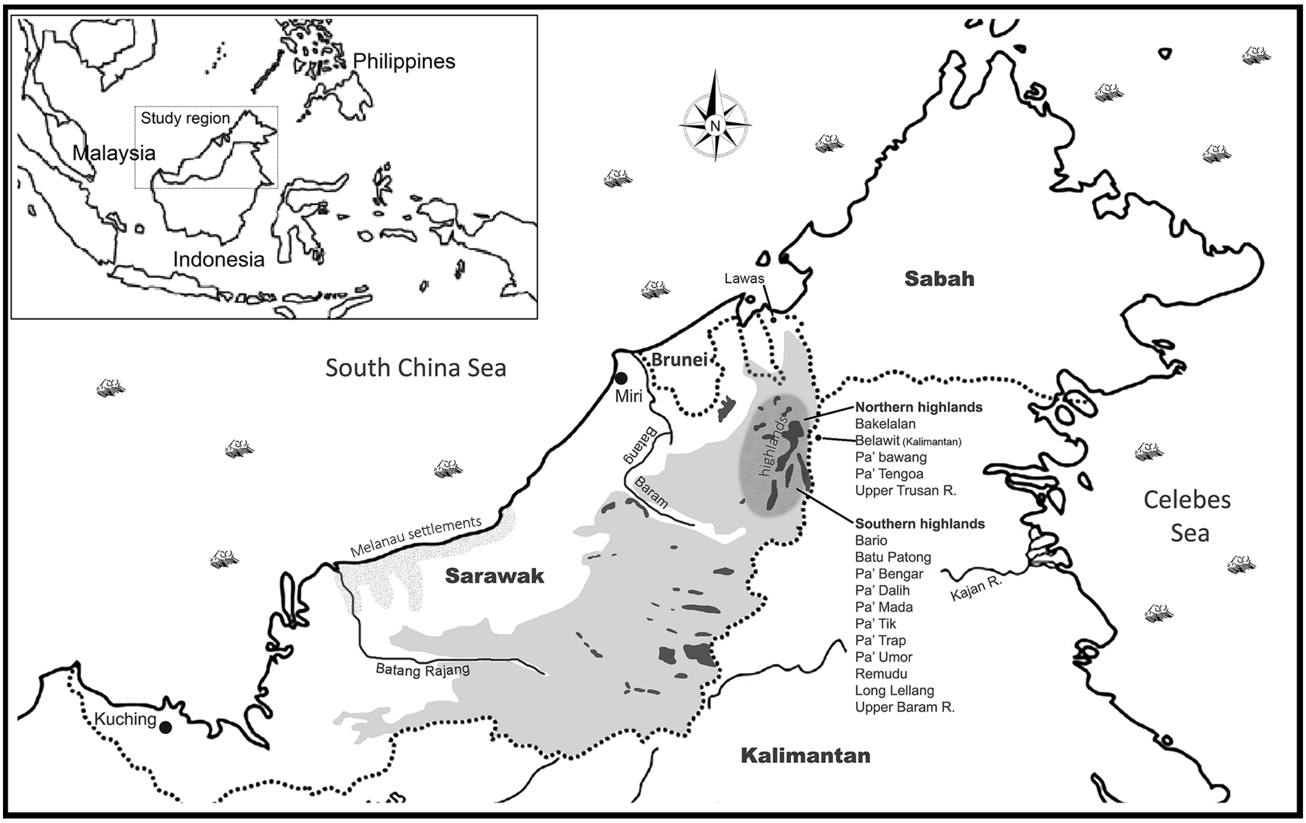

Figure 2. Map of the study region. Sites mentioned in Table 1 are listed for the lowland and highland regions. The stippled area on the coast and hinterland denotes the distribution of Melanau communities that utilise swamp sago palms, *Metroxylon sagu* Rottb. Pale grey landscape shading denotes land between 150–300 m asl. Dark grey shading denotes land above 1200 m asl.

1951a, 1951b), but historically, none of the communities that were the source of these tools claimed to be eaters of sago. Instead, they would state that the hunter-gatherer Penan were sago eaters and that their own primary food staple is, and always has been rice (Barton, 2012).

Sago and sago processing technology

Sago is a common term for the starch-rich slurry that may be extracted from a wide variety of palms that store starch in their trunk. The word sago [*sagu*] probably entered the English language in the middle of the 16th century as a result of explorations in the Moluccas: 'In all the Ilandes of Molucca is founde cloves, ginger, breade of the roote of Sagu, ryse, goates' (d'Anghiera, 2010 [1555]). The term is also used for wet pastes and dried flours of other starch-storing plants such as cycads (Thieret, 1958) and some species of tree ferns (Stonor, 1948).

Ellen (2008) provides an excellent review of the technology used to process sago across the Indo-Malaysian archipelago. He divides this technology into three main groups: pounders, rasps, and scrapers. Our concern is with the class of pounding tools. Rasps are mostly found in the eastern end of the archipelago, known from Sumatra and from the north-west coast of Sarawak, used exclusively in Borneo by one ethnic group, the Melanau (see stippled area in Fig. 1). This group also processes swamp sago palms, *Metroxylon sagu* Rottb., that is likely a prehistoric introduction and only grows in the lowlands (Morris, 1953). Other groups in Borneo exploit known endemic palm genera, primarily, *Arenga* spp., *Caryota* spp., and *Eugeissona* spp. (Ruddle *et al*., 1978; Barton, 2012).

Sago pounders are found across the Indo-Malaysian archipelago and eastwards into New Guinea (Lewis, 1923; Crosby, 1976; Ellen, 2008). They are predominantly multi-component tools made from organic materials (wood, bamboo, rattan, and fibre) or made from organics and stone, and in some cases, iron (Ellen, 2008). In the historic period sago was still widely utilised as a fall-back food across Borneo by rice farming communities including the Dusun of North Borneo (Rutter, 1929: 95–96), the Maloh of west Kalimantan (King, 1985: 154), the Kayan (Rousseau, 1990: 146), the Kajang (Nicholaisen, 1986), the Kejaman (Strickland, 1985), the Iban (Freeman, 1955: 105), Malays of southwest Sarawak (Harrisson, 1970), and the Kelabit (Harrisson, 1959: 66). Unfortunately, no record of the tools used to process sago were recorded in these papers, but it is assumed that they used the wooden adzes used by their hunter-gatherer neighbours, the Penan.

Penan hunter-gatherers living across the interior of Borneo have used a wooden adze, known in Sarawak as a *puloo* to process the pith of split sago palm trunks. This tool has an unusual shape in that the adze blade (made from a single piece of timber) is very long, up to a metre or more, tapered to a narrowing blade, with a very short handle (Fig. 3). The blade is lifted and dropped in repeatedly in a short working arc to chop and pound the fibrous pith. This breaks up the pith which is later transferred to a wooden platform where the starch is washed from the fibres. The platform is layered with rattan mats and leaves (essentially operating as a large sieve), through which water is poured, and then the pith is trampled to release a starchy slurry into the final layer of woven mats where gravity separates out the final wet starchy flour (https://youtu.be/VomE4GN9Z6I).

Figure 3. Wooden sago adze, *puloo*, from the Kelabit Highlands in use to process sago pith from the trunk of a hill sago palm, *Eugeissona utilis* Becc. Photo by Huw Barton, 2003.

Cylindrical stone adzes

The Borneo tools discussed here and those of similar form from New Guinea (Lewis, 1923), should, I propose, be categorised typologically as 'cylindrical stone adzes'. These tools had a particular function reflected in their form and in the ethnographic evidence of their use. Sellato (1996) thought of them as hand-held pounders, the cupped end being used to aid in cracking a nut exocarp, rather than smashing or crushing it, as would occur with a flat-ended pounder. However, closer examination of a wider sample of tools from Borneo and microwear and residue analyses confirm that these implements are cylindrical adzes, designed to cut and separate palm pith. They are directly analogous with tools recorded by Lewis (1923) and Gonthier (1987) from the north-west coast of Papua, also described as sago pounders:

> This [sago palm pith] is then pounded and mashed with a peculiar hammer made especially for this purpose, having at the lower end a cup-shaped depression with sharp edges. This cuts out the pith and mashes it at the same time. The cutting head may be of hard wood, bamboo, or stone, according to the locality (Lewis, 1923: 2–3).

It is not known how standardised these tools were when initially manufactured, but the overall variation in size and the wear patterns suggest that these tools were well maintained and reduced in length over their use-lives. The shortest tool in this sample is 50 mm, which may indicate the limits of their use life as a hafted implement (Table 2). When Harrisson (1951a, 1951b) first described these tools he saw similarities in form between them and conical pounding tools known from New Guinea and Australia (see Postscript), and referred to them in publication as 'sago pounders', though

Table 2. Physical description of cylindrical sago adzes recorded in the Sarawak Museum (SM) archives, Kuching, Malaysia. Dimensions in mm.

SM reg. no.	raw material	length[a]	mid-point width	cup max. diameter	butt height[b]	butt width	description
3154	Quartzite	174	44	47	20	30	Tapered cylinder with rounded butt. Yellow patina. Butt with minor chipping. Cup margin chipped and with reflective gloss.
3155	Quartzite	178	41	47	12	29	Tapered cylinder. Yellow patina. Cup margin chipped and with reflective gloss. Conical butt.
3156	Quartzite	73	0	43	0	0	Tapered cylinder. Transverse mid-shaft break. Cup margin chipped and with reflective gloss.
3159	Quartzite	161	41	40	7	29	Tapered cylinder. Yellow patina. Butt pointed type. Some chipping on butt end and one longitudinal flake scar. Cup end is rounded and with reflective gloss.
3164	Quartzite	130	41	44	0	0	Tapered cylinder. Yellow patina. Break at butt end. Soot blackened.
3166	Quartzite	91	36	54	0	0	Tapered cylinder. Asymmetric working end. Break at butt end. Strongly tapered form. Cup margin chipped and with reflective gloss.
3170	Quartzite	142	41	43	7	30	Tapered cylinder. Yellow patina. Cup margin chipped and with reflective gloss. One large flake removal. Rounded butt with battering.
3174	Quartzite	172	41	46	22	28	Tapered cylinder with elaborate butt. Butt modified with two-stepped and tapered grooves. Large flake removal from cup end.
3178	Quartzite	104	42	40	0	33	Tapered cylinder. Yellow patina. Flat butt, heavily chipped around margin. Cup margin chipped and with reflective gloss. Deliberate secondary flaking from cup.
3180	Sandstone	110	41	40	0	41	Straight-sided cylinder. Flattened butt. Butt with battering. Cup chipped around margin. Soot blackened.
3191	Volcanic	120	37	41	7	30	Tapered cylinder. Fine dressing of tool by pecking. Cup margin chipped and with reflective gloss. Trapezoidal butt
3193	Quartzite	184	44	52	23	34	Tapered cylinder with elaborate butt. Butt modified with two-stepped and tapered grooves. Cup margin chipped and with reflective gloss.
3195	Quartzite	130	53	48	10	30	Tapered cylinder. Trapezoidal butt. Cup margin flaked with reflective gloss.
3196	Quartzite	95	47	50	8	38	Tapered cylinder. Trapezoidal butt. Butt with battering. Cup chipped and pitted in concavity.
3197	Quartzite	133	43	48	0	31	Tapered cylinder. Fine dressing of tool by pecking. Finial flattened by battering. Cup margin chipped and with reflective gloss. Soot blackened.
3198	Quartzite	114	45	53	13	34	Tapered cylinder. Asymmetrically worn at cup end. Cup margin chipped and with reflective gloss. Rounded butt.
3200	Quartzite	135	47	48	6	30	Tapered cylinder. Yellow patina. Reused as a pounder/pestle. Both cup and butt are battered and without patina.
50.173	Quartzite	116	40	41	0	34	Tapered cylinder with flat butt. Butt battered and chipped. Cup margin chipped and with reflective gloss. Soot blackened.
50.182	Quartzite	66	0	47	0	0	Tapered cylinder. Yellow patina. Break at butt. Cup margin chipped and with reflective gloss.
50.184	Quartzite	95	39	38	8	37	Straight-sided cylinder. Recycled as a pounder/pestle. Rounded finial. Cup margin chipped and with reflective gloss.
50.186	Quartzite	99	43	41	12	39	Straight-sided cylinder. Cup margin chipped and with reflective gloss. Trapezoidal butt. Soot blackened.
50.200	Quartzite	76	42	45	0	0	Tapered cylinder. Break at butt end. Cup margin chipped and with reflective gloss. Soot blackened.
50.202	Quartzite	80	36	39	9	30	Tapered cylinder. Small form. Dark patina. Cup chipped around margin. Rounded butt.
50.208	Quartzite	126	38	42	0	30	Straight-sided cylinder. Break at butt. Cup margin chipped and with reflective gloss. Soot blackened.
50.213	Quartzite	105	49	52	10	38	Tapered cylinder. Rounded finial. Butt chipped and battered. Cup margin chipped and with reflective gloss.
50.214	Quartzite	90	34	41	0	0	Tapered cylinder. Break at butt. Cup margin deliberately flaked longitudinally and transversely. Small patch of original surface remains in centre of cup with reflective gloss.
50.215	Quartzite	124	40	42	0	32	Tapered cylinder. Butt battered. Cup chipped around margin.
50.216	Quartzite	102	42	41	0	0	Straight-sided cylinder. Yellow patina. Butt is battered and chipped. Cup margin chipped and with reflective gloss. Soot blackened.
50.219	Quartzite	105	31	35	0	0	Tapered cylinder. Cup margin chipped and with reflective gloss.
50.220	Quartzite	90	36	40	0	0	Tapered cylinder. Cup margin chipped and with reflective gloss.
50.230	Quartzite	117	38	0	15	30	Tapered cylinder with elaborate butt. Butt modified with two-stepped and tapered grooves. Break at cup end.

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Table 2 (continued from previous page). Physical description of cylindrical sago adzes recorded in the Sarawak Museum (SM) archives, Kuching, Malaysia. Dimensions in mm.

SM reg. no.	raw material	length[a]	mid-point width	cup max. diameter	butt height[b]	butt width	description
50.231	Quartzite	73	48	45	0	0	Straight-sided cylinder. Break at butt end. Cup margin chipped and with reflective gloss.
50.542	Quartzite	131	43	56	0	22	Tapered cylinder. Yellow patina. Asymmetric wear at cup end (bevelled). Chipped around cup margin. Flat butt type. Butt end with battering. Water-worn. Soot blackened.
50.543	Quartzite	96	39	41	0	0	Straight-sided cylinder. Break at butt end. Butt is battered and chipped. Cup margin chipped and with reflective gloss. Heavily weathered and water worn.
50.544	Quartzite	100	36	31	0	0	Tapered cylinder. Yellow patina. Original cup broken off. Butt re-worked into new cup. Cup margin chipped and with reflective gloss. Soot blackened
50.545	Quartzite	89	36	30	0	0	Tapered cylinder. Yellow patina. Soot blackened. Original cup end now flat, with new cup at butt end. Cup margin chipped and with reflective gloss.
50/138	Quartzite	50	0	36	0	0	Straight-sided cylinder. Transverse break through butt. Cup margin chipped and with reflective gloss.
59/97	Quartzite	75	0	45	0	0	Tapered cylinder. Transverse break through butt. Cup margin chipped and with reflective gloss.
59/98	Quartzite	98	0	30	0	0	Tapered cylinder. Yellow patina. Original cup end with break. Butt re-worked into new working cup. Cup margin chipped and with reflective gloss.
64/226	Quartzite	130	43	49	8	29	Tapered cylinder. Cup margin chipped and with reflective gloss. Rounded butt type.
64/229	Quartzite	134	41	41	7	35	Straight-sided cylinder. Rounded butt. Cup margin chipped and with reflective gloss.
64/230	Quartzite	119	42	48	13	30	Tapered cylinder. Pointed butt. Cup removed by flaking and battering. Recycled as pounder/pestle.
64/239	Quartzite	133	40	42	0	37	Tapered cylinder. Dark patina with white interior. Sampled at butt for mineralogical analysis. Cup margin chipped and with reflective gloss. Flat butt.
65/258	Quartzite	93	41	44	0	0	Tapered cylinder. Break at butt end. Butt with battering. Broken at finial end. Cup margin chipped and with reflective gloss.
65/260	Quartzite	98	39	42	15	32	Tapered cylinder. Yellow patina. Tool appears heavily weathered (water-worn). Rounded butt.
65/376	Quartzite	88	0	0	0	0	Tapered cylinder. Broken tool split longitudinally. Butt flaked into nosed scraper. Grey patina. Flake scars are without patina.
PDH07[c]	Quartzite	n.d.[c]	n.d.	n.d.	n.d.	n.d.	Tapered cylinder. Pointed butt type. Cup margin chipped and with reflective gloss.

[a] Length measurements were taken from the apex of the butt along the axis of the tool to the cup rim.

[b] Butt height was measured from the first major change in angle at the narrow end of the tool. Butt width at the widest point of the tapered end.

[c] The owner of this pounder would not allow me to take measurements in case my handling of it caused the *lalud* stored in the stone to drain away. This tool was touched to other tool surfaces to transfer 'power' to hunting equipment. Total length is about 200 mm.

there is nothing in his writings to indicate why he thought that this was their likely use. He might have been aware of the paper by Lewis (1923) on sago production on the northwest coast of Papua, though he did not reference it, or he may have had in mind organic types of pounder from Indonesia, where bamboo varieties have a natural 'cup' on their working end. Harrisson had earlier shown a sample of pounding and polished tools to Henry Collings at the Singapore Museum (Collings, 1949), who also drew direct parallels between the conical pounders from Sarawak and those from New Guinea (presumably also known from Lewis' earlier work). While sago production was his interpretation of tool function, Harrisson was also interested in broader typological comparisons with material from Australia described by Robert Etheridge Jnr of the Australian Museum as 'cylcons' or 'cylindro-conical implements' (Etheridge, 1916). Fred McCarthy, also at the Australian Museum, later discussed this typological grouping, referencing a similar tool form in Australia (McCarthy, 1953: 250). McCarthy visited Indonesia in 1938 and met archaeologists there and caught up with his friend H.V.V. Noone, anthropologist and museum curator at the Raffles Museum in Singapore (Khan, 1993: 3). McCarthy and Harrisson were likely in correspondence about these tools at some point as the Sarawak Museum archive contains several 'conical pounders' from Australia, originally from the Australian Museum based on the E. register numbers (Table 3). However, beyond their superficial similarities of form, these tools are functionally distinct.

Bernard Sellato (1996) undertook an earlier study of stone pounding tools (bark beaters, basalt tools from an ethnic group known as the Ngorek, and conical pounders) from the interior of Borneo/Kalimantan that included several specimens reviewed as part of this study (Sarawak Museum registration numbers: #3112; #3119; #3146; #3148; #3193;

Table 3. Sandstone pounders ('cylindro-conical' and 'cornuted' stones) from Australia in the Australian Museum, Sydney (AM). Dimensions in mm.

AM reg. no.	raw material	length	width	cup diameter	description	origin (from register)
E44857-1	Sandstone	270	53	42	Cylindrical implement. Shaft is dressed by pecking and grinding. Cup end is concave and has minor chipping around margin of bowl.	Purch. Estate late A. J. Bentice, 1938.
E21251	Sandstone	363	72	56	Cylindrical implement. Working end is concave and chipped around margin of bowl.	Belali, Warrego River, N.W. of Bourke. Purch. J. Tyrell, 1912
E26613	Sandstone	247	71	57	Irregular, roughly ovate in cross-section. Butt end curves away from main shaft in profile, giving a horn-shape (cornuted stone). Working end is flat, pecked and ground and striated.	Broken Hill District, NSW. Presented to Mining and Geological Museum. Sent to M. and G. Museum with mineralogical specimens by J. E. Hellawell, Mosman, North Sydney, 1921.
E44857-2	Sandstone	n.d.	n.d.	n.d.	Irregular, roughly ovate in cross-section. Butt end curves away from main shaft in profile, giving a horn-shape (cornuted stone). Working end is slightly concave and pecked. Some chipping around margin of cup.	No label, no data.

#3194; #3082). In his review of these items, Sellato proposed their use as nut cracking tools. Specifically, he argued that they were used to crack nuts of *Aleurites moluccana* (L.) Willd., the Indian walnut or 'candlenut', a common name derived from its use in Java and Sulawesi, where it is combined with copra and cotton to produce a substitute fat for candles (Sellato, 1996: 54). There is a note of its use by the Bukit people of the Meratus Mountains in Southern Kalimantan Province of Indonesian Borneo using the fat rendered from the nut for lighting (Sellato, 1996: 54). Sellato's rationale for thinking of these tools as nut cracking implements stems from the knowledge that the candlenut has a very hard exocarp that would require a stone pounder to crack, and his common sense observation that the cupped end of these pounders would be well suited to the task (Sellato, 1996: 52). Sellato interpreted the visible battering around the margin of some of these tools as likely derived from further use as a pestle to mash the nutmeat.

The functional analysis of these tools conducted for this study shows that these tools are not pounders used in this manner but are a primarily a type of adze used to chop plants. The macro and microwear is consistent with that interpretation, as are the organic residues that show processing of starch-bearing palms. There is evidence of further use of these tools as pestles and grinders as well as evidence of chipping and deliberate flake removals. I will argue below that these additional uses are not likely prehistoric but have occurred in their renewed life as *batu perahit* (Janowski and Barton, 2012), after rediscovery by Kelabit and Lundayeh.

Functional analyses

Macroscopic wear

Figures 1, 4 and 5 show the typical form of the cupped end and the typical wear that is visible by eye on the study sample. Macroscopic wear of the cup end shows wear in three groups:

1 Very minor flaking damage, with small, short flake removals on the outer side of the cup, aligned with the shaft, or into and across the concavity of the cup (Figs 1A, 5A,B). These tools are often associated with a highly visible surface gloss (polish), and evidence of rounding (Figs 4C,D, 5A,B);
2 A pattern of intermittent, larger flake scars, especially on the margin of the cup aligned with the shaft (Fig. 1B,D). In some examples, a major section of the tool has broken away (Fig. 1D); and
3 Major flaking around the perimeter of the cup (Fig. 4A,B). Flake scars are typically short with step or hinge terminations.

In all these cases, the polished surface of the cup does not show any other signs of damage, such as pounding or pitting. This observation is important as it is one of the key pieces of evidence, along with the microwear and residues evidence below, that is in direct contradiction to their interpreted use as hand-held crackers of hard nuts as proposed by Sellato (1996).

The pattern of flake removals around the perimeter indicates that periodically these tools were rotated in their hafts during use to refresh the cutting edge. The asymmetric profile shape of #50.542 (Fig. 4E) suggests a working repair to damage incurred by a large flake removal as seen in Fig. 1D. The working edge of #50.542 was ground into a new concave cup (not shown) that has sustained further abrasive wear and minor chipping (Table 2). One of the sample tools has been prepared with cups on opposing ends (#59/98: Fig. 5A,B). During use, this tool suffered a break on the normal working end and rather than discarding the tool, a new cup was ground into the butt end and the tool re-hafted. It is possible that the owner deemed the nature of the break such that regrinding to renew the cutting edge would remove too much material (tool length is 98 mm) and decided that creating a new cup at the butt end was a better working solution.

Depending on the qualities of the raw material, these implements have developed a highly reflective visible gloss on the cup end (Figs 4A, 6A). This is most visible on tools made from a dense, highly siliceous type of quartzite (Table 2). The gloss is either found around the entire perimeter of the tool or may be developed asymmetrically. The gloss is not evenly distributed from the working edge along the shaft but has a sinuous profile. This pattern is consistent with a tool that maintained angled contact with the worked material that sustained wear unevenly at different stages of use. Personal observation in 2003 of the pounding of sago pith by a Penan family, indicated that the labour was shared between husband and wife when one tired, and the pattern of mallet use changed in the hands of each, which caused changes in the wear patterns.

Figure 4. (*A* and *C*) #50.216. Cylindrical adze (quartzite) from Pa' Umor, Sarawak. The cutting edge is heavily chipped and worn. Note that the usewear is entirely around the circumference of the cup, showing that the tool was rotated in its haft. Note also the visible gloss and lack of damage to the remaining cup base (*C*). Cup exterior diameter 41 mm. (*B*) #3191. Cylindrical adze (volcanic) from Belawit, Kalimantan. Note the chipping around the entire circumference and that the cup base is undamaged. Cup exterior diameter 41 mm. (*D*) #3155. Cylindrical adze (quartzite) from Pa' Mada, Sarawak. Visible gloss and minor chipping on the cutting end. Cup exterior diameter 47 mm. (*E*) #50.542. Cylindrical adze (quartzite) from the Kelabit Highlands. Tool is asymmetrically worn on the cutting edge. Note also the implement has been made with a stepped-down taper towards the butt. This suggests that this tool was socketed, with a 'stop' to prevent the haft from sliding forward during use. Length 131 mm.

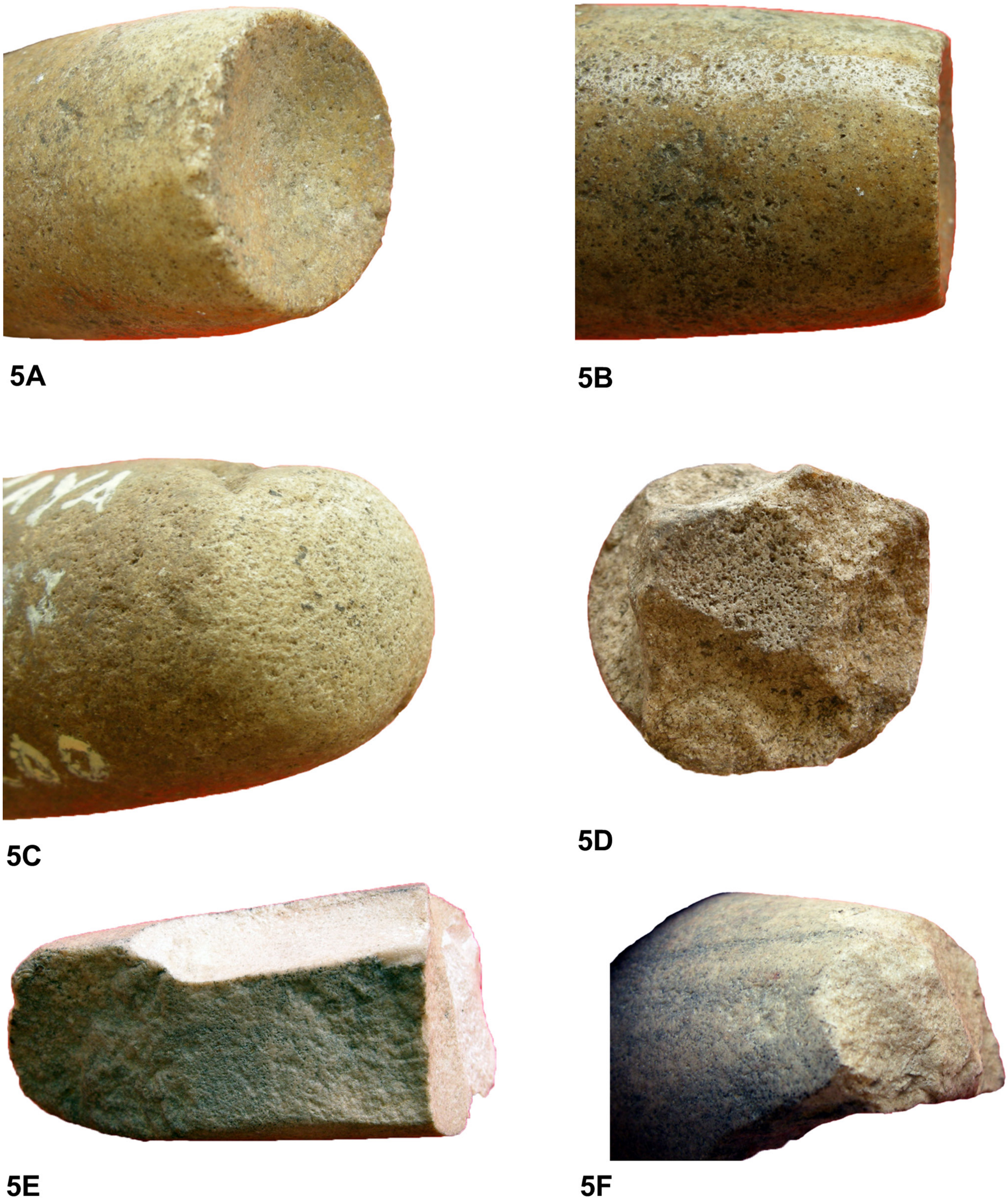

Figure 5. (*A* and *B*) #59/98. Cylindrical adze (quartzite), from an unknown locality, Sarawak. View is of the butt end that has been re-worked into a new cutting edge, which is why the working end is narrower than the shaft. There is minor chipping and visible gloss on the working end (*B*). Cup exterior diameter 30 mm. (*C*) #3200. Cylindrical adze (quartzite), found Lawas, Sarawak. View is of the butt that has been re-used as a pestle/pounder. Butt width 30 mm. (*D*) #50.214. Cylindrical adze (quartzite), from Pa' Umor, Sarawak. Tool has been flaked from the worked edge. Note the residual portion of cup. The flaking is invasive and unlike wear typically resulting from use. (*E* and *F*) #65/376. Cylindrical adze (quartzite), found Bario, Sarawak. This piece has been heavily modified by flaking along the shaft from the cutting edge and across the shaft. The butt end has been flaked into a steep-edged 'nosed' scraper. Flake scars appear younger than the shaft patina and two appear relatively 'fresh'.

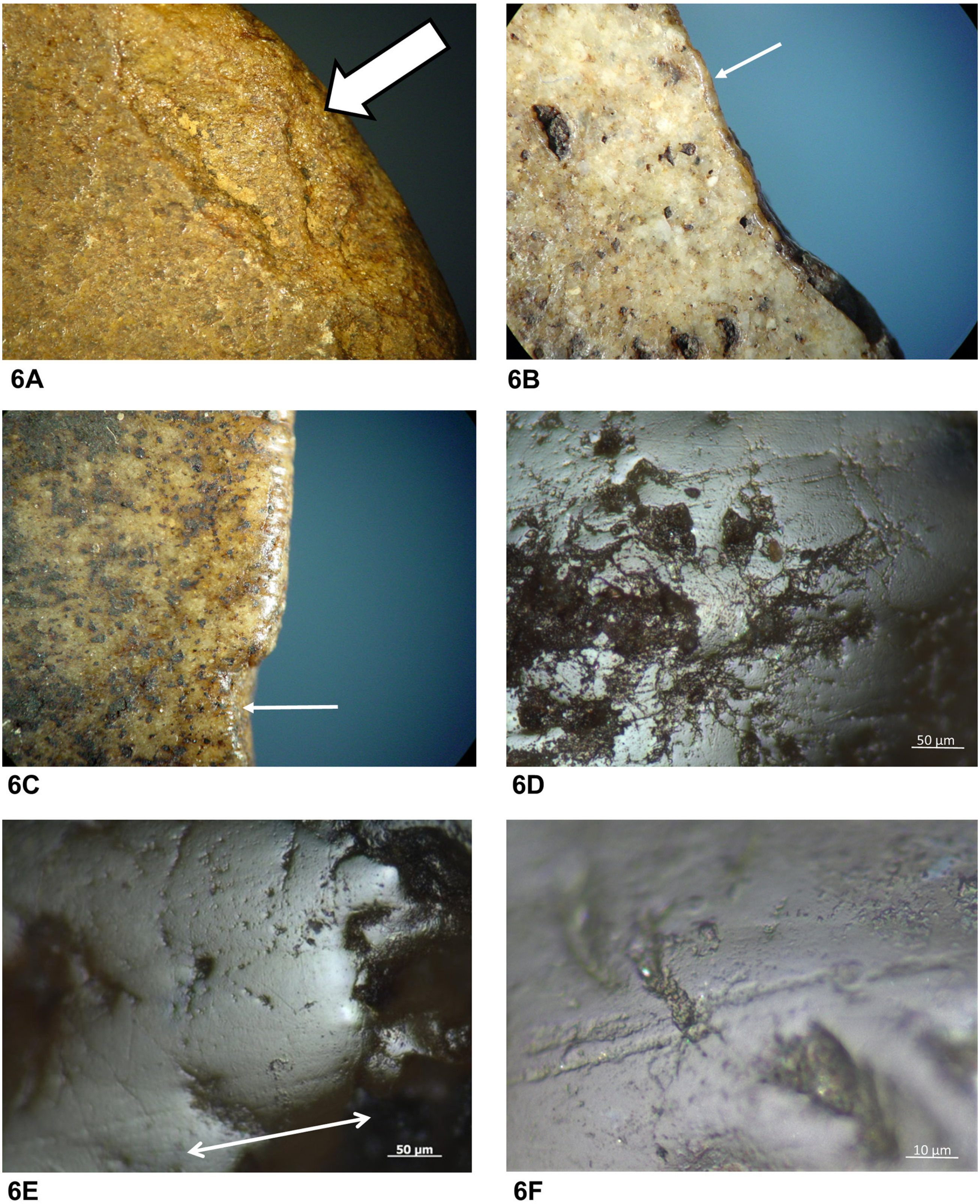

Figure 6. (*A*) #3141. Cup end at ×6.5 magnification. Flake scars with step and hinge terminations. Scars located on the concave end of the tool, consistent with the cup edge contacting worked material in an angled chopping action. Large arrow indicates flake scars and direction of flake initiation. (*B*) #3194. Cup end at ×6.5 magnification. Arrow indicates edge rounding and gloss on the base of flake scars that were initiated on the cup end but run longitudinally along the tool shaft. This shows that the working end continued in use following flake removals and generated new usewear. (*C*) #3189. Cup end at ×6.5 magnification. High gloss polish around the perimeter of cup. Arrow indicates flake scar (bending initiation). (*D*) #3189. High magnification view of gloss polish on cup perimeter (scale 50 µm). (*E*) #3189. High magnification view of gloss polish on cup perimeter. Double-ended arrow indicates orientation of linear features on tool surface (scale 50 µm). (*F*) #3194. High magnification view of striation morphotype that is typical on polish surfaces. Shallow and flat-bottomed (scale 10 µm).

The formation of a gloss or highly reflective surface sheen on these tools is likely a combination of physical abrasion during contact with plant fibres and the physico-chemical processes known generically as 'silica gloss' (Semenov, 1964; Meeks *et al*., 1982; Kamińska-Szymczak, 2002). Explanations of the formation of this sheen or gloss are normally divided into two camps:

1 Physical removal of material by mechanical processes (e.g., Fullagar, 1991 who emphasises the role of amorphous plant silica; also see Kamminga, 1979; Plisson and Mauger, 1988); or
2 Physico-chemical processes with interactions occurring between the worked material and the tool material, creating a new deposit or micro-layer on the tool surface (e.g., Anderson, 1980; Unger-Hamilton, 1984; Anderson-Gerfaud, 1986).

A more recent study of gloss formation on metal and flint tools proposes that the visible gloss on prehistoric tools, which is often different in kind from experimental samples, involves a third, post-depositional process, whereby silica dioxide in soils, replaces hydrated oxides in the tool residue 'crust' following tool discard (Kamińska-Szymczak, 2002).

Microwear

A sub-sample of four tools (Sarawak Museum registration nos: #3127; #3141; #3189; #3194) were further analysed in the Residue and Use-wear Laboratory in the School of Archaeology and Ancient History at the University of Leicester. A stepped approach to the analysis was undertaken (Fullagar, 2006). Tools were given a light clean with ultrapure water to remove surface dust from museum storage. Following this, initial observations were made at low magnification using a Zeiss Stereo microscope (×1.5–50), followed by sampling for tool residues using a micropipette and ultrapure water (see Barton, 2007 for procedure). Lastly, areas identified for high magnification analysis of wear were given a heavier clean using ultrapure water to remove adhering sediment to improve visibility of surface wear. Surfaces were assessed using a Zeiss AxioMAT (× 50–1000) reflected light microscope.

Low magnification analysis of the cup rims revealed short flake scars with step terminations running across the concave surface from the rim; these are consistent with angular, contact-driving flake removals across the cup surface (Fig. 6A). Worked edges also have a high degree of surface polish and edge rounding along the cup margins of these tools (Fig. 6B,C). This rounding was present on all edges analysed and particularly visible on the higher quality quartzite, having an almost 'melted' appearance in some places. At low magnification, the dominant wear on tools analysed is a glossy surface sheen, particularly on the margin of the cup rim, and edge rounding (Fig. 6B,C). This pattern of wear is consistent with the use of these tools on worked material that was softer than the tool material and partially yielding.

High magnification analysis of areas with visible surface gloss reveals extensive, well-developed, smooth use-polish (Fig. 6D–F). The polish surface is domed and undulating; with rounded edges, that follows the irregularities of the tool surface (Fig. 6E). The polish surface may contain faint linear traces or more developed shallow striations (Fig. 6D,E). The general direction of these run perpendicular or roughly perpendicular to the cup margin, consistent with a mode of use of these tools in a cutting or chopping action. Such well-developed, smooth polishes, sometimes referred to as 'domed' (e.g., Xauflair *et al*., 2016: 120) have previously been reported on quartzite flakes from Niah Cave (Barton, 2016) and on experimental tools made from jasper to process palm (*Caryota* sp.), bamboo (*Schitzostachyum* sp.) and rattan (*Calamus* sp.) (Xauflair *et al*., 2016: 120–121).

The micro-polish resulting from *Caryota* processing develops extremely fast, and appears very bright, very flat and very invasive. At macro-scale it produces an intense gloss of the edge which is already visible to the naked eye and is associated with rounding (Xauflair *et al*., 2016: 119).

This evidence is consistent with the use of these tools to chop woody palm pith in the processing of sago. None of the low-magnification or high-magnification observations are consistent with the interpretation of these tools being used as hand-held pounders. Such activities would lead to battering and crushing of the cup margin, rather than the intense glossy polish and rounding that is visible and typical on the study sample.

Organic residues

A study of the organic residues extracted from the previously noted sub-sample of four implements recovered starch granules, phytoliths and plant fibres. Residue extractions were undertaken in the School of Archaeology and Ancient History, University of Leicester, UK following standard extraction protocols (Barton, 2007). Tool extractions recovered starch granules typical of palms (Fig. 7A–D) and globular echinate phytoliths (Fig. 7E,F). Starch granules consist of generic palm types (Fig. 7D) that includes *Eugeissona utilis* Becc., *Metroxylon sagu* Rottb., and morphotypes that are uniquely typical of a minor sago palm, *Arenga undulatifolia* Becc. (Fig. 7A–C).

Cosmological biographies of cylindrical adzes

Old stone tools are important to people in these regions, falling into a broad category of items referred to as *batu perahit* (Janowski and Barton, 2012) and *batu nggau* (Sellato, 1996: 46): objects that were created by natural forces, sometimes lightning, or are stones somehow imbued with the flow of *lalud*—spiritual life forces (Janowski and Barton, 2012; Janowski, 2020). Simply owning these tools may confer benefits to their owners, but these forces may also be accessed by humans in different ways, often through physical contact, to release the flow of *lalud* for human benefit. For example: tools maybe placed in rice barns to increase the quantity of rice; buried in rice fields to increase yield; or *lalud* may be accessed by physical interaction such as washing in water (the water is then used medicinally), rubbing, abrading, and scratching the tool surface, and flaking (Janowski and Barton, 2012; Barton, 2013). As part of his study on these objects, Sellato asked his informants about the function of these conically shaped tools, and while they could readily identify implements such as 'bark beaters'—even those from archaeological contexts—they were unable to provide an interpretation for the conical pounders (Sellato, 1996: 51–52).

Several tools in the collection have been altered by human intervention and by normal post-depositional processes (Table 4). Some show signs of weathering from immersion in a stream or river (n = 3), some have been knapped (n = 3), several used as a pounder or pestle (n = 3) (Fig. 5C), and many are heavily coated in a layer of black soot (n = 10). The accumulation of soot will almost certainly have resulted from the storage of these tools inside the longhouse, either nearby or above the hearth. Kelabit and Lundayeh hearths are central features of the living space constructed on the

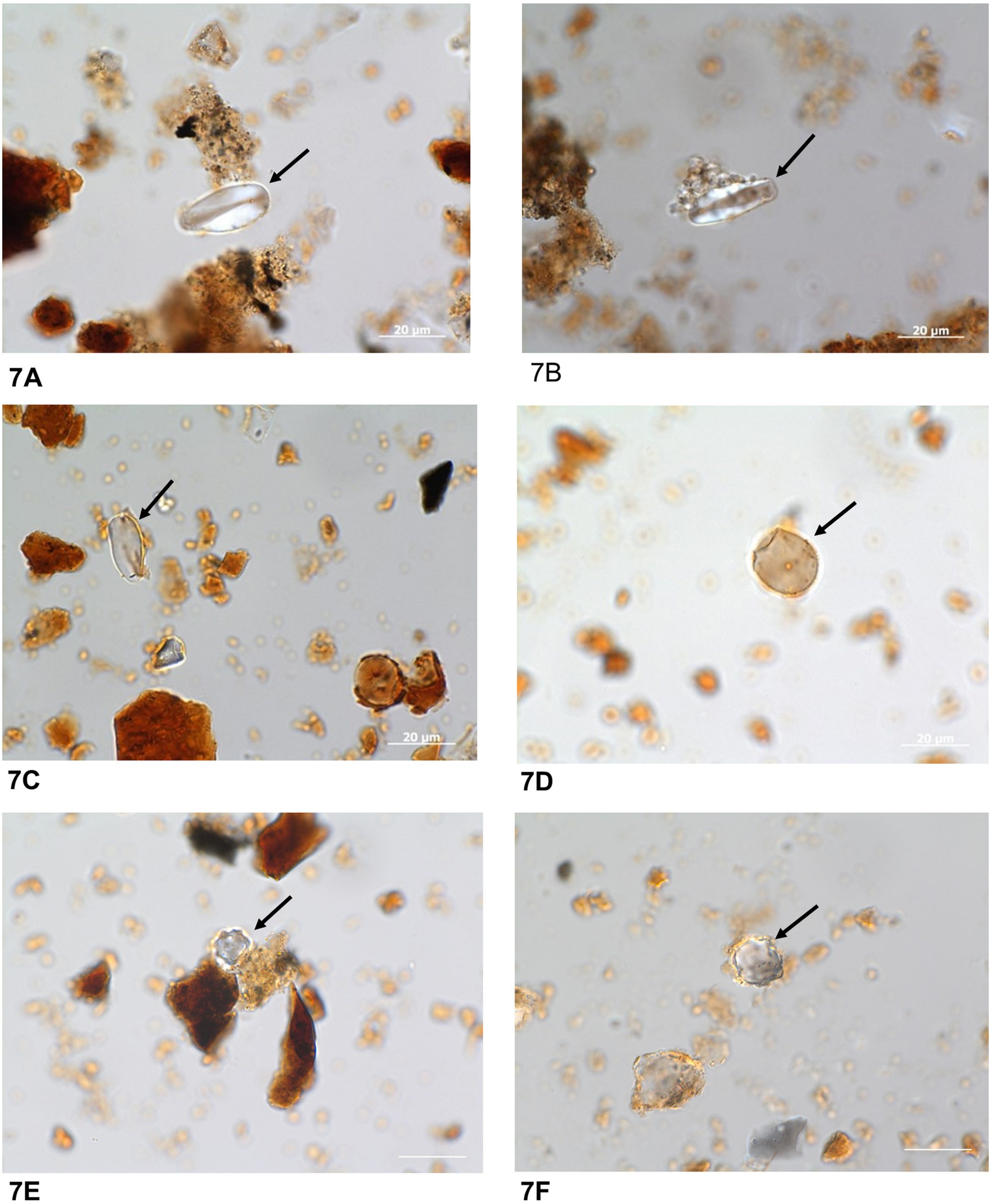

Figure 7. (*A–C*) Starch granules of palm species, *Arenga undulatifolia* Becc.; *A* and *B* in partial cross-polarised light (scales 20 µm). (*D*) Palm type starch granule, likely *Eugeissona utilis* Becc. (scale 20 µm). (*E* and *F*) Globular echinate phytoliths (consistent with palm types), a common type recovered from the cup end of all tools sampled for residues (#3127, #3141, #3189, #3194) (scales 20 µm). Arrows indicate starch granules (*A–D*) and globular echinate phytoliths (*E, F*).

Table 4. Post-depositional modifications of sago adzes in the Sarawak Museum (SM), Kuching, Malaysia.

SM reg. no.	modification from storage in longhouse	other modification (pre museum)
3164	soot	—
3178	—	Deliberate flake removals.
3180	soot	—
3197	soot	—
3200	—	Macroscopic usewear consistent with use as a pounder and/or pestle.
50.173	soot	—
50.184	—	Macroscopic usewear consistent with use as a pounder and/or pestle.
50.186	soot	—
50.200	soot	—
50.208	soot	—
50.216	soot	—
50.214	—	Deliberate flake removals.
50.542	soot	Water-worn.
50.543	—	Water-worn.
50.544	soot	—
64/230	—	Macroscopic usewear consistent with use as a pounder and/or pestle.
65/376	—	Deliberate flake removals.
65/260	—	Water-worn.

longhouse floor with a wooden structure above that is used for drying food products, and storing firewood (Barton, pers. obs., 2007). The storage of these tools above the hearth may have simply been for practical purposes or it may also have been important to associate these tools with a focal area of human life within the longhouse.

Three tools have been flaked (see two in Fig. 5D–F) and each are quite different in how they have been treated. Fig. 5D has a centripetal pattern of removals from the conical end leaving short, thick, flake scars. Fig. 5E appears to have broken during use and the residual end has been flaked along the shaft and across the transverse break. Several flake scars are without patina and thus younger than the original tool break. The butt end of this tool has been modified into a nosed scraper (Fig. 5F). There is some patina on these scars, and this appears to be a modification that occurred at different times.

The physical alteration of these tools is thought consistent with their value as *batu perahit* and the ways in which humans may access beneficial flows of *lalud* noted above. Flakes removed from these objects may also have been removed for use other ways. In one example from Indonesia, flakes of powerful stones were tied to the spurs of fighting cocks to help achieve victory (Barton, 2013: 521). The additional use of these tools as pounders/pestles may also be consistent with their new role as implements capable of transferring power to medicinal preparations or other recipes involving potency such as the preparation of hunting poisons. One informant I worked with in the village of Pa' Dalih, would not let me physically touch a *batu perahit*, that was a cylindrical stone adze (PDH07: Table 2), as he was concerned that my physical interaction with it might drain away its power. This individual was a keen hunter and used the *batu perahit* to sharpen metal blades used in hunting wild boar.

Histories of sago and sago adzes in Borneo

For the Penan of Sarawak, indigenous sago palms are a food staple, primarily using the hill sago palm, *Eugeissona utilis* Becc., but also they consume other minor palms including *Arenga* sp., *Caryota* sp., and *Livistonia* sp. (Ruddle *et al*., 1978). It appears that rice farming communities like the Kelabit and the Iban did once cultivate wild sago palms as well as using them as emergency food when rice crops failed (Freeman, 1955: 105; Harrisson, 1959; Barton, 2012), though locals may give conflicting replies about this when questioned. Today, foods like sago, taro, and cassava, are considered low-status foods in these communities. They may be consumed as snack foods, but their use a food staple would be frowned upon (Barton, 2012: 102), which may explain their reluctance to discuss the palm as a cultivar. Among the Kelabit today, there is no knowledge of using stone tools to process sago palm pith.

Today in Borneo, only one lowland sedentary agricultural community continues to rely on sago palms as a food staple, the Melanau (Fig. 1), and they use the introduced swamp sago, *Metroxylon sagu* Rottb., not the endemic hill sago, *Eugeissona utilis* Becc., which is thought to have been introduced into the region from western New Guinea or the Moluccas (Ehara *et al*., 2015). The date of that introduction is unknown, but the swamp sago palm is now widespread throughout the swampy lowlands of Indonesia, Malaysia and into parts of India (Blench, 2012). Archaeological evidence also shows extensive inter-island transport of obsidian within the Indonesian archipelago throughout the Holocene (Spriggs *et al*., 2011), and of long-distance transport from New Britain and the Admiralty Islands to Sabah in the third millennium BP (Spriggs *et al.*, 2011). The genetic studies on the history of domesticated bananas also reveal widespread interisland exchanges throughout the Philippine and Indonesian archipelagos, ultimately influencing the emergence of domesticated genotypes by at least the mid-third millennium BP (Perrier *et al*., 2011).

Archaeological survey and excavations conducted in the Kelabit Highlands as part of the Cultured Rainforest Project (2007–2010) recovered a range of evidence indicating human occupation of the upland interior from at least the early Holocene (Barker *et al*., 2008, 2009, 2017). A pollen core

(BPG) taken from a palaeo-channel used in rice cultivation, showed evidence of human-induced disturbances including burning, soil erosion and canopy opening dating from at least 7000 to 6000 years ago (Jones *et al*., 2013a). The earliest direct evidence of human occupation in the region comes from an open site on a river terrace called Ruma Ma'on Dakah. Excavations revealed a buried soil horizon and a post-hole associated with abraded sherds of earthenware pottery, a fragment of a polished stone implement and burnt stones. Charcoal in its fill was dated to around 3700 years ago (Barker *et al*., 2017). By 3000 years ago, at the site of Pa' Dalih (core PDH212) there was a marked decline in forest taxa and a parallel increase in open ground and scrub taxa with, a century later, the appearance of echinate (palm) phytoliths and a notable band of charcoal (Jones *et al*., 2013b). A second pollen core PDH223, near the village of Pa' Dalih, showed significant increases in pollen from wild hill sago, *Eugeissona utilis* Becc., at about 2300 years ago, along with evidence of open terrain and increased charcoal deposition (Jones *et al*., 2013b). The presence of this palm near a river channel, along with vegetation disturbance, may be indirect evidence of deliberate cultivation of wild hill sago at this time (Jones *et al*., 2013b). From the site of Menatoh Long Diit, a single fragment of a cylindrical stone sago adze was recovered from sub-surface wall rubble with charcoal providing a relative age of 1700–1500 cal. BP (Beta-280499) (Barker *et al*., 2017: table 3).

Several rice phytoliths, including a rice bulliform, were also recovered from core PDH212 dating from 1790 to 1800 cal. BP (Jones *et al*., 2013b: 715). These dates are the earliest evidence of rice in the highlands and now tie in with the revised dating of domesticated rice from the lowland cave site of Gua Sireh (Datan, 1993). Here, micro CT scans have identified spikelet remains of domesticated rice in pottery that is dated between 2000 to 800 BP (Barron *et al*., 2020: 9). In summary, the archaeological and palaeo-environmental data from the highlands suggest that an indigenous system of plant management, including palm cultivation, may pre-date the arrival of domesticated rice from the Philippines (Bellwood, 2005: 135), and be part of wider regional flows of materials and plants and ideas into and out of the region (e.g., Andaya, 2017; Blench, 2012; Swadling, 1996).

The cylindrical stone adzes from Borneo and swamp sago palms (*Metroxylon sagu* Rottb.) from New Guinea may be evidence of such long-distance relationships along the Indonesian island archipelago. Stone adzes may have been moved from the interior to the coast and to New Guinea, or the adzes could have been moved from New Guinea along with swamp sago to the northwest coast of Borneo and later up-river to the interior, where the adzes may have been adopted into indigenous systems of sago cultivation (Jones *et al*., 2013a). It is also possible that the two types of cylindrical adze in New Guinea and Borneo are independent adaptations of tools made from bamboo internodes, the stone adze being a copy of the natural shaft and cupped end of bamboo tools (see Ellen, 2008). In Borneo, for whatever reasons, these stone tools were abandoned and forgotten, disappearing into prehistory at an as yet unknown point in time, while they continued in use in New Guinea until the recent past (Lewis, 1923). Penan wooden sago adzes are a very different solution to the problem of sago processing—with a metal blade they can be fashioned in a matter of minutes (Barton, pers. obs., 2003). The stone cylindrical pounders by contrast represent a much larger investment in time and expertise in their production. I suspect that these are tools that could have lasted many years of use, possibly even existing as heirloom items.

Conclusion

I suggest that the stone tools discussed in this paper should be termed as 'cylindrical stone adzes.' In Borneo, these tools appear unique to the highlands and similar to tools known from the northwest coast of Papua (Lewis, 1923; Gonthier, 1987). They are not strictly pounders and were likely hafted and used to chop and separate the pith of sago palms. Analyses of the macro- and microscopic wear and organic residues reinforce this interpretation of their function. These tools were used in the extraction of sago flour from palms that included *Arenga undulatifolia* Becc., and possibly *Eugeissona utilis* Becc., by at least the middle of the first millennium AD and possibly by the end of the last millennium BC. Their similarities with the Papuan material are striking and raise further questions about the connections between these regions and of the flows of people, sago, and other things, back and forth across the island archipelagos of Malesia during the Holocene.

Postscript: The Australian cylindro-conical pounders and cornuted stones

Within the Sarawak Museum collections are several Australian conical stone tools stored with the cylindrical stone adzes (Table 3). These tools fit the description of 'cylindro-conical' and 'cornuted' stones by Etheridge Jr (1916). McCarthy (1953) also wrote about these conical pounders, expanding his comparative review with material from Java. It is possible that these tools were sent to the Sarawak Museum in the early 1950s when both McCarthy and Harrisson were writing about their collections and thinking about the diffusion of cultural influences across the island archipelago and into Australia.

Two of these stones fit the description of 'cylindro-conical' (Australian Museum registration nos E44857-1, E21251) and two as 'cornuted' stones (E26613, E44857-2). One of these was not fully recorded in the museum. While these objects share broad similarities in overall shape with the Borneo tools, there are important differences between them that suggest that the visual similarities are more likely outcomes of convergence, arriving at similar forms. It was difficult to distinguish any traces of visible edge damage

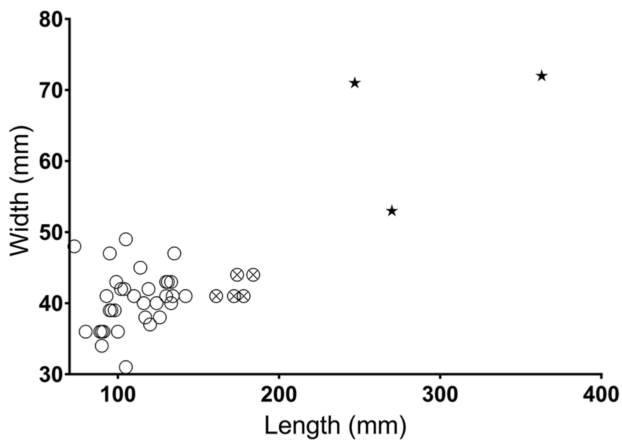

Figure 8. Size distribution of conical stone adzes from the Sarawak Museum archive (open circles). Circles with inset crosses denote tools that appear to be complete or near complete examples with little or only minor physical wear. Stars indicate the conical pounders and cornuted stones from Australia held within the Sarawak Museum archive.

Figure 9. (*A* and *C*) #E44857-1. Large cylindrical implement (sandstone), no locality, Australia. The entire surface has been shaped by pecking and grinding. The shaft is parallel-sided and tapers at one end to a rounded point. The other end has been shaped into a cup that is also pecked across its surface and has chipping around its margin (*C*). Length 270 mm. Cup exterior diameter 42 mm. (*B* and *D*) #E21251. Large cylindrical implement (sandstone), from Belali, Warrego River near Bourke, NSW, Australia. The implement has a similar tapered form to Bornean cylindrical stone adzes and with a concave end opposite the butt (*D*). Margin of the tool has some chipping and modern contact damage from storage. Length 363 mm. Cup exterior diameter 56 mm.

Figure 10. (*A* and *C*) #E26613. Irregular, roughly ovate in cross-section, from Broken Hill, NSW, Australia (coll. 1921). Butt end curves away from the main shaft in profile (not shown in image) producing a horn-shape ('cornuted' stone). The flat working end is pecked, ground and striated. The striations on the base are same as those on the lower end of the shaft and appear to be marks from a shaping tool. Length 247 mm. (*B* and *D*) #E44857-2. Irregular, roughly ovate in cross-section, from Australia. This tool has no label and no collection data. Butt end curves away from the main shaft in profile, giving a horn-shape ('cornuted' stone). The working end is very slightly concave and pecked, with some chipping around the cup margin (*D*). No length measurement available.

on these Australian objects beyond clear traces associated with their manufacture. The clear differences between the Australian cylindro-conical tools and the Bornean sago adzes are their sheer size (Fig. 8), the macroscopic wear patterns, and the sandstone raw materials they are shaped from.

The cylindro-conical tools are parallel-sided along their length and taper at the butt end. The cylindrical stone adzes by comparison are tapered along their length and flare at the working end (having the shape of a cone, rather than a cylinder, see Fig. 1). Like the Bornean adzes, they show signs of pecking and grinding to create their overall form, and both have concave cup ends (Fig. 9). The cup margins of the Australian tools are gently rounded with little evidence of chipping from use. Both show evidence of damage from handling and storage conditions (Fig. 9C–D). The cups of these tools show no obvious signs of working damage. E448571-1 has numerous pits and depressions, but this is consistent with the features on the shaft associated with manufacture rather than use. E21251 has a well-ground concavity that shows no signs of impact damage. The size of these implements suggests that they were probably hand-held rather than hafted. There is certainly no evidence of the kinds of high impact wear on the cupped ends of these tools that would suggest uses similar to those of the cylindrical adzes of Borneo.

The two ‘cornuted’ stones (E26613, E44857-2, Fig. 10) are quite unusual in their overall form. They are well named, as both have a pointed end that tapers asymmetrically from the main shaft of the piece. The working ends of these implements are either flat (E26613: Fig. 10C) or have a slight concavity (E448571-2, Fig. 10D). Both are made from sandstone. E26613 is a relatively soft stone that has been pecked, rubbed, and scraped into its final form (Fig. 10C). Tool marks from scraping are evident all over this piece and particularly at the flat end (Fig. 10C). It is difficult to determine the type of tool that has left the fine parallel linear traces: perhaps shell. The wide ends of both tools have minor flaking damage around their margins that could be wear from light duty use, and the faces of both retain pecking marks from the manufacturing process. E22613 also has linear scraping marks across the face, suggesting that either the worked material was soft, or that it underwent maintenance after use.

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References

Andaya, L. Y. 2017. Flights of fancy: the bird of paradise and its cultural impact. *Journal of Southeast Asian Studies* 48(3): 372–389.
https://doi.org/10.1017/S0022463417000546

Anderson, P. 1980. A testimony of prehistoric tasks: diagnostic residues on stone tool working edges. *World Archaeology* 12(2): 181–194.
https://doi.org/10.1080/00438243.1980.9979791

Anderson-Gerfaud, P. C. 1986. A few comments concerning residue analysis of stone plant processing tools. *Early Man News* 9/10/11: 68–82.

Barker, G., H. Barton, D. Britton, I. Datan, B. Davenport, M. Janowski, S. Jones, J. Langub, L. Lloyd-Smith, B. Nyíri, and B. Upex. 2008. The Cultured Rainforest Project: the first (2007) field season. *Sarawak Museum Journal* 85: 121–190.

Barker, G., H. Barton, E. Boutsikas, D. Britton, I. Datan, B. Davenport, I. Ewart, L. Farr, R. Ferraby, C. Gosden, C. Hunt, M. Janowski, S. Jones, J. Langub, L. Lloyd-Smith, B. Nyíri, K. Pearce, and B. Upex. 2009. The Cultured Rainforest Project: the second (2008) field season. *Sarawak Museum Journal* 86: 119–184.

Barker, G., C. Hunt, H. Barton, C. Gosden, S. Jones, L. Lloyd-Smith, L. Farr, B. Nyiri, and S. O’Donnell. 2017. The ‘cultured rainforests’ of Borneo. *Quaternary International* 448: 44–46.
https://doi.org/10.1016/j.quaint.2016.08.018

Barron, A., I. Datan, P. Bellwood, R. Wood, D. Fuller, and T. Denham. 2020. Sherds as archaeobotanical assemblages: Gua Sireh reconsidered. *Antiquity* 94: 1325–1336.
https://doi.org/10.15184/aqy.2020.166

Barton, H. 2007. Starch residues on museum artefacts: implications for determining tool use. *Journal of Archaeological Science* 34: 1752–1762.
https://doi.org/10.1016/j.jas.2007.01.007

Barton, H., 2012. The reversed fortunes of sago and rice, *Oryza sativa*, in the rainforests of Sarawak, Borneo. *Quaternary International* 249: 96–104.
https://doi.org/10.1016/j.quaint.2011.03.037

Barton, H. 2013. Myanmar and Malaysia. In *World Archaeology at the Pitt Rivers Museum: A Characterisation*, ed. D. Hicks and A. Stevenson, pp. 517–524. Oxford: Archaeopress.
https://doi.org/10.2307/j.ctv17db2mz.32

Barton, H. 2016. Functional analysis of stone tools from the West Mouth. In *Archaeological Investigations in the Niah Caves, Sarawak*, ed. G. Barker and L. Farr, pp. 279–300. Cambridge: McDonald Institute for Archaeological Research.

Bellwood, P. 2005. *First Farmers: The Origins of Agricultural Societies*. London: Blackwell Publishing.

Blench, R. 2012. Was there an arc of vegeculture linking Melanesia with Northeast India? In *Pacific Archaeology: Documenting the Past 50,000 Years to the Present*, ed. G. Summerhayes and H. Buckley, pp. 1–16. University of Otago Studies in Archaeology no. 25. Dunedin: University of Otago.

Collings, H. D. 1949. Some Neolithic tools from Sarawak. *Sarawak Museum Journal* 5(1): 16–22.

Crosby, E. 1976. Sago in Melanesia. *Archaeology and Physical Anthropology in Oceania* 11(2): 138–155.
http://www.jstor.org/stable/40386263

d’Anghiera, P. M. 2010 [1555]. *The Decades of the Newe Worlde or West India Conteynyng the Nauigations and Conquestes of the Spanyardes.* Translated by Richard Eden. London: William Powell. March of America Facsimile Series, Number 4. Ann Arbor: University Microfilms.

Datan, I. 1993. Archaeological Excavations at Gua Sireh (Serian) and Lubang Angin, Sarawak, Malaysia. *Sarawak Museum Journal, Special Monograph* no. 6.

Ehara, H., T. Takamura, Y. Yamamoto, and H. Shimoda. 2015. Origin, dispersal and distribution. In *The Sago Palm: The Food and Environmental Challenges of the 21st Century*, ed. K. Smith, pp. 1–40. Kyoto: Kyoto University Press.

Ellen, R. 2008. Distribution and variation in sago extraction equipment: convergent and secondary technologies in island southeast Asia. *Archaeology in Oceania* 43(2): 62–74. https://doi.org/10.1002/j.1834-4453.2008.tb00031.x

Etheridge Jr, R. 1916. The Cylindro-Conical and Cornuted Stone Implements of Western New South Wales and their Significance. *Memoirs of the Geological Survey of New South Wales, Ethnological Series* no. 2. Sydney: Government Printer.

Freeman, D. 1955. *Iban Agriculture: A Report on the Shifting Cultivation of Hill Rice by the Iban of Sarawak*. London: H. M. Stationary Office.

Fullagar, R. 1991.The role of silica in polish formation. *Journal of Archaeological Science* 18(1): 1–24. https://doi.org/10.1016/0305-4403(91)90076-2

Fullagar, R. 2006. Residues and usewear. In *Archaeology in Practice*, ed. J. Balme and A. Paterson, pp. 207–234. Malden: Blackwell.

Gonthier, E. 1987. Étude du Matérial Lithique des Papous Indonesiens. Unpublished PhD thesis, École des Hautes Études en Sciences Sociales, Paris.

Harrisson, T. 1949. Explorations in Central Borneo. *The Geographical Journal* 114: 129–149. https://doi.org/10.2307/1789578

Harrisson, T. 1951a. Stone hooks and cyclons [sic] from West Borneo. *Sarawak Museum Journal* 5: 534–540.

Harrisson, T. 1951b. Notes on some neolithic implements from Borneo. *Man* 51: 21–24. https://doi.org/10.2307/2794485

Harrisson, T. 1959. *World Within: A Borneo Story*. London: Cresset Press.

Harrisson, T. 1970. *The Malays of South-West Sarawak before Malaysia*. London: MacMillan.

Janowski, M. 2020. Stones alive! An exploration of the relationship between humans and stone in Southeast Asia. *Bidgragen tot de Taal-, Land- en Volkenkunde* 176: 105–146. https://doi.org/10.1163/22134379-bja10001

Janowski, M., and H. Barton. 2012. Reading human activity in the landscape. *Indonesia and the Malay World* 40: 354–371. https://doi.org/10.1080/13639811.2012.709005

Jones, S. E., C. O. Hunt, H. Barton, C. J. Lentfer, and P. J. Reimer. 2013a. Forest disturbance, arboriculture and the adoption of rice in the Kelabit highlands of Sarawak, Malaysian Borneo. *The Holocene* 23(11): 1528–1546. https://doi.org/10.1177/0959683613496293

Jones, S. E., C. O. Hunt, and P. J. Reimer. 2013b. A 2300 yr record of sago and rice use from the southern Kelabit Highlands of Sarawak, Malaysian Borneo. *The Holocene* 23(5): 708–720. https://doi.org/10.1177/0959683612470180

Kamińska-Szymczak, J. 2002. Cutting Graminae tools and "sickle gloss" formation. *Lithic Technology* 27(2): 111–151. https://doi.org/10.1080/01977261.2002.11720994

Kamminga, J. 1979. The nature of use-polish and abrasive smoothing on stone tools. In *Lithic Usewear Analysis*, ed. B. Hayden, pp. 143–157. New York: Academic Press.

Khan, K. 1993. Frederick David McCarthy: an appreciation. In *F. D. McCarthy, Commemorative Papers (Archaeology, Anthropology, Rock Art)*, ed. Jim Specht. *Records of the Australian Museum*, *Supplement* 17: 1–5. https://doi.org/10.3853/j.0812-7387.17.1993.54

King, V. T. 1985. *The Maloh of West Kalimantan*. Dordrecht, Netherlands: Foris Publications.

Lewis, A. B. 1923. *The Use of Sago in New Guinea*. Chicago: Field Museum of Natural History.

McCarthy, F. D. 1953. The Oceanic and Indonesian affiliations of Australian Aboriginal culture. *Journal of the Polynesian Society* 62(3): 243–261. http://www.jstor.org/stable/20703380

Meeks, N. D., G. de Sieveking, M. S. Tite, and J. Cook. 1982. Gloss and use-wear traces on flint sickles and similar phenomena. *Journal of Archaeological Science* 9(4): 317–340. https://doi.org/10.1016/0305-4403(82)90038-3

Morris, H. S. 1953. *Report on a Melanau Sago Producing Community in Sarawak*. Colonial Research Studies no. 9. London: H. M. Stationary Office, for the Colonial Office.

Nicholaisen, I. 1986. Pride and progress: Kajang response to economic change. *Sarawak Museum Journal* 36: 75–116.

Perrier, X., E. De Langhe, M. Donohue, C. Lentfer, L. Vrydaghs, F. Bakry, I. J. Carreel, I. Hippolyte, C. Horry, C. Jenny, V. Lebot, A. Risterucci, K. Tomekpe, H. Doutrelepont, T. Ball, J. Manwaring, P. de Maret, and T. P. Denham. 2011. Multidisciplinary perspectives on banana (Musa spp.) domestication. *Proceedings of the National Academy of Sciences of the USA* 108(28): 11311–11318. https://doi.org/10.1073/pnas.1102001108

Plisson, H., and M. Mauger. 1988. Chemical and mechanical alteration of microwear polishes: an experimental approach. *Helenium* 28: 3–16.

Rousseau, J., 1990. *Central Borneo: Ethnic Identity and Social Life in a Stratified Society*. Oxford: Oxford University Press.

Ruddle, K., D. Johnson, P. K. Townsend, and J. D. Rees. 1978. *Palm Sago: A Tropical Starch from Marginal Lands*. Honolulu: University of Hawai'i Press.

Rutter, O. 1929. *The Pagans of North Borneo*. London: Hutchison and Co.

Sellato, B. 1996. Stone nutcrackers and other recent finds of lithic industry in interior Northeastern Kalimantan. *Journal of the Sarawak Museum* 71 (New Series): 39–57.

Sellato, B. 2016. The Ngorek of the central highlands and 'megalithic' activity in Borneo. In *Living and Past Megalithisms: Interwoven Approaches*, ed. C. Jeunesse, P. Le Roux, and B. Boulestin, pp. 117–149. Oxford: Archaeopress Archaeology. https://doi.org/10.2307/j.ctvxrq101.11

Semenov, S. A. 1964. *Prehistoric Technology*. London: Cory, Adams and Mackay.

Spriggs, M., C. Reepmeyer, Anggraeni, P. Lape, L. Neri, W. P. Ronquillo, T. Simanjuntak, G. Summerhayes, D. Tanudirjo, and A. Tiauzon. 2011. Obsidian sources and distribution systems in Island Southeast Asia: a review of previous research. *Journal of Archaeological Science* 38: 2873–2881. https://doi.org/10.1016/j.jas.2011.06.015

Stonor, C. 1948. On the use of tree-fern pith for sago in the Assam Himalayas. *Man* 48: 137. https://doi.org/10.2307/2792087

Strickland, S. S. 1985. Long-term development of Kejaman subsistence: an ecological study. *Sarawak Museum Journal* 36: 117–171.

Swadling, P. 1996. *Plumes from Paradise: Trade Cycles in Outer Southeast Asia and their and Impact on New Guinea and Nearby Islands until 1920*. Port Moresby: Papua New Guinea National Museum in association with Robert Brown and Associates.

Thieret, J. W. 1958. Economic botany of the cycads. *Economic Botany* 12(1): 3–41. https://doi.org/10.1007/BF02863122

Unger-Hamilton, R. 1984. The formation of use-wear polish on flint: beyond the "deposit versus abrasion" controversy. *Journal of Archaeological Science* 11(1): 91–98. https://doi.org/10.1016/0305-4403(84)90044-X

Xauflair, H., A. Pawlik, C. Gaillard, H. Forestier, H. J. Vitales, J. R. Callade, D. Tandang, N. Amano, D. Manipon, and E. Dizon. 2016. Characterisation of the use-wear resulting from bamboo working and its importance to address the hypothesis of the existence of a bamboo industry in prehistoric Southeast Asia. *Quaternary International* 416: 95–125. https://doi.org/10.1016/j.quaint.2015.11.007

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Up Close and Personal: James Edge-Partington in Australia in 1897

Susan M. Davies[1] and Michael Quinnell[2]

[1] Independent Researcher, 17 O'Brien Court, Arundel QLD 4214, Australia

[2] Honorary Associate, Cultural Environments, Queensland Museum Network, South Brisbane BC QLD 4101, Australia

Abstract. British ethnologist, collector and author, James Edge-Partington visited Australia twice in the late 19th century. His first Australian sojourn was marked by sight-seeing and social events, with his travels interrupted by side trips to Fiji and Tonga, where he developed a passion for artefact collecting. In contrast, his second journey was focused on gathering information and sketching Pacific Islander and Australian Aboriginal artefacts held in museums and private collections. These drawings were later published between 1890 and 1898 in three volumes that became a major reference source for museum curators and researchers. This paper outlines Edge-Partington's 1879–1881 visit before focusing on his 1897 trip which included visits to five public museums and one university museum and produced more than 600 sketches of cultural material. This trip also produced many drawings of objects held in private collections. The paper documents Edge-Partington's visit to the Queensland Museum where he spent most of his time examining and sketching objects from the field collection of Sir William MacGregor, the colonial administrator of British New Guinea. Edge-Partington's motives for focusing on this particular collection rather than others held by the Museum are discussed and the possibility that Edge-Partington later acquired artefacts from the MacGregor assemblage for his personal collection is also considered. The paper shows how his sketches can be used to improve the documentation for existing museum collections, such as the MacGregor collection that is now dispersed through several museums.

Introduction

The British ethnologist James Edge-Partington (1854–1930) (Fig. 1) made two visits to Australia and the Pacific region in the last quarter of the 19th century. His first visit in 1879–1881 sparked an interest in collecting ethnographic artefacts that continued for the rest of his life. Although he published more than 40 papers on aspects of Pacific material culture between 1896 and 1922, Edge-Partington is better known for his contribution to the work titled '*An Album of the Weapons, Tools, Ornaments, Articles of Dress of the Natives of the Pacific Islands*' (also known as the *Ethnographical Album of the Pacific Islands*, hereafter *Ethnographical Album*) which he published privately with his friend Charles Heape between 1890 and 1898 (Edge-Partington and Heape, 1890, 1895, 1898a). Comprising sketches of Pacific artefacts from private collections and museums, this work was an essential reference source for many 20th century museum curators trying to establish the provenance of undocumented artefacts. Two facsimile editions published in 1969 and 1996 attest to the *Ethnographical Album*'s enduring legacy (Edge-Partington, 1969; Edge-Partington and Heape, 1996).[1]

Aspects of Edge-Partington's life, work, travels and collecting activities are documented through several published sources (Dalton, 1931; Edge-Partington, 1883; Neich, 2009; Neich and Kaufmann, 2011). Close scrutiny of these sources, and, in particular, Neich's (2009) seminal paper reveal that while Edge-Partington's travels in Australia, Fiji, Tonga, Samoa and New Zealand between 1879–1881 are well-documented through his published account (Edge-Partington, 1883), details pertaining to his trip to Australia and the Pacific in 1897 are rather more elusive. The main

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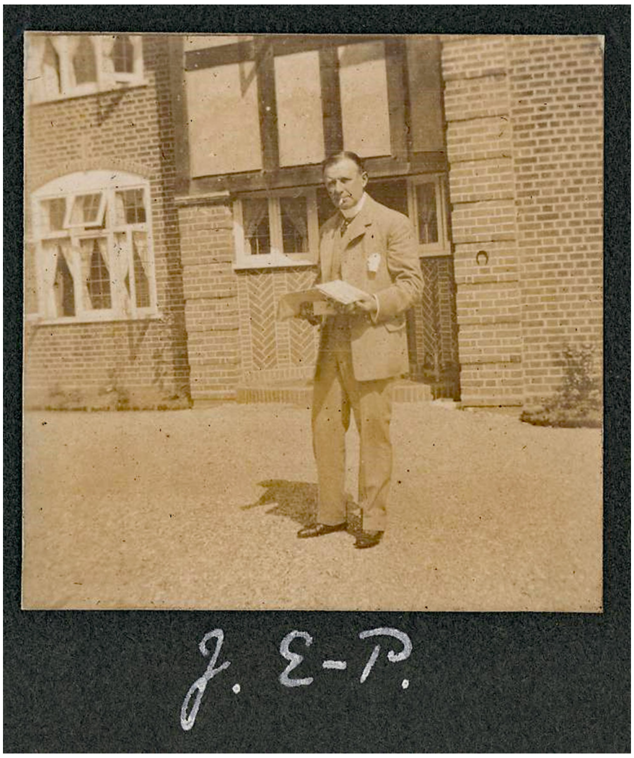

Figure 1. James Edge-Partington, prior to 1920. Photographer not known. Photo: © British Museum, Thomas Edge-Partington album 6, Oc,Ca46.46. Courtesy of the Trustees of the British Museum.

objective of the second trip was to gather information and new material for the third volume of the *Ethnographical Album* (Edge-Partington and Heape, 1898a).

Neich (2009: 81) noted that the 'only known records' of the 1897 trip are Edge-Partington's 'brief, often cryptic, handwritten letters' to British Museum curator Charles Hercules Read. Neich (2009: 81–83) constructed a rough itinerary of Edge-Partington's 1897 travels based on these letters that show that between April and June 1897 he visited the Australian cities of Adelaide, Melbourne and Sydney before travelling to New Zealand, Fiji, Honolulu, San Francisco, Seattle and Vancouver. One Australian city is entirely absent from the 1897 itinerary reconstructed by Neich: Brisbane, which Edge-Partington visited in May 1897 (Queensland Museum Minute Book, 3 May 1897 [hereafter QM Minute Book]). Edge-Partington's visit to the city of Brisbane and the Queensland Museum is the primary focus of our paper.

This aspect of Edge-Partington's 1897 trip was of particular interest to us because during that visit he sketched objects from the collection of ethnology amassed by the Administrator and later, Lieutenant-governor of British New Guinea, Sir William MacGregor. This collection is the focus of an ARC Discovery Grant, 'Excavating MacGregor', one of the aims of which is 'to re-assemble and re-connect' MacGregor's private and public ethnological collections that are now dispersed through three Australian museums and six overseas museums (Anonymous, 2016). A major part of that project has involved creating a new listing of MacGregor's extensive field collection of 10,959 objects that were deposited in the Queensland Museum between 1892 and 1898 (Davies, 2017). Since Edge-Partington's visit to the Queensland Museum occurred just prior to the distribution of nearly 2500 objects as 'duplicates' from this collection to other museums, it was anticipated that sketches he made in the New Guinea Gallery might impart new information about certain objects in the collection, or perhaps even provide an image of an object for which no trace remains today.

This paper outlines Edge-Partington's first trip to Australia 1879–1881 before focusing on the 1897 visit, and in particular his visit to the Queensland Museum. It uses the third and final volume of the *Ethnographical Album* (Fig. 2) to chart his activities in the Australian colonies in 1897 and to provide a background for his visit to the Queensland Museum (Edge-Partington and Heape, 1898a). Edge-Partington's sketching activities in the Queensland Museum are reviewed before investigating whether Edge-Partington later acquired artefacts from the MacGregor assemblage for his own personal collection.

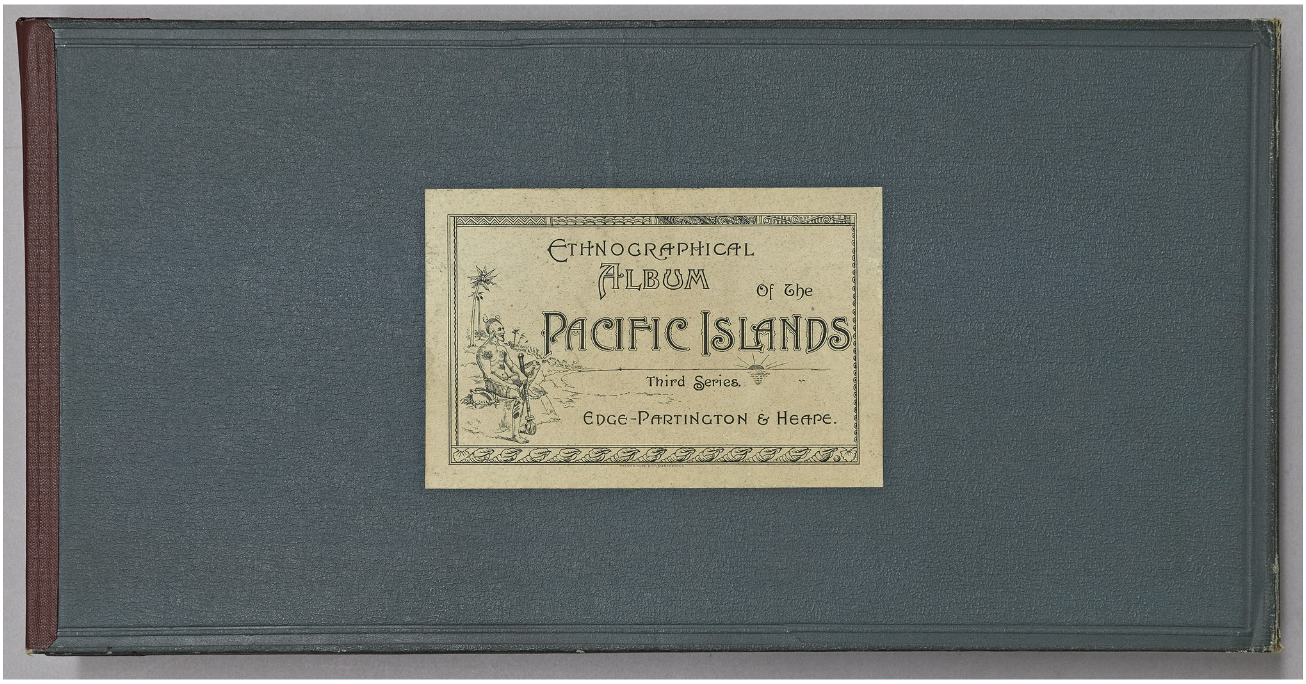

Figure 2. Front cover, *Ethnographical Album of the Pacific Islands* (Edge-Partington and Heape, 1898a). Photo: Queensland Museum Digital Imaging Unit QMDIU_03087. Courtesy of Queensland Museum Library.

First visit to Australia (1879–1881)

Edge-Partington's first trip to Australia was markedly different to that which followed nearly a decade later. His activities during the former are well-documented through his published account of his travels, *Random Rot: a journal of three years' wanderings around the world* (Edge-Partington, 1883), which indicates that when he left England on 10 May 1879 he intended to spend three months in the Australian colonies before visiting China (Edge-Partington, 1883: 379). Instead, he spent the next two years travelling through parts of Australia and making the occasional trip to islands in the Pacific, including Fiji, Tonga, Samoa and New Zealand.

His first stay in the Australian colonies lasted just over six weeks (1 July to 16 August 1879) and was followed by two sojourns of several months' duration (13 October 1879 to 8 June 1880; 11 October 1880 to 3 February 1881) (Edge-Partington, 1883: Itinerary). His extensive travels in the colonies of Victoria, South Australia, New South Wales and Tasmania were largely marked by sight-seeing and attending a range of social events, such as the theatre, balls, dances and horse races. In stark contrast, his first visit to Fiji (28 August 1879 to 2 October 1879) appears to have sparked a lifelong interest in collecting artefacts (Neich, 2009: 62). Collecting also preoccupied his time in Tonga, Samoa and New Zealand.

Two international exhibitions were held in Australia during Edge-Partington's visit, the Sydney International Exhibition (1879–1880) and the Melbourne International Exhibition (1880–1881). References to both exhibitions appear in *Random Rot* but it would seem that he only visited the latter (Edge-Partington, 1883) since his itinerary indicates that he arrived in Sydney about two weeks after the Sydney International Exhibition closed. However, he had some interest in the Sydney exhibition for he later purchased a collection of Solomon Island curios that had reputedly been part of it (Neich, 2009: 65; Edge-Partington, 1883: 200).[2]

After an absence of nearly three years, Edge-Partington returned to England on 27 January 1882. His return journey was via China, Japan and the United States. In the following year he published *Random Rot*, which reveals that he developed a passion for collecting Pacific material culture during his time abroad. Back in England, he formed strong connections with British Museum curators A. W. Franks and C. H. Read (Neich, 2009: 74). He later became a volunteer at the British Museum, donating his time and expertise to improving the documentation and labelling of its Pacific collections. The *Ethnographical Album* comprising his sketches of Pacific Island artefacts based on public and private collections in England followed (Edge-Partington and Heape, 1890). This volume, limited to 150 copies, was published privately with his friend, Charles Heape, with acknowledgements to the assistance provided by A. W. Franks and C. H. Read at the British Museum (Edge-Partington and Heape, 1890: Preface, 1898b)). It illustrated many specimens from the British Museum and appears to have been aimed largely at museums and private collectors. The publication was apparently generally well received, as Franks noted that the work 'is greatly valued by the ethnographical museums of the world' and A. C. Haddon described it 'as invaluable to students of ethnology as it is to collectors and curators' (Neich, 2009: 76, 83). Despite these accolades, the information associated with some objects was later subject to correction (Neich, 2009: 84). A second volume of the *Ethnographical Album* followed (Edge-Partington and Heape, 1895) and, like its predecessor, it contained lithographic plates featuring artefacts solely originating from British collections, especially those held in the British Museum.

In 1897, Edge-Partington made a second trip to Australia and the Pacific region. The aim of the journey was to gather 'information and drawings' of specimens not included in the previous two volumes of the *Ethnographical Album (*Edge-Partington and Heape, 1898a). Sketches made during the trip were published in the third volume of the *Ethnographical Album,* a work that was much wider in scope than the previous two volumes, as it illustrated cultural material held in museums and private collections in Australia, New Zealand, Hawai'i, Canada and the United States (Edge-Partington and Heape, 1898a).

Second trip to Australia (1897)

Aspects of Edge-Partington's time in Australia in 1897 have been pieced together from a series of letters he wrote to C. H. Read of the British Museum (Neich, 2009: 81–83). These letters provide important but limited information about Edge-Partington's activities in Australia. In this paper, another source, namely the third and final volume of the *Ethnographical Album* is used to chart his activities in the colonies (Edge-Partington and Heape, 1898a). The authors' preface to this volume reveals that the reason for his journey was to acquire ethnographic material that had not yet reached Europe and to discover what the various colonial museums contained (Edge-Partington and Heape, 1898a: Preface). There was also some expectation that being nearer to the place of origin of an object would ensure 'greater accuracy' in its description.

Edge-Partington's itinerary in Australia and the Pacific region in 1897 has been uncertain. According to Neich (2009: 81–83) his travels in Australia included visits to Adelaide (April), Melbourne (April) and Sydney (April, May, June) (Neich, 2009: 81). Neich (2009: 82–83) determined that by early July he was in New Zealand, placing him in Dunedin (5 July), Wellington (9 August) and Auckland (18 August). From there he travelled to Fiji, Honolulu (1 September) and Seattle (28 September). He left the USA on 26 October bound for England. Despite Neich's extensive investigations, significant gaps remain concerning our knowledge of his Australian sojourn (April–June 1897).

Importantly, in addition to visiting Adelaide, Melbourne and Sydney, our research shows that Edge-Partington also spent about a week in Brisbane in May 1897.

When Edge-Partington left England in 1897 he was 'armed with letters of recommendation' from Read and the principal librarian of the British Museum asking museum directors to assist him in his endeavours (Neich, 2009: 81). Presumably, these letters were of some assistance for he gained access to public collections in South Australia, Victoria, New South Wales and Queensland. Moreover, it appears that some of the museum curators he met on his travels introduced Edge-Partington to individuals with collections in his areas of interest, because he examined and sketched several notable private collections in Australia (Fig. 3).

Edge-Partington visited five colonial museums in Australia between late March and the end of June 1897 (Table 1). He appears to have made about 134 sketches in the Adelaide Museum (now named the South Australian Museum), a tally that corresponds closely to the 130 sketches he noted in a letter to C. H. Read on 1 April 1897 (Neich, 2009: 81). At what Edge-Partington called the 'Melbourne Museum' (i.e. the Industrial and Technological Museum, now part of Museums Victoria), he seems to have

Figure 3. J. W. Lindt's studio 'Ethelred' in Hawthorne, Melbourne. c.1885-1894. Photo: State Library Victoria H85.40/2. Courtesy of the State Library of Victoria. The walls of the studio are adorned with Papuan artefacts, probably collected by Lindt when he visited British New Guinea in 1885.

sketched around 55 artefacts; this number probably reflects the fact that he 'devoted some days to the revision of the ethnographic collection' during his time there (Walcott, 1898).[3] Curator Richard Henry Walcott later acknowledged Edge-Partington's contribution, noting that it had enabled the Museum 'to rectify many errors which had crept into the classification' of its ethnographic collections (Walcott, 1898).

A large number of sketches (around 239) were made in Sydney during Edge-Partington's visits to the Australian Museum. While this may reflect the length of time he appears to have spent in the city (April–June), it should be noted that a number of these sketches were from photographs of artefacts lent by curator Robert Etheridge, Jnr. and museum conchologist Charles Hedley. For example, 40 artefacts from Funafuti Atoll (Tuvalu) from the Australian Museum's collections that appear in the *Ethnographical Album* (1898) are based on photographs supplied by Hedley.[4] At some point during his stay in Sydney he visited the Technological Museum (now the Powerhouse Museum within the Museum of Applied Arts and Sciences) where he sketched one object (Edge-Partington and Heape, 1898a: plate 133). His visit to the 'Brisbane Museum' (the Queensland Museum) in early May produced approximately 214 sketches.

Edge-Partington appears to have targeted certain collection areas during his visits to public museums in Australia (Table 2). When in Adelaide and Melbourne he focused more on indigenous Australian holdings than Pacific collections. Whilst in Sydney he made a concerted effort to document artefacts from the Australian Museum's holdings of indigenous Australian and Micronesian artefacts. In contrast, his visit to the Queensland Museum concentrated on sketching aspects of Papuan material culture from the field collection made by the colonial administrator Sir William MacGregor.

Visit to the Queensland Museum, May 1897

As noted, Edge-Partington spent about one week in Brisbane in May 1897. Although sketching in the museum probably filled most of his time, he possibly took the opportunity to see some of the city's attractions, such as the Queensland International Exhibition that opened at Bowen Park on 5 May 1897.

Edge-Partington's reputation was already well-established when he contacted Queensland Museum curator Charles de Vis in 1897. The Agent-General for Queensland in London had deposited a copy of the first volume of the *Ethnographical Album* in the Queensland Museum Library in May 1891 (Parry-Okeden, 1891). Curator de Vis noted receipt of the album, observing that it 'forms a most useful supplement to the ethnological collection of the museum' (de Vis, 1891).

On 3 May 1897, de Vis reported to the Queensland Museum Trustees that he had 'granted … Mr Partington, an English Ethnologist, permission to draw certain objects in

Table 1. Approximate number of sketches made by Edge-Partington during visits to public collections in Australia, 1897.

museum former name	museum present name	Australian city	number of sketches[a]	estimated date of visit 1897
Adelaide Museum	South Australian Museum	Adelaide	134	late March–1 April
Melbourne Museum	Museums Victoria	Melbourne	55	1 April–c. 26 April
Australian Museum	Australian Museum	Sydney	239	27 April–early May, June
Brisbane Museum[b]	Queensland Museum	Brisbane	214	3–8 May
Technological Museum	Powerhouse Museum	Sydney	1	c. April–June

[a] number of sketches from Edge-Partington and Heape (1898a)
[b] Edge-Partington used 'Brisbane Museum' throughout the 1898a *Ethnographical Album*, but it was known as the Queensland Museum in 1897.

the New Guinea Gallery' (QM Minute Book, 3 May 1897). The New Guinea gallery was metaphorically bursting at the seams in 1897. MacGregor sent five consignments totalling about 9770 items to the Queensland Museum between 25 October 1892 and 1 March 1897. Several thousand objects from MacGregor's collection of Papuan ethnology jostled for space along with the museum's other holdings, such as items gathered by the trader-collector Andrew Goldie and those associated with the Royal Geographical Society of Australasia's Fly and Strickland River expedition of 1885 (Davies, 2012). Together with collections that had been previously displayed at the Colonial and Indian Exhibition of 1886 and the Melbourne International Exhibition of 1888–1889, there was a great deal of material to look at.

Edge-Partington does not appear to have been troubled by the crammed nature of the New Guinea gallery. All sorts of things attracted his attention, including sword clubs, shields, spears, arrows, clubs, fishhooks, wooden bowls, earthenware pots, shields, house ornaments, charms, bullroarers, food hooks, body ornaments, fish traps and adzes. His extensive knowledge of the British Museum's collections is evident in the fact that he chose to sketch particular items but ignore others. He knew which items were rare and thus spent time photographing a collection of barkcloth as well as drawing items like a unique betel nut mortar made from clam shell (E8748). Somehow, he managed to navigate his way through the crowded gallery selecting items to sketch, assisted by an attendant who removed objects from cases so that he could draw and measure them (Fig. 4). No doubt he had learnt from prior experience to make such requests in advance of his visit for when in Adelaide he had been denied such access on at least one occasion (Edge-Partington and Heape, 1898a: Preface).

Our research indicates that Edge-Partington sketched 154 objects in the New Guinea gallery, of which 146 originated from the field collection assembled by Sir William MacGregor in British New Guinea (Table 3). Edge-Partington was probably drawn to this assemblage because it contained a wide spectrum of everyday utilitarian objects from many different localities as well as some rare or unique items. Since many of the objects were not represented in other museums or private collections, they represented new material which would be suitable for inclusion in the

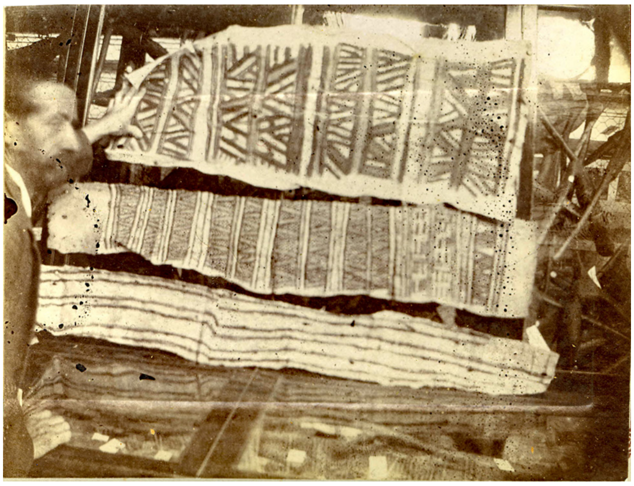

Figure 4. Barkcloths on display in the New Guinea Gallery, Queensland Museum, May 1897. Photographer: James Edge-Partington. Photo: © British Museum Oc,A9.33. Courtesy of the Trustees of the British Museum. The barkcloths featured in this photograph are MAC5065 (top), MAC4985 (middle) and MAC2657 (bottom).

Table 2. Geographic scope and approximate number of Edge-Partington sketches of items in Australian museum collections, 1897 (Edge-Partington and Heape, 1898a).

museum former name	museum present name	total	approximate number of sketches by region
Adelaide Museum	South Australian Museum	134	Admiralty Is (3); New Hebrides (1); Australia (130)
Melbourne Museum	Museums Victoria	55	Fiji (2); Solomon Islands (3); New Britain Archipelago (9); New Hebrides (7); New Guinea (3); Australia (31)
Australian Museum	Australian Museum	239	East Pacific (1); Fiji (3); Solomon Islands (7); New Britain Archipelago (13); Admiralty Is (33); Micronesia (44); New Hebrides (5); New Caledonia (3); New Guinea (20) Australia (105); New Zealand (5)
Brisbane Museum	Queensland Museum	214	Solomon Islands (3); New Britain Archipelago (3); Admiralty Is (7); New Hebrides (1); Torres Strait Islands (2); New Guinea (154); Australia (44)
Technological Museum	Powerhouse Museum	1	Australia (1)

Table 3. 'New Guinea' Plates 72–93 in Edge-Partington and Heape (1898a). 'BNG' refers to British New Guinea.

plate	figure	artefact type	museum or private collection	collector	no. of objects	notes
72	1–2	Wooden objects [skull racks?]	—		2	
73	1–11	Sword clubs, implements and arrows	Brisbane Museum	Sir William MacGregor	11	
73	12–14	Spears and sawfish club	Lindt coll., Melbourne		3	
74	1–2, 6–7, 10	Wooden object and club; engraved boards; toy	Brisbane Museum		4	1 and 10 (toy) are part of MacGregor's BNG Official collection
74	3–5, 8–9	Clubs; Bull roarers?	Australian Museum		5	
74	11	Coconut 'bottle'	Rev. George Brown coll.		1	
75	1–8	Wooden bowls (1–7); coconut ladle (8)	Brisbane Museum		8	All likely part of MacGregor's BNG Official collection
76	1–12	Pots	Brisbane Museum	Sir William MacGregor	12	Part of MacGregor's BNG Official collection
76	13	Pot	Australian Museum		1	Lawrence Hargrave collection?
77	1–10	Carved house ornament; paddles	Brisbane Museum	Sir William MacGregor	10	Part of MacGregor's BNG Official collection
77	11	Paddle	Melbourne		1	
78	1	Fishhook	—		1	No particulars regarding collection
79	1, 7, 8	Shield; Flint-headed lancet; Hammer for beating sago	Brisbane Museum		3	Locality for hammer (8) is Purari River, suggesting that it is likely part of MacGregor's BNG Official collection
79	2	Shield	Basel Museum, Switzerland		1	
79	3–4	Spoon and bowl	P.G. Black coll.		2	
79	5	Fishhook	Macleay Museum		1	
79	6	Bamboo box covered with cord and bark cloth for pigments	Australian Museum		1	
79	9	Skull of crocodile as a house ornament	Lindt coll., Melbourne		1	
80	1–11	Dagger; ornament (?); neck ornaments; armlets, cup; betel nut mortar; lime gourd	Brisbane Museum	Sir William MacGregor	11	All associated with MacGregor's BNG Official collection
80	12	Charm of wood face covered with skin and feathers from breast of Toucan	Australian Museum		1	Probably a hornbill ornament; described but not illustrated in the *Ethnographical Album*
81	1–14	Drums (1–10); musical instrument (?); nut; whistle and shell trumpet	Brisbane Museum	Sir William MacGregor	14	Part of MacGregor's BNG Official collection
82	1–8	Stone heads of clubs	Australian Museum		8	
83	1–12	Tapa beaters; adzes; sling-stone; needles; piece of lava [pumice stone?]; lime knife; pounder; hammers; cloth board	Brisbane Museum	Sir William MacGregor	12	Part of MacGregor's BNG Official collection
84	1	Adze	Edge-Partington coll.		1	
85	1–5	Adze blades	P.G. Black coll.		5	
86	1–2	Chisel and adze	P.G. Black coll.		2	
86	3–7	Adzes	Brisbane Museum	Sir William MacGregor	5	Part of MacGregor's BNG Official collection
86	8	Adze	Rev George Brown		1	
87	1–13	Armguards, necklaces, ornaments, betelnut mortar	Brisbane Museum	Sir William MacGregor	13	Part of MacGregor's BNG Official collection
88	1–2	Food hooks	P.G. Black coll.		2	
88	3	Bone Lime spatula	Auckland Museum		1	
88	4–5	Handles of lime spatulas	Australian Museum		2	
88	6	Clam shell vessel	Brisbane Museum		1	Betel-nut mortar made of clam shell donated by Anthony Musgrave 16 October 1889 (Donation no. D5755). E8748 in QM
89	1–2	Pig catchers	Australian Museum		2	
89	3–5, 8–9	Head ornaments; House ornament and Wooden ornament in form of Mask	Brisbane Museum		5	nos. 3–5 are consistent with items in the BNG Official collection
89	6–7	Paddle shaped ornament and canoe ornament	Lindt coll., Melbourne		2	
89	10	Bone Implement	Hardy coll.		1	
90	1–4, 7	Fish hooks and fishing line	Brisbane Museum		5	fig.7 is likely part of MacGregor's BNG Official collection
90	5–6	Fish traps	Melbourne Museum		2	
91	1–14	Ornaments and implements	Brisbane Museum	Sir William MacGregor	14	Includes some Tugeri objects
92	1–13	Bark cloth	Brisbane Museum	Sir William MacGregor	13	Part of MacGregor's BNG Official collection
93	1–12	Bark cloth	Brisbane Museum	Sir William MacGregor	12	Part of MacGregor's BNG Official collection

planned third volume of the *Ethnographical Album*. Indeed, a significant proportion of the collection was acquired through MacGregor's initial encounters with local peoples during administrative 'visits of inspection' (Quinnell, 2000: 84). Edge-Partington likely had some inkling of what the collection might contain, for a few years earlier he had looked over Sir Basil Thomson's private collection in England (Edge-Partington and Heape, 1895: plates 160, 161, 166). Thomson had served as MacGregor's first private secretary (1888–1889) in British New Guinea, and had accompanied MacGregor on his first field explorations (Thomson, 1889).

Barkcloths were obviously one of the highlights of the MacGregor assemblage in the New Guinea gallery. These included a large group from the Musa River, the first to have been collected from that area and which MacGregor considered 'to be of very great value… the patterns quite uninfluenced by anything introduced by Europeans' (MacGregor, 1895). Edge-Partington would have been captivated by the visually striking asymmetric schematic motifs and patterns on some of the cloths. He chose through the medium of photography to make a permanent record of 83 from Oro Province and two from Hokeko village, in the Vailala River area of the Papuan Gulf (Fig. 5; Table 4). His photographs of the MacGregor barkcloths, themselves still in near pristine condition only three years after collection, illustrate the degree of pigment fade on these fragile objects under an uncontrolled environment in a sub-tropical coastal city for the subsequent 90 years. Twenty-five barkcloths were later reproduced as sketches in the third volume of the *Ethnographical Album* (Edge-Partington and Heape, 1898a: plates 92, 93, figs 1–25) (Fig. 6).

Figure 5. Barkcloth (MAC4998) from Musa River (Oro Province) on display in the Queensland Museum, May 1897. Photographer: James Edge-Partington. Photo: © British Museum Oc,A9.30. Courtesy of the Trustees of the British Museum. See Fig. 6, No. 1, for Edge-Partington's sketch of the same barkcloth (MAC4998).

Edge-Partington also appears to have been fascinated by a range of objects associated with the little-known Tugeri (Marind-anim) people of Dutch New Guinea (Edge-Partington and Heape, 1898a: plate 81, figs 10–13; plate 87, figs 10–11 and plate 91, figs 5–6). For the most part, these artefacts were among those 'captured' by MacGregor's party following a skirmish with a large Tugeri raiding party in the Wassi Kussa River district in May 1896 (MacGregor, 1896: 55–56; Quinnell, 2000: 87). Head-hunting paraphernalia, such as a unique head carrier and bamboo beheading knife, were among the Tugeri objects that Edge-Partington sketched and later published (Fig. 7; Edge-Partington and Heape, 1898a: plate 91). Interestingly, Edge-Partington's sketching activities in the Queensland Museum in 1897 were not confined to the New Guinea Gallery. Other objects from the Pacific region, as well as some Australian Aboriginal artefacts, were clearly of interest (Table 2).

Some of the objects that Edge-Partington sketched in the New Guinea Gallery in 1897 are no longer extant. For example, one hair ornament comprising a length of human hair plaited with a shell ornament is illustrated, but cannot be located today (Edge-Partington and Heape, 1898a: plate 87, fig. 9). Another drawing confirms that an artefact that missed registration in 1892 is definitely part of the MacGregor assemblage (Edge-Partington and Heape, 1898a: plate 74, fig. 10). These examples highlight the value of Edge-Partington's work. The sketches have not only added valuable information to existing objects but have also provided important clues as to what certain objects looked like for which no trace can be found today. Such objects may have been exchanged out in the early part of the twentieth century and possibly exist in overseas museums, though no records are known to us that support this.

Edge-Partington's visit to the Queensland Museum was timely, for his arrival coincided with the finalisation of plans to cull so-called 'duplicates' from MacGregor's collection. On 3 May 1897, de Vis submitted a proposal to the Trustees for the distribution of these items (QM Minute Book, 3 May 1897). This was the same day on which de Vis reported

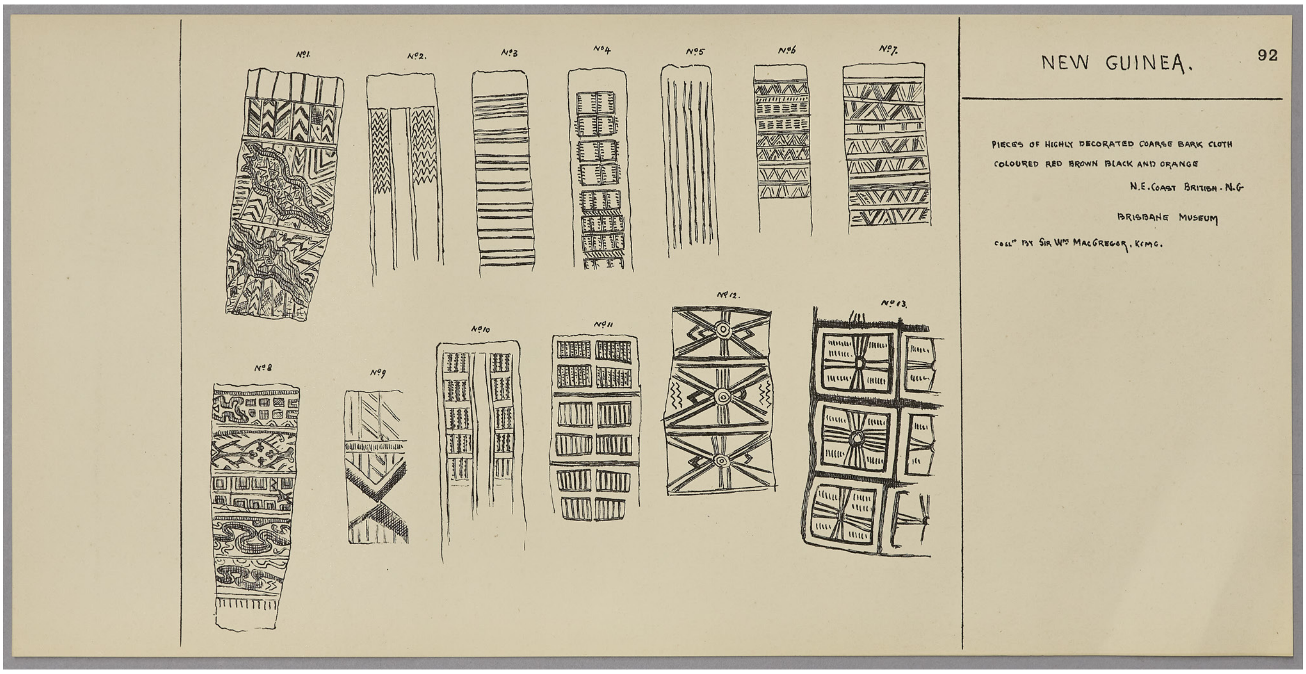

Figure 6. Plate 92 of the *Ethnographical Album of the Pacific Islands* (Edge-Partington and Heape, 1898a) illustrating 13 barkcloths on display in the New Guinea Gallery, Queensland Museum, May 1897. Photo: Queensland Museum Digital Imaging Unit QMDIU_03095. Courtesy of Queensland Museum Library. Sketch No. 1 is the barkcloth (MAC4998) illustrated in Fig. 5.

Table 4. List of photos of the MacGregor collection of barkcloths in the James Edge-Partington Photograph Album Oc,A9.1 to Oc,A9.61, British Museum (BM).

BM image number	position on photo	QM or BM reg. no.	QM reg. no.(1890s)	locality	collector	collection date	transfer number	transfer date	plate number E.-P./Heape, 1898a	present location
Oc,A9.3	Left	MAC8863	14593	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.3	Right	MAC5007	14592	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896	Plate 92, No.11	QM
Oc,A9.4	—	MAC5027	14577	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.5	—	MAC4970	14569	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896	Plate 93, No.12	QM
Oc,A9.6	—	MAC5013	14584	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.7	Left	MAC4984	18669	Musa River, Oro Province	Sir William MacGregor		T60	01 Mar 1897		PNG-NMAG
Oc,A9.7	Right	MAC4968	18670	Musa River, Oro Province	Sir William MacGregor		T60	01 Mar 1897		QM
Oc,A9.8	Left	MAC5047	15906	Moni River Valley, Oro Province	Sir William MacGregor	Sep 1895 or Jan 1897	T60	01 Mar 1897		QM
Oc,A9.8	Right	MAC5064	15912	Moni River Valley, Oro Province	Sir William MacGregor	Sep 1895 or Jan 1897	T60	01 Mar 1897		PNG-NMAG
Oc,A9.9	—	MAC4969	14587	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.10	Left	MAC5035	14576	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.10	Right	MAC5004	14583	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.11	Left	MAC2707	14321	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896	Plate 93, No.4	QM
Oc,A9.11	Centre	MAC4980	14335	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896	Plate 93, No.5	PNG-NMAG
Oc,A9.11	Right	MAC5003	14617	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896	Plate 93, No.6	PNG-NMAG
Oc,A9.12	—	MAC5011	15893	Collingwood Bay, Oro Province	Sir William MacGregor		T60	01 Mar 1897	Plate 93, No.1	PNG-NMAG
Oc,A9.13	Left	MAC5067	14579	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.13	Right/upper	MAC2648	14581	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.13	Right/lower	Not identified								not known
Oc,A9.14		MAC5010	15910	Moni River Valley, Oro Province	Sir William MacGregor	Sep 1895 or Jan 1897	T60	01 Mar 1897		QM
Oc,A9.15		MAC5034	14618	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896	Plate 93, No.9	QM
Oc,A9.16	Left	MAC5017	14597	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896	Plate 93, No.3	PNG-NMAG
Oc,A9.16	Right	Not identified								not known
Oc,A9.17 duplicates		Oc,A9.9								
Oc,A9.18	Left	MAC5014	15898	Collingwood Bay, Oro Province	Sir William MacGregor		T60	01 Mar 1897	Plate 93, No.11	PNG-NMAG
Oc,A9.18	Right	MAC5052	15894	Collingwood Bay, Oro Province	Sir William MacGregor		T60	01 Mar 1897		PNG-NMAG
Oc,A9.19	—	MAC4965	14574	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.20	Left	MAC5000	15896	Collingwood Bay, Oro Province	Sir William MacGregor		T60	01 Mar 1897	Plate 92, No.8	QM
Oc,A9.20	Right	MAC8865	14314	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896	Plate 92, No.9	PNG-NMAG
Oc,A9.21	—	MAC4974	14596	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.22	Left	MAC5068	14588	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.22	Right	MAC5074	14586	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.24	Left	MAC4994	14604	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896	Plate 92, No.12	PNG-NMAG
Oc,A9.24	Right	MAC5036	14612	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.25	Left	MAC2669	11595	Hokeko vill., Vailala R, Gulf Prov.	Sir William MacGregor	27 Jan 1893	T47	04 Mar 1893	Plate 93, No.7	QM
Oc,A9.25	Right	MAC2663	11593	Hokeko vill., Vailala R, Gulf Prov.	Sir William MacGregor	27 Jan 1893	T47	04 Mar 1893		PNG-NMAG
Oc,A9.26	Left	MAC8859	14591.2	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.26	Right	MAC5018	14585	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.27	Left	MAC4977	14315	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896		PNG-NMAG
Oc,A9.27	Right	MAC2664	14606	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.29	—	MAC4975	14568.2	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.30	—	MAC4998	14565	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896	Plate 92, No.1	PNG-NMAG
Oc,A9.31		MAC5031	14611	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.32		MAC5040	15908	Moni River Valley, Oro Province	Sir William MacGregor	Sep 1895 or Jan 1897	T60	01 Mar 1897		PNG-NMAG
Oc,A9.33	Top	MAC5065	14328	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896		QM

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Table 4 (coninued from previous page). List of photos of the MacGregor collection of barkcloths in the James Edge-Partington Photograph Album Oc,A9.1 to Oc,A9.61, British Museum (BM).

BM image number	position on photo	QM or BM reg. no.	QM reg. no.(1890s)	locality	collector	collection date	transfer number	transfer date	plate number E.-P./Heape, 1898a	present location
Oc,A9.33	Middle	MAC4985	14307a	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896		PNG-NMAG
Oc,A9.33	Bottom	MAC2657	14333	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896	Plate 92, No.5	PNG-NMAG
Oc,A9.34		MAC4962	15899	Collingwood Bay, Oro Province	Sir William MacGregor		T60	01 Mar 1897		QM
Oc,A9.35 duplicates		Oc,A9.48 (Left)								
Oc,A9.35	Right	MAC2662	14342	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896		QM
Oc,A9.36	—	MAC4963	14573	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.37 duplicates		Oc,A9.16								
Oc,A9.38	Left	MAC5073	14567	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.38	Right	MAC2651	10100	Oro Province (attrib.)	Sir William MacGregor		T46	25 Oct 1892		QM
Oc,A9.39	Left	MAC4996	15916	Moni River Valley, Oro Province	Sir William MacGregor	Sep 1895 or Jan 1897	T60	01 Mar 1897		QM
Oc,A9.39	Right	MAC5050	15901	Moni River Valley, Oro Province	Sir William MacGregor	Sep 1895 or Jan 1897	T60	01 Mar 1897		PNG-NMAG
Oc,A9.40	Left	MAC5063	14607	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.40	Right	MAC5076	14620	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.41	Left	MAC5005	14334	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896		QM
Oc,A9.41	Right	MAC8864	14317	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896		QM
Oc,A9.42 duplicates		Oc,A9.20								
Oc,A9.43	Left	MAC2711	14326	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896	Plate 92, No.3	QM
Oc,A9.43	Centre	MAC2708	14331	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896	Plate 92, No.4	PNG-NMAG
Oc,A9.43	Right	MAC5022	14322	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896	Plate 92, No.2	PNG-NMAG
Oc,A9.44	—	MAC5059	15905	Moni River Valley, Oro Province	Sir William MacGregor	Sep 1895 or Jan 1897	T60	01 Mar 1897		QM
Oc,A9.45		MAC5069	15923	Moni River Valley, Oro Province	Sir William MacGregor	Sep 1895 or Jan 1897	T60	01 Mar 1897		QM
Oc,A9.46	Left	MAC5016	14619	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.46	Right	MAC5060	14590	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.47 duplicates		Oc,A9.20 (Left) and Oc,A9.42 (Left)								
Oc,A9.48	Left	MAC4990	14306	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896		PNG-NMAG
Oc,A9.48	Right	MAC4979	14299	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896		PNG-NMAG
Oc,A9.49	Left	MAC4993	15920	Moni River Valley, Oro Province	Sir William MacGregor	Sept 1895 or Jan 1897	T60	01 Mar 1897		PNG-NMAG
Oc,A9.49	Right	MAC5020	15891	Oro Province (attrib.)	Sir William MacGregor		T60	11 Jan 1896		PNG-NMAG
Oc,A9.50 duplicates		Oc,A9.18								
Oc,A9.51	Left	MAC5009	14325	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896	Plate 92, No.10	QM
Oc,A9.51	Right	MAC5001	14324	Musa River (attrib.), Oro Province	Sir William MacGregor		T55 (attrib.)	11 Jan 1896	Plate 93, No.2	PNG-NMAG
Oc,A9.52	Left	MAC2658	10099	Oro Province (attrib.)	Sir William MacGregor		T46	25 Oct 1892		PNG-NMAG
Oc,A9.52	Centre	MAC5024	14603	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.52	Right	MAC5046	14610	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.53 duplicates		Oc,A9.31								
Oc,A9.54	—	MAC5072	14575	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.55	—	MAC5026	14599	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896	Plate 92, No.13	PNG-NMAG
Oc,A9.56	Left	MAC5029	14594	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG

Continued on next page ...

Table 4 (coninued from previous page). List of photos of the MacGregor collection of barkcloths in the James Edge-Partington Photograph Album Oc,A9.1 to Oc,A9.61, British Museum (BM).

BM image number	position on photo	QM or BM reg. no.	QM reg. no.(1890s)	locality	collector	collection date	transfer number	transfer date	plate number E.-P./Heape, 1898a	present location
Oc,A9.56	Right	MAC5044	14591	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.57	Top	MAC4992	15889	Oro Province (attrib.)	Sir William MacGregor		T60	01 Mar 1897		PNG-NMAG
Oc,A9.57	Bottom	MAC5015	15907	Moni River Valley, Oro Province	Sir William MacGregor	Sep 1895 or Jan 1897	T60	01 Mar 1897		PNG-NMAG
Oc,A9.58	Left	MAC6289	14600	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG
Oc,A9.58	Right	MAC4989	14570	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896	Plate 93, No.8	QM
Oc,A9.59	—	MAC5051	14578	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896	Plate 93, No.10	PNG-NMAG
Oc,A9.60	—	MAC4973	14571	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		QM
Oc,A9.61	—	MAC5025	14572	Musa River, Oro Province	Sir William MacGregor	10 April 1894	T55	11 Jan 1896		PNG-NMAG

that he had granted permission to Edge-Partington to make sketches in the New Guinea Gallery. He probably informed Edge-Partington of progress concerning the matter because the British Museum was one of the intended recipients of the dispersal of duplicates.

Edge-Partington may have had some input into the selection of duplicates for the British Museum, an idea based on similarities between several objects that he sketched in the New Guinea gallery and those which were sent to the British Museum (Table 5). For example, an oval-shaped board used for beating barkcloth now in the British Museum (Oc,MCG.64) is the same type as Edge-Partington sketched in the Queensland Museum in May 1897 (compare Edge-Partington and Heape, 1898a: plate 83, fig. 12). This board was sent to the British Museum in September 1897 as part of its share of the MacGregor duplicates (721 objects). Neither the Australian Museum nor the Melbourne Museum was assigned an example in their share of the duplicate distribution (943 and 817 objects respectively) (Torrence *et al.*, 2020: 113). A further 3297 items were repatriated to the Papua New Guinea National Museum and Art Gallery (PNG-NMAG) between 1979 and 1992 (Quinnell, 2000: 97).

Most of Edge-Partington's time in Brisbane appears to have been spent in the Queensland Museum. He does not seem to have met with any private collectors during his stay in the city for there are no sketches associated with Brisbane-based private collectors in the *Ethnographical Album* (Edge-Partington and Heape, 1898a). Shipping departures show that he left Brisbane on the steamer *Aramac* on 8 May bound for northern ports, including Cooktown (Anonymous, 1897, *The Brisbane Courier*, 10 May 1897).

Australian content in the Ethnographical Album

When the third volume of the *Ethnographical Album* was published in 1898 it comprised 225 lithographic plates and around 1800 sketches (Edge-Partington and Heape, 1898a: Preface). Issued for private circulation, the volume was limited to 175 copies, of which 25 were reserved for the British colonies (Edge-Partington and Heape, 1898b). Representing the final volume in the series, the work largely reflects Edge-Partington's sketching activities abroad in 1897. As with the first and second volumes, some illustrations were created by the artist Charles Praetorius; these can be identified by the signature (C. PRAETORIUS) or monogram (C.P in a rectangle with four inward pointing triangles). Charles Hedley at the Australian Museum also produced a number of sketches for the volume (Edge-Partington and Heape, 1898a: plates 68, 70, 71).

Close inspection of the 225 plates in the 1898 volume reveals that 83 plates with 642 sketches are connected to colonial (now State) museum collections in Australia (Table 2). Edge-Partington also viewed several notable private collections whilst in Australia in 1897. These included those of Harry Stockdale (Adelaide), Sir Walter Baldwin Spencer (Melbourne), J. W. Lindt (Melbourne) (Fig. 3), Le Souef (Melbourne), Sylvester Browne (Melbourne), Rev. George Brown (Sydney), Norman Hardy (Sydney) and P. G. Black (Sydney). While most of these collections were likely viewed in the homes of their owners, that assembled by the then deceased politician Sir William John Macleay required a visit to the Macleay Museum at the University Sydney. P. G. Black was employed by Burns Philp and Co. as Branch Inspector (1889–1902). Access to his collection may have been difficult since later sources indicate that it was stored in wooden cases in the basement of the headquarters of Burns, Philp and Co. (Foster, 2012: 158).

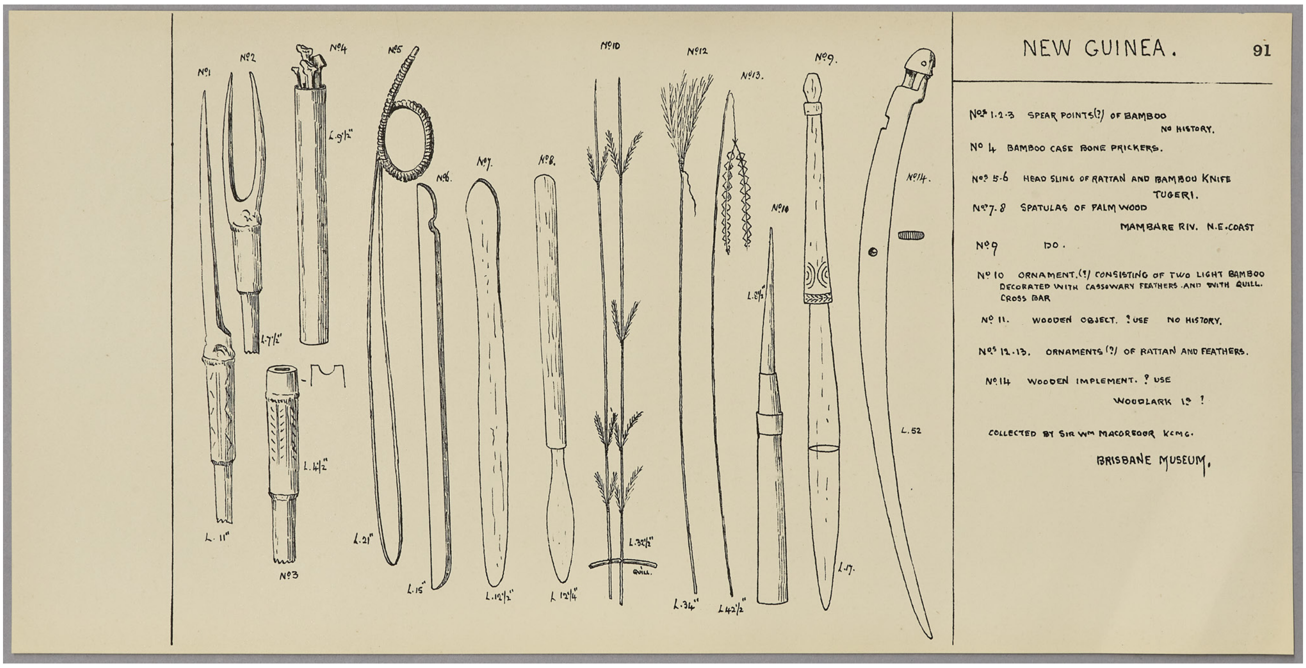

Figure 7. A group of objects sketched by James Edge-Partington in the New Guinea Gallery, Queensland Museum, May 1897. Plate 91 in *Ethnographical Album of the Pacific Islands* (1898a). Queensland Museum Digital Imaging Unit QMDIU_03094. Courtesy of Queensland Museum Library.

Several of the private collectors whom Edge-Partington met in Australia in 1897 had significant holdings of Australian Aboriginal and Pacific Islander material culture. P. G. Black's collection of Oceanic material culture comprised 6200 items when it was purchased for the Buffalo Museum of Science in 1938 (Foster, 2012: 149). Norman Hardy's holdings also appear to have been extensive judging by the number of artefacts from his collection that appear in the 1898 volume. Charles Hedley or Robert Etheridge Jnr at the Australian Museum may have provided introductions to Hardy (and perhaps Black). Indeed, Hedley and Etheridge occasionally exhibited articles from Hardy's collection at meetings of the Linnean Society of New South Wales (Etheridge, 1896: 14; Hedley, 1897a: 289). Etheridge and Hardy were in fairly close contact in 1897 for Hardy lent Edge-Partington photographs of dilly bags in his collection and in the Australian Museum; these bags appear to have been displayed at the Anthropological Institute in London at the time of Edge-Partington's visit to Sydney (see Edge-Partington and Heape, 1898a: plates 96–99).

Since Edge-Partington was an avid collector of ethnographic artefacts himself, he undoubtedly welcomed the opportunity to interact with others who shared his interests. In fact, he seems to have established good relations with the museum staff and private collectors he met in Australia in 1897. As previously noted, Hedley at the Australian Museum shared photographs of ethnological items from the 1896 expedition to Funafuti (Edge-Partington and Heape, 1898a: plates 48–50; Hedley 1897b). Hedley also produced a number of sketches of artefacts from New Caledonia for the 1898 volume (see Edge-Partington and Heape, 1898a: plates 68, 70, 71). Of the private collectors whom Edge-Partington met in Australia, Norman Hardy, appears to have left a lasting impression as Edge-Partington subsequently acquired 27 of Hardy's original watercolours, and in 1914 wrote his obituary for the journal *Man* (Edge-Partington, 1915, 1926: 35).

Edge-Partington's personal collection

Edge-Partington's personal collection of ethnographic artefacts originally comprised around 2684 items acquired over three decades (Neich, 2009: 85–89). The geographic range of the collection was extensive, with significant holdings from places like New Zealand (222 objects), Australia (284), Fiji (334) and the Solomon Islands (423). By far the largest proportion of objects in his collection originated from New Guinea (574). Over time, his collecting interests shifted to books, manuscripts and prints (Edge-Partington, 1926; Francis Edwards Ltd and Edge-Partington, 1934). A downsizing in domestic circumstances in 1912 led him to sort through his artefact collection with the aim of retaining some articles for himself and selling what remained (Neich, 2009: 85). Accordingly, in 1913 he sold some items to the Pitt Rivers Museum (Oxford), the Horniman Museum (London), and the

Table 5. List of Edge-Partington's sketches of artefacts in the Queensland Museum (QM) compared to the 'duplicate' items sent to the British Museum (BM), 1897.

Edge-Partington and Heap (1898a)	QM reg. no.	BM reg. no.	description in Edge-Partington and Heape (1898a)
Plate 83, No. 12	11902	Oc,MCG.64	Board on which tapa is beaten. Trobriand Island. Tapa is manufactured both in Trobriand and D'Entrecasteaux Groups.
Plate 87, No. 8	18709	Oc,MCG.67	Hair bound with black and buff leaf, cut from a man's head. Northeast coast.
Plate 91, No. 2	15194	Oc,MCG.80	1–3. Spear points (?) of bamboo. No history.
Plate 91, No. 3	15359	Oc,MCG.50	1–3. Spear points (?) of bamboo. No history.

British Museum, the latter making a further purchase in 1915. The Auckland Museum (Tāmaki Paenga Hira Auckland War Memorial Museum) acquired what remained of the collection in 1924 (Neich, 2009: 85, 99–102).

In addition to his interest in MacGregor's collection at the Queensland Museum, Edge-Partington acquired a set of the British New Guinea *Annual Reports* that covered the period of MacGregor's administration of the colony (1888–1898) as well as some publications relating particularly to MacGregor's field activities, such as his ascent of Mt. Victoria and explorations of the Owen Stanley Range in British New Guinea in 1890 (Francis Edwards Ltd and Edge-Partington, 1934). The publications provided further information about the history of the items and the circumstances under which MacGregor acquired such material.

One artefact previously in Edge-Partington's personal collection (U458), a barkcloth beater from Sikube village, Mt. Scratchley, now registered 15671 in the Auckland Museum, is reputed to have originated from the MacGregor collection in the Queensland Museum (Edge-Partington, n.d.). Edge-Partington probably obtained this item through an undocumented exchange with the Queensland Museum. A closer look at the New Guinea portion of Edge-Partington's personal collection now held in the Auckland Museum (registered between the range 15328–15769) reveals that several objects originate from 'Dyke Acland Bay' (e.g., 15589, 15599, 15605, 15606.1–2, 15628 and 15643), a locality also associated with MacGregor's collection in the Queensland Museum. This raises the possibility that there is more MacGregor related material in Edge-Partington's collection than previously considered. This is certainly a possibility given than there are around 700 objects currently missing from the MacGregor collection in the Queensland Museum (Davies, 2017). Further research is required to confirm a MacGregor connection for these items.

Conclusion

Our paper has focused mainly on Edge-Partington's activities in public museums in Australia in 1897, and, in particular, the time he spent in the Queensland Museum. The sketches he made during his time in Australia in 1897 are a remarkable visual archive of a range of objects on display in several museums. Moreover, his work provides a rare insight into the ethnological collections held in private hands in Australia towards the end of the 19th century.

The geographic scope of Edge-Partington's work in Australia in 1897 was much wider and more extensive than previously generally appreciated. Importantly, his drawings have filled some of the gaps in our current knowledge concerning the field collections from British New Guinea associated with the colonial administrator, Sir William MacGregor. This assemblage underwent a series of dispersals, physical relocations and re-registration processes following Edge-Partington's visit.

Close scrutiny of the 1898 *Ethnographical Album* reveals some articles that were once in the MacGregor collection for which no trace can be found today. Continuing efforts to match all 146 objects from the MacGregor field assemblage that Edge-Partington sketched in the Queensland Museum in 1897 is likely to reveal objects currently missing, lost or destroyed for which the sketches are the only surviving visual record. A detailed study of the photographic images that Edge-Partington took in the Queensland Museum has identified 83 barkcloths that are now held in either the Queensland Museum or PNG-NMAG; only two remain unidentified.

Another valuable aspect of Edge-Partington's work in 1897 is that he recorded the provenance for objects he sketched. The enormous size of MacGregor's official collection, and the differing circumstances under which it was displayed and later stored in the Queensland Museum, has led to some loss of field labels and information about the origin and use of some objects. Again, Edge-Partington's sketches and corresponding data confirm or add to our knowledge surrounding particular items in that collection.

Several sketches in the 1898 *Ethnographical Album* suggest that Edge-Partington played a key role in selecting certain objects as duplicates from the MacGregor assemblage for subsequent transfer to the British Museum in 1897. As a long-term volunteer in the Ethnography department at the British Museum, he would have been well-informed about the department's holdings and any gaps in the collection that needed filling.

Our review of Edge-Partington's personal collection of 'New Guinea' artefacts now in the Auckland Museum suggests that at least one object derives from the MacGregor assemblage at the Queensland Museum. The circumstances surrounding Edge-Partington's acquisition of this object remains unknown though it is possible it was procured through an undocumented outwards exchange from the Queensland Museum.

The *Ethnographical Album* published by James Edge-Partington and Charles Heape between 1890 and 1898 has stood the test of time. A 19th century reference work on Pacific Islander material culture, it has been used by researchers and museum curators for more than a century to document objects of unknown provenance. This paper has demonstrated the usefulness of the third volume in adding new information to some artefacts in the MacGregor field collection. Importantly, the volume also provides an important visual record of objects from that assemblage that are either missing or no longer extant. However, the value of the *Ethnographical Album* extends well beyond the obvious benefits of improving the documentation for existing museum collections. For researchers interested in collections of Pacific material culture gathered during the 19th century, the *Ethnographical Album* is a rich visual archive of the kinds of objects that European colonists, missionaries, mariners and explorers obtained from indigenous peoples over a wide geographic area. Since material is arranged by island group or country there is the potential to focus on a body of material culture from a particular region. This has important implications for researchers interested in the role cultural artefacts played in brokering social relations in colonial settings. The objects sketched by Edge-Partington are part of a much wider narrative surrounding cross-cultural interactions between Pacific peoples and Westerners in the 19th century.

Notes

1 The portfolio cover of the third volume (Edge-Partington and Heape, 1898a) is titled *Ethnographical Album of the Pacific Islands*. The 1969 facsimile edition is in two parts and omits Charles Heape as the second author. A Second [Third] Edition (Facsimile) was published in a single volume under the title, *Ethnographical Album of the Pacific Islands* (Thailand: SDI Publications. 1996).

2 Strangely, this collection, which was purchased for £250 and described as one belonging to Mr Stevens, does not appear among the lists of exhibits enumerated in the *Official Catalogue of the Ethnology Gallery* (Richards, 1880).

3 The collections in the 'Melbourne Museum' which Edge-Partington sketched in 1897 were then in the Industrial and Technological Museum, now part of Museums Victoria. For more information on the complex history of the museums in Melbourne, see Torrence *et al.* (2020: 116–118).

4 Similarly, the sketches of a series of Australian Aboriginal dilly baskets which appear between plates 96–99 were based on photographs supplied by Etheridge (these are not included in the total of 239 sketches as they are described as from the collection of Norman Hardy or the Australian Museum).

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References

Anonymous, 1897. Shipping departures. *The Brisbane Courier*, 10 May 1897: 3.
http://nla.gov.au/nla.news-article3650566

Anonymous, 2016. Excavating MacGregor—Chau Chak Wing Museum, University of Sydney.
https://www.sydney.edu.au/museum/our-research/excavating-macgregor.html

Dalton, O. M. 1931. Obituary: James Edge-Partington, born 6th February, 1854, died 4th November, 1930. *Man* 31: 129–131.
https://www.jstor.org/stable/2790042

Davies, S. M. 2012. Andrew Goldie: his collecting and collections. *Memoirs of the Queensland Museum Culture* 6: 131–161.

Davies, S. 2017. Creating a master list for the 'official collection.'
https://www.sydney.edu.au/content/dam/corporate/documents/chau-chak-wing/our-research/macgregor-blog-creating-a-master-list-susie-davies.pdf

de Vis, C. 1891. Recent Additions to the Queensland Museum. *Brisbane Courier*, 9 June 1891, page 6.
http://nla.gov.au/nla.news-article3527130

Edge-Partington, J. No date. Edge-Partington file. MacGregor Archive Box 1, Anthropology Laboratory, Queensland Museum.

Edge-Partington, J. 1883. *Random Rot. A Journal of Three Years' Wanderings about the World*. Altrincham: privately printed.
http://nla.gov.au/nla.obj-52791907

Edge-Partington, J. 1915. Obituary. Norman H. Hardy; d. January 10, 1914. *Man* 15: 9–10.
https://doi.org/10.2307/2787357

Edge-Partington, J. 1926. *Australasian Prints, Drawings, etc., in the Collection of J. Edge-Partington, Esq. Beaconsfield.* Beaconsfield: privately printed.

Edge-Partington, J. 1969 [1890–1898]. *An Album of the Weapons, Tools, Ornaments, Articles of Dress etc., of the Natives of the Pacific Islands*, second edition (facsimile, in two parts). London: The Holland Press.

Edge-Partington, J., and C. Heape. 1890. *An Album of the Weapons, Tools, Ornaments, Articles of Dress etc., of the Natives of the Pacific Islands Drawn and Described from Examples in Public & Private Collections in England by James Edge-Partington. Issued for Private Circulation by James Edge-Partington and Charles Heape*. Manchester: J. C. Norbury.

Edge-Partington, J., and C. Heape. 1895. *An Album of the Weapons, Tools, Ornaments, Articles of Dress etc., of the Natives of the Pacific Islands Drawn and Described from Examples in Public & Private Collections in England by James Edge-Partington. Series II. Issued for Private Circulation by James Edge-Partington and Charles Heape*. Manchester: Palmer Howe and Co.

Edge-Partington, J., and C. Heape. 1898a. *An Album of the Weapons, Tools, Ornaments, Articles of Dress etc., of the Natives of the Pacific Islands Drawn and Described from Examples in Public & Private Collections in Australasia by James Edge-Partington. Third Series. Issued for Private Circulation by James Edge-Partington and Charles Heape.* Manchester: Palmer Howe and Co.

Edge-Partington, J., and C. Heape. 1898b. Letter to Subscribers, September 1898. Stirling Papers, South Australian Museum. AA309/1/193.

Edge-Partington, J., and C. Heape. 1996 [1890–1898]. *Ethnographical Album of the Pacific Islands*. Second Edition [Third] (all three volumes in one facsimile edition). Expanded and edited by Bruce L. Miller. Bangkok, Thailand: SDI Publications.

Etheridge Jr, R. 1896. Descriptions of further highly ornate boomerangs from New South Wales and Queensland. *Proceedings of the Linnean Society of New South Wales* 21(1) (no. 81): 14–22.
https://doi.org/10.5962/bhl.part.8456

Foster, R. J. 2012. Notes for a networked biography: The P. G. T. Black collection of Oceanic things. *Museum Anthropology* 35: 149–169.
https://doi.org/10.1111/j.1548-1379.2012.01129.x

Francis Edwards Ltd, and J. Edge-Partington. 1934. *Catalogue of the Australasian Collection of Books and Pictures Formed by the Late James Edge Partington: With a Memoir by Harry G. Beasley.* London: Frances Edwards Ltd.

Hedley, C. 1897a. Stray notes on Papuan ethnology. Part ii. *Proceedings of the Linnean Society of New South Wales* 22(2) (no. 86): 288–296.
https://doi.org/10.5962/bhl.part.12725

Hedley, C. 1897b. The ethnology of Funafuti. *Australian Museum Memoir* III, Pt 4.
https://doi.org/10.3853/j.0067-1967.3.1897.497

MacGregor, W. 1895. Letter to de Vis, 15 December 1895. Queensland Museum Archives, Inwards Correspondence, Letter 4852.

MacGregor, W. 1896. Despatch Reporting Expedition Undertaken to Repel Tugeri Invaders. *Annual Report on British New Guinea* 1895–96: 52–56. Brisbane: Government Printer.

Neich, R. 2009. James Edge-Partington (1854–1930): an ethnologist of independent means. *Records of the Auckland Museum* 46: 57–110. Auckland War Memorial Museum.
https://www.jstor.org/stable/42905908

Neich, R., and C. Kaufmann. 2011. Collections across the divide: the ethnographic collections of James Edge-Partington (1854–1930) and William Ockleford Oldman (1879–1949). *Pacific Arts*, *New Series* 11(1): 5–17.
https://www.jstor.org/stable/23412129

Parry-Okeden, W. E. 1891. Letter to Curator [Charles de Vis], Queensland Museum, 14 May 1891. Inwards Correspondence: Letter No. 3444A. Queensland Museum Archives.

Queensland Museum. 1897. Minute Book of Monthly Meetings, Trustees Minutes, 3 May 1897. Queensland Museum Archives.

Quinnell, M. 2000. 'Before it has become too late': the making and repatriation of Sir William MacGregor's official collection from British New Guinea. In *Hunting the Gatherers*, ed. M. O'Hanlon and R. L. Welsch, pp. 81–102. New York: Berghahn Books. https://doi.org/10.2307/j.ctt1x76fh4.9

Richards, T. 1880. *Official Catalogue of the General Ethnological Collection. Sydney International Exhibition, 1879*. Sydney: Government Printer.

Thomson, B. H. 1889. New Guinea: narrative of an exploring expedition to the Louisiade and D'Entrecasteaux Islands. *Proceedings of the Royal Geographical Society and Monthly Record of Geography*, *New Monthly Series* 11(9): 525–542. https://doi.org/10.2307/1801335

Torrence, R., E. Bonshek, A. Clarke, S. Davies, J. Philp, and M. Quinnell. 2020. Regimes of value in museum practices: a networked biography of the MacGregor field collection from British New Guinea. *Museum History Journal* 13(2): 111–131. https://doi.org/10.1080/19369816.2020.1807122

Walcott, R. H. 1898. *Report of the Trustees of the Public Library, Museums, and National Gallery of Victoria for 1897 with a Statement of Income and Expenditure for the Financial Year 1896–7*. Melbourne: Government Printer.

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The Dancing Trees: Objects, Facts and Ideas in Museums

Erna Lilje[1] and Jude Philp[2]

[1] Junior Curator Western New Guinea, Museum Volkenkunde, Leiden, Netherlands

[2] Senior Curator Macleay Collections, Chau Chak Wing Museum, University of Sydney NSW 2006, Australia

Abstract. In this paper we consider the ways that museum objects have multiple and mutable identities through a focus on three objects from the southeast coast of Papua New Guinea. Our approach is to scrutinise the materiality of these three objects to understand the ways that an object changes physically and symbolically from the point of making, to collection, through to museum acquisition and potential exchange, conservation, exhibition and research. Through this approach we show how small 'fact' details about objects from museum documentation systems become entangled in ideas and notions far beyond those of the times in which the objects were created and collected. We conclude that to understand museum objects we need to recognise their roles in the socio-cultural worlds of their makers and those of the collector-museum.

> *A museum's life revolves around objects, it is contact with them which renders the visit a unique experience for the public. Nevertheless it is not so much the objects' existence in itself to be crucial, as the knowledge about them and the way in which it is transmitted* [sic] (Gnecchi-Ruscone translation [2011: 176] of an observation by Maria Camilla De Palma).

> Paradisea raggiana*, Choqeri* [Sogeri] *district 'fanava' … The plumed birds usually congregate in the morning and towards sunset on trees, called by the natives 'Marrara' (dancing) trees, sometimes in considerable numbers. The natives in this district catch them with a long string … when pulled smartly, this catches the bird by the leg. This is how plumes are obtained from the coast natives, who trade with them with the inland tribes* (Sharpe, 1882: 443 quoting a personal communication from Andrew Goldie).

Introduction: knowing about objects

This paper is in the realm of historically-oriented museum research that engages with the legacy of scientific knowledge-making practices in the museum context. As De Palma suggests (above) this legacy includes the ways objects are exhibited, as well as the information chosen to be associated with them. We are motivated by three objects obtained between 1875 and 1924 on the southeast coast of what is now Papua New Guinea which were coincidently on exhibit in three different countries in 2018: a bag in Castello D'Albertis, Genoa, Italy, a feathered headdress in Royal Academy of Arts, London, Britain and another feathered headdress in the Australian Museum, Sydney, Australia. Our ideas are framed around the kinds of information that become attached to museum objects from the time of their collection to exhibition today. We suggest that in order to make the most of the research value of the tens of thousands of collection items acquired in New Guinea and stored in museums across the world, we should reconnect objects to the cultural aspects not only of the society where they originated past and present, but also of the collecting, and specimen-making society. The need to find balance between knowledge systems can be seen in the work of ornithologist Miriam Supuma (2018) on the ethical and ecological gains that can be made in ornithology by connecting animals with their cultural histories. These ideas are encapsulated in the term 'dancing trees' (Sharpe, 1882: 443). *Marrara* relates to what zoologists call '*lek* grounds', spaces created by particular species for competitive displays for mating. The specific ecological knowledge acquired in the Sogeri region was used by Sharpe as an important note identifying the trees

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where the birds gathered to display. Beyond this, however, the name could also relate to ownership and hunting rights of these *marrara* and recall those men and women of the Port Moresby and inland regions who use the skins of *Paradisea reggiana* in their own dances.

Information that objects bring with them to museum contexts is part of their biography, a concept raised by the authors in Appadurai's seminal *Social Life of Things* (1986). But this suggests a finite group of ideas from the past. We are seeking also to work with the pathways to knowledge that radiate from objects. This distinction allows for change in the object and in ideas through time, such as might come from archaeological perspectives (Torrence, 2003: 109) or future political events (e.g., see Charr, 2020). We first explore how ideas are manifest in the materiality of objects made from hornbill species. We then give an overview of theoretical ideas that have influenced our thinking before moving to discussion of three objects. Each object was collected during a time when it was thought possible to collect 'the facts' about people through the objects that they made (Urry, 1972). These facts may be listed in a register documenting the incoming and outgoing museum items, or on labels explaining the object to a visiting public as well as in narratives, letters and other documents associated with the acquisition. These 'facts' are not always constant but change over time with expanding understanding and different socio-cultural eras. In concluding we argue that a fuller understanding of objects can be given to museum audiences through making obvious the multiple social, cultural and historic perspectives that radiate from an object in the museum context.

Animals in the museum

Hornbills

The Australian Museum cultural collections include two hornbill heads collected by the missionary William Wyatt Gill in the late 1870s (Fig. 1). In storage they both have their 19th century exhibition labels attached: on one is printed 'homicide badge Koitapu tribe, Caution Bay', on the other 'Use: Prowess Emblem Dufaure Island, Torres Straits and Rigo District'. These physical objects are composed of the skin of a *Rhyticeros plicatus* (Forster, 1781: 40) mounted over a piece of wood. In making the object from the hornbill a critical detail has been retained—they have 'eyelashes'. This species of hornbill is one of the few birds that have these 'eyelashes' or, rather, long specialised feathers around their eyes (Graham and Coetzee, 2004). These objects show great skill in their making, involving precision cuts to remove the skin that keeps the line of feathers intact, and re-fixing it while making sure the fringe of eyelash-feathers sits well on the eye socket. Hornbill zoological skins contemporary with these hornbill heads are often mangled or lack this detail of species specificity. As the affixed exhibition label shows the 19th century visitor was not invited to assess the taxidermic prowess of the maker, or contemplate this aspect of species differentiation and its relationship to the object on view. Rather, a cultural description that emphasised features of physical violence within society was given to reveal the 'facts' of the objects (see also Hassett, 2020: 27).

The retention of the labels by curators over successive generations points to the eagerness with which curators seize upon 'facts' associated with a given object and its past. Labels like these rarely form part of the object on exhibition, although in storage they are part of the object history. Because of this we can recognise in the label texts

Figure 1. Skilful indigenous taxidermy of a hornbill head from Central Province, Papua New Guinea. Australian Museum, E347. Photo: R. Torrence.

one way the museum once projected colonial visions of superiority and purposefulness. Science was for many emblematic of this superiority for the European diaspora and home populations—and it is not surprising that observational species knowledge of indigenous peoples was not recognised as science in its time (Olsen and Russell, 2019: 55). This small exploration shows, however, that it is possible to attribute new 'facts' to old objects through, in this case, investigation of their material composition.

Mullet

In the Macleay Museum a fish in a jar of ethanol and water has a small wooden toggle attached to the tail. The fish, a mullet, was instantly recognised by Dairi Arua, a Motuan visitor from Port Moresby to the Macleay in 2008. Dairi Arua was invited to visit Sydney because of his expertise in making material culture items of the Motu. The visit to the store for fishes was part of a gesture to make visual some of the purposes of European collecting endeavours in his country. And so he posed for the camera, making a visual joke pretending to head off with specimen jars of mullet. The mullet is not just a delicacy in his community but his own favourite and something he missed during his time in Sydney. So he laughs that he'll just take them off for supper.

The fish specimen was collected in the late 1870s and catalogued for scientific purposes to a specific species. The toggle, another kind of label, references its collector, Andrew Goldie, a Port Moresby shop keeper (Mullins and Bellamy, 2012). This species is referenced by indigenous people of the southeast coast (including Port Moresby) through the patterns used on bags, skirts, and other objects and in songs, stories and histories (van Heekeren, 2004). Mekeo peoples, from a region about 100 km northwest of Port Moresby, have historical trade connections with Motu. Ecological and behavioural aspects of mullet are referenced in the North Mekeo skirt design *angai kepo afunga* which recalls patterns that the fish create on rocks as they nibble algae (Lilje, 2013: 127). For over one hundred years Mekeo have performed in Port Moresby at dances coordinated and photographed by colonial agents. These references suggest further reasons for Arua's glee when he saw the jar of fish.

It was only in the 20th century, as anthropologists began to see 'whole' societies, that the absence of knowledge in museum collections became fully apparent. The objects on

Figure 2. Not a specimen but an object. *Paradisea raggiana* Probably Western Province, Papua New Guinea. Luigi Pigorini National Museum of Prehistory and Ethnography, Italy. Photo: E. Lilje.

shelves are not pregnant with 'glee' or any other emotive or cultural state. The 'facts' that accompany them do not allow the museum beholder to look at a mullet-patterned bag and see the symbolic world of the mullet in Motu or other southeast New Guinea people's lives and how it relates differently to fishing, people and spiritual things. In recognising the difference and diversity of beliefs, and in seeing objects as integrated parts of social wholes, writers like Bronislaw Malinowski changed the focus on 'ethnographic' objects from museum collections to lived social spaces (Young, 2004: 427-434). But the 'facts' within the museum remained.

In the next section we focus on ideas and 'facts' connected to a bag and two headdresses. For any exhibition curatorial choices are made about objects that emphasise a particular 'fact' of the object from the viewpoint of either the museum or the peoples from where the object originated (Schildkrout, 1989). We draw attention to this sequentially through the idea of place at Castello d'Albertis, presence at the Royal Academy of Art, and story at the Australian Museum, as we explore how interventions of materials and information change and shape our understanding of these three objects today.

Place: a bag at Castello d'Albertis, Genoa, Italy

On the hillside overlooking the port of Genoa stands the castellated home built by Captain Enrico D'Albertis in celebration of the 400th anniversary of Christopher Columbus' 1492 expeditions. After retiring in 1874 from service on the Italian royal and merchant navy ships, Enrico funded his own explorations and adventures (Surdich, 1985). He wrote extensively on his travels for popular and scientific readerships, and was as famous for his historical understanding of medieval sailing as for his antiquarian collections. Castello D'Albertis is the house he retired to, where he wrote, entertained and enjoyed the richness of his experiences. The house, now a public museum of world cultures, continues to be a place to converse over the stories of his life and the objects connected to his journeys across the world. It also houses a smaller collection of objects acquired in New Guinea by his cousin Luigi Maria D'Albertis (hereafter simply D'Albertis) who travelled to western New Guinea in 1872 in the company the naturalist Odoardo Beccari. He returned to the island in 1874. From his base on Yule Island, off the southeast coast of New Guinea, c. 100 km northwest of Port Moresby, he spent four years collecting animals and objects across the region.

The majority of his collections was purchased by two wealthy individuals who had trained and mentored him because of their interest and investment in science and education for the nascent Italian nation: Giacomo Doria at Genoa and Henri Giglioli in Florence. In dividing the collections for sale, animals were predominantly sent to Doria as zoological specimens, while the things made of and by persons were traded to Giglioli as ethnographic items (Fig. 2). D'Albertis also collected human remains as both physical specimens of human difference and as examples of cultural practice. A few things, presumably personal gifts between cousins, remained in Castello D'Albertis when it was given over to the city for use as a museum. Today, displayed in a domestic-museum style sympathetic to its surrounds, these objects are grouped in elegant 19th century glass-topped cases (Gnecchi-Ruscone, 2011).

The animal parts of objects

If one peers into the case (Fig. 3), varieties of the animal parts of objects can be discerned: molluscs' shells, cassowaries' feathers and bones, pigs' tusks and skin. In the right hand corner is an intricately worked bag constructed with a looping technique. It is composed of two-ply string that has been spun by the makers by rolling strands of tree bark-derived fibre across their upper thigh with the flat of the hand. Along with the skin, sweat and hair of the maker thus entwined in the bag's fabric, an animal's parts are looped on bamboo threads into the bag's structure—these are the anuses and tails of pigs. It is in a way a promissory note for the delivery of an animal/s in the future, as bags of this kind were part of the wealth given between parents of children intending to marry. The pigs that were referenced through the anuses of other pigs were consumed long ago by the guests at the ceremonies welcoming the union.

Within the case the bag is simply labelled 'Nacchi (Nokin); tessuli e maglie; F. Fly, N. Guinea [Nacchi (Nokin), mesh bag, Fly River, New Guinea]'. The story of its use and

Figure 3. Animal parts on display in cabinet in Castello D'Albertis, Genoa. Photo: E. Lilje.

meaning comes not from the Fly River, however, but from Koita traditions much further east. The identification of the pig parts, and the identity of the bag itself, were provided via the commonplace anthropological technique of asking modern descendants for information about objects their ancestors made. In this case it was Max Madaha, a Koita man from Kilakila, near Port Moresby which is several days east of the Fly River by sail. Madaha who was also a hunter, identified the bag from a photograph and supplied the information about marriage (pers. comm. M. Madaha to Philp, 2008). Whether D'Albertis was in error in his Fly River designation or not, in the way that cultural objects can take on new ideas and meanings, it will now also serve as a reference point to a practice of the Koita from whom, perhaps, no bags were ever collected

In this case the museum label is not the only place to look for 'facts'. Many come from D'Albertis himself through his popular narrative *New Guinea. What I Did and What I Saw* (1881). It follows the model of many other European travellers' tales of this period that presented the author as a determined protagonist, a lone individual who undertook a perilous journey to paradise, and many pages are filled with lyrical descriptions of the sheer beauty and scale of the geographical spaces he had to negotiate physically. In reality these 'individually' endured hardships were generally shared with an international company of people including deckhands and cooks, engineers and shooters from island Southeast Asia, China and Europe as well as local guides. Many of the difficulties they encountered were also geographical features, rivers that went nowhere, mountains that never ended, torrid streams resisting crossing, reefs and sand bars that stopped the progress of boats. But the principal dangers were perceived to be animal—mosquitoes and people, neither of which were well understood.

Figure 4. A feather head ornament exchanged for cloth or iron at Redscar Point, Central Province, Papua New Guinea in September 1849. British Museum, Oc1851,0103.35. Photo: courtesy of ©The Trustees of the British Museum.

We can imagine that for those indigenous peoples who met D'Albertis, and others like him, the desires and needs of these strangers would have seemed relatively familiar because of the similarity of the goods wanted to those of customary trade: bird skins and mammals, safety, food and water. And indigenous people presumably prepared by making sure they had protection from the harm that strangers intentionally and unintentionally bring, such as rape and disease. Explorers often noted the absence of women and the strong perfume of the leaves and flowers that indigenous people wore at these meetings. It is useful to note that botanical specimens were used both as decorative elements of dress and as compounds of magical devices made to protect the wearer or to enhance their potential (Mosko, 2007).

Both Europeans and indigenous people seem to have shared the difficulties of establishing a way to progress these fleeting encounters. Materials, the things that were worn and carried by Europeans and the things that were worn and carried by indigenous people, were a starting point from the outset of British experiences (Fig. 4) (Philp, 2009). When mediation failed, violence frequently followed. For D'Albertis and many collectors warfare, or indigenous desertion in the face of foreign fire-power, was another opportunity for collection (Gnecchi-Ruscone, 2011). There is no suggestion here that D'Albertis shot people in order to obtain their objects, but he did shoot towards people to disperse them, and shot at people when under attack. And he frequently writes of then obtaining objects and human remains in the subsequently deserted villages, writing on one occasion 'Exclaim, if you will, against my barbarity—say that I have sacrilegiously violated the grave! I shall turn a deaf ear; I am too delighted with my prize to heed reproof' (D'Albertis, 1881: 102). These kinds of 'facts' so differently understood by the public of the times, are today employed to give truth to the circumstances of collection.

D'Albertis' 'facts' for bags like this were necessarily simple, given his inability to communicate directly with local villagers. As with the animals he pursued, it was the *distribution* of object types and technologies that was of interest to him. On writing of his second voyage up the Fly in 1876 and a visit to an 'abandoned' village he recounts:

> It seems worthy of remark, that in this village I did not see one single netted bag; but I noticed a great quantity of bags, old and new, empty and full, all made of plaited palm-leaves or bark…no less interesting is the fact that there is not a single hammer of silica … necklaces of dogs' teeth seem to be worn, but they are rare (D'Albertis, 1881: 137).

In displaying the bag in the small wooden cabinet, curator Camilla de Palma allowed the physicality of the ornate house to give context for Italian audiences unfamiliar with Papua New Guinea and indeed with D'Albertis' work there. With its grand rooms designed for conversation and enjoyment of a private collection, the house is a frame of reference for visitors to understand past contexts and present sensibilities. Further references were created by de Palma with the 19th century style cabinets, the maintenance of early original labels affixed to the objects on exhibition, and the staged juxtapositions between displays of D'Albertis' guns and text panels. These included recent quotes from indigenous Papua New Guineans giving their view on D'Albertis' collecting (Gnecchi-Ruscone, 2011). These decisions ensured that the bag assumed ideas and history from the house itself—a place where New Guinea was framed within 19th century Italian nationalism but with recognition of today's sensibilities.

The Castello D'Albertis permanent exhibition curated in 2004 owes much to a new landscape of material culture theory that has been steadily growing over the past 50 years. This scholarship has ensured collections like that of D'Albertis have been the focus of academic study in a different way from that intended by the original donors and sellers. In anthropological studies the intellectual impact of New Guinea peoples and their philosophies on museum scholarship has been enormous. This influence can be seen in the work of University-based and museum-based scholarship. Chris Gregory's (1982) theoretical commodities' study is particularly pertinent as it was written to understand the complexities of social relations in the multiple economies of colonial Papua New Guinea. Marilyn Strathern's (1988, 1997) gift-centred theoretical models of relationship are studies of the intent and purpose of Melanesians' materially-mediated encounters. Arjun Appadurai (1986) moved the focus onto the object when he brought together a diverse group of scholars to unpack the concept that things can be considered to have a social life as they move through transactional moments. Similarly Nicholas Thomas's (1991) idea of objects entangled in cross-cultural meanings used a focus on specific moments of object transactions to make obvious the realms of value implicit in cross-cultural transactions. These publications stimulated the work of a number of academic curators, leading studies closer to the material facts of the collections.

In a variety of ways curators like Jim Specht and Lissant Bolton (Specht and Bolton, 2005; Thomas *et al.,* 2013), Elizabeth Bonshek (2017) and Joshua Bell (2006), amongst others, have worked outwards from the collections towards the people for whom objects have particular meaning. Their work has brought new social relations and transactional moments to the collections, particularly through funding the contribution of contemporary experts from where the collections originated. This has brought new insights to objects in museum collections and into shaping the collections through acquisitions (Bolton *et al*., 2017). Anita Herle and others have worked to make the contexts of objects more freely available through their efforts to share the material traces of collectors and their encounters with those makers/former owners through publication of archival papers, photographs, notebooks and journals (Herle and Philp, 2020; Ballard, 2013). Archaeologists using museum collections have lent their material focus too. Sarah Byrne, Rodney Harrison, Robin Torrence and Annie Clarke have worked with the idea of collections as assemblages to trace networks and to find traces of individuals who transacted objects with Europeans (Byrne *et al*., 2011). Throughout the last fifty years, and long before, practitioners debated the idea of 'art' and what it means when constituted through objects made in non-European art contexts (see, for example, Haddon, 1894; Gell, 1998).

Presence: art and the specimen

Zoologists, practising within a European scientific tradition, have been working since the late 1600s on how to understand and then account for zoological diversity across the world, with a particular focus on the mechanisms for the moment of, or trigger for, the conception of life on earth. In Europe and then in European colonies, museums were firstly places to debate, and later as Government-sponsored establishments of education and research, to explore taxonomic differences between species, based on individual specimens in collections. From the early 20th century research was organised and displayed increasingly in terms of arrangements of specimens to show ecological relationships, and deep time.

The art of specimen making

Natural history specimens in museums can also be thought of as examples of material culture, specifically of the European biological scientific tradition. The wallaby that is the voucher specimen for the one brought back by D'Albertis (and all others alive or dead) is a good example of the fabrication of zoological specimens. The voucher specimen was part of the collections of the New South Wales parliamentarian and squatter, William John Macleay, who retired to Sydney in the 1860s to pursue his interest in natural history and enhance zoological knowledge for public benefit. He assisted and hired a number of scholars to describe and publish zoological specimens from his collections. One of these was Russian naturalist and ethnographer, Nikolai Nikolayevich Miklouho-Maclay who came to Sydney in 1876 to recuperate from an extensive period of fieldwork on the north coast of New Guinea. The two had much in common, a deep curiosity about the world and a desperate interest and investment in the importance of the mission of science. Miklouho-Maclay worked on some of Macleay's natural history collections where, amidst the mammal specimens, he looked for species new to science.

One of these specimens was a wallaby that Macleay had purchased from Andrew Goldie. It was put in a vat of brine and brought back to Sydney, probably during Macleay's 1875 *Chevert* expedition. By the time Miklouho-Maclay arrived in Sydney, Macleay had decided to leave the family collections to the University of Sydney for study, and so he had a number of the specimens that had been stored in spirits taxidermied for exhibition. He had trained his taxidermist Edward Spalding for the task and this specimen shows how he deftly worked the hide (Mather, 1986: 41). This involved removing all the organs and wet matter, scraping meat and

Figure 5. Artist Ann Ferran's portrait of a specimen, NHM.419, makes obvious the emotive characteristics created through European museum taxidermy. Photo: Ann Ferran, 2014. Courtesy of Chau Chak Wing Museum, University of Sydney.

sinew off bone, drying out the pelt and covering it with arsenic soap. Once it was dry, Spalding would have inserted plaster around the skull to achieve the desired contours for the eyes and nose. Forming a shape by twisting together wires to take the place of the vertebrae, he would have inserted this into the body cavity, anchoring it to head, leg and forearm bones. Only then could the whole wallaby be stuffed with a neutral material and stitched up. While the specimen was still relatively moist, final modifications to the 'attitude' and shape could be made: plaster holding in glass eyes would be painted black, eyelids and eyelashes carefully arranged, as seen in one of Spalding's works (Fig. 5), a wallaby specimen from Mudgee in New South Wales, Australia (Blackburn *et al*., 2015).

Working with the wallaby in this stuffed state, Miklouho-Maclay did what taxonomists continue to do today and carefully described the specimen. Noting and measuring the particularity of specific features in relation to other species (one of his particular interests being the whorls of hair on the back), he determined that it was entirely novel—never described before. He published his conclusion in the journal that Macleay had established and funded, *Proceedings of the Linnean Society of NSW* (Miklouho-Maclay, 1885). And so the taxidermied specimen rests, for evermore, as the reference to this description and, in this case, to the wallaby that he chose to name in honour of his host *Dorcopsulus macleayi*, Macleay's Dorcopsis.

It is with reference to this one fabricated animal that zoologists and others continue to write about *Dorcopsulus macleayi* today. These examples illustrate that specimens can be thought of as examples of material culture, specifically, artefacts of the European biological scientific tradition.

As discussed above, in New Guinea people also created new forms of animals from their skins. Adult male birds of paradise were de-boned, smoked and reset to best capture their appearance during mating when their specialised muscles manipulated their feather mass to extraordinary effect during *lek* displays. Hornbill heads were preserved with particular attention to the redundant eye feathers or 'eyelashes' particular to their species, as described above. Fish were also remade, such as the Florence Museum trumpeter fish with its red, yellow and black colouration, that was skinned, stuffed and overpainted with ochre (Fig. 6). Songs and utterances by hunters recorded aspects of biodiversity, habitat and behaviour, movements and relationships between male and female birds mimicked in public performances and gatherings (Supuma, 2018; Sillitoe, 2002). Within the colonial museum, and only slowly changing today, indigenous knowledge was catalogued as small facts—often linking a local language name to a specimen, as with Sharpe's use at the beginning of this paper. Indigenous knowledge is less likely to be interrogated along with other scientific collection information but becomes 'cultural', in a similar way as the animal preparations were—predominantly catalogued into departments dealing with cultural difference. As a material form of knowledge New Guinean-produced birds of paradise skins were collected as scientific specimens until the early 1880s (Swadling, 1996). Over time these were seen to be inferior for scientific study because of the Papuan method of preservation and mounting (Philp, 2021). Such skins can look something like the one in Fig. 2. It could be equally described as a headdress ornament, for in this 'trade' form they were inserted into large headdresses made up of a variety of bird feathers and bird skins.

Figure 6. Indigenous taxidermy of a trumpeter fish acquired in the 1870s and now on display in the New Guinea gallery of the Museum of Anthropology and Ethnography, Florence, Italy. Photo: E. Lilje.

Animals as Art

Until D'Albertis' era these trade skins were highly valued as both ornaments and scientific objects in European tradition. In the 1870s advances in definitions and rules for zoological practice directed museums to acquire skins made in a specific way, as we discuss below (Swadling, 1996; Philp, 2021). Preserved animals, prepared for Papuan purposes, continued to be collected for museums but these were increasingly catalogued into expanding ethnographic collections. They became ethnographic objects, their worth, in the museum and knowledge-making context, lay in their connection to the peoples and places of their origin. European methods of preparation and preservation increasingly became the norm for natural history specimens. It was a style refined over time and eventually led to the use of a partially bony-skin becoming 'specimens' and taxidermised 'mounts' of specimens being reserved for exhibition to communicate messages to the museum-going public (Philp, 2021).

Across New Guinea men and women use the skins and feathers of birds of paradise to wear on their bodies and in so doing at times create images of triumphant splendor. Their staging, the discussions they raise and costs involved have many parallels to European art traditions. Regardless

Figure 7. The Roro-Lala clan headdress as exhibited for *Sea of Islands* (2019). Museum Volkenkunde, Leiden, The Netherlands, RV_1999_550. Photo: courtesy of Museum Volkenkunde.

Figure 8. Detail of Fig. 7 showing the layering of *koiyu*, lorikeet, and white bird of paradise feathers on the Roro-Lala clan headdress. Photo: courtesy of Museum Volkenkunde.

of whether or not it is appropriate to use the term 'art' in relation to them it is certain that they are masterpieces of New Guinean aesthetics, albeit differently conceived, understood and made across the island (Brunt and Thomas, 2018).

Today, on the southeast coast of Papua New Guinea (PNG), the Roro and Mekeo peoples are known for their spectacular fan-shaped headdresses (Figs 7 and 8). Nevertheless very few exist in museum collections. This grand headdress was made and used by people from either Yule Island or the adjacent mainland areas, speakers of Roro and Lala (also known as Nala, Nara, Pokao) languages. It was brought to the Netherlands in 1914 by a father of the Missionaires du Sacré-Coeur (a mission established on Yule Island from 1889). The radiating struts were once covered in feathers fastened into place with string binding that remains visible. Weighted with shells near their tips, the struts would have swayed gracefully as the wearer danced. A stately grace, given that the weight and size of the construction demands an upright bearing and poise.

No bird skins are present on this style of headdress, but the individual bird feathers and skin pieces from birds of paradise, recall their flight through forest spaces. Termed *koiyu* in the Roro language, twenty-three rounded forms made from drilled and moulded turtle shell affixed to a carved conus shell backing recall the sea (Brunt and Thomas, 2018: 299). The headdress suffered from some neglect before the mid-twentieth century that resulted in the loss of feathers along the radiating struts. Despite this damage, it is an exceptional headdress measuring an astonishing 2.5 by 2 m.

In the early 1900s anthropologist Charles Seligmann determined from his research that for the people of this area these large feather headdresses were a form of clan 'badge' (Seligmann, 1910: 210). Particular designs were reserved for the use of clan members. However neither the clan name, nor exact location, was recorded by van Neck for this headdress. Large feather headdresses were only worn by more prominent people of the clan. Historical photos show that within a community dressed for dancing only a small number wear the large headdresses with others wearing smaller feather headdresses and ornaments. Although primarily associated with prominent men these images (Fig. 9) also show that while it was less common, women could wear large headdresses.

Figure 9. Detail from a photograph of a dance at Waima, Central Province, Papua New Guinea. Photo: Rev. A. M. Fillodean, c. 1890s. Courtesy of Cambridge University Museum of Archaeology and Anthropology, P.2126.

Collected by Father Henri van Neck before 1913, the headdress was sold to the Rijks Ethnographisch Museum in Leiden Volkenunde along with 638 other objects. Though detailed in documentation as from Yule Island, it is likely that it received this 'fact' because it was the location of the Sacred Heart Missionary headquarters on Yule Island. During his first stint in New Guinea (1902–1913) van Neck was responsible for establishing a church and school at Vanamai, on the mainland c. 15 km from Yule Island. Van Neck had made the collection with the intention of using it for the promotion of the mission's work in Europe; bringing back artefacts to increase awareness and support of overseas missions, was a popular practice (Nationaal Museum van Wereldculturen, RV-1990-550_TXT003607). However circumstances led him to instead sell the collection to the Rijksmuseum Volkenkunde, presumably to raise funds for the chronically underfunded mission (Langmore, 1989: 242). These circumstances speak to van Neck's commitment to the mission and its people. His return to Belgium in 1913 had been forced by exhaustion, due to his poor living conditions.

From his correspondence with the Volkenkunde Museum we learn that van Neck had motivations in addition to fund-raising as he wanted the collection to remain together (van Neck, 1920). He also hoped that when the headdress was displayed it would be together with other accoutrements that might have been worn with a feather headdress. In other words for van Neck the 'facts' of the headdress could best be comprehended through the entire assemblage associated with the performer. The distance of time and the consuming nature of his work, however, led to no direct notes on what constituted the 'whole'. Instead it is this partial, while extravagant, headdress that remains.

Isolated from the objects and people the headdress was once part of, it was a centrepiece for the major exhibition *Oceania* that opened at the Royal Academy of Art, in London in 2018, afterwards at the Musée du quai Branly-Jacques Chirac in Paris, and then as part of *A Sea of Islands: Masterpieces of Oceania* in Leiden. Lead curator for the exhibition Nicholas Thomas has long sought to educate and enliven understanding of Pacific art practice and of the European collections that recorded this in the past. His work has also documented and promoted Oceanic artists whose work responds to and challenges European perception. Staging the exhibition at the Royal Academy in London (an institution of the European Enlightenment's high art practices) reinforced the message of Art. The exhibition catalogue makes it clear that Oceanic art practice is philosophically different and oftentimes a distributed practice rather than an individual one (Brunt and Thomas, 2018). In this state of isolation, the headdress was seen not towering above head-height but at chest level for most visitors to give a sense of its appearance when worn; it was displayed as a masterpiece of Oceanic art.

Both Erna Lilje in a discussion of the headdress to camera shown on the Royal Society website (Lilje and Royal Academy, 2018) and Michael Mel (2018) noted common attributes of such masterpieces within PNG: these objects are made up of the distributed labours of many people; and they are ephemeral. It is possible that the Roro makers accepted van Neck's idea to collect this stage of the objects' lives, and that the collection of them included the agreement of all participants. If not, at the end of their performance the feathers and *koiyu* would have been returned to their various owners; strings of lorikeet feathers would have been wound back onto sticks and stored for safe-keeping.

The constant state of movement involved in making, and unmaking a headdress is another 'fact' of this clan's work. Even before the time of its making was planned, people worked shells and feathers into singular objects, valuables that would later be brought to the frame. One imagines that discussion would take place over the composition of the headdress before each element was tied in place. The respected and revered person who would carry it upon their head would be still while many hands applied and adjusted other ornaments, fibres, oils, fragrances, ochres and pitch onto the person enclosed within this moment. And then movement again. As Mel recalls in describing Mogei performances thousands of miles away in the highlands of PNG's Melpa region:

> Bedecked with accoutrements, the decorated body is not and cannot be seen as the self-expression of the person, nor, in performance, as the physical expression of an individual actor. … plumes came alive as … both creatures (human and bird) were no longer separate. (Mel, 2018: 75–76).

Exhibitions are rarely able to accomplish transitional moments such as the making and unmaking of a headdress. Snatches of filmed performances are instead used in museum exhibitions to create links between the static and the moving spectacle. Related objects (such as van Neck wanted displayed) often have no place in displays of art as they can mute rather than reinforce the power of the singular statement. The presence that curators created through related publicity as well as lighting and position assisted in 'making' this headdress a singular, dramatic and astounding object for the exhibition. There are other reasons to maintain the object in this state. Masterpieces, and particularly rare masterpieces such as this is, have extraordinarily high insurance values. As a physical part of Museum Volkenkunde, a component of the National Museum of World Cultures, it must perform as an exhibition object within prescribed and agreed boundaries—that include conditions that constrain any movement, even a breath of air, that may weaken this historical structure. Within the conservation strategies structured around its long-term continuity as a museum object, it must also remain beyond human touch for the oils of human hands are now understood as a weakening rather than strengthening feature of human intervention.

For this headdress agreement seems to have been reached between Roro people and van Neck to allow this person-less visualisation of their identity to leave their community. In so doing they ensured the headdress would become akin to an historical document resonant with their combined identity and clan affiliation. Thinking about how feathered headdresses were made in the highlands region of Mount Hagen, anthropologist Marilyn Strathern used the idea of portraiture (Strathern, 1997). In this way the headdress on exhibition is a portrait of these unknown men and women. It was *their* presence that was promoted through the exhibition of the headdress. In the final case study, we look at another headdress that continued to work as a dispersable material assemblage within another museum context.

Figure 10. Vaieki junior wearing a headdress at Elevala, National Capital District, Papua New Guinea, 1922. Photo: Frank Hurley. Courtesy of National Library of Australia, nla.obj-158068771.

Stories:
Captain Hurley and the paradise plumes

Frank Hurley is one of Australia's most famous photographers. Fig. 10 is one of his images and shows a young man called Vaieki in Elevala village, near Port Moresby. The image was taken during Hurley's second expedition to New Guinea (1922–1923), when he joined forces with the Australian Museum's ichthyologist Allan McCulloch to collect objects for future exhibitions. Although deeply involved in the project to collect objects, Hurley's principal purpose was to gather footage for his black and white film *Pearls and Savages* (Hurley, 1924). He also made a commercial arrangement with *The Sun* newspaper through which he used his talents as a story-teller to create public interest in the expedition and its results (Specht and Field, 1984).

There is no better image of Frank Hurley and Allan McCulloch's self-styled triumph of their expedition's success than the picture that graced the front page of *The Sun* on their return on 4th February, 1923 (Fig. 11). In the picture a laughing and gesticulating Hurley and museum officer Allan McCulloch stand either side of Hurley's wife Antoinette. Each is wearing a dramatic and large feathered headdress; the subtle differences between the feathered arrangements, give a sense of the variation in this art form.

The collections of hundreds of objects from the expedition that came into the Australian Museum early in 1923 included three headdresses incorporating fifteen plumes of *Paradisea raggiana* (Australian Museum Archives AMS6 17/1923). By March 1923 Hurley was negotiating with Museum Director Charles Anderson to acquire some Bird of Paradise plumes to add further spectacle to his narratives for the silent black and white film presentations (Specht, 2003). Anderson duly wrote to the Papuan Collector of Customs to clear the restricted plumes for Hurley's use to further ornament 'two New Guinea headdresses which he is retaining for himself.' The Collector of Customs refused, reminding Anderson that legally only scientific institutions could obtain them (Specht, 2003). But he offered a suggestion that the Museum could retain them but loan them to Hurley for the stated purposes 'provided it be clearly understood that the articles will be ultimately returned to the Museum' (Australian Museum Archives AMS A23/4715; C23/15).

The Museum Register reveals the Museum took a different path, through the administrative designation of 'exchange'. By this means Hurley sent the Museum bundles of arrows (of which they already had a plethora) and in return Hurley received 14 Bird of Paradise plumes, 'prepared in the native way', from Elevala, along with the two feathered frames he retained.

On the face of it the values of the things exchanged were not equal; neither in New Guinea nor in Sydney would a bundle of arrows be worth fourteen plumes. However, for the Museum, much of the value lay in the relationship this established with Hurley himself (Torrence *et al.,* 2020). The photographer and filmmaker had achieved considerable fame through his work on no less than three Antarctic expeditions, as well as receiving the rank of honorary captain as an official photographer during World War I (Dixson, 2011; Specht and Field, 1984). Through his fame and prowess in creating stories around his work, the Museum could attract new audiences. In addition to the value of Hurley's fame, the majority of his New Guinea photographs were sold to the Museum for their use. In the light of this it is easier to understand why the Museum risked government censure and the charge of illegality for Hurley through 'lending' the plumes—in reality, a mixture of feather-strings and bird skins prepared in the New Guinea manner (Swadling, 1996).

Evidently by 1924 the Museum's headdress was missing the Bird of Paradise plumes which in Michael Mel's memories of similar Highlands' headdresses were made to 'live again' in the swaying movements of the decorated dancers (Mel, 2018: 76). The Australian Museum renewed the headdress by doing what people in PNG did: looking to other people's collections (within the Australian Museum stores) to seek out ornaments for this spectacle. It was made anew with 11 valuables originating from various places across PNG (Fig. 12), including trade skins from Asaro in the Eastern Highlands Province, brought in from Goroka by the Southern International Film Company who co-produced *Walk into Paradise* [1956]. This was the version of the headdress shown in the Australian Museum's *Pieces of Paradise* exhibition in 1988. When the time came for the exhibition to be taken down, conservators and curators faced a difficult question. Should the headdress be returned to its original, less-ornamented state? The decision was made to retain this Australian Museum version, but in doing so museum practices had to be followed. The result was a museum spectacle in keeping with PNG aesthetics—for each object a shelf-label linked the viewer to an individual collector, a place and a moment through the notation of the object numbers of each element. The headdress now conformed to a united vision, one where stillness and isolation prevailed, but where multiple relationships were brought together and performed for those who visited the Pacific store. It was this version that was included in the Australian Museum *Rituals of Seduction* exhibition of 2018 that explored PNG Highlanders' knowledge of species ecology, taxonomy and diversity (Australian Museum, 2018).

In an act that cemented the Australian Museum's creative control over, and making of this object, the headdress was chosen as one of the 100 designated 'treasures' amidst the 300 or so objects and animals exhibited in the Westpac Long Gallery opened in 2017. For this new exhibition Hurley's fame is strongly associated with the headdress, with curator Peter Emmett going as far as saying 'Hurley's photograph (Fig. 10) is as much a treasure as the headdress' (Power, 2017). Strangely, the identity of the headdress changed several times in the flurry of the exhibition launch. Emmett reported that Motuan Vaieki was not only wearing the headdress in Elevala, he was the maker. The Museum's Annual Report (2016-2017) titled it 'Roro headdress. Port Moresby', labelling that was echoed in the Long Gallery exhibition. Despite these interventions it was still recognisable to people of Port Moresby. On presenting this form of the headdress and its history to a Facebook audience of Motu people in 2020, Lilje found only appreciation and satisfaction in the form that it had become. One person reporting that *ibara* like this were no longer made in Port Moresby.

Conclusions

This paper has focused on the multiple and mutable identities of museum items. In doing so we believe we have made explicit the kinds of minimal information of many museum objects and the great archival recognisance that needs to be undertaken to restore even the base-line collecting information, such as a place, a date, a person and a social or natural relationship.

From the point of collection, through to museum acquisition and potential exchange, conservation, exhibition and research, the nature of museum objects is that of changelings. Financial systems and conservation strategies conspire to constrain their movements, small 'fact' details are scrutinised for veracity and become entangled in ideas and notions far beyond those of the times in which the objects were created and collected. These changes materialise the multiple social relations that caused the creation of the object, along with those relations that account for it within one museum or another. Each component, original or otherwise, leads to the multiple historical moments and places associated with the object, whether this is a feathered eyelash or museum label.

Figure 11. Allan McCulloch with Antoinette and Frank Hurley on the front page of *The Sun*, 4th February 1923. *The Sun* and Hurley probably staged this photograph to signal what he saw as his triumphant return to Sydney from a successful collecting expedition. This ignored the Australian Administration's impounding most of the collections over concern about the questionable methods Hurley and McCulloch had used to acquire them (Specht, 2003).

Figure 12. Headdress frame (E27490) with additional elements of Chimbu feather sticks (E58233, E58234); shell ornaments from Central Province (E3091, E3092) and New Britain (E47514, E52269), and plumes from Eastern (E58214, E58224), Western (E54751, E54752) and Southern (E49979) Highlands Provinces. Photo: R. Torrence.

The indigenous peoples of Papua New Guinea and indigenous peoples of former British and European colonies are increasingly working with and researching museum collections. Their perspectives and interventions into museum 'facts' and histories are balancing the coloniser view that the 19th century museums have brought with them into modern times through their philosophy, organisation and systems. Approached from different perspectives through time, these objects become ever richer objects for study and enlightenment.

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References

Appadurai, A., ed. 1986. *The Social Life of Things: Commodities in Cultural Perspective*. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511819582

Australian Museum. 2018. *Rituals of Seduction: Birds of Paradise*. Exhibition website (updated 2019).
https://australian.museum/about/history/exhibitions/birds-of-paradise/#gallery-297-93

Ballard, C. 2013. The return of the past: on drawing and dialogic history. *The Asia Pacific Journal of Anthropology* 14(2): 136-148.
https://doi.org/10.1080/14442213.2013.769119

Bell, J. 2006. Losing the forest but not the stories in the trees: contemporary understandings of F. E. Williams's 1922 photographs of the Purari Delta. *The Journal of Pacific History* 41(2): 191-206.
https://doi.org/10.1080/00223340600826094

Blackburn, R., A. Gill, L. Lui-Chivizhe, and J. Philp. 2015. *Stuffed, Stitched and Studied: Taxidermy in the 19th Century.* Sydney: Sydney University Museums.

Bolton, L., N. Thomas, E. Bonshek, J. Adams, and B. Burt. 2017. *Melanesia: Art and Encounter.* London: British Museum Press.

Bonshek, E. 2017. *Tikopia Collected: Raymond Firth and the Creation of Solomon Islands Cultural Heritage*. Canon Pyon (Herefordshire, UK): Sean Kingston Publishing.

Brunt, P., and N. Thomas, eds. 2018. *Oceania*. London: Royal Academy of Arts.

Byrne, S., A Clarke, R. Harrison, and R. Torrence. 2011. *Unpacking the Collection: Networks of Material and Social Agency in the Museum. One World Archaeology*. New York: Springer-Verlag.

Charr, M. 2020. How have museums responded to the Black Lives Matter protests? *MuseumNext*. [Accessed 3 May 2021].
https://www.museumnext.com/article/how-have-museums-responded-to-the-black-lives-matter-protests/

D'Albertis, L. M. 1881. *New Guinea. What I Did and What I Saw.* London: Sampson Low, Marston, Searle and Rivingston.

Dixson, R. 2011. *Photography, Early Cinema, and Colonial Modernity: Frank Hurley's Synchronized Lecture Entertainments*. London: Anthem Press.

Forster, J. R. 1781. Zoologica Indica Selecta Tabulis *XV Aeneis Illustrata. Indische Zoologie, oder, Systematische Beschreibungen seltener und unbekannter Thiere aus Indien mit 15 illuminirtten Kupfertafeln erläutert ...* Halle: Johann Jacob Gebauer.

Gell, A. 1998. *Art and Agency: An anthropological theory*. Oxford: Oxford University Press.

Gnecchi-Ruscone, E. 2011. From New Guinea 1872–78 to Genova 2004: recovering Luigi Maria D'Albertis' private collection. *Journal de la Société des Océanistes* 132: 165–181.
https://doi.org/10.4000/jso.6571

Graham M., and H. Coetzee. 2004. Visual fields in hornbills: precision-grasping and sunshades. *Ibis* 146(1004): 18–26.
https://doi.org/10.1111/j.1474-919X.2004.00211.x

Gregory, C. 1982. *Gifts and Commodities.* London and New York: Academic Press.

Haddon, A. C. 1894. *Decorative Arts of British New Guinea: A Story in Papuan Ethnography.* Dublin: Royal Irish Academy.

Hassett, D. 2020. Acknowledging or occluding "The System of Violence"? The representation of colonial pasts and presents in Belgium's Africa Museum. *Journal of Genocide Research* 22(1): 26–45.
https://doi.org/10.1080/14623528.2019.1653522

Herle, A., and J. Philp, eds. 2020. *Recording Kastom: Alfred Haddon's Journals from the Torres Strait and New Guinea, 1888 and 1898.* Sydney: Sydney University Press with Museum of Archaeology and Anthropology, University of Cambridge.
https://doi.org/10.2307/j.ctv18x4jjk

Hurley, F. 1924. *Pearls and Savages: Adventures in the Air, on Land and Sea in New Guinea*. New York: G. P. Putnam's Sons.

Langmore, D. 1989. *Missionary Lives: Papua, 1874–1914*. Honolulu: University of Hawai'i Press.

Lilje, E. 2013. *From Maker to Museum: Fibre Skirts from Central Province, Papua New Guinea*. Unpublished PhD thesis, University of Sydney.

Lilje, E., and Royal Academy. 2018. *Learn about this spectacular headdress in Oceania*. Video. [Accessed 3 May 2021]
www.royalacademy.org.uk/article/oceeania-video-roro-headdress

Mather, P., ed. 1986. *A Time for a Museum: A History of the Queensland Museum 1862-1986*. Brisbane: Queensland Museum.

Mel, M. 2018. Performance and the body. In *Oceania,* ed. P. Brunt and N. Thomas, pp. 75–76. London: Royal Academy of Arts.

Miklouho-Maclay, N. N. 1885. On two new species of Dorcopsis from the south coast of New Guinea. *Proceedings of the Linnean Society of New South Wales* 10(2): 145–150.
https://doi.org/10.5962/bhl.part.17908

Mosko, M. 2007. Fashion as fetish: The agency of modern clothing and traditional body decoration among North Mekeo of Papua New Guinea. *The Contemporary Pacific* 19(1): 39–83.
https://doi.org/10.1353/cp.2007.0028

Mullins, S., and M. Bellamy. 2012. Andrew Goldie: the experience of empire. In *Andrew Goldie in New Guinea 1875–1879: Memoir of a Natural History Collector*, ed. S. Mullins, M. Bellamy, and C. Moore, pp. 7–38. *Memoirs of the Queensland Museum, Culture* 6. Brisbane: Queensland Museum.

Olsen, P., and L. Russell. 2019. *Australia's First Naturalists: Indigenous Peoples' Contribution to Early Zoology*. Canberra: NLA Publishing.

Philp, J. 2009. Days of desolation on the New Guinea coast. In *In the Wake of the Beagle: Science in the Southern Oceans from the Age of Darwin,* ed. I. McCalman and N. Erskine, pp. 125–137. Sydney: UNSW Press.

Philp, J. 2021. Circulations of paradise: or how to use a specimen to best personal advantage. In *Mobile Museums: Collections in Circulation,* ed. F. Driver, M. Nesbitt, and C. Cornish, chapter 9, pp. 230–260. London: University College London Press.
https://doi.org/10.14324/111.9781787355088

Power, J. 2017. Curator Peter Emmett's top picks of Australian Museum's treasures. *Sydney Morning Herald.* [Accessed 3 May 2021].
https://www.smh.com.au/national/nsw/curator-peter-emmetts-top-picks-of-australian-museums-treasures-20171010-gyy1wd.html

Schildkrout, E. 1989. Art as evidence: a history of the American Museum of Natural History African Ethnology Collection. In *ART/Artifact*, ed. A. Danto and The Centre for African Art, pp. 153–160. New York: The Center for African Art.

Seligmann, C. G. 1910. *The Melanesians of British New Guinea*. Cambridge: Cambridge University Press.

Sharpe, R. B. 1882. Contributions to the ornithology of New Guinea, Part 8: on collections made by Dr A Goldie in the Astrolabe Mountains. *Proceedings of the Linnean Society of London (Zoology)* 16(94): 422–447.
https://doi.org/10.1111/j.1096-3642.1882.tb02387.x

Sillitoe, P. 2002. Maggots in their ears: hunting incantations and indigenous knowledge in development. *Journal of Ritual Studies* 16(1): 64–77.
https://www.jstor.org/stable/44368626

Specht, J. 2003. *When the Cause of Science is Not Enough: Frank Hurley in Papua.* 6th Maurice Kelly Lecture. Armidale (NSW): Museum of Antiquities, University of New England.

Specht, J., and L. Bolton. 2005. Pacific islands' artefact collections: the UNESCO inventory project. *Journal of Museum Ethnography* 17: 58–74.
https://www.jstor.org/stable/40793769

Specht, J., and J. Field. 1984. *Frank Hurley in Papua: Photographs of the 1920–1923 Expeditions*. Sydney: Robert Brown and Associates.

Strathern, M. 1988. *Gender of the Gift: Problems with Women and Problems with Society in Melanesia*. Berkeley: University of California Press.
https://doi.org/10.1525/9780520910713

Strathern, M. 1997. Pre-figured features: a view from the Papua New Guinea Highlands. *The Australian Journal of Anthropology* 8(2): 89–103.
https://doi.org/10.1111/j.1835-9310.1997.tb00179.x

Supuma, M. 2018. *Endemic Birds in Papua New Guinea's Montane Forests: Human Use and Conservation*. PhD thesis, James Cook University, Townsville.
https://doi.org/10.25903/5d0194ca93995

Surdich, F. 1985. D'Albertis, Enrico Alberto. *Dizionario Biografico degli Italiani* 31 [Accessed 3 May 2021].
https://www.treccani.it/enciclopedia/enrico-alberto-d-albertis/

Swadling, P. 1996. *Plumes from Paradise: Trade Cycles in South-East Asia and their Impact on New Guinea and Nearby Islands until 1920.* Boroko: Papua New Guinea National Museum and Art Gallery.

Thomas, N. 1991. *Entangled Objects: Exchange, Material Culture, and Colonialism in the Pacific*. Cambridge (Mass.) and London: Harvard University Press.

Thomas, N., L. Bolton, and E. Bonshek, eds. 2013. *Melanesia: Art and Encounter* London: British Museum Press.

Torrence, R. 2003. Just another trader? An archaeological perspective on European barter with Admiralty Islanders, Papua New Guinea. In *The Archaeology of Difference: Negotiating Cross-Cultural Engagements in Oceania,* ed. R. Torrence and A. Clarke, pp. 107–145. London: Routledge.
https://doi.org/10.4324/9780203298817

Torrence, R., E. Bonshek, A. Clarke, S. Davies, J. Philp, and M. Quinnell. 2020. Regimes of value in museum practices: a networked biography of the MacGregor field collection from British New Guinea. *Museum History Journal* 13(2): 111–131.
https://doi.org/10.1080/19369816.2020.1807122

Urry, J. 1972. 'Notes and queries on anthropology' and the development of field methods in British anthropology, 1870–1920. *Proceedings of the Royal Anthropological Institute of Great Britain and Ireland* 1: 45–57.
https://doi.org/10.2307/3031732

van Heekeren, D. 2004. Feeding relationship: uncovering cosmology in Christian Women's Fellowship in Papua New Guinea. *Oceania* 75(2): 89–108.
https://doi.org/10.1002/j.1834-4461.2004.tb02871.x

van Neck, H. 1920. Letter to the Director, 10 June, 1920. Correspondentie archief NL-LdnRMV-A01 (99). Leiden: Museum Volkenkunde.

Young, M. 2004. *Malinowski: Odyssey of an Anthropologist 1884–1920.* Yale: Yale University Press.

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Papuan Gulf Spirit Boards and Detecting Social Boundaries: A Preliminary Investigation

James W. Rhoads

Independent researcher, PO Box 217, Glen Forrest WA 6071, Australia

Abstract. This paper is an exploratory investigation of Papuan Gulf spirit boards. These ceremonial items and their designs were owned by clans and other patrilineal groups and comprised an important aspect of traditional ceremonial life. During the early contact period, they were intensively collected by Europeans and now appear among world-wide museum holdings of Papua New Guinea material culture. The Australian Museum has an extensive collection of spirit boards that provide the primary data for this study. Here spirit board design elements are analysed to understand how they are distributed between or only retained within cultural groups living in the east-central Papuan Gulf. The paper also examines ways to analyse spirit board designs.

Prologue. During 1983 I carried out fieldwork in the Orokolo villages, Papuan Gulf, on behalf of the Australian Museum. Most days over almost two months I interviewed village elders who provided me with a wealth of critical information about their cultural heritage. The information I collected about the relationship between their social system and the designs appearing on their traditional ceremonial material culture is significant, especially given more than 50 years had passed since the major ceremonies ceased being performed. The elders were both candid and patient, and I am greatly indebted to them for the trust they showed in me. By mutual agreement, I promised to begin all publications that used the cultural information they passed on to me by recognising these holders of community wisdom with their photographs (Fig. 1).

Introduction

Social identity, social structure, intergroup boundaries and interaction, social networks and migration patterns are key objectives of much current archaeological research (e.g., Chiu, 2015; McDonald and Veth, 2012; Rigaud *et al*., 2018; Stone, 2003; Torrence, 2011). One common interpretative framework relies on social behavioural models, mostly borrowed from critical research in other disciplines such as anthropology, evolutionary biology or behavioural science (e.g., Appadurai, 1986; Barth, 1969; Lave and Wenger, 1991; Lipo and Madsen, 2001; Wobst, 1974). More information comes to hand in the form of direct observations (Graves *et al*., 2016; Wiessner, 1984), comprehensive historic records (McBryde, 2000) or well-documented museum collections (Torrence and Clarke, 2016).

Using ethnographic and historic records, this paper explores the social symbols found on Papuan Gulf spirit boards (Fig. 2). These artefacts were collected in substantial numbers during the early stages of the contact period from the late 19th century to just prior to World War II (Welsch, 2015a: 22–26) and important holdings are in the Australian Museum, as well as other world-wide institutions. Spirit boards are attractive and frequently occur in ethnographic art compilations (e.g., Welsch *et al*., 2006).

F. E. Williams, Papua New Guinea's first Government Anthropologist, documented Papuan Gulf cultures between 1923 and 1937, spending 16 months with the Elema and eight with the Purari, their western neighbours, recording their traditional cultures (Williams, 1924: vii, 2015: xi). He noted (2015: 246–247, fig. 11, plate 28) that some designs carved on *hohao*, Elema spirit boards, as well as those portrayed on other ceremonial items, communicated their ownership by particular social groups—clans (*bira'ipi*) and patrilineal

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Figure 1. Orokolo Elder Informants, 1983 Australian Museum Ethnographic Research Project.

descent groups (*aualari*). Thus, spirit boards should be a valuable resource for investigating traditional social group boundaries in the Papuan Gulf.

Moreover, spirit boards may have utility for archaeological investigations in the region. Almost 50 years of archaeological research into South Papuan coastal trade and exchange (e.g., Allen, 2017; Rhoads, 1982; Skelly and David, 2017; Urwin *et al*., 2021) demonstrates a diverse suite of exotic goods arrived in the Papuan Gulf from distant areas to the east, west and north. However, we have little idea about how these goods were distributed and ferried through the region. An understanding of social identity and social networks among Papuan Gulf peoples is key to revealing local trade and exchange systems. Spirit boards offer one of the few avenues to investigate early historic Papuan Gulf society. This paper examines the viability of a comprehensive research project focused on Papuan Gulf spirit boards.

The paper consists of three parts. The first considers theoretical underpinnings for analysing social boundaries in Papua New Guinea and associated methodological approaches. As well, the ethnography of spirit boards—their role in traditional society and their designs—is examined.

The second section sets out the research methodology—the recording of design elements and analytical techniques. It presents a pilot study of a small collection of Western Elema (Orokolo) *hohao*, mostly from the Australian Museum, that have detailed contextual documentation. It then investigates a more substantial collection of Papuan Gulf spirit boards that are more diverse, both geographically and culturally.

The third section assesses the success of this exploratory investigation. It concludes by considering whether spirit boards can serve as a proxy for social markers capable of detecting intra- and inter-regional sharing of designs.

Design elements research, social boundaries and the Papuan Gulf

New Guinea art typically conveys messages, and these are frequently communicated through ritual and ceremonial behaviour. As a consequence, meaning is conveyed at a system-wide or group level as style. In other words, meaning is contained in a circumscribed regional design system (Forge, 2017: 111, 114–115). Seeking meaning in Abelam art Forge (1965: 23) asked:

> How far is the art of the Sepik a means of communication? … How far does the art form a system *sui generis* or, in other words, to what extent can we take carvings and paintings as things in their own right relating to each other and the beholder, and not as mere manifestations of some other order of cultural fact such as mythology or religion? Does plastic art of a group have its own rules, not just style, but also of meaning and interpretation?

Forge (2017) later provided a lead-in to social boundary analyses by noting:

> Frequently certain sacra are owned by clans or other segments of the group performing the ritual and have segment specific names; these, and sometimes designs, are property whose copyright is to be defended … The clan-owned designs on the hevehe masks of Orokolo are a classic and well-known example of this class of division of property.

Kaitilla (1997: 402) further illustrated the role of art incorporated into traditional Papua New Guinea buildings and how this incorporation integrated social groups and their art:

> Primitive art objects [e.g., men's house posts and carved boards] were displayed prominently both inside and outside of men's spirit houses as a visible sign serving to ensure a feeling of security and survival, as a warning to outsiders about the supernatural forces in them. In this sense social organisation and regulation [are] the primary functions of primitive art.

Moving from theory to methodology, Conkey's (1978) study of Upper Palaeolithic art and group borders argued that art objects contain structural elements, specifically information content, understood by different territorial groups. These identify boundaries separating different groups through distinct graphic designs (Conkey, 1982: 116). Conkey's approach is most relevant to this study since it is well-founded on linguistic (Schapiro, 1969) and anthropological theory (Barth, 1969; Leach, 1976). Conkey's analysis focused on three basic structural elements of art: (i) design—a typological system starting with elements as the basic unit and continuing to analysed motif forms; (ii) design field—properties of the space within which images

Figure 2. Orokolo *hohao*. Reproduced courtesy of the Australian Museum. Pacific Collection reg. no. E000258.

occur; and (iii) design configuration—the positioning of motifs as a whole on an object (Conkey, 1978: 120, 1980: 615–617). Her use of multivariate statistics as a basic analytical tool also serves as a guide for this study. This approach has proved useful in recent studies of cultural identity relevant to Australian Indigenous rock art and shield designs (McDonald, 2009; McDonald and Harper, 2016).

Papuan social groups, material representations and spirit boards

Among Papuan Gulf peoples (Fig. 3), specific symbols and designs belong to different social groups (i.e. the designs associated with clans (*bira'ipi*) and patrilineal descent groups (*aulari*) among the Elema). These were incorporated into the patterning of designs on spirit boards, ceremonial masks, bullroarers and bark belts. Additional information can be assembled from Williams (1940: 246, fig. 11) and Beier and Kiki (1970). Other information is contained in my notes for the 1983 Orokolo fieldwork for the Australian Museum (Rhoads, 1984). Together, these all provide a substantial body of information about Western Elema material culture.

Local names for boards varied between the different major Papuan Gulf groups—*hohao* among the Elema, *kwoi* (*koi*) for the people living in the Purari delta, *gope* among communities along the Era and Wapo Rivers and at Urama Island, and *titi ebiha* for the Kerewo in the Goaribari Island area (Beier and Kiki, 1970; Bell, 2009; Newton, 1961: 15, 19; Welsch, 2015b).

Spirit boards were stored in men's houses—*eravo* (Elema), *ravi* (Purari) and *dubu* (Urama)—along the partitions separating sleeping areas for initiated men belonging to the same clan. Large ceremonial masks were suspended along the central aisle of men's houses. The spirit boards were rarely, if ever, removed from these houses. Elema and Purari men believed the spirit boards embodied the strength of important ancestral/mythological figures, who empowered them in the hunt and at war (Beier and Kiki, 1970: 12; Williams, 1940: 8, 12–13). Once a board deteriorated, a copy—usually an exact replica (Beier and Kiki, 1970: 23)—was made, with the board ownership typically retained by the original social group. Williams (1940: 156) comments that many *hohao* are 'very ancient', an idea supported by Beier's and Kiki's informants who reported the first *hohao* were made following the deaths of clan heroes (1970: 12).

Frankel (2010) described Papuan Gulf spirit board manufacture based on his field observations during a 1978 archaeological fieldwork expedition to Kinomere Village (Urama Island). The boards were traditionally fashioned into an oval shape from planks of light wood or portions of old canoes, typically measuring 120–150 cm long and 20–30 cm wide. Senior men owned these full-sized spirit boards. Smaller versions did occur, and these are said to be neither secret nor sacred (Welsch, 2006: 6), and may belong to young uninitiated males.

Frankel (2010: 51–54, fig. 5) identified as many as 15 different stages involved in manufacturing a spirit board. Eye, cheek and mouth motifs were carved before other designs, so human features formed a central design structure around which other design elements were carved. Primary design motifs (*ovo laea*) included eyes, navel and geometric designs that were symbols for clouds, trees, stars and land or territory, all 'invented' designs of the patrilineal clans (Beier and Kiki 1970: 27). My informants consistently remarked that eye motifs were key social markers, but few commented that mouth and cloud motifs have social meanings as well

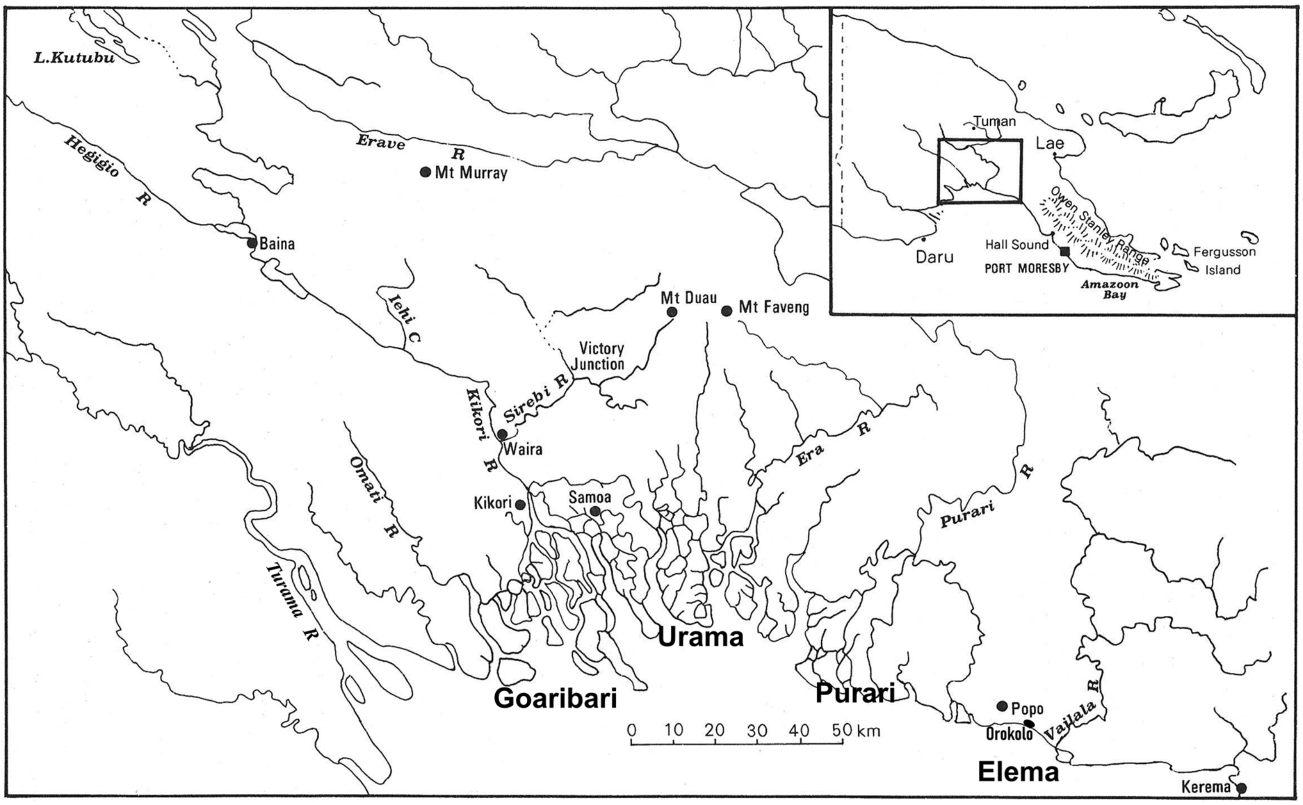

Figure 3. Papuan Gulf study area of Papua New Guinea.

(Rhoads, field notes, 15–16 November 1983). Spirit boards were mostly coloured with charcoal and red or pink ochre (*mou*), which was obtained from either peoples living near the present-day Kikori Station or eastern Elema groups living in the Hall Sound area through trading sago for ochre and stone axes (Beier and Kiki, 1970: 24; Rhoads, field notes 14 November 1983).

Research methods and analyses

I assembled a collection of 39 spirit board images from the Western Elema, Purari and Urama study area held in the Australian Museum, to which I added another 101 published in various indigenous art compilations (Brake *et al*., 1979; Lewis, 1973; Newton, 1961; Friede and Friede, 2005; Webb, 2015a; Welsch *et al*., 2006). Those chosen for analysis from the 140 spirit board images, needed to have good local provenance information and date to or before World War II, with the exception of some items from the Urama area. While Western Elema culture was severely impacted c. 1919 as a result of the Vailala Madness cult, the cessation of traditional Elema ceremonies and the destruction of ritual material culture were not universal (Williams, 1934: 370). Generally speaking, traditional activities in the Papuan Gulf continued in some manner until the late 1940s/early 1950s. Appendix 1 lists the 93 spirit boards selected for this study and provides analysis code numbers and source documentation for each.

Before progressing, it is necessary to clarify how Conkey's three basic structural elements of art—designs, design fields and design configurations—are used in this paper.

1. Designs are described using two terms. First, a design element is the basic unit of analysis and consists of a distinct patterning of geometric marks. When specific design elements are discussed in this paper, they are designated DE, for example DE #25. Second, motifs are the product of analysis and can be either a special design element or a distinctive cluster of design elements. Motifs are often identified as a social group's designs by traditional elders (e.g., Beier and Kiki, 1970; Munn, 1962, 1966; Rhoads, 1984). These may be a particular eye style, a material culture item (e.g., headdress, ornament) or a particular graphic design (e.g., parallel lines indicative of clouds). These social symbols are referred to as social motifs in this paper. In summary, the basic distinction here between 'design elements' and 'motifs' is that design elements are used as a generic term, while motifs are an informed or technical designation.
2. Design fields are the areas of an object within which design elements and motifs occur. These form the spatial units for analysis (see below).
3. Design configuration is the positioning of motifs across an entire object. In some instances (e.g., Beier and Kiki, 1970: 59–60, fig. 5, caption), social symbols and their patterning comprise 'notations of conversations and story-telling', as well as mythological designs (Munn, 1962: 978).

The design elements and social motifs used in the analysis were initially drawn from those identified by the Orokolo elders (Rhoads, 1984) and those noted in *Hohao* (Beier and Kiki, 1970).

New design elements were assigned whenever they were not identical to one already allocated to my sample. A frame consisting of nine, equal-sized rectilinear cells or design fields—designated A–I (Fig. 4)—was closely draped over each spirit board image while recording design elements (Table 1). This approach aligns with Conkey's (1982) analysis of how design space is used, specifically whether or not symmetry is a consistent feature of design configurations. When a design element was repeated in an adjacent or several

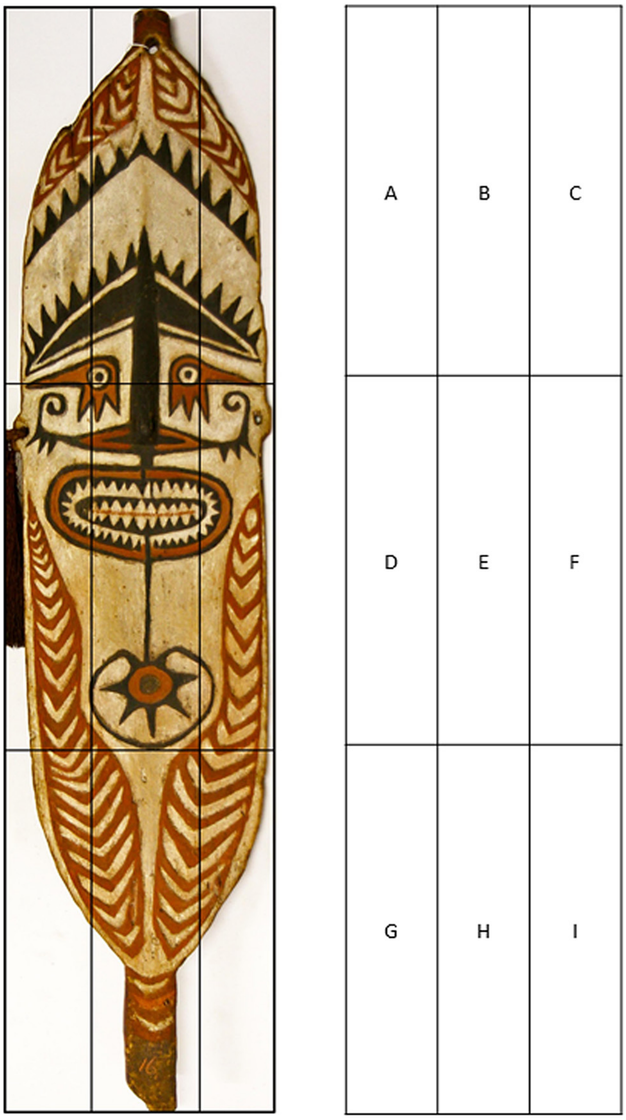

Figure 4. Recording overlay for Papuan Gulf spirit board design elements. Orokolo *hohao* reproduced courtesy of the Australian Museum. Pacific Collection reg. no. E000257.

cells on one board, it was only noted once for the board. The data matrix, *n* rows (boards) and *m* columns (design elements), is thus presented as a table of zeros/ones (0/1).

The analysis employed familiar multivariate routines available in the *PAST* statistics package (PALeontological Statistics) v 3.2 (Hammer *et al*., 2001). The first routine, Correspondence Analysis (CA), is useful for data exploration (Hammer, 2018: 101–102; de Leeuw and Mair, 2006) and its use in Australian Indigenous rock art studies (McDonald and Harper, 2016; McDonald, 2009: 241, 253–256) has demonstrated its utility for comparable studies. Generally, CA is applicable to most types of data and is commonly employed for counted or ratio-scale data expressed as non-negative integers (Bolviken *et al*., 1982; Carlson, 2017: 279–280; Greenacre, 2010; Shennan, 1997: 308–313). This statistic determines those 'hypothetical variables' (components or eigenvalues) that account for the possible variance in the study sample, based on Chi-squared distances. The reduction of a matrix of *n* rows (usually objects) and *m* columns (variables) to a two-dimensional graphic display (map) showing the affinity between objects and attributes is a particularly useful aspect of this multivariate routine.

Two multivariate clustering routines (Hammer, 2018: 110–111, 113) were used to group spirit boards or design elements. Hierarchical cluster analysis produces a dendrogram that shows how the data groups, starting with 'each observation representing a cluster and merging observations and clusters until we have combined everything into a single group' (Carlson, 2017: 334). Ward's method, employing a Euclidean distance coefficient, was used in this study to produce relatively balanced clusters for which in-group variance is minimised (Shennan, 1997: 241). The second clustering method, *k*-means, is a non-hierarchical method that accommodates missing data. It divides a sample into the number of groups specified by the analyst. In this procedure, the cluster assignments, while random at the outset, are reallocated to different groups through an iterative process until reassignment stops. In particular, *k*-means establishes a proposition or model of how observations cluster and this, in turn, may be interrogated by related but separate data (Carlson, 2017: 321).

Orokolo hohao pilot study

A pilot study of the Orokolo *hohao* sample was designed to investigate patterning among the social motifs because the sample size was small and its social context well-documented. As well, the late prehistoric/early historic period archaeology and oral traditions of the area have been comprehensively studied (Rhoads, 1994; Urwin, 2018). The pilot analysis of these *hohao* asked four questions:

1. How do design elements and social motifs vary geographically, particularly as Orokolo is a relatively small, culturally unified region?
2. How are they allocated among the different design fields?
3. How useful are the analytical routines chosen for exploring design patterning?
4. How long have spirit boards been used in the Orokolo region?

The pilot study was thus designed to assess the utility of my methods prior to expanding investigations to include a greater number of Papuan Gulf spirit boards belonging to several cultures.

Orokolo sample characteristics

The Orokolo pilot study sample (Table 2) comprised 30 boards, of which 23 are part of the Australian Museum's Pacific collection. The remaining seven, also well-documented traditional spirit boards, are published in Beier and Kiki (1970). Twenty in the Australian Museum collection have exceptionally good provenance. Three were acquired by T. Bevan, an early Papuan Gulf explorer, in 1883 from coastal Orokolo villages, while S. Macdonell, a trader living in the area during the early 20th century, collected the remaining boards from people inhabiting both coastal and inland areas of Orokolo. Figure 5 illustrates the distribution of localities relevant to the pilot study. These include:

Table 1. Example of the design element record for E000257 (Fig. 4).

reg. no.	locality	A	B	C	D	E	F	G	H	I
E000257	Orokolo	9, 37, 43, 44, 53	3, 9, 37, 43, 44, 53	9, 37, 43, 44, 53	53, 71, 72, 87, 99	53, 71, 72, 87	53, 71, 72, 87, 99	99	87, 99, 117	99

Table 2. Orokolo Pilot Study *hohao*: name, social affiliations and geographical attribution.

board registration number/Beier & Kiki, 1970: plate no.	board's personal name and locality attribution	social group(s) attribution
A0156768	*Ailaka*; Kavava village	Akai clan, Purari aualari
E000256	*Merava*; coastal Orokolo	Milahiru clan
E000257	*Kiki*; Harevavo village	Lavai-ipi clan
E000258	*Korope*; Harevavo village	Hoirahiru clan
E021046	*Marupai*; Kaivukavu village	Milahiru clan*
E022633	*Meakere*, coastal Orokolo	Hururu clan
E022634	*Kaiakere*; Kavakava village	Hururu clan; displayed with *Meakere* in the men's house (*eravo*)
E023104	Muro area	—
E023105	Orokolo area	—
E023108	*Eipepe*; Kaivakavu village	Hururu clan
E023109	*Auaro*; Orokolo area	Kairipopo clan*
E023112	Muro area	—
E023113	Paivea area (inland from Orokolo)	—
E023114	Muro area	—
E024469	Kaivakava village	—
E024471	Orokolo area	—
E026296	Orokolo area	—
E026299	Orokolo area	—
E026300	*Miaikere*; Kavava village	Hururu clan
E026301	Muro area	—
E072964	*Epe*; Muro area	Heh clan
E072965	Marea village	—
H 1	*Ila Klaika*; Hopaiku village; ancestor in clan's origin myth	Maori clan
H 2	*Ila Kalaika*; Harilareva village	Kaivamauka clan (Deep Water section)
H 3	*Maria Ere*; Harilareva village	Kaivamauka clan
H 4	*Hilake*; Harehavo village	Vailala clan (Hilake Pilore section)
H 5	*Eoe*; Harevavo village	Vailala clan
H 7	*Auaro*; Kaiva; Kovu village; board's 'twin hohao' called *Iko*	Kaivamauka clan
H 8	*Lakekavu* (turtle); Harevavo village; mythological story associated with the board	Kaivamauka clan (Deep Water section), Moro aualari
H 9	*Epe*; crocodile motif is Epe's first form after 'descending from the sky'	Epe Havora clan

* Not mentioned in Williams (2015) or Beier and Kiki (1970).

1 The central cluster of Orokolo settlements.
2 Two groupings of villages at the western end of Orokolo Bay.
3 Other smaller villages dispersed eastward toward the government station at Ihu.
4 Inland villages, particularly Muro.

Roughly two-thirds of the Orokolo *hohao* have personal names, mostly attributed to ancestral figures and belonging to recognised clan groups. About half are attributed to named villages (Tables 2 and 3). This social group distribution of spirit boards parallels Williams' early observations about how clans were distributed among the Orokolo settlements and the different named social groupings, as well as the significance of human figures portrayed on *hohao* (Williams, 1940: 35–37, 154). The naming of *hohao* is important here because Williams (1940: 156) argued that named *hohao* are 'obviously very ancient.'

Analyses

The pilot study first assessed the spatial patterning of design elements near the edge of a board (Fig. 4: sample cells A, C, D, F, G and I). Empirical observation indicated a high degree of bilateral symmetry among design elements positioned in these design fields. Fig. 6 presents histograms illustrating the patterning along the left (A, D and G) and right (C, F and I) board margins. Comparisons of cells A vs C and G vs I indicate a high degree of left-right symmetry at the top and at the bottom of boards. The same degree of symmetry is not as apparent when comparing the top and bottom design fields along each side—cells A vs G and C vs I. Also, some design elements overlap in adjacent cells, A vs D and D vs G, where design elements often cross the margin between recorded design fields. Based on these results, I limited my *hohao* analyses to one margin and the areas along a board's centre, in other words cells A, B, D, E, G and H.

A total of 118 design elements were recorded for the 30 boards. On average, nine were noted for each board. Only 270 cells of the resultant data matrix (7.4%) contained a value of one, so I used clustering routines to reduce the size and sparseness of the matrix. I first used hierarchical analysis (Ward's method) to determine how well the data formed distinct groupings. The hierarchical dendrogram (Fig. 7) was a promising result, as it showed only low-level chaining, or sequential joining of attributes. I determined that 10 groups, selected by using an arbitrary cut off of 2.5–3.0 (Euclidean distance), constituted a useful grouping of design elements.

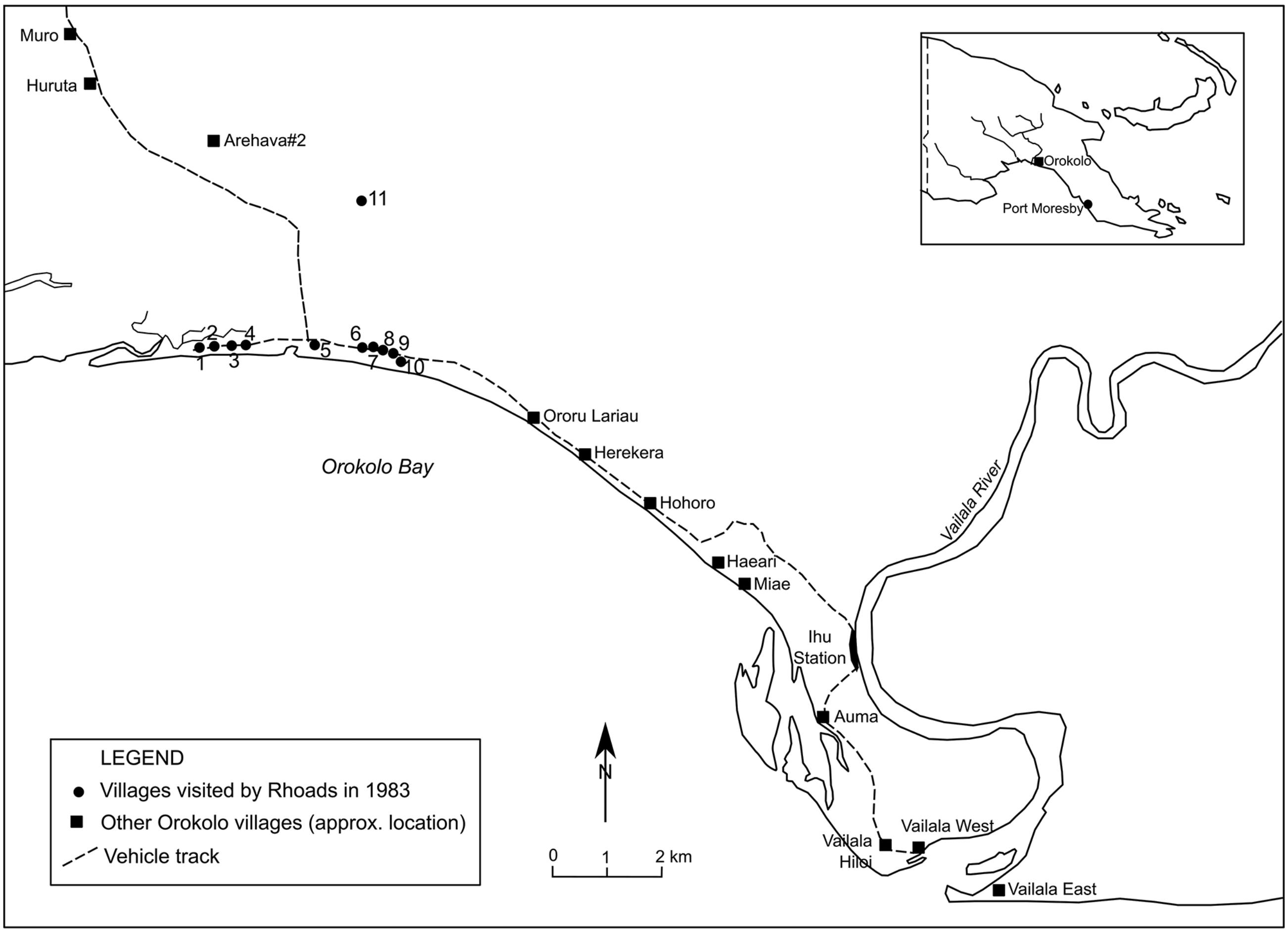

Figure 5. Orokolo locality map. (*1*) Harevavo; (*2*) Marea; (*3*) Kaivakavu; (*4*) Larihairu; (*5*) Ioku; (*6*) Harilareva; (*7*) Hopaiku; (*8*) Mirimaru; (*9*) Kavava; (*10*) Hururu; and (*11*) Paivea.

A *k*-means cluster analysis for 10 groups was undertaken. This produced a pronounced reorganisation of the design elements according to particular design fields (e.g., upper board, upper or lower margin, and central area). No group consisted of homogenous design elements; however, subgroups consisting of similar designs were evident in each group. I reorganised the *k*-means cluster groups into 37 new cluster groups, mostly by subdividing each group into two or three new groupings of comparable designs. Ten of the new groups consisted of rare design elements. The impact of the *k*-means procedure and my reorganising *k*-means groups produced a notable reduction of data matrix 'sparseness'—21% of cells now had values of one. It is important to note that a new numbering system, beginning with 200, was used for the 37 clustered design elements groups (CG); this helped eliminate any confusion with the original system for recording design elements (see Table 3).

The clustered groups highlight some designs that commonly served as social symbols. These include:

1 Centrally positioned human figures: CG #223 (motifs 29, 30, 36)
2 Eye motifs: CG #204 (59, 60), CG #220 (52, 55)
3 'Distinctive' designs: CG #203 (19, 27, 28), CG #213 (114), CG #218 (106), CG #233 (75)

This process also draws attention to two cluster groups said by Orokolo elders to be 'just decoration': upper board design elements CG #225 (40) and CG #226 (8). I next undertook a correspondence analysis using the clustered groups of design elements as attributes for the Orokolo *hohao* sample. Fig. 8 presents separate plots for (A) cluster groups and (B) *hohao*. The area around the plot's centre is shaded because the attributes (CGs) mapped in this area of the CA map are not statistically different from one another. Importantly, the X and Y axes relate to the first and second eigenvalues (component scores), respectively, and together account for only 20% of variation in design elements for the entire Orokolo *hohao* sample. In fact, 11 components were necessary to accommodate 76% of sample variability. This may reflect only that a small group of *hohao* were sourced from a relatively small region.

Examining the CA map further, the clustered groups of design elements strongly aggregate near the plot's centre, and mostly to the right of the origin (Fig. 8A). The map also shows a distribution of motif groups that form a 'string' of outliers near the first axis and streaming away to the left of the origin—CGs #211, #215, #223 and #229. This suggests an underlying structure for *hohao* designs. CG #223 (centrally positioned human figure), given its position, is a significant 'contributor' to sample variation and my informants remarked that central human figure motifs comprise social markers. The remaining clustered groups in this area of the CA map do not have a similar level of importance.

Five clustered groups—CGs #216, #217, #228, #230 and #235—comprise the attributes most influential for the second axis (9% of sample variance). Their significance is difficult to judge because they consist mostly of relatively rare design elements. However, social markers CGs #204, #213 and #230 map at some distance away from the origin and their importance may appear as contributors to sample variance, when mapping other CA components.

Figure 8B shows the village localities associated with

Table 3. Orokolo Pilot Study *hohao*: design element analysis codes, key motif illustrations, and descriptions.

Clustered Design Element Groups Code (CG)	Design Element Description	Primary Design Element code	Design Element Illustration	Informant Comments (relevant spirit board analysis codes, see Appendix)
200	navel, sun burst design	91		(26)
		92		(29)
		93		(16, 30)
201	navel, various designs	94		(1)
		95		(4, 6, 10)
		96		(23)
		97		(15)
		98		(18)
202	chevron/triangular design, upper board	14		(4, 10, 12, 15, 18, 22, 23, 24, 25, 27, 28, 29, 30, 31)
		16		motif of Akai clan, Purari aualari (1)
		17		(17)
203	distinctive designs, upper board	18		hands motif—clan Ancestor Epe reaching down from the sky (23, 31)
		19		hair comb motif called *kou*—Hururu clan marker (10)
		20		motif at the top of the board called *hura kaikaia*,—hole in the sand formed by a small crab-like creature (11)
		22		(15, 20)
		23		(16, 18)
		24		(17)
		25		(18)
		26	see Figure 9a	motif associated with Muro area (14)

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Table 3 (continued from previous page). Orokolo Pilot Study *hohao*: design element analysis codes, key motif illustrations, and descriptions.

204	eye motif, multiple projections	58		eye motif called *aipa laka* (6)
		59		eye design—orchid motif, "sacred" to Maori clan (24)
		60		eye motif called *rove*—clan marker (7)
205	eye motif, circular surround design	56		(23)
		62		eye motif associated with Muro (13)
		63		(30)
		64		(6, 17, 29)
		65		eye motif used by many clans (9, 10)
		66		(16, 18)
206	unembellished mouth designs	67		(1, 4, 15, 16, 19, 26)
		68		(1, 4, 15, 16, 19, 26)
		69		(29)
207	outlined mouth designs	70		(13, 30)
		71	see Figure 4	(3, 6, 7)
		73		(10, 17, 18, 25)
208	designs connecting face directly to mid-lower board	78	see Figure 2	sawtooth motif around face lower face and belly button called *maure rove*, cockatoo crest (4)
		79		(27)
		80		(29)
		81		(10, 17, 26, 30)
209	finial, no design	3		(2, 3, 8, 10, 12, 13, 15, 16)
210	finial, various design elements	1		(1, 4, 5, 9)
		2		(31)
		4		(7)
		5		(14)
		6		(17)

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Table 3 (continued from previous page). Orokolo Pilot Study *hohao*: design element analysis codes, key motif illustrations, and descriptions.

211	different design elements, lower board area	109		nested triangles motif—clouds [**NB** clouds played important role in Elema mythology (*Hohao* p. 23)] (29)
		110		(5)
		111		(11, 16)
		112		(14)
212	undecorated area, lower board	113		(19)
213	face motif, lower board	114		upside down face motif called *Hae,* the ancestor Maria Ere's spirit (26)
214	board's stand	115		undecorated (1, 10, 11, 12, 13, 14, 16, 17, 22, 28, 29, 31)
		116		parallel lines design (2, 4, 23, 26, 27)
		117		chevron design (3, 5, 6, 18, 30)
		118		elaborate designs (15)
215	various designs, along lower board margin	99	see Figure 4	chevron motif called *piku ove,* wood grub (3, 14)
		100		chevron motif called *miave poku*, hornbill beak (8)
216	various geometric designs, lower board	101	see Figure 9b	linear (11, 13, 20)
		102		sawtooth lines (15)
		103		y-shaped (16)
217	back bone designs	104		motif called *uki korari* (7)
		105		(17)

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Table 3 (continued from previous page). Orokolo Pilot Study *hohao*: design element analysis codes, key motif illustrations, and descriptions.

218	lower board, human torso and legs, different designs	106		lower torso belongs to Kurua [aka Mila Maipala], a mythological giant (*Hohao* p. 59) (28)
		107		(11, 24)
219	curved eye motif	46	see Figure 9c	(15)
		47		eye motif—pig tusk (1)
		48	see Figure 9d	eye motif called *orae* ("It is just decoration.") (2)
		54		(12)
220	eye motif, pointed designs	49		eye motif called *lavo*, mountain in Owen Stanley Ranges, which has associations with the Kaivamauka and Maori clans (25)
		50		(5)
		51		eye motif called *piku ova*—shadow (or spirit) of the woodworm (26, 27)
		52		eye motif called *miripapu*, river meander; clan marker originating in the Purari area; remainder of the face comprises a single motif called *makoura*, a mushroom found along river meanders—the forehead being the cap, nose the stem and mouth the root. (11)
		53		(3)
221	design, immediately below face	82		beard-like design (12)
		83		curvilinear design (12)
		84	see Figure 9c	hand-like designs (15, 23)
		85		board attributed to Orokolo area (16)

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Table 3 (continued from previous page). Orokolo Pilot Study *hohao*: design element analysis codes, key motif illustrations, and descriptions.

222	navel, sawtooth surround	86		(13)
		87	see Figure 4	navel motif called *hekure*, central portion of the *paru* fruit (3)
		88		(24, 25)
		89		sawtooth motif around navel called *merove ari*—cane thorns, clan marker (27, 28)
		90	see Figure 9d	sunburst motif symbolises a turtle shell or bailer shell, which are strongly associated with the Orokolo area (7, 8)
223	centrally positioned human figure	29		crocodile motif - Vailala clan marker. (31)
		30	see Figure 9e	clan ancestor (5)
		31		Muro area (8)
		32	see Figure 9a	Muro area (14)
		34	see Figure 9b	Muro area (20)
		36		clan ancestor *Epe* (22)
224	various designs, top of head	37	see Figure 9d	sawtooth motif above head, cassowary feather headdress (2, 3, 4, 5, 6, 7, 10, 11, 13, 15, 16, 19, 23, 24, 25, 26, 28, 29, 30)
		41		small disc shell ornament motif, curved line along top of forehead (6, 19, 24)
		43	see Figure 9d	half-moon design above eyes—symbolises “unoccupied land,” places where clan wishes to “conquer or farm” (2, 3, 4, 5, 6, 7, 10, 11, 13, 15, 16, 17, 18, 19, 23, 24, 25, 26, 27, 28, 29, 30)
225	designs above forehead	39		motif called *kou*, shark's teeth headband (7, 16)
		40		"just decoration" (5)

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Table 3 (continued from previous page). Orokolo Pilot Study *hohao*: design element analysis codes, key motif illustrations, and descriptions.

226	geometric with chevron infill, upper board margin	8	see Figure 9d	"just decoration" (2, 23)
		9		(3, 4, 6, 7)
		11		(7, 9)
227	geometric with no infill, upper board margin	10		(5, 20)
		13		(19)
228	forehead design	42		headdress motif represents coconut fronds (1, 9)
229	sawtooth line, upper board	44		shark's teeth motif (3, 4, 22)
230	drooping eye motif	55		eye motif called *merove*—palm leaf, clan marker (28)
		57	see Figure 2	eye motif called *ori veo vahae*, hornbill beak (4, 19)
231	downward pointing chevron, lower board margin	15		chevron motif called *mealalau meakaroro*, high clouds (2, 6, 9, 10, 11, 12, 13, 15, 18, 5, 27, 30, 31)
232	nose ornament, very elaborate design	72	see Figure 4	young fern or young cane shoot design (3, 23)
233	nose and nose ornament design	74, 75		nose ornament (2, 3, 16, 25)
234	designs outlining tassel hole	76		(2, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16)
235	lobe outlining lower portion of face	77		black bulge motif either side of lower face called *ikavari* - string or magic vine connecting known and unknown worlds—clan marker (29)
236	headdress motif	38		motif called *lupu* – pig bristle headband (27)

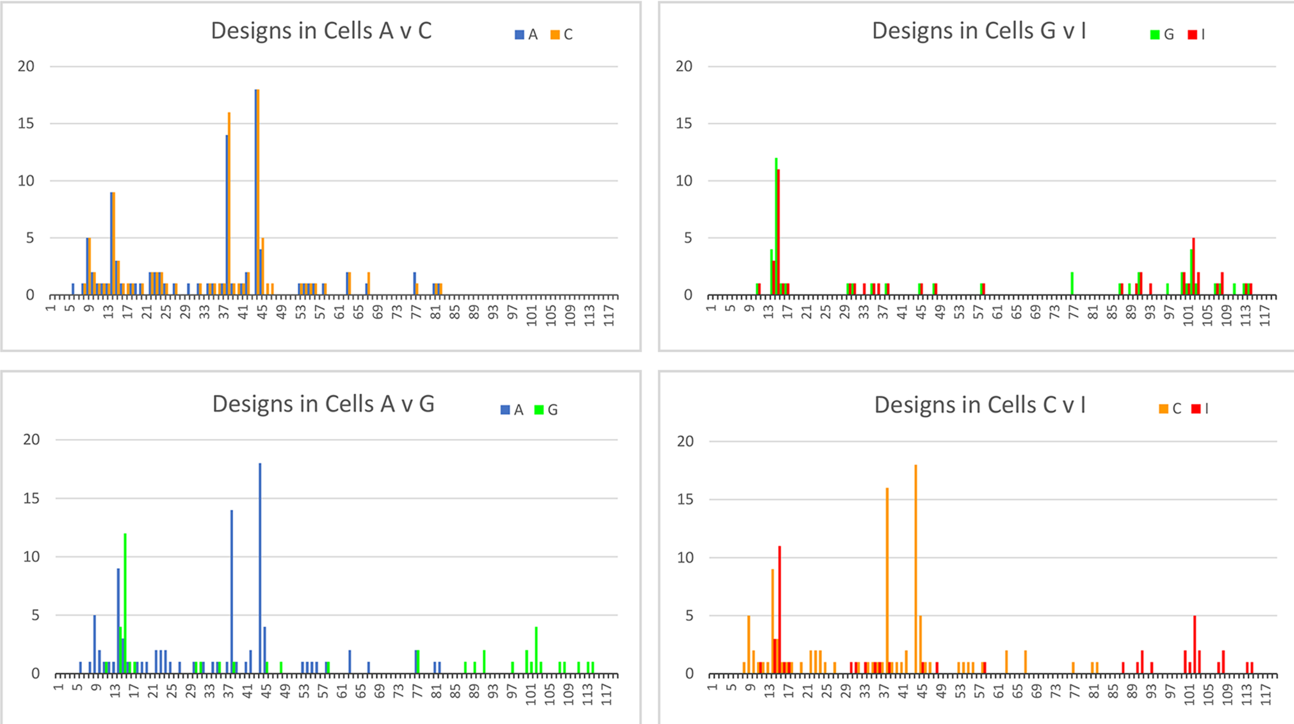


Figure 6. Histograms comparing the frequency distribution of design elements (code numbers) among different design fields (recording cells—see Fig. 4).

the *hohao* on the CA map. Two patterns are apparent. First, *hohao* from coastal areas, where the large Orokolo villages were situated, appear as a large aggregation near the map's centre. Second, more than 80% of boards from the inland areas (E023104, E023114, E026301, and E072964) plot to the map's left, noticeably associated with central human figure motifs (CG #223) (Table 3; Fig. 8B). As explained above, this cluster comprises a strong design feature of the Orokolo area *hohao* sample, and marks differences between inland (Muro area) and coastal design elements. Importantly, this is consistent with informants' reports that clan motifs for inland, as opposed to coastal, areas were quite distinct (Rhoads, field notes 17 November 1983). Figure 9 illustrates this difference in *hohao* design structures.

The results of the pilot study produced some encouraging results. The sample exhibited highly interrelated design elements and motifs among spirit boards. Those sourced to the Muro area form a recognisable and significant geographical assemblage that aligns with Western Elema oral history. Urwin recorded stories relating to the abandonment of Popo, the people's ancestral village. Some groups migrated to the coast, where early historic villages were recorded. Others moved farther inland and to the west, close to present-day Muro (Urwin pers. comm., 4 June 2018). Urwin estimates this event occurred some six generations ago, and his archaeological investigations place this time to c. 140 cal. BP (Urwin, 2018: 277).

Less promisingly, the data does not seem to be well-structured throughout. The CA maps demonstrate that outliers strongly influence sample variance. The need to calculate 11 CA components to accommodate 76% of sample variance further demonstrates this point. At present it is unclear whether there are problems with the analytical routine selected to explore the data, the internal characteristics of the data, or both.

Western Elema to Urama Island social boundaries investigation

This section of the paper concerns spirit boards from three Papuan Gulf cultures—the Elema who mostly live near the coastal strand around Orokolo, the Purari whose villages are situated in and around the mouth of the Purari River, and the Urama who inhabit the swamplands farther west (Fig. 3). While differing linguistically (Franklin, 1973), these cultures share comparable ways of life and ritual. This offers an ideal situation to test the use of spirit boards in marking social boundaries. The questions asked are similar to those outlined for the Orokolo sample, with two differences. First, asking whether spirit boards were in use prior to the contact period is omitted. Second, spirit boards from the three cultural areas are assumed to differ in varying amounts, and this idea is investigated by assessing the degree to which spirit boards share design elements.

Sourcing and sample characteristics

As described above, this sample consists of 93 spirit boards (Appendix 1) that met provenance and collection date criteria. The Orokolo sample, in addition to the *hohao* in the pilot study analysis, now included an additional 11 *hohao* from Orokolo and five from Vailala, all dating to 1912 and collected by A. B. Lewis, an American anthropologist who purchased artefacts for the Field Museum in Chicago while visiting the Papuan Gulf. A small assortment of other *hohao* were also added to the sample, notably the 1891 specimen attributed to the Thursday Island-based missionary the Rev. Savage (Webb, 2015a: plate 1). The sample of Western Elema *hohao* now totalled 50, attributed to four localities (Fig. 10).

The Purari *koi* sample consists of material from seven villages. Lord Moyne likely collected the five Iari Village boards for the British Museum during his 1935 visit to the Papuan Gulf (Webb, 2015b: 35). The eight spirit boards from Kaimari are a part of the Frank Hurley collection held by the Australian Museum. These pertain to his visit to the Purari-

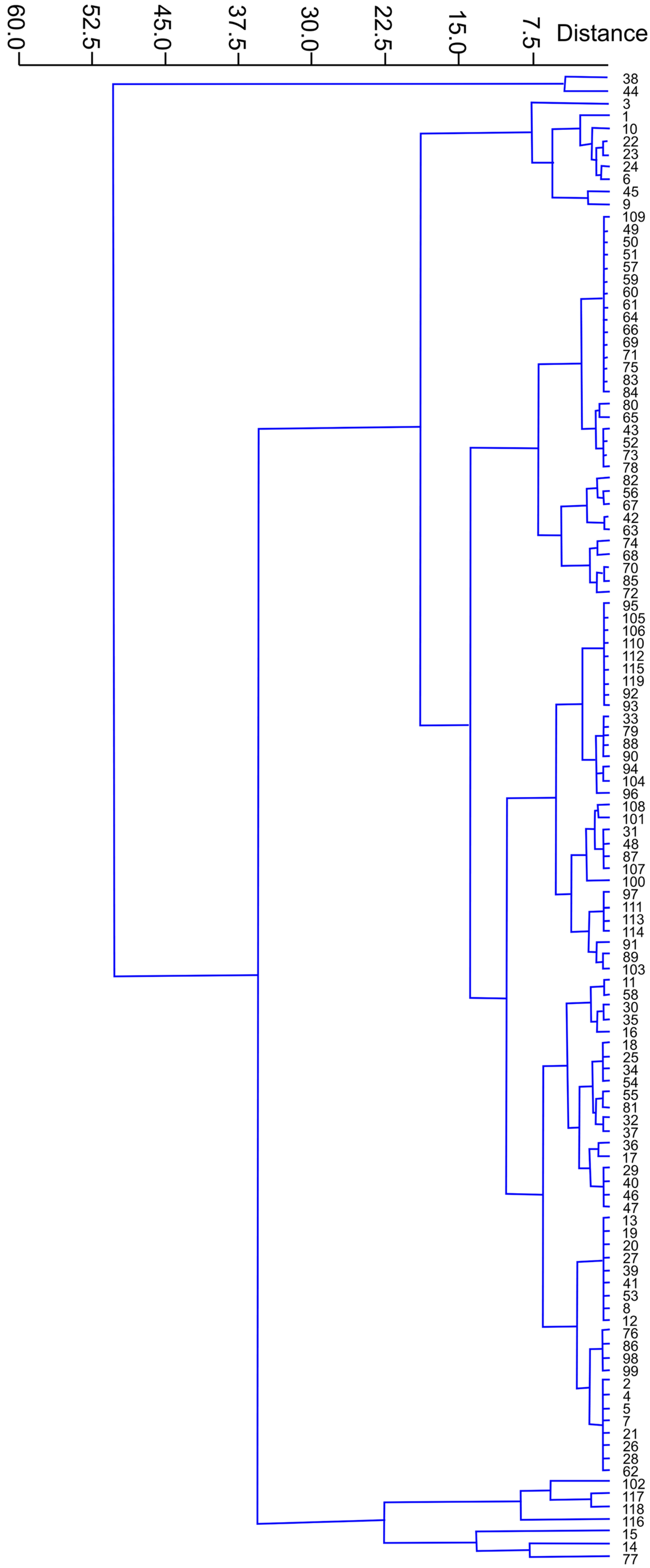


Figure 7. Orokolo *hohao* sample: hierarchical cluster analysis (Ward's method) of design elements (numerical codes).

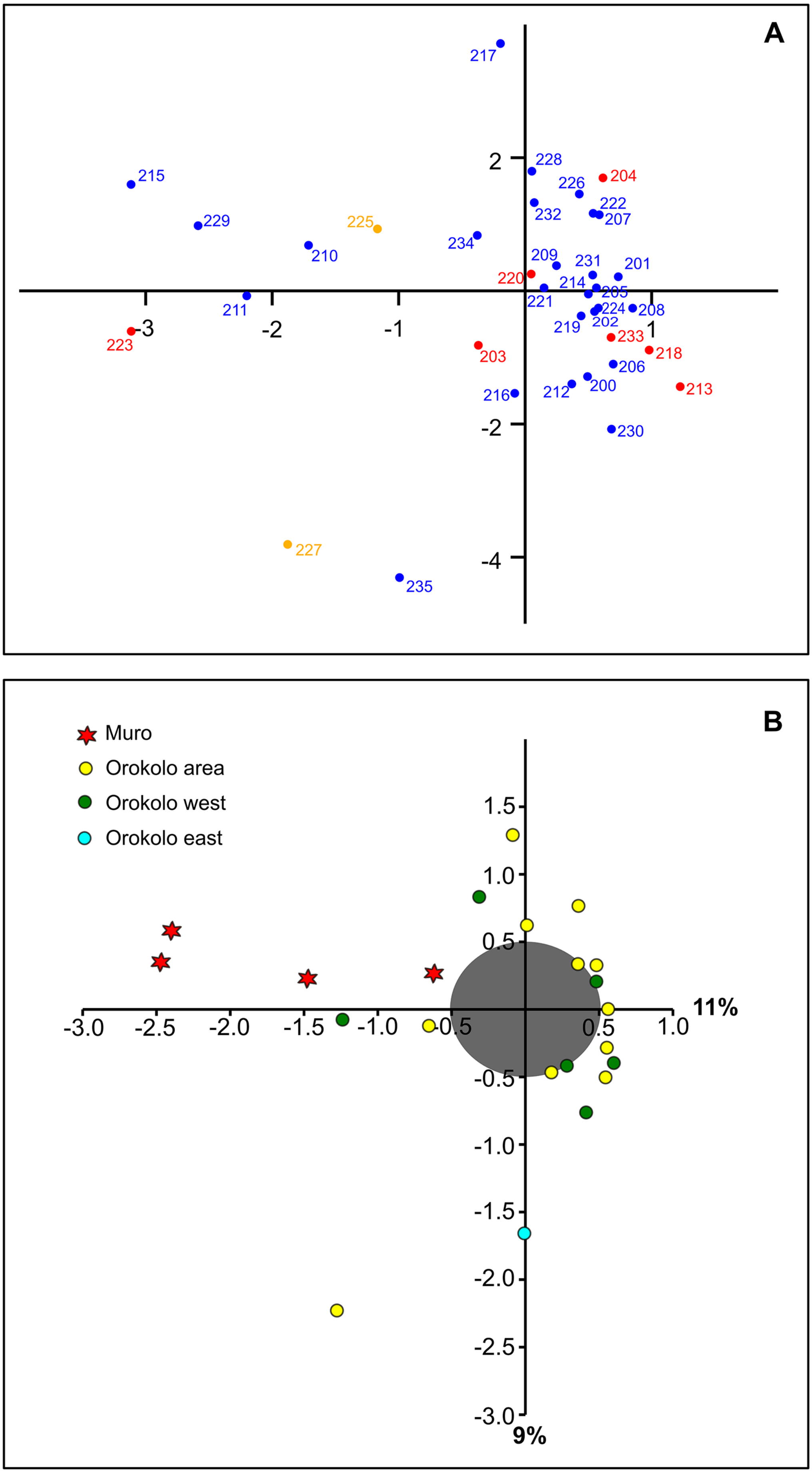


Figure 8. Orokolo pilot study multivariate analysis (CA) map, showing (*A*) distribution of design elements, with social motifs indicated in red, 'just decoration' in orange, and other design elements in blue; (*B*) plotting individual *hohao* showing locality attribution.

Figure 9. Comparison of Muro (*a–c*) and Orokolo (d, e) *hohao*. Reproduced courtesy of the Australian Museum. Pacific Collection reg. nos (from left to right) E023114, E026301, E024469, E000256 and E021046.

Kikori Delta in 1921 and 1922 (Australian Museum accession records). A. B. Lewis collected the two Kaivare boards and three others from Maipua in 1912. The remaining Maipua board, as well as the one from Kairu, were collected by A. C. Haddon, an English anthropologist, in 1914. The Mapaio (? Maipua) spirit board is an item from Schultze-Westrum's 1966 expedition to the Gulf. The boards attributed to Ukiravi and Urika date to 1915 and 1920, respectively. Macdonell is recorded as the collector for the first; the other has no source information. The *koi* sample totals 24 and is attributed to seven localities (Fig. 10). Like the *hohao*, the Purari *koi* incorporated distinctly human features, especially in their facial designs (Bell, 2009). *Koi* were individually owned and inherited patrilineally (Williams, 1924: 66–67, 84, 146).

The earliest of the 19 Urama Island spirit boards, *gope*, date to 1921/1922 and belong to the Australian Museum's Pacific Collection. Although not attributed to a locality, they were likely acquired at Kinomere Village, as is likely the case for three boards collected in 1930 by the Swiss anthropologist P. Wirz. The remainder of the Urama sample, with one exception, was collected by Schultze-Westrum at Kinomere in 1960 and 1966 and at Omaumere in 1966. The addition of recent spirit boards from Urama was a compromise to increase sample size. The last Kinomere board is held by the de Young Museum (San Francisco) as a part of the Jolika Collection (Friede and Friede, 2005: plate 466) and is dated to the late 19th/early 20th century. Urama *gope* boards differ from *hohao* and *koi* by not exhibiting prominent central designs characteristic of human forms (Schultze-Westrum, 2015). Also, they were not given personal names, nor were they associated with a patrilineal ancestor. *Gope* were not long-term family heirlooms or possessions. Schultze-Westrum further claims that Urama spirit boards are primarily related to head-hunting cults and served as the source of power and strength to vanquish one's opponents.

The design elements used for the Orokolo pilot served as the starting point for the analysis of this larger sample.

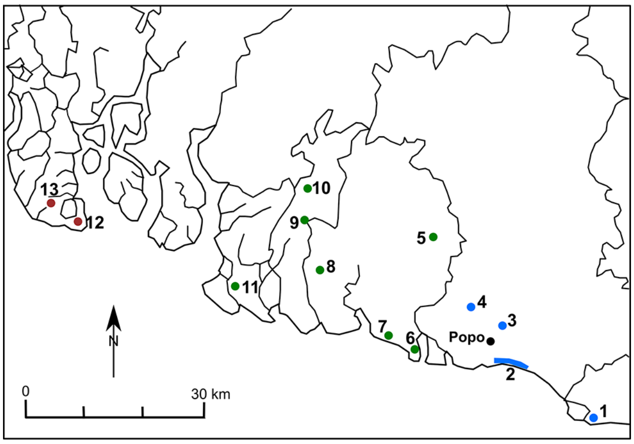


Figure 10. Western Elema-Urama region: historic villages discussed in the analysis—Urama (red), Purari (green) and Orokolo (blue). The numbers in parentheses in the key indicate the number of spirit boards appearing in the sample from each village (mapped from Johnston and Green, 1932; Gullick and Carne, 1913; unknown, 1942; unknown, n.d.; Wirz, 1934: karte 2). Key:

1	Vailala (5)	8	Maipaio/Mapaio (1)
2	Orokolo (40)	9	Kairu (1)
3	Paivera (1)	10	Ukiravi (1)
4	Muro (4)	11	Kaimari/Kaivare (10)
5	Iari (5)	12	Kinomere/Urama Island (17)
6	Maipua (5)	13	Omaumare (2)
7	Urika (1)		

New design elements were added as needed following the procedures outlined above. The analytical routine used, however, differs. Only the central panel (recording cells B, E and I) design fields, excluding design elements on the board's finial and stand, were analysed. This approach concentrated on the area of the spirit boards judged to contain the most definitive social motifs. Moreover, the number of design attributes were substantially minimised, thereby limiting the data matrix's size.

Analyses

The Western Elema-Urama spirit board sample consisted of 93 spirit boards from 13 localities. A total of 292 design elements were recorded for these boards. The resultant data matrix was very sparse with only 3% of the cells having a value of one. Unexpectedly, an exploratory CA using only three eigenvalues accounted for 100% of sample variability. Nevertheless, the attribute map for the first and second components (72% variability) showed an extreme degree of design element clustering around the origin, with one outlier either end of the X axis and two at each end of the Y axis. All but one of these outliers occurred on spirit boards from Purari villages and Urama Island. A Muro *hohao* with a central human figure was the exception. When these boards were removed from the sample and the CA recalculated, more than 40 eigenvalues were required to account for 75% of variability.

Consequently, I began assessing the data employing the same clustering routines used to group the design elements and social motifs in the Orokolo pilot study. The hierarchical cluster dendrogram (Fig. 11) demonstrated an unacceptably high degree of chaining when clustering spirit board design elements. In other words, there are excessive numbers of ‘small clusters joining within a large cluster rather than forming new large clusters’, and this leads to ‘close groups being incorrectly merged’ (Flynt and Dean, 2016: 211). This suggested that the clustering routine I had chosen to explore the design element dataset was not suitable.

Both the Orokolo elders and the ethnographic literature agree that eye and mouth motifs comprise principal clan markers. This suggested that creating a subset consisting of facial designs (forehead, eyes, nose and mouth) and any associated design elements (e.g., headdress or nose ornament) offered another avenue to analyse spirit boards. This procedure reduced the dataset to 106 design elements. The sample was reduced from 93 to 90 spirit boards by eliminating three Muro *hohao*, each with a complete human figure motif, which incorporated several facial design elements not recorded separately.

The nine prevalent design elements, those that occur 10 or more times in the facial design sample, are listed in Table 4. Fig. 12 illustrates their distribution in the Orokolo, Purari and Urama areas. Five significant findings emerge. First, the sawtooth headdress (DE #37) is virtually an exclusive characteristic of Orokolo *hohao*. Second, the lower nose motif (DE #75) holds almost the same importance among Urama *gope*. Third, three other motifs—‘toothy smile’ (DE #69), nose ornament (DE # 74) and solid line bordering face (DE #81)—also comprise important Western Elema design elements. Fourth, the half-moon-shaped forehead (DE #43), the most prevalent motif in the entire Western Elema—Urama sample, occurs across all three regions, although the percentage representations are not particularly high. Finally, the plain eye design (DE #64) and two mouth motifs (DE #67, DE #68) are shared in roughly comparable percentages in the study area, although the small number of occurrences warrants caution.

A hierarchical cluster analysis (Ward’s method) of the facial design sample was undertaken to determine how

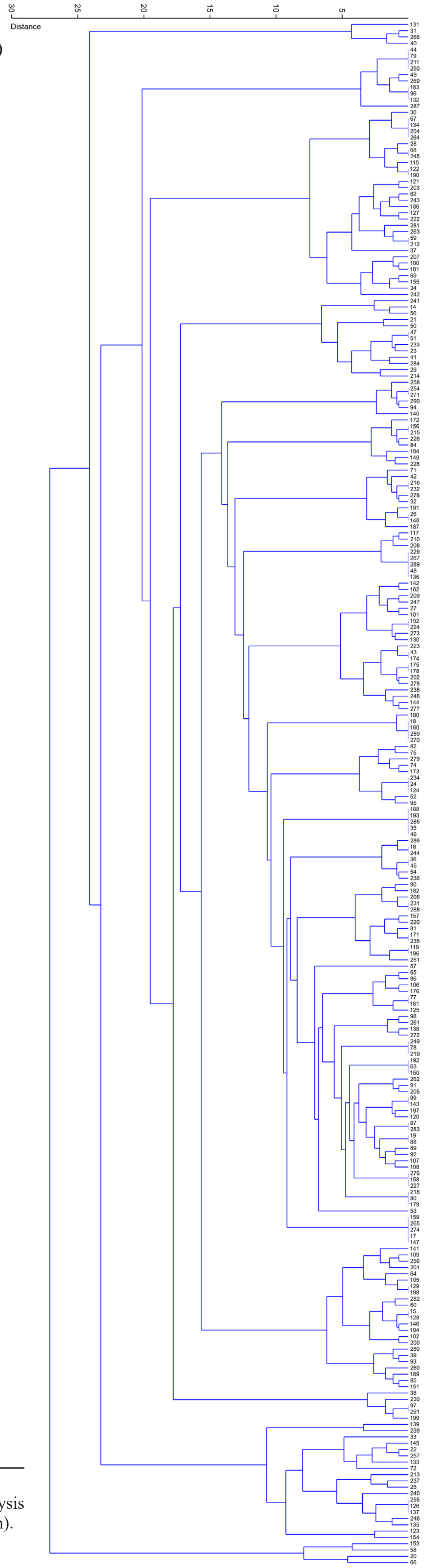


Figure 11. Western Elema-Urama spirit boards: hierarchical cluster analysis (Ward’s method) dendrogram of design elements (code numbers shown).

Table 4. Western Elema-Urama facial designs sample: key motifs. These *design element (DE) codes* correspond with those used in Table 3.

Design Element (DE) Code	Description	Image
37	sawtooth headdress	
43	half-moon-shaped forehead	
64	plain eye motif	
67	v-shaped mouth	
68	oblong-shaped mouth	
69	‘toothy smile’	
74	nose ornament	
75	lower nose motif	
81	solid line bordering face	

well the spirit boards in the sample formed groups. Fig. 13 presents the results. There were four unambiguous spirit board clusters or groups, each of which is divided into two subgroups for purposes of analysis.

Group 1 is an outlier consisting of 14 boards ‘distantly related’ (in terms of Euclidean distance) to the other three clusters. Spirit boards from each area occur in Group 1a and they all share the half-moon-shaped forehead, plain eye design and toothy smile motifs in common (Table 4). More than half of the spirit boards in Group 1b are attributed to the Urama Island region. DE #135 (mouth surrounded by red-infilled ellipse) is recorded on three spirit boards, two of which are Kinomere *gope* (Table 5). Group 2 comprises 26 *hohao* and one *koi* and is not closely ‘related’ to the other groups, perhaps due to the high number of *hohao*. The single *koi* (Kaimari) has a very distinctive cheek hook design (DE #84), but the presence of ‘toothy smile’ and nose ornament design elements, discussed above, demonstrates that the board has some affinity with Orokolo *hohao*. So far, this analysis indicates a trend towards culturally specific design elements.

Groups 3 and 4 are closely related to one another and comprise 29% and 26%, respectively, of the facial design sample. Group 3a has an even distribution of boards from all three regions. Aside from the occurrence of social motifs among the sample, few design elements appear more than once. Group 3b primarily consists of Orokolo and Urama boards that have rare design elements, demonstrating little overlap. Two design elements—DE #126 (elongated eye) and DE #137 (triangular mouth)—only occur together on

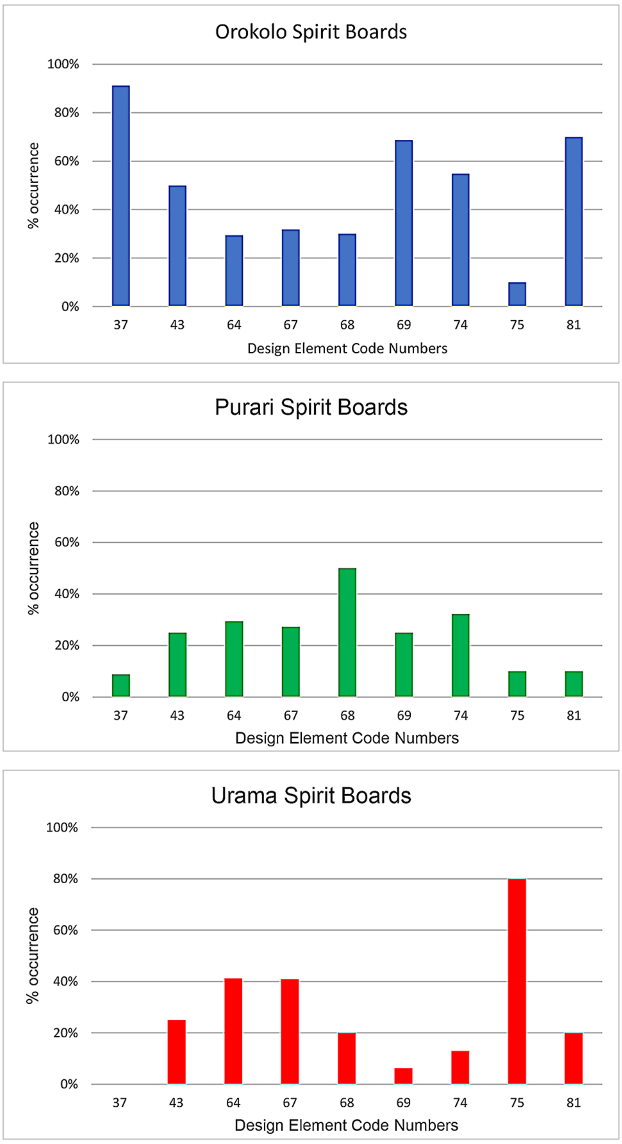


Figure 12. Western Elema-Urama spirit board 'facial designs' sample: histogram illustrating the distributions of the most prevalent design elements occurring on spirit boards from different cultural areas.

two Urama spirit boards, perhaps reflecting a 'classic' *gope* design. Group 4 has notably different subgroups—4a being a relatively even distribution of boards from the three regions, whereas Purari and Orokolo boards comprise the larger 4b subgroup. Here the sharing of common design elements across cultural boundaries is absent. This provides an opportunity to investigate locality-specific design elements. Among 4b spirit boards, there are four examples where the multiple occurrences of village-specific designs occur in the entire Elema-Urama Island sample. These include (see Table 5):

1 DE #94 (two-pronged eyes)—Kaimari
2 DE #117 (elongated curvilinear eyes)—Iari
3 DE #122 (flared eyes bordered by parallel sawtooth lines)—Orokolo
4 DE #155 (parallel lines across bridge of nose)—Orokolo

In summary, general trends begin to emerge when instances of particular design elements occur on more than 10% of the spirit board sample. These instances are rare, so inter-regional motif sharing is not demonstrated. A sample of spirit boards exhibiting fewer design elements is

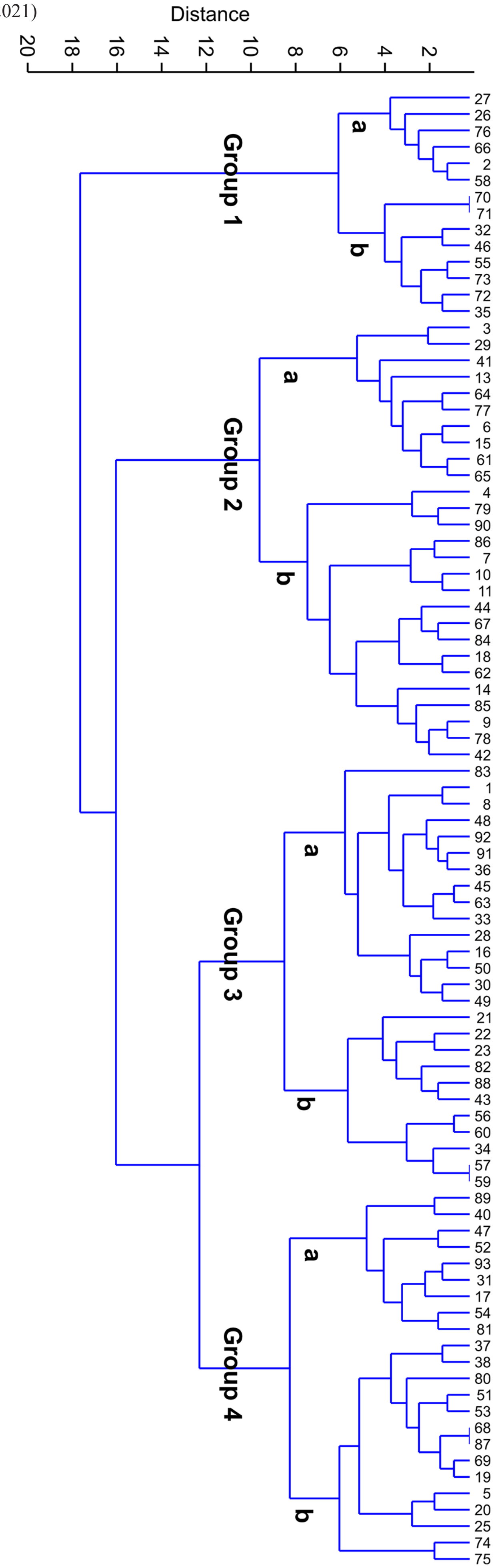
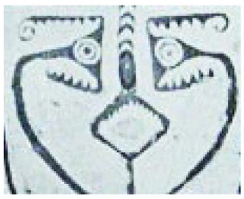


Figure 13. Western Elema-Urama spirit board 'facial designs' sample: hierarchical cluster analysis (Wards method) dendrogram indicating board groupings.

Table 5. Western Elema-Urama facial designs sample: rare motifs. New *design element (DE) codes* were assigned for the Western Elema-Urama Island sample; therefore, they do not correspond with those described in Table 3.

Design Element (DE) Code	Description	Image
84	cheek hook feature	
94	two-pronged eye	
117	elongated curvilinear eye	
122	flared eye bordered by parallel sawtooth lines	
126	elongated eye	
135	mouth surrounded by red-infilled ellipse	
137	triangular mouth?	see 126 above
155	parallel lines across bridge of nose	

required to be more confident of the results. This suggests that minor differences between design elements and social motifs probably occur and these are the product of inexact replication of motifs when a dilapidated spirit board is copied. If correct, future analyses will improve if very similar motifs are combined rather than differentiated. This will, in turn, assist more efficient recording of spirit board designs, identifying 'analytical' motifs and interpreting design elements that are shared across regional cultural boundaries.

Conclusion

This study of Papuan Gulf spirit boards was intended to be speculative and exploratory. The use of design elements as proxies for social systems has not been widely tested in the New Guinea context. The pilot study of Orokolo *hohao* demonstrated how different design fields were used for different designs along board margins, even though they are not as well-documented ethnographically as are the motifs on a board's central panels. The study also showed that spirit boards possess patterns of design elements at a geographical level of differentiation. This supports regional cultural level investigations, but perhaps not the contribution of local variability to social boundaries, unless a large collection of spirit board images is available. An analysis comparable to the Orokolo pilot study might be expanded for *hohao* collected among Elema communities farther to the east. An analysis of spirit boards from across the entire Kikori-Purari Delta region also seems possible. However, a more robust sample will also be required if the degree to which design elements were shared between the different cultural groups is to be detected. For example, Fig. 12 suggests that while the Elema possessed a clear set of design elements, others were shared with the Purari and Urama. However, it is unclear which ones were not shared and this knowledge is essential in order to analyse the social networks in the Papuan Gulf.

This study demonstrated that 'simple' Correspondence Analysis has its limitations. McDonald (2009: 241) observed that variables often need to be aggregated to avoid the impact of rare attributes, which may result in the remaining variables becoming clumped around the centroid in a CA map. Creating clustered variables for the Orokolo pilot study helped alleviate this problem but failed to do the same for the Western Elema-Urama study. Different CA routines (Greenacre, 2010, 2013; de Leeuw, and Mair, 2009) may prove to be more applicable. Regardless, descriptive analysis similar to that undertaken for the facial designs database will likely prove to be a better starting point from which to initiate multivariate analyses.

Finally, the safe answer to the question of the likely age of spirit board use is c. 140 cal. BP. That was the time when the Western Elema's ancestral village Popo was abandoned, probably because the coastline shifted southward from its much earlier position near their settlement. Some people moved south nearer to the new coastline and others settled the areas farther inland in the vicinity of Muro. A less cautious estimate is that *hohao* came into use not long after the Popo area was settled, about 600 BP (Urwin, 2018: 261). At this time, as the oral history tells us, there was major social change among the people and Urwin (2018: 108) surmises that this was when the Western Elema clan system was established.

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References

Allen, J. 2017. *Excavations on Motupore Island, Central District, Papua New Guinea*. 2 volumes. Working Papers in Anthropology Number 4. Dunedin: University of Otago.
http://hdl.handle.net/10523/7073
http://hdl.handle.net/10523/7074

Appadurai, A. 1986. Introduction: commodities and the politics of value. In *The Social Life of Things: Commodities in Cultural Perspective*, ed. A. Appadurai, pp. 3–63. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511819582.003

Barth, F. 1969. Introduction. In *Ethnic Groups and Boundaries: The Social Organization of Culture Difference*, ed. F. Barth, pp. 9–38. London: Allen & Unwin.

Beier, U., and A. Mori Kiki. 1970. *Hohao: The Uneasy Survival of an Art Form in the Papuan Gulf*. Melbourne: Thomas Nolan.

Bell, J. A. 2009. Documenting discontent: struggles for recognition in the Purari Delta of Papua New Guinea. *The Australian Journal of Anthropology* 20: 28–47.
https://doi.org/10.1111/j.1757-6547.2009.00002.x

Bolviken, E., E. Helskog, K. Helskog, I. M. Holm-Olsen, L. Solheim, and R. Bertelsen. 1982. Correspondence analysis: an alternative approach to principal components. *World Archaeology* 14(1): 41–60.
https://doi.org/10.1080/00438243.1982.9979848

Brake, B., J. McNeish, and D. Simmons. 1979. *Art of the Pacific*. Oxford: Oxford University Press.

Carlson, D. L. 2017. *Quantitative Methods in Archaeology Using R*. Cambridge: Cambridge University Press.

Chiu, S. 2015. Where do we go from here? Social relatedness reflected by motif analysis. In *The Lapita Cultural Complex in Time and Space: Expansion Routes, Chronologies and Typologies*, ed. C. Sand, S. Chiu, and N. Hogg, pp. 185–206. Noumea: Institut d'archéologie de la Nouvelle-Calédonie et du Pacifique.

Conkey, M. 1978. An Analysis of Design Structure: Variability among Magdalenian Engraved Bones from North coastal Spain. Unpublished PhD thesis. University of Chicago.
https://search.proquest.com/docview/302890883

Conkey, M. 1980. The identification of prehistoric hunter-gatherer aggregation sites: the case of Altamira. *Current Anthropology* 21(5): 609–630.
https://doi.org/10.1086/202540

Conkey, M. 1982. Boundaries in art. In *Symbolic and Structural Archaeology*, ed. I. Hodder, pp. 115–128. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511558252.012

de Leeuw, J., and P. Mair. 2009. Simple and canonical correspondence analysis using the R Package anacor. *Journal of Statistical Software* 31(5): 1–18.
https://doi.org/10.18637/jss.v031.i05

Flynt, A., and N. Dean. 2016. A survey of popular R packages for cluster analysis. *Journal of Educational and Behavioural Statistics* 41(2): 205–225.
https://doi.org/10.3102/1076998616631743

Forge, A. 1965. Art and environment in the Sepik. *Proceedings of the Royal Anthropological Institute of Great Britain and Ireland* 1965: 23–31.
https://doi.org/10.2307/3031753

Forge, A. 2017. The problem of meaning in art. In *Style and Meaning. Essays on the Anthropology of Art*, ed. A. Clark and N. Thomas, pp. 111–121. Leiden: Sidestone Press. [originally published in S. M. Mead ed., 1979].

Frankel, D. 2010. Carving a gope board. *The Artefact* 33: 49–55.
https://doi.org/10.5040/9781474293488.0042

Franklin, K. J. 1973. *Linguistic situation in the Gulf District and adjacent areas, Papua New Guinea.* Pacific Linguistic series, C, 26. Canberra: Department of Linguistics, Research School of Pacific Studies, Australian National University.
https://doi.org/10.15144/PL-C26

Friede, M., and J. Friede. 2005. *New Guinea Art: Masterpieces from the Jolika Collection of Marcia and John Friede*. San Francisco: California Fine Arts Museum of San Francisco.

Graves, M., J. Skibo, M. Stark, and M. Schiffer. 2016. An anthropological archaeologist: the contributions of William A. Longacre to archaeological theory, method and practice. *Journal of Archaeological Method and Theory* 23: 990–1022.
https://doi.org/10.1007/s10816-016-9303-1

Greenacre, M. 2010. Correspondence analysis. *Wiley Interdisciplinary Review: Computational Statistics* 2(5): 613–619.
https://doi.org/10.1002/wics.114

Greenacre, M. 2013. The contribution of rare objects in correspondence analysis. *Ecology* 94(1): 241–249.
https://doi.org/10.1890/11-1730.1

Gullick, W. A., and J. E. Carne. 1913. *Map showing the approximate position of coal, gas, and oil discoveries of the Purari and Vailala Rivers, Western Division of Papua* [cartographic material].
http://nla.gov.au/nla.obj-234240022

Hammer, O. 2018. *PAST: Paleontological STatistics Version 3.2: Reference Manual*. Oslo: Natural History Museum, University of Oslo.

Hammer, O., D. Harper, and P. Ryan. 2001. PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica* 4(1): 1–9.
https://palaeo-electronica.org/2001_1/past/past.pdf

Johnston, L. F., and H. J. Green. 1932. *Papua*. Map produced by the Australian Department of Works and Railways, Lands and Surveys Branch. Sydney: Government Printer.
http://nla.gov.au/nla.obj-412527710

Kaitilla S. 1997. The role of primitive art on vernacular architecture: its relevance on contemporary architecture in Papua New Guinea. *Habitat International* 21(4): 397–407.
https://doi.org/10.1016/S0197-3975(97)00013-1

Lave, J., and E. Wenger. 1991. *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511815355

Leach, E. 1976. *Culture and Communication: The Logic by which Symbols are Connected*. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511607684

Lewis, A. B. 1973. *Decorative Art of New Guinea*. New York: Dover Publications.

Lipo, C., and M. Madsen. 2001. Neutrality, 'style,' and drift: building methods for studying cultural transmission in the archaeological record. In *Style and Function: Conceptual Issues in Evolutionary Archaeology*, ed. T. Hunt and G. Rakita, pp. 91–118. Westport (Connecticut): Bergin and Garvey.

McBryde, I. 2000. 'Barter…immediately commenced to the satisfaction of both parties': cross-cultural exchange at Port Jackson, 1788–1828. In *The Archaeology of Difference: Negotiating Cross-Cultural Engagements in Oceania*, ed. A. Clarke and R. Torrence, pp. 245–284. Florence: Routledge.
https://doi.org/10.4324/9780203298817

McDonald, J. 2009. *Dreamtime Superhighway: Sydney Basin Rock Art and Prehistoric Information Exchange*. Terra Australis 27. Canberra: ANU E Press.
https://doi.org/10.22459/DS.08.2008

McDonald, J., and S. Harper. 2016. Identity signalling in shields. How coastal hunter-gatherers use rock art and material culture in arid and temperate Australia. *Australian Archaeology* 82(2): 123–138.
https://doi.org/10.1080/03122417.2016.1186345

McDonald, J., and P. Veth. 2012. The social dynamics of aggregation and dispersal in the Western Desert. In *A Companion to Rock Art*, ed. J. McDonald and P. Veth, pp. 90–102. Chichester: Wiley-Blackwell.
https://doi.org/10.1002/9781118253892.ch6

Mead, S. M., ed. 1979. *Exploring Visual Art of Oceania*. Honolulu: University Press of Hawaii.

Munn, N. 1962. Walbiri graphic signs: an analysis. *American Anthropologist* 64(5): 972–984.
https://doi.org/10.1525/aa.1962.64.5.02a00060

Munn, N. 1966. Visual categories: an approach to the study of representational systems. *American Anthropologist* 68(4): 936–950.
https://doi.org/10.1525/aa.1966.68.4.02a00050

Newton, D. 1961. *Art Styles of the Papuan Gulf*. New York: University Publishers.

Rhoads, J. W. 1982. Prehistoric Papuan exchange systems. In *The Hiri in History*, ed. T. Dutton, pp. 131–151. Canberra: Research School of Pacific Studies, Australian National University.
http://hdl.handle.net/1885/133722

Rhoads, J. 1984. Papuan Gulf Ethnographic Research Project. Unpublished report to the Trustees, the Australian Museum. Sydney.

Rhoads, J. W. 1994. Recent Gulf ceramics. In *Archaeology of a Coastal Exchange System: Sites and Ceramics of the Papuan Gulf*, ed. D. Frankel and J. W. Rhoads, pp. 53–69. Canberra: Division of Archaeology and Natural History, Australian National University.

Rigaud, S., C. Manen, and I. Garcia-Martinez de Lagrán. 2018. Symbols in motion: flexible cultural boundaries and the fast spread of the Neolithic in the western Mediterranean. *PLoS ONE* 13(5): e0196488.
https://doi.org/10.1371/journal.pone.0196488

Schapiro, M. 1969. On some problems in the semiotics of visual art: field and vehicle in image signs. *Semiotica* 1(3): 223–242.
https://doi.org/10.1515/semi.1969.1.3.223

Schultze-Westrum, T. 2015. Ovoid: Gope and other ceremonial objects. In *Embodied Spirits: Gope Boards from the Papuan Gulf*, ed. V.-L. Webb, pp. 39–46. Milan: 5 Continents Editions.

Shennan, S. 1997. *Quantifying Archaeology*. 2nd edition. Edinburgh: Edinburgh University Press.
https://doi.org/10.1016/C2009-0-21716-8

Skelly, R. J., and B. David. 2017. *Hiri: Archaeology of Long-distance Maritime Trade along the South Coast of Papua New Guinea.* Honolulu: University of Hawaii Press.

Stone, T. 2003. Social identity and ethnic interaction in the Western Pueblos of the American Southwest. *Journal of Archaeological Method and Theory* 10(1): 31–67.
https://doi.org/10.1023/A:1022808529265

Torrence, R. 2011. Finding the right question: learning from stone tools on the Willaumez Peninsula, Papua New Guinea. *Archaeology in Oceania* 46(2): 29–41.
https://doi.org/10.1002/j.1834-4453.2011.tb00097.x

Torrence, R., and A. Clarke. 2016. Excavating ethnographic collections: negotiations and cross-cultural exchange in Papua New Guinea. *World Archaeology* 48(2): 181–195.
https://doi.org/10.1080/00438243.2016.1146161

Unknown. 1942. Kikori, New Guinea [cartographic material]. Drawn and reproduced by L. H. Q. (Aust.) Cartographic Company.
http://nla.gov.au/nla.obj-233136298

Unknown. n.d. Sketch map of the southern part of the Delta Division, [Gulf of Papua].
http://nla.gov.au/nla.obj-514474532

Urwin, C. 2018. Building and Remembering: Constructing Ancestral Place at Popo, Orokolo Bay, Papua New Guinea. Unpublished PhD thesis, Monash University, Melbourne.

Urwin, C., J. W. Rhoads, and J Bell. 2021. Swamp and delta societies of the Papuan Gulf, Papua New Guinea. In *The Oxford Handbook of the Archaeology of Indigenous Australia and New Guinea*, ed. I. J. McNiven and B. David. Oxford: Oxford University Press.
https://doi.org/10.1093/oxfordhb/9780190095611.013.34

Webb, V.-L., ed. 2015a. *Embodied Spirits: Gope Boards from the Papuan Gulf*. Milan: 5 Continents Editions.

Webb, V.-L. 2015b. Impressions and encounters: historical photographs and imaging of spirit boards. In *Embodied Spirits: Gope Boards from the Papuan Gulf*, ed. V.-L. Webb, pp. 29–37. Milan: 5 Continents Editions.

Welsch, R. L. 2006. Coaxing the spirits to dance. In *Coaxing the Spirits to Dance: Art and Society in the Papuan Gulf of New Guinea*, ed. R. L. Welsch, V.-L. Webb, and S. Haraha, pp. 4–45. Hanover (New Hampshire): Hood Museum of Art.

Welsch, R. L. 2015a. A view from afar: history and encounter with Papuan Gulf objects. In *Embodied Spirits: Gope Boards from the Papuan Gulf*, ed. V.-L. Webb, pp. 21–28. Milan: 5 Continents Editions.

Welsch, R. L. 2015b. Finding meaning in a spirit board. In *Embodied Spirits: Gope Boards from the Papuan Gulf*, ed. V.-L. Webb, pp. 47–55. Milan: 5 Continents Editions.

Welsch, R. L., V.-L. Webb, and S. Haraha, eds. 2006. *Coaxing the Spirits to Dance: Art and Society in the Papuan Gulf of New Guinea*. Hanover (New Hampshire): Hood Museum of Art.

Wiessner, P. 1984. Reconsidering the behavioral basis for style: a case study among the Kalahari San. *Journal of Anthropological Archaeology* 3: 190–234.
https://doi.org/10.1016/0278-4165(84)90002-3

Williams, F. E. 1940 [2015]. *Drama of Orokolo: The Social and Ceremonial Life of the Elema*. Reprint 2015. Port Moresby: University of Papua New Guinea Press.

Williams, F. E. 1924. *The Natives of the Purari Delta*. Anthropology Report 5. Port Moresby: Government Printer.

Williams, F. E. 1934. The Vailala madness in retrospect. In *Essays Presented to C. G. Seligman*, ed. E. Evans-Pritchard, R. Firth, B. Malinowski, and I. Schapera, pp. 369–379. London: Kegan Paul.

Wirz, P. 1934. *Beiträge zur Ethnographie des Papua-Golfes, Britisch-Neuguinea*. Leipzig: B. G. Teubner.

Wobst, H. 1974. Boundary conditions for Paleolithic social systems. *American Antiquity* 39(2): 147–178.
https://doi.org/10.2307/279579

Appendix 1. Western Elema-Urama spirit board sample: source information.

spirit board analysis codes[a]		source Information
1		Brake *et al.*, 1979: fig 55
2		Welsch *et al.*, 2006: fig. 13
3		Welsch *et al.*, 2006: fig. 92
4		Welsch *et al.*, 2006: fig. 95
5	(1)	A015768[b]
6	(2)	E000256
7	(3)	E000257
8	(4)	E000258
9	(5)	E021046
10	(6)	E022633
11	(7)	E022634
12	(8)	E023104
13	(9)	E023105
14	(10)	E023108
15	(11)	E023109
16		E023110
17	(12)	E023112
18	(13)	E023113
19	(14)	E023114
20	(15)	E024469
21	(16)	E024471
22	(17)	E026296
23	(18)	E026299
	(19)	E026300[c]
24	(20)	E026301
25		E027126
26		E027129
27		E027136
28		E028092
29		E028094
30		E028096
31		E028102
32		E028104
33		E028106
34		E028107
35		E028108
36		E028109
37		E035104
38		E035106
	(21)[d]	
39	(22)	E072964
40	(23)	E072965
41		Webb, 2015a: plate 1
42		Webb, 2015a: plate 3
43		Webb, 2015a: plate 9
44		Webb, 2015a: plate 17
45		Webb, 2015a: plate 29
46		Webb, 2015a: plate 31
47		Webb, 2015a: plate 33
48		Webb, 2015a: plate 34
49		Webb, 2015a: plate 41
50		Webb, 2015a: plate 45
51		Webb, 2015a: plate 46
52		Webb, 2015a: plate 47
53		Webb, 2015a: plate 48
54		Webb, 2015a: plate 49
55		Webb, 2015a: plate 105
56		Webb, 2015a: plate 108
57		Webb, 2015a: plate 109
58		Webb, 2015a: plate 115
59		Webb, 2015a: plate 116
60		Webb, 2015a: plate 125
61	(24)	Beier & Kiki, 1970: plate 1
62	(25)	Beier & Kiki, 1970: plate 2
63	(26)	Beier & Kiki, 1970: plate 3
64	(27)	Beier & Kiki, 1970: plate 4
65	(28)	Beier & Kiki, 1970: plate 5
66	(29)	Beier & Kiki, 1970: plate 7
67	(30)	Beier & Kiki, 1970: plate 8
68	(31)	Beier & Kiki, 1970: plate 9
69		Beier & Kiki, 1970: plate 10[e]
70		Friede & Friede, 2005: plate 464
71		Friede & Friede, 2005: plate 465
72		Friede & Friede, 2005: plate 466
73		Friede & Friede, 2005: plate 469
74		Lewis, 1973: plate VI.1a
75		Lewis, 1973: plate VI.1b
76		Lewis, 1973: plate VI.2a
77		Lewis, 1973: plate VI.2b
78		Lewis, 1973: plate VIIa
79		Lewis, 1973: plate VIIb
80		Lewis, 1973: plate VIIc
81		Lewis, 1973: plate VIIIa
82		Lewis, 1973: plate VIIIb
83		Lewis, 1973: plate VIIIc
84		Lewis, 1973: plate Xd
85		Lewis, 1973: plate XIIa
86		Lewis, 1973: plate XIIc
87		Lewis, 1973: plate XIVc
88		Lewis, 1973: plate XIVb
89		Newton, 1961: fig. 42
90		Newton, 1961: fig. 43
91		Newton, 1961: fig. 187
92		Newton, 1961: fig. 188
93		Newton, 1961: fig. 189

[a] Spirit board codes for Orokolo pilot study are indicated in parentheses.

[b] Pacific Collection, Australian Museum alphanumeric registration number.

[c] E026300 is exceptionally small when compared with other boards in the Western Elema to Urama sample and was excluded from this sample. It was included in the Orokolo pilot study only to increase sample size.

[d] The provenance for spirit board E057244 (21) is uncertain and was dropped from all analyses before they began.

[e] The design elements for spirit board 69 were quite different from others in the Orokolo pilot study, and predictably this board would have been an outlier in the analysis; therefore, this board was omitted from the pilot. However, given that the overall diversity of design elements in the Western Elema to Urama sample was substantially greater, this board was included in this latter sample.

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The Longgu Community Time Capsule: Contemporary Collecting in Solomon Islands for the Australian Museum

Elizabeth Bonshek

Visiting Academic, British Museum, London, United Kingdom

Abstract. The *Longgu Community Time Capsule* was a collaborative project to acquire a contemporary collection from the Longgu community in Guadalcanal, Solomon Islands for the Australian Museum, Sydney. It built upon an earlier engagement of Longgu community representatives, Steward Bungana and Florence Watepura, with the Ian Hogbin collection from Longgu made in 1933. Bungana and Watepura reported back to their community and through the *Longgu Community Time Capsule* project, Longgu people formulated the subject and methodology for the creation of a contemporary collection. This paper describes aspects of their engagement with the Museum, its collections, and researchers, which formed the basis for making ceremonial feasting bowls for the Museum. Through interaction with the historical collection the Longgu decided that carving manifested cultural knowledge but carving skills were endangered. The project provided an example of the process of value production described by Howard Morphy in which museum collections are continually re-contextualised, re-examined, and made relevant in the present. The project also supported the view that museum collections are cultural resources that allow for distinctive collaborative methodologies for interrogating both the past and the present in a process described by Nicholas Thomas as the 'museum as method.'

Introduction

The *Longgu Community Time Capsule* was an innovative and collaborative research project to acquire contemporary collections in an ethical fashion from Solomon Islands for the Australian Museum, Sydney (Torrence and Bonshek, 2013). Longgu is the name of the language spoken by some 1500 people living on Guadalcanal Island approximately six hours combined trip by car and motorboat from Honiara, the nation's capital (Fig. 1). I visited Nangali, one of the Longgu villages, between 10 and 24 January 2013, and acquired thirteen items including carved food bowls and woven baskets (Table 1). I also recorded carvers making the bowls using digital video and photographs.

The selection of the objects to make this collection was built upon the response of the Longgu people to the Australian Museum's existing collection from their villages that was made in 1933 by anthropologist Ian Hogbin (1964). During his career Hogbin acquired collections from the Solomon Islands and Papua New Guinea (Beckett and Gray, 2007) that are now housed at the Australian Museum in Sydney as part of the University of Sydney Collection. He also deposited an extensive photographic collection with the University of Sydney Archives (Conway, 2012).

Through making objects as part of the *Time Capsule* project the Longgu people recognised aspects of social change in their contemporary practices. Their reflection on the historical collections influenced their decisions about what to make. The project provides an example of the process of value production described by Howard Morphy in which museum collections are continually re-contextualised, re-examined, and made relevant in the present (Morphy, 2020: 32). This research supports the view that museum collections are cultural resources which, while disconnected from contemporary communities by the passage of time (Morphy, 2020: 116), may not be completely disconnected

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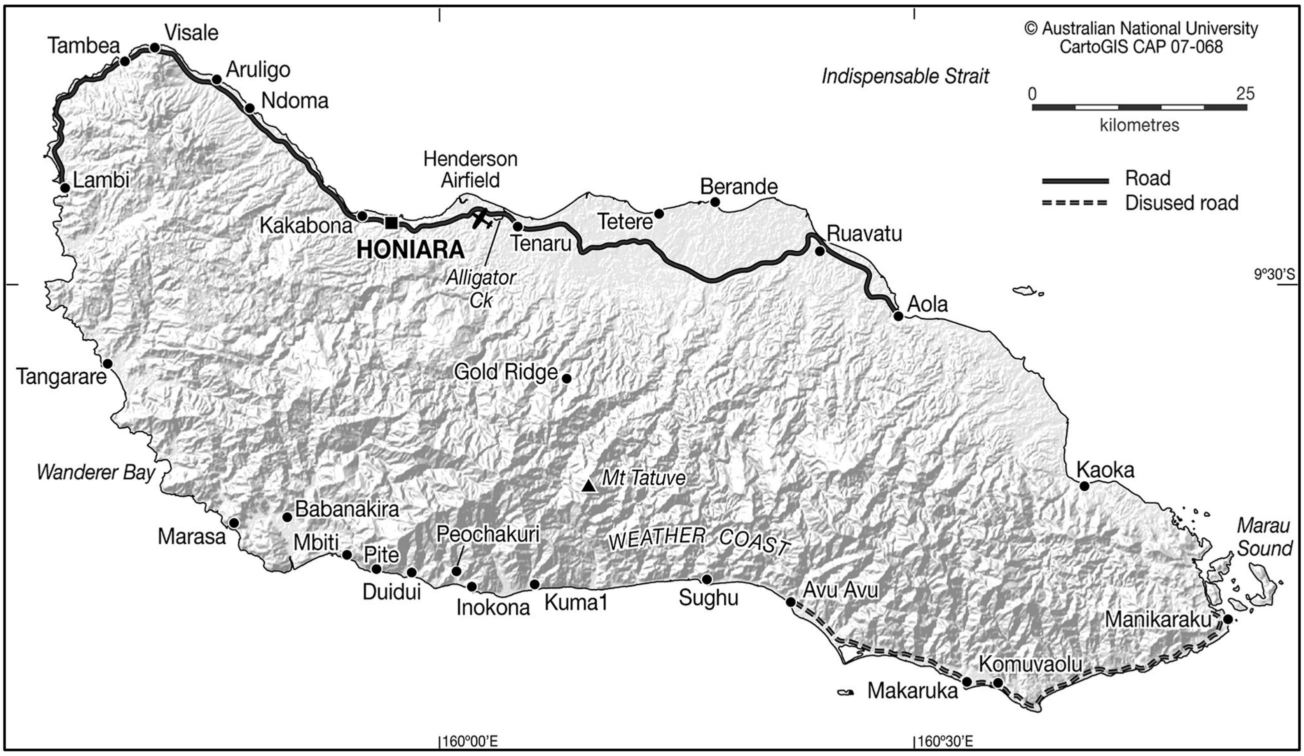

Figure 1. Guadalcanal, Solomon Islands. Nangali village is located inland from the area marked Kaoka, the name used by Hogbin to refer to the Longgu (Hill, 2002: 538). Map reproduced with the permission of CartoGIS Services, College of Asia and the Pacific, The Australian National University, Canberra.

from contemporary cultural production—although, as the Longgu discovered, they may be in danger of becoming so. The process of engaging with the Museum, its infrastructural elements such as registration documents, labels, photographs and archives, as well as its collection objects, provided a distinctive collaborative methodology for interrogation of both the past and the present which Nicholas Thomas (2010) has described as using the 'museum as method.'

The strength of the collecting strategy of the *Time Capsule* project lay in having the Longgu people decide what was important to them for the Australian Museum to acquire, preserve and house in Australia. At the same time, the strategy maintained the aims of the Museum to build upon its existing collections (Bonshek, 2015). As reflected in its collection strategy (Australian Museum, 2008) the Museum sought to extend the time-line represented by its current collections through the acquisition of a

> highly coherent set of modern material … In this approach a "time capsule" comprised of material items is selected by community members to represent how they represent their contemporary lives and their identity and place in the modern globalized world (Australian Museum Archives, 2011).

In the case of the Solomon Islands, the Museum's collection had seen few additions since the 1930s.

This contemporary collecting project is therefore distinguished from conventional practice in that the Longgu themselves decided which types of objects and accompanying digital images and video records could be acquired by the Museum, rather than having them selected by Museum staff or researchers. Through this process the Museum enhanced its collections through an understanding of how the Longgu community viewed itself within a global world while simultaneously supporting the Museum's contemporary collecting strategy.

The success of the *Time Capsule* project rested upon an earlier engagement between Longgu people and the Museum's collections during *The Kaoka Speakers Revisited* project of 2012 (described below). This resulted in interactions that confirm Thomas' (2019: 3) observation that museum engagements are both 'revelatory and inspiring.' The *Time Capsule* project extended these earlier engagements, and led to a plan by the Longgu community for the creation of new things and memories (Bonshek, 2016) that would ensure continuity in the knowledge of specific techniques of cultural reproduction (see Thomas, 2015: 19).

A foundation for the Longgu Community Time Capsule

The Kaoka Speakers Revisited project established the foundation for the *Longgu Community Time Capsule* by bringing together the Longgu community, the author and Deborah Hill, a linguist and long-term researcher with the Longgu, to examine Hogbin's collections at the Australian Museum, his photographs held by the Chau Chak Wing Museum in the University of Sydney and his field notes in the University of Sydney Archives. The project cemented the support of the Nangali residents for the ethos of preserving objects and social practices, which is a core focus of museums (Thomas, 2019). This resulted in Steward Bungana and Florence Watepura (Fig. 2) being selected by the Longgu villagers and their chiefs to travel to Sydney in 2012 to see the collection and to report on their findings. At the completion of the visit the Australian Museum expressed interest in making a new Longgu collection through the *Longgu Community Time Capsule* project. Bungana and Watepura discussed this new project with the community, which resulted in Bonshek's visit to Nangali village in 2013 to initiate the project.

Figure 2. Steward Bungana and Florence Watepura reading Ian Hogbin's field notebooks held by the University of Sydney Archives. Photo: E. Bonshek, 9 February 2012.

Talking about collections

One of the central issues for museums holding cultural collections concerns representation: who has the authority to speak about collections? The Longgu community resolved this matter in their preparations for the *Kaoka Speakers* project through the appointment of Bungana and Watepura by the *Suloma* (House of Chiefs). The selection of Bungana, who was also an advisor to the *Suloma*, and Watepura, a mother then residing in Honiara, meant that they carried a great responsibility. The two delegates represented the 'authorised voice' (Bourdieu, 1991) of the Longgu community. Deborah Hill explained that the *Suloma*'s decision was based upon Bungana and Watepura holding the appropriate knowledge to deal successfully with the task at hand, and also their fitness to withstand the journey to Australia. Success in dealing with the trip involved having cultural knowledge about Longgu culture; knowledge of how to deal with non-village ways of doing things; ability to deal with the demands of the project itself; and the life experience to deal with the strains of living for one month in a distant country. Bungana and Watepura were fully empowered by the community, through the chiefs, to undertake not only an arduous physical journey from Solomon Islands to Australia, but also to take an intellectual and emotional journey on their behalf. In this sense they can also be seen as 'cultural brokers' (Jacobs, 2014).

Encountering museums and collections

A significant part of dealing with the demands of the project and non-village ways of doing things involved engagement with the phenomena of museums, cultural heritage, and the concept of museums having a role in society. This required an understanding of Hogbin's collection within the broader perspective of the Western intellectual tradition that emphasises the importance of museum collections as history. Western museums and archives manifest preoccupations with the preservation of material objects from the past, and concerns for the role of the past in the present and future. While some have argued that Western museums represent a wholly alien practice for indigenous people, others have argued for indigenous forms of curation to appropriate the museum—especially the colonial museum (e.g., Stanley, 2007).

Some of these ideas were given physical presence for Bungana and Watepura through the structures of the Australian Museum and University buildings, as well as through the collections. They wanted to see where Hogbin had worked, and we took them to see the lecture room in which he delivered his talks and presented his slides, including those taken during his visit among the Longgu. Watepura used the term 'network' (Bonshek, 2016: 40-41) to refer to the resources she perceived to be connected and linked across the collections, involving the Museums, their staff, and researchers.

To access Longgu objects physically, we walked through the Australian Museum's storage area in which the Guadalcanal material was stored. This amounted to some 20 or so shelves of objects on open shelves and in pull-out drawers. In this way we identified 13 additional items that were either from the Longgu area or were familiar to Bungana and Watepura. As they looked, discussed and explained the objects, it was not immediately evident what their thoughts about the collection were. Time was needed for them to digest what they were seeing and experiencing. After the first survey of the Longgu and Guadalcanal collections we moved to a more in-depth examination of the objects that the delegates had chosen to speak about; we started with their choice, two wooden bowls. It became clear later that carving was significant to Watepura and Bungana because contemporary carving knowledge rested with the carvers of Nangali (see Bonshek, 2016). A process of recognising social practices while engaging with historical objects was in train; perhaps these two bowls were the inspiration for the idea to make feasting bowls for the Museum's collection.

Table 1. Objects acquired for the *Longgu Community Time Capsule*.

AM reg. no.	object	maker
E095488	Round wooden bowl	Reuben Vigane
E095489	Long wooden bowl, with frigate bird design	Isaac Pegoa
E095490	Square wooden bowl	Gabriel Ropovono
E095491	Wooden mortar	Paul Zugia
E095492	Double wooden bowl	Peter Mette
E095493	Woven tray, tightly coiled	Peter Mette
E095494	Disposable food plate made from coconut frond	Danial Seka
E095495	Basket made of coconut frond	Danial Seka
E095496	Basket *pera* with white rim made from plain and dyed coconut fronds	Alice Mary Wotaiya
E095497	Large basket with 'flower of vine designs' made from plain and dyed coconut fronds	Alice Mary Wotaiya
E095498	Basket with brown rim; a very strong and sturdy basket	Alice Mary Wotaiya
E095499	Spoon, made from coconut endocarp	Margaret Arumana
E095500	Spoon, made from coconut endocarp	Amos Voua

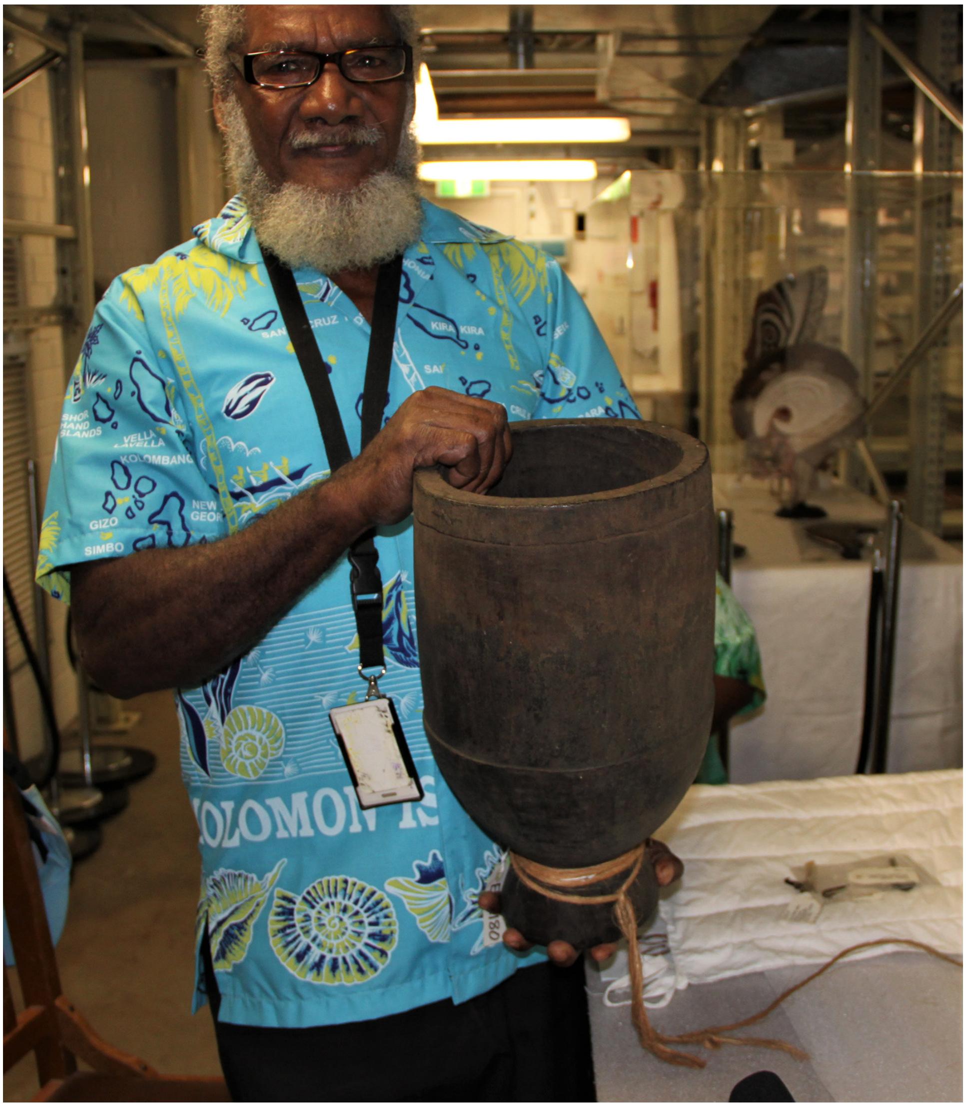

Figure 3. Steward Bungana holding a mortar collected by Ian Hogbin, held by the Australian Museum. Photo: E. Bonshek, 8 February 2012.

Recognising feasting

Bungana and Watepura commented that Hogbin's photographs had repeatedly captured scenes and activities relating to ceremonial feasting (Bonshek, 2016: 36-38). Knowing this, perhaps it is not surprising that he collected items used in food preparation and prestation. These included *lali* (square shaped food bowls), a mortar for pounding food into a mash (Fig. 3), a 'shaping bowl' for moulding it, and cooking tongs. The women of Longgu continue to use mortars (Fig. 4) and cook with hot stones (rather than on wood fires) for which tongs are essential. Every household kitchen, a small covered structure located apart from the sleeping area, is constructed with a large square or rectangular fireplace where stones are heated. When the stones are hot enough, parcels of food are placed amongst them to cook. Once cooked food has been mashed, it must be reheated. The cook picks up a hot stone with a pair of tongs, plunges it into a bowl of water to cool it slightly, and then places it into the wooden serving dish containing the mash to warm it up. When the food is hot enough the stones are removed. A head pad (an example is also in Hogbin's collection) is used by women for carrying heavy loads including items such as food bowls.

At the end of their visit Watepura declared that Hogbin had 'captured the heart of the Longgu' (Bonshek, 2016: 42–43); and it was from this observation, perhaps, that the focus on feasting in the *Time Capsule* project emerged. The scenes of carvers working in 2013 (Fig. 5) echoed those captured by Hogbin in 1933, such as his photograph of Steward's grandfather, Mete, making four bowls (Bonshek, 2016: 41, fig. 2.7). In the photo Mete sits amongst bowls in various stages of construction. We see him chipping out a bowl with an adze while using his feet to stabilise the work in front of him. Behind him there is a gouging tool for hollowing vessels, placed inside a *lali* (a square shaped food bowl), and a roughly shaped bowl stands in front of him, with what appears to be a 'blank' placed to his left. There are three different sized adzes in view, and perhaps a second gouging tool to one side, resting on the blank.

Through the process of interacting with the Museum collection the Longgu, through Watepura and Bungana, came to realise that the material knowledge practices demonstrated in the photographs and manifest in the objects were compromised in contemporary village life. While memories of how objects were used and made were reactivated by seeing the collections, Bungana and Watepura became aware of the next generation's inability to draw upon similar memories. Engaging with the collection generated contemplation of the impacts of social change in Longgu and consideration of the fragility or longevity of customary social practices, their preservation or loss. Connerton (2009) suggests memories are maintained and preserved through

Figure 4. Alice Mary Wotaiya in her cooking house pounding *yangi* made from sweet potatoes in a *tabili* (mortar). Her stone oven is to her left. Photo: E. Bonshek, 16 January 2013.

Figure 5. Carvers at work. Photo: E. Bonshek, 17 January 2013.

familiar objects and places and disconnection from these is the means by which 'modernity' causes a break with the past, and both social practices and values are forgotten. In carrying out the *Time Capsule* project, Bungana and Watepura decided to create memories for the next generation and maintain connections with a re-valued past.

Difficult heritage

However, not all objects in the collection were easy to speak about. There was one object, a small segment of 'shell currency' used in traditional exchange throughout the Solomon Islands, which evoked something akin to 'difficult heritage' (MacDonald, 2010) and a reminder of something best forgotten (Connerton, 2009, 2011).

From my perspective as a researcher, this object raised an opportunity to explore the local context of shell currency as an object of complex meaning, as 'money or not money' (Szabó, 2018: 36)—particularly in terms of a search for the significance of museum examples—and stemming from my reflection on the contemporary role of money and other valuables (Bonshek, 2009). See also a broader context provided by Akin and Robbins (1999) and Burt and Bolton (2014). The presence of shell money in the Longgu collection was, from the point of view of the life cycle of a particular object type (Appadurai, 1986; Kopytoff, 1986), potentially valuable in providing a commentary on exchange networks from the Longgu viewpoint. For these reasons I drew the delegates' attention to the shell currency with a sense of anticipation, but they made no comment to me, switching from English to a near whisper in Longgu. My inability to speak Longgu transformed their choice not to communicate with me about the object into a silence.

However, there are reasons why, from an emic perspective, speaking out might be problematic. The silence that might accompany the viewing of objects from Melanesia in museums may have many meanings. To speak about an object that does not 'belong' to one's group, or which may not be recognised as such, can be a delicate matter. This might be because a speaker does not have the authority to speak about a particular object; or the object itself may be known to be dangerous; or the object may be dangerous because its use is unknown (e.g., Barker, 2001; Bonshek, 2008, 2009; Haraha, 2007).

Later that day Bungana and Watepura's response was made clear. An understanding of the civil unrest in Solomon Islands in 2000 provided the reason for their discomfort. The unrest had been the culmination of tensions between Guadalcanal islanders, the customary landowners, and people of Malaitan descent living on Guadalcanal. The Longgu, living in the southeast of Guadalcanal, are in close proximity to Malaita and have ancestral and linguistic connections with Malaitans. During the unrest they did not want to re-affirm this connection. This sentiment emerged in the museum stores some 13 years later. Hill referred to this hesitation as the 'blocking' of cultural information and its dissemination where this might touch upon the complicated relationship between Longgu, other Guadalcanal people and the people of Malaita (Hill, 2012: 275; Kwa'ioloa and Burt, 2007).

Apart from the single item of shell currency and the silence that surrounded it, which in itself denoted great significance, Bungana and Watepura were most forthcoming about the other objects in the collection, including items not collected by Hogbin. The identification of an additional 13 objects clearly represented territory into which it was safe for them to venture.

Watepura and Bungana returned home to Solomon Islands and reported on their visit and their findings. Once the idea of making a contemporary collection was raised by the Museum, the Longgu suggested that wood carving would be an activity that the broader community would be interested to explore and have recorded. The engagement with the collection had provided the means through which an idea to carve new feasting bowls was conceived. This became the central aim of the *Longgu Community Time Capsule*.

The creation of new things

I sent money for the purchase of carving tools to Watepura that she was to forward to the carvers. The intention was that prior to my arrival in Nangali the carvers would have bowls available for sale and that during my presence there I could also record the process of manufacture of additional examples. My assumption was that the process of carving bowls would be a lengthy one and likely stretch beyond the period of my visit. However, for various reasons, the tools did not arrive in Nangali ahead of my arrival and as a result I was able to record the manufacture of the bowls now in the collection.

Five carvers, Isaac Pegoa, Peter Mette, Gabriel Ropovono, Reuben Vigana and Paul Zugia, worked intensively for seven days and produced four types of food presentation bowls, expanding the range represented in the Museum's collection. The carvers also made a *tabili*, a mortar used in the preparation of food, and a *lali* (Bonshek, 2016: 36, fig. 2.1). *Lali* are used on important ceremonial occasions such as brideprice prestations, and in former times they were traded for shell currency. This occurred when the Longgu were middle-men in an extensive exchange network that saw shell money move from the neighbouring island of Malaita into exchange networks on Guadalcanal.

These trade networks have ceased, and the knowledge of carving wooden bowls now remains with only the five carvers in Nangali. Of these, Isaac Pegoa, who holds the reputation of being the most experienced carver, took on the role of mentor to the other four. At the establishment of this project several of these men, including Gabriel Ropovono, decided to take up carving again after several years of inactivity. Rather than carve individually and close to their homes, the five men decided to work together near the primary school where villagers could congregate and watch them. Over seven days a number of spectators gathered to watch, many of whom were unfamiliar with carving and the types of trees utilised, as well as the plants used for colouring and finishing. Many of the observers over the period included children and youths.

The nature of the work was physically demanding, commencing with chopping down the tree in the bush and carving out suitably sized segments (Figs 6 and 7). The five men helped one another in various aspects of the work. Their sons, nephews and grandchildren also came to their assistance. While the carvers' favourite pop music played and they bandied jokes with one another, they passed on their skills to their contemporaries and their juniors. When specific techniques were to be pointed out, they were not spoken about, but enacted. Isaac Pegoa drew my attention to what he was about to do and directed me to film specific actions, saying: I am going to show you how to do this. He performed the action accompanied by minimal, and often no commentary. The other carvers watched. The purpose was to demonstrate an action: in this sense, doing was knowing and doing was learning. The Longgu carvers used the Museum's acquisition project to play an important role

Figure 6. Preparing the blanks from which to carve. Photo: E. Bonshek, 18 January 2013.

Figure 7. Blanks ready for carving. Photo: E. Bonshek, 18 January 2013.

Figure 8. Alice Mary Wotaiya weaving a *pera*, basket. Photo: E. Bonshek, 16 January 2013.

in their intergenerational transmission of cultural knowledge through the act of carving.

Other items were acquired in parallel to the carving project. These were offered by individuals and included woven baskets called *pera,* made by Alice Mary Wotaiya of Nangali (Fig. 8) and an undecorated basket for everyday use made by Daniel Seka, a senior member of the community who was keen to demonstrate his own weaving skills.

Creating heritage and preservation: implications for Nangali villagers

At the end of the visit to the Australian Museum both Watepura and Bungana were video-recorded reflecting upon their experience. They had consented to participating in these recordings, as well as to audio recordings of discussions in the Museum's stores prior to the commencement of the project. Watepura stated that Longgu feasting was a recurring theme in Hogbin's photography. Also, she said that through the course of the visit she realised that there was a network of institutions focussed on preservation; she felt that people of her own generation should not 'leave our culture out, but we should stick with it' (Bonshek, 2016: 43).

Watepura, and people of her generation, especially those living in town, were no longer in daily contact with village life and customary ways of doing things. But while they had memories of this way of life, their children have neither these experiences nor memories of them. So, the Longgu decision to make feasting bowls was generated by their desire to keep younger people in touch with village traditions.

The Longgu were not ignorant of 'preservation' programs *per se* as they have been involved in language documentation work for over two decades. The Australian Museum project extended this concept to embrace the documentation of aspects of village life for Longgu people of today and for future generations. The Museum's acquisition of the carvings and the recording of their manufacturing process fostered interest in revitalising and reaffirming traditional values for contemporary generations, especially among young people. Carving emerged as significant because this knowledge is now restricted to the carvers in the village of Nangali; none of the other Longgu villages have carvers.

In an attempt to establish an interest in preservation and re-valuing of local knowledge with a life beyond the project, the project donated a camcorder, computer, external hard drive for storage, and film editing software to Nangali (the villagers have the capacity to generate electricity to power this equipment). This equipment was formally accepted on behalf of the village by Watepura, who used the camcorder to record one of the weavers and generated interest amongst those watching her (Fig. 9). One youth displayed great commitment and determination to learn how to use the equipment and commenced recording the carvers as they worked. Later he moved on to make short recordings of daily activities in the village.

Figure 9. Florence Watepura with video camera. Photo: E. Bonshek, 16 January 2013.

Figure 10. Isaac Pegoa, carver, with bowls made during the *Longgu Community Time Capsule* Project. Australian Museum registration numbers, from right to left (see Table 1): *tabili*, mortar (E95491); *rambo losingu*, long bowl (E95489); *lali*, for gifting of cooked food on ceremonial occasions (E95490); *rambo o nigurai*, round bowl, for presentation of food (E95488); one round bowl not acquired; one double bowl not acquired; *rambo*, double bowl, for serving cooked food (E95492). Photo: E. Bonshek, 21 January 2013.

The dangers of commodification: the problem of payment

In contrast to the amounts paid to the weaver for her baskets, the payment of cash for the wooden bowls was problematic. While the weavers had established a pricing structure for their *pera*, the 'purchase' of the carved bowls using cash challenged individual perceptions. While I had set aside a sum equivalent to that given to the School Board, I had no clear idea how this would be distributed. From the commencement of the project, discussions with Watepura about prices for the bowls remained unresolved (Bonshek, 2015). It was not until the night before the carvings were completed that a decision was made: Hill, Watepura, Gabriel Ropovono and I were present, and differing views emerged. One felt strongly that each carver should be paid individually but would not name an amount for each carving. Another commented that the project had contributed so much to the community already and assiduously avoided the question of price. Another was reluctant to set a price and wanted me to do this. However, while I felt I simply could not set a price, not knowing local expectations, I broke the stalemate by declaring the budget. Watepura immediately commented that the amount was too much; and repeated that it was important that a fair price was paid, but that it should not be excessive. She was particularly concerned that the price for the carvings should not drive down the quality of future carvings and insisted that Longgu people should make such things for themselves, not just for the cash that they might generate. She was fearful of the development of an ethos that would associate the production of traditional objects with commercial expectations rather than the affirmation of traditional values. She suggested a pricing methodology based upon the division of the budgeted sum by the number of objects, followed by re-jigging these fractions in light of the amount of labour that each object manifested. The latter was arrived at by Ropovono and me, as the others had not been present during the manufacturing process. We all waited for the last word from Ropovono. In the end, the agreed amounts, which were to remain undisclosed, were handed to the carvers individually once they had completed their work. The carvers also made a statement to the camera (in Longgu and in Solomons Pijin) about the use of the bowls (Fig. 10).

Conclusion

Bungana and Watepura used the *Time Capsule* project to refocus Nangali villagers' attention on feasting bowls and the possibility of their falling into disuse. The carving workshop attracted Nangali villagers, young and old. Many watched, and some gave hands-on assistance. The carvers' sons, especially children, remained close by to help their fathers. Bungana and Watepura created a public event in which the transmission of *kastom* knowledge could be witnessed by the community. Hill (2014: 23) has since reported that the project has provided impetus for community members to commission bowls from the carvers and the Paramount Chief of the Longgu area also commissioned a large *lali* from the Nangali carvers.

In this sense, the *Time Capsule* project can be viewed as a success for the Longgu community. It resulted in the positive revaluing of customary practices against a background in which people have increasingly come to view their own cultural practices as in some way of less importance to life outside the village, a view expressed by Watepura while she was in Sydney. Watepura used the project to energise and reaffirm traditional values for contemporary generations and awakened a concern that young people should witness the enactment of traditional values.

The Longgu Community Time Capsule was a success for the Museum, confirming Morphy's statement that museum collections are continually recontextualised and made relevant. The museum also obtained an ethically acquired collection. The project had the full support of the Longgu community, who made substantial inputs into deciding what would be collected for the Museum, and how they would be acquired, and who would benefit from the project. The Museum maintained its core collection development requirement, to extend the existing collections to embrace material of contemporary significance in Solomon Islands. Through a process of collaborative research, the Museum's historical collections were transformed from things from the past, into the 'evidentiary accumulation' (Thomas, 2015: 18) of the multiple relationships that surround collections, their making over time and their significance in the present. This transformation was facilitated largely through Bungana and Watepura's experience and understanding of the Museum's aims together with their methodology to affect change in their community: while making feasting bowls for the museum, they illuminated endangered cultural practices at home, and through this promoted changes to ensure the preservation of precarious material knowledge.

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References

Akin, D., and J. Robbins. 1999. *Money and Modernity: State and Local Currencies in Melanesia.* Pittsburgh: University of Pittsburgh Press.

Appadurai, A. 1986. Introduction: commodities and the politics of value. In *The Social Life of Things: Commodities in Cultural Perspective*, ed. A. Appadurai, pp. 3–63. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511819582.003

Australian Museum. 2008. *Ethnographic Collection Development Strategy, 2008–2012*. Sydney: Australian Museum.

Australian Museum Archives. 2011. *Australian Museum HPE Content Manager—D20/5488*.

Barker, J. 2001. Dangerous objects: changing indigenous perceptions of material culture in Papua New Guinea. *Pacific Science* 55(4): 359–375.
https://doi.org/10.1353/psc.2001.0028

Beckett, J., and G. Gray. 2007. Hogbin, Herbert Ian Priestley (1904–1989). *Australian Dictionary of Biography* 17.
http://adb.anu.edu.au/biography/hogbin-herbert-ian-priestley-12644

Bonshek, E. 2008. When speaking is a risky business: understanding silence and the interpreting the power of the past in Wanigela, Oro Province, Papua New Guinea. *Journal of Material Culture* 13(1): 85–105.
https://doi.org/10.1177/1359183507086220

Bonshek, E. 2009. A personal narrative of particular things: *tevau* (feather money) from Santa Cruz, Solomon Islands. *The Australian Journal of Anthropology* 20(1): 74–92.
https://doi.org/10.1111/j.1757-6547.2009.00004.x

Bonshek, E. 2015. Ethics and collecting in the 'Postmodern' museum: a Papua New Guinea example. In *The Ethics of Cultural Heritage*, ed. T. Ireland and J. Schofield, pp. 145–163. Ethical Archaeologies: The Politics of Social Justice 4. New York: Springer.
https://doi.org/10.1007/978-1-4939-1649-8_9

Bonshek, E. 2016. Making museum objects. A silent performance of connection and loss in Solomon Islands. In *Beyond Memory. Silence and the Aesthetics of Remembrance,* ed. A. Dessingué and J. Winter, pp. 31–52. London and New York: Routledge.

Bourdieu, P. 1991. Authorized language: the social conditions for the effectiveness of ritual discourse. In *Language and Symbolic Power*, ed. J. B. Thompson, pp. 107–116. Cambridge: Polity Press.

Burt, B., and L. Bolton, eds. 2014. *The Things We Value: Culture and History in Solomon Islands*. Canon Pyon: Sean Kingston Publishing.

Connerton, P. 2009. *How Modernity Forgets*. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511627187

Connerton, P. 2011. *The Spirit of Mourning: History, Memory and the Body*. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511984518

Conway, R. 2012. Revisiting the past to shape the future. *Muse* 2: 14–15.

Haraha, S. 2007. The Papua New Guinea National Museum and Art Gallery as a modern Haus Tumbuna. In *The Future of Indigenous Museums. Perspectives from the Southwest Pacific*, ed. N. Stanley, pp. 137–150. New York and Oxford: Berghahn.

Hill, D. 2012. One community's post-conflict response to a dictionary project. *Language, Documentation and Conservation* 6: 273–281.
http://hdl.handle.net/10125/4554

Hill, D. 2014. Heart of the community. *Muse* 2: 14–15.

Hogbin, I. 1964. A *Guadalcanal Society—The Kaoka Speakers*. New York: Holt, Rinehart and Winston.

Jacobs, M. 2014. Development brokerage, anthropology and public action. Local empowerment, international cooperation and aid: safeguarding of intangible cultural heritage. *Volkskunde* 3: 299–318.

Kopytoff, I. 1986. The cultural biography of things: commoditization as process. In *The Social Life of Things: Commodities in Cultural Perspective*, ed. A. Appadurai, pp. 64–92. Cambridge: Cambridge University Press.
https://doi.org/10.1017/CBO9780511819582.004

Kwa'ioloa, M., and B. Burt. 2007. 'The Chiefs' Country': a Malaitan view of the conflict in Solomon Islands. *Oceania* 77(1): 111–127.
https://doi.org/10.1002/j.1834-4461.2007.tb00008.x

Macdonald, S. 2010. *Difficult Heritage. Negotiating the Nazi Past in Nuremberg and Beyond*. Abingdon and New York: Routledge.
https://doi.org/10.4324/9780203888667

Morphy, H. 2020. *Museums, Infinity and the Culture of Protocols. Ethnographic Collections and Source Communities*. London: Routledge.
https://doi.org/10.4324/9780203705186

Stanley, N., ed. 2007. *The Future of Indigenous Museums. Perspectives from the Southwest Pacific*. New York and Oxford: Berghahn.

Szabó, K. 2018. Shell money and context in Western Island Melanesia. In *Pacific Presences. Oceanic Art and European Museums*, ed. L. Carreau, A. Clark, A. Jelinek, E. Lilje, and N. Thomas, pp. 25–38. Leiden: Sidestone Press.

Thomas, N. 2010. Museum as method. *Museum Anthropology* 33(1): 6–10.
https://doi.org/10.1111/j.1548-1379.2010.01070.x

Thomas, N. 2015. *A Critique of the Natural Artefact: Anthropology, Art and Museology*. Gordon H. Brown Lecture 13, Art History Lecture Series. Wellington (NZ): University of Victoria.

Thomas, N. 2019. What are museums for? *Apollo Magazine*, 23 September, pp. 14–18.

Torrence, R., and E. Bonshek. 2013. Community-driven time capsule. *Explore* 35(2): 28–29.

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Tomoko: Raiding Canoes of the Western Solomon Islands

Peter J. Sheppard

Department of Anthropology, School of Social Sciences,
University of Auckland, Auckland 1142, New Zealand

Abstract. The Australian Museum has in its collection a fine example of a large plank-built raiding canoe from the Western Solomon Islands. This canoe was obtained in 1915 from Roviana Lagoon where it is known as a *tomoko* in the Roviana language. These canoes are examples of great technical ability and artistry. They have been and continue to be important cultural symbols in the Solomon Islands. In this paper I review the history of the *tomoko* raiding canoes in the Western Solomons and describe their role in 19th century traditional society. I discuss efforts by the British colonial government first to destroy them and the political system they represented, and then to co-opt them as symbols of the new colony and subsequently the nation-state.

Introduction

In the centre of Roviana Lagoon on the island of New Georgia in the Western Solomon Islands lies the small island of Nusa Roviana (Fig. 1), just east of the modern town of Munda. In the 19th century, this island was the political and religious focus of the Roviana people, the largest language group in the Western Solomons. Roviana's population and geographical centrality made it the focus of European trade at that time. This was despite its reputation as the home of fierce head-hunters, renowned for their 'outrages' committed against Europeans, widely publicised at that time in the newspapers of Australia and New Zealand. Nusa Roviana was densely populated in the 19th century, with a series of hamlets running along the coast below a large hillfort constructed of stone and earthen walls and terraces, spread over a distance of 700 m along the spine of the ridge in the centre of the island. Climbing the ridge from the northern end and moving south, one encounters a series of defensive walls and shrines associated with powerful ancestors and with ritual activities concerning warfare (Sheppard *et al*., 2000; Thomas *et al*., 2001). At the southernmost end of the fort, its highest and most heavily defended point, there is a good view over the lagoon and towards the approaches to Roviana by sea. The last shrine is encountered here. It is decorated with a small carved head of a dog, said to be the remains of a once-living dog and culture hero called *Tiola*, the watchman of Nusa Roviana. In 1997 Mr Silas Oka of Patmos village, in the interior of Roviana Lagoon to the east of Nusa Roviana, recounted a long story involving the adventures of *Tiola* and some animal companions as they paddled around the Western Solomons. This voyage culminated with *Tiola* arriving at Nusa Roviana and turning into a human seeking marriage with a chief's daughter. *Tiola* hoped to impress the chief by presenting new ideas to the people:

> *Tiola* gave this idea [a new house style] because he wanted to marry the *banara*'s [a *mbangara*, a chief of Roviana] daughter. But still, the *banara* wouldn't allow the marriage. So *Tiola* came up with another idea. He asked the people to build a canoe. Standing up he said the canoe should be in the shape of his body. 'Put the ribs of my body upside down so they can hold the planks together.' So, the people started to follow this design. It was the people from Vuragere [western side of Nusa Roviana] who started the war canoe (*tomoko*) with *Tiola*. The original war canoe design was more curved on the long axis than the modern one which is flatter. After they finished the war canoe *Tiola* said it was time to launch it. When they built the first one, they built it on the ground so they were sewing it with some roots which were lying on the ground. Therefore, when they wanted to launch it, they pulled the roots and the canoe came apart. *Tiola* told them to put logs (*langono*) underneath and build the canoe on top of the logs. They rebuilt the canoe and sewed it together again and carried it down to the sea. They asked 'What should we put in the boat?' *Tiola* said 'My statue will be the one

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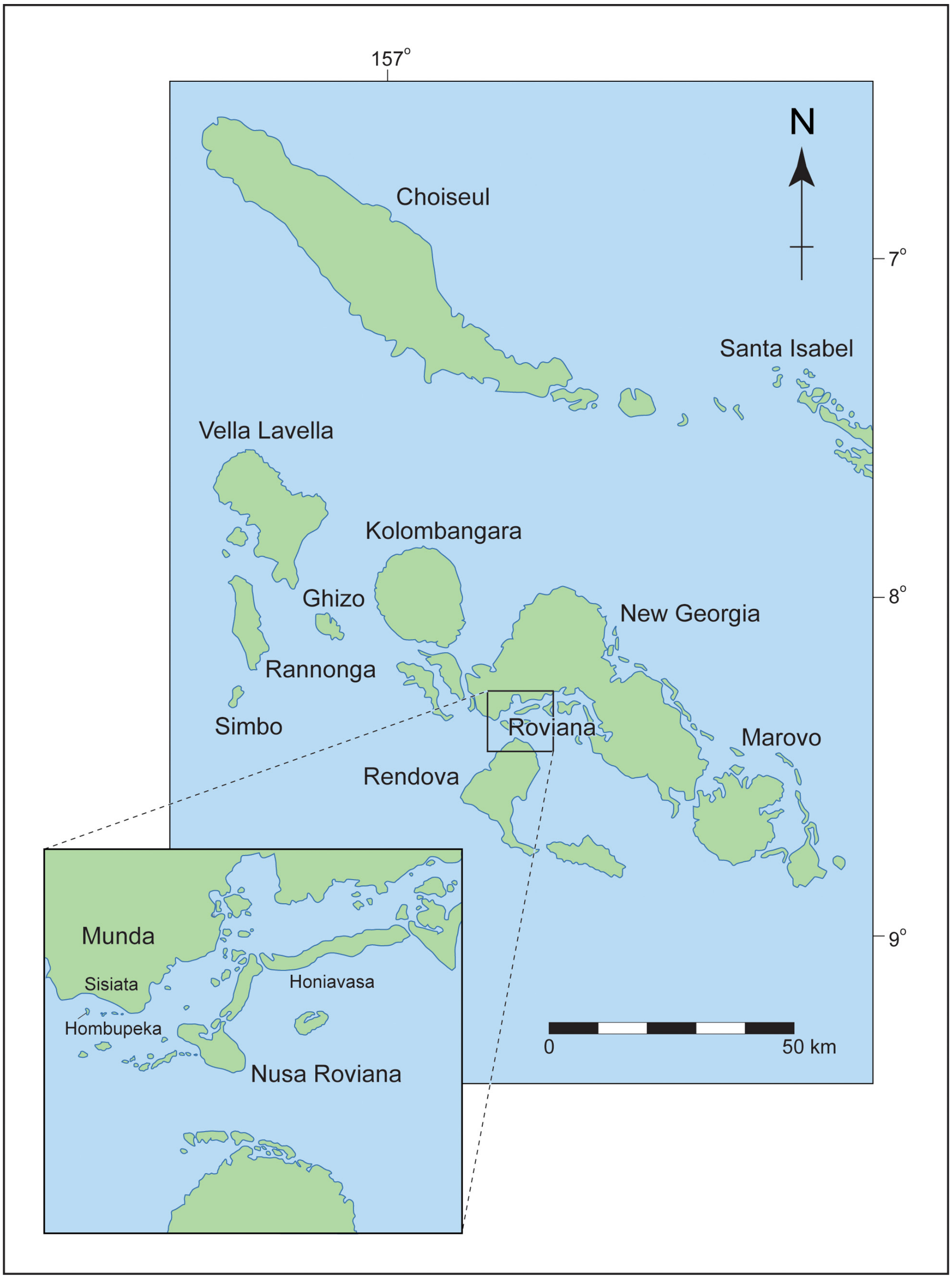

Figure 1. Map of the Western Solomon Islands.

> in front (*nguzunguzu*).' So, the people made a carving of *Tiola's* head and hands and put it on the front of the canoe. (Silas Oka video interview Patmos (Ndora Island, Roviana Lagoon) Sept. 1997; translated from Roviana by Kenneth Roga) (see also Aswani, 1999).

The vision of a Roviana raiding canoe or *tomoko* as the body of a dog is apt given the upraised sweeping 'tail' at the stern of the canoe, the ribs holding planks, rather than dugout construction, and the carving of a dog-like prognathous head (*nguzunguzu*) placed just above the water line at the prow (Hviding, 2014). This plan of a plank-built canoe with upraised stern and prow is common in the western and northern Solomons and there is no reason to think the design originated in Roviana, however, the *nguzunguzu* decoration is characteristic of Roviana and the New Georgia group.

Europeans visiting the Western Solomons in the 19th century were struck by the technical virtuosity and beauty of these elegant canoes and that, plus their association with head-hunting and raiding, undoubtedly made them attractive to the museums of the world. Soon after the establishment of the British colonial government in 1893, and at a time when the colonial authorities were seizing and destroying canoes in an effort to end head-hunting, traders and administrators facilitated the movement of many canoes to Australian and European museums (e.g., the Australian Museum, The National Museum of Victoria, the British Museum, the Vatican Museum).

The canoe held in the Australian Museum (E23373) (Fig. 2a,b) was built sometime before 1910, and was acquired by Harry Wickham, son of Frank Wickham, a trader who

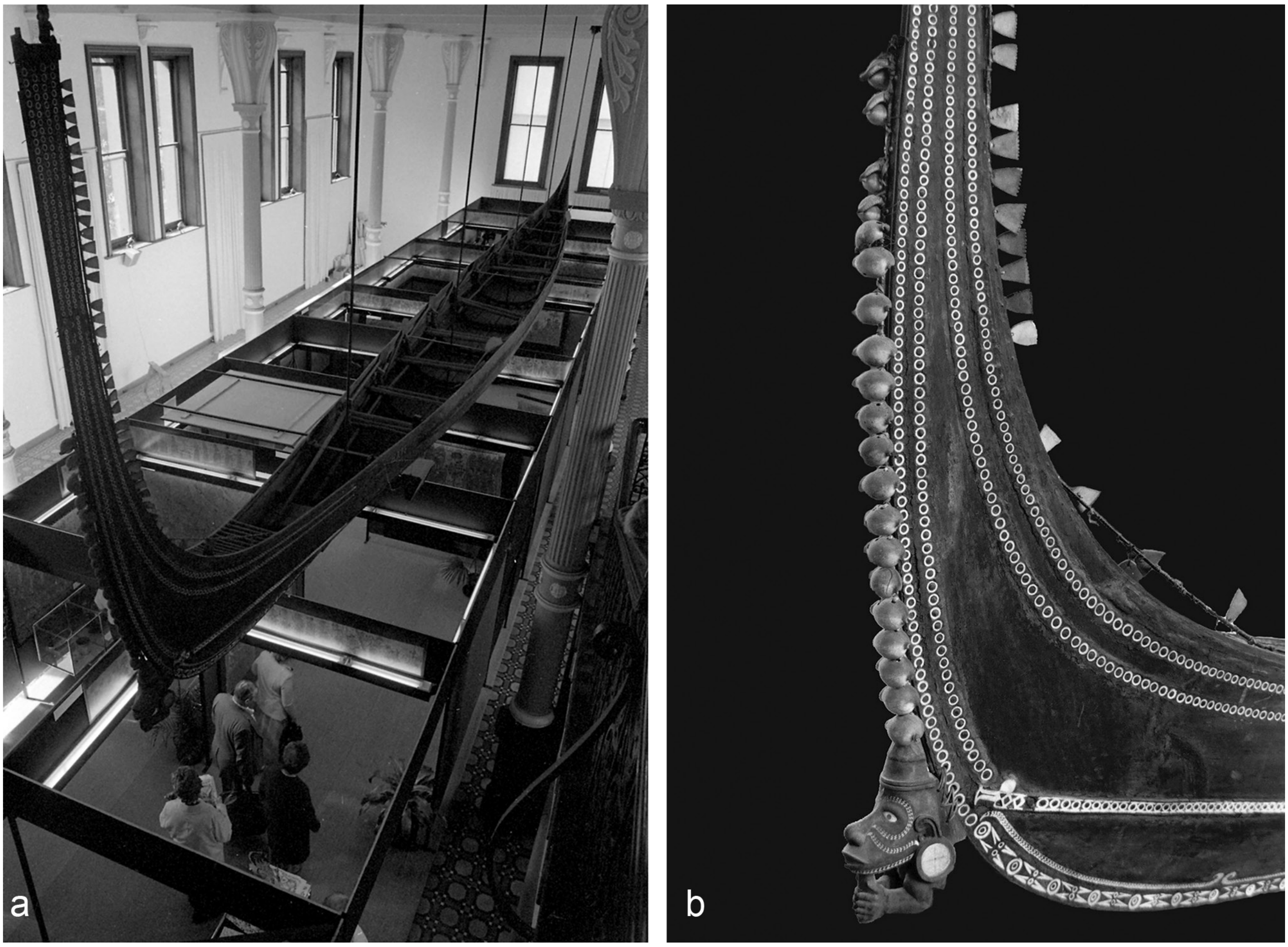

Figure 2. (*a*) Roviana t*omoko* held in the Australian Museum collection (E23373); (*b*) prow of the canoe showing *nguzunguzu* figure. Photo G. C. Clutton. Courtesy of Australian Museum Archives AMS391/M1289_19.

had lived in Roviana Lagoon since 1881. In 1915 Wickham transported the canoe to Sydney where it was eventually donated to the Australian Museum. The appearance of the canoe in Sydney attracted much attention and was reported in many local papers. Upon its arrival in Sydney Harbour, on the 21st of July 1915, the Sydney Morning Herald, which had been reporting for many decades what it described as 'outrages of the Roviana head-hunters', made much of that connection:

> A war canoe, nearly 80 ft long, and with a towering prow, was brought to Sydney yesterday by the steamer Kulambangra, from the Solomon Islands. As the gift, per Mr. W. T. Crick, of Mr. Harry Wickham, a planter In the Islands and the brother of Mr. A. Wickham the well-known swimmer, to the Australia Day Fund. It will shortly be either raffled or sold at auction, and it is expected that as much as 1000 guineas will probably be bid for its possession. The body of the great canoe, which will hold 28 men and which has actually taken part in various raiding expeditions, is hewn out of a single piece of timber, but the bow, with its grotesque war-god carved underneath the soaring and shell-bedizened prow, is joined on separately, and is inlaid with three rows of mother-of-pearl. Each stage of the building of this canoe was celebrated by feast and sacrifice. The canoe is at present at the Museum in College Street, where it will be on view for some days before being disposed of on behalf of the Australia Day Fund. (Sydney Morning Herald, 1915a).

The Sydney Sun of July 18th, 1915 printed a picture of this canoe while The Daily Telegraph of 31st July reported as follows:

> HEAD HUNTERS' CANOE
> A Solomon Island head-hunting canoe has been presented to the Australia Day Fund by Mr. H. Wickham, of Hobupeka, Roviana Lagoon, New Georgia, British Solomon Islands. The canoe is 46ft. long, with a beam of nearly 4ft. The elevated bow and stern pieces are 10ft. high. The former is decorated with white egg cowry shell, whilst the hull is inlaid with mother of pearl shell. Mr. W. T. Crick, who is trustee of the canoe on behalf of the Australia Day Fund, has agreed to donate the canoe to the trustees of the Australian Museum, Sydney, if £1000 is raised for the fund. Subscriptions, endorsed Canoe Fund, Australia Day, should be sent to Mr. R. Etheridge of the Australian Museum, or to the Australia Day Committee. The canoe is on view at the Museum (Sydney Daily Telegraph, 1915).

Additional reporting in the Sydney Morning Herald of July 31st stated that: 'It is reported that there is a move afoot to purchase the canoe and send it out of the country' (Sydney Morning Herald, 1915b). The money raised was apparently to be donated to the Red Cross for the Wounded Fund, referring to support for wounded WWI soldiers (Sydney Sunday Times, 1915), and as part of the very first Australia Day celebrated on 30th July 1915. How much was donated through a box at the museum, or directly, is unreported. However, the canoe appears to have remained where it was first displayed. In 1921 Mr William Thorpe described the canoe in the Australian Museum Magazine upon its display, after some logistical effort, in the galleries as '… a thing of both beauty and intricate construction.' (Thorpe, 1921).

It is not clear why Harry Wickham sent the canoe to Sydney. He had attended school in Sydney. As well, together

Figure 3. Hingava's canoe house at Sisieta Munda, Roviana Lagoon. British Museum Oc, B75.1. Photo Charles Woodford 1887(?). Courtesy of the © Trustees of the British Museum.

with his brother Alec, a renowned swimmer, Harry is credited with introducing the Australian crawl (a.k.a. 'freestyle') to Australia from Roviana. Alec had at that time been a Sydney resident for 15 years and his father Frank had moved to Sydney after selling his Solomon holdings in 1908. Harry Wickham was raised in part by the Roviana chief H(I) ingava (Osmond, 2013), who was a close friend of Frank Wickham, living at his trading station on the small island of Hombupeka, just offshore from the hamlet of Sisieta. Hingava had two large canoe houses at Sisieta, in modern Munda (Fig. 3). A photograph taken by John Thurston, High Commissioner of the Western Pacific, on a visit to Munda in 1894, shows a large *tomoko* (Fig. 4) very probably owned by Hingava, offshore at Sisieta. Hingava died in 1907 (Edge-Partington, 1907) and the canoe photographed by Thurston may be the same one donated by Wickham, although it is also reported to have been built for Harry Wickham (Thorpe, 1921) in 1912 and used in races associated with the Methodist church in Munda (Mitchell, 2015). If it is not the same canoe, then the canoe in the Thurston photo is from a very similar provenance.

The estimated value of £1000 for raffle or sale of the canoe, was a considerable sum with a purchasing power of over $100,000 in today's Australian currency (Hutchinson and Ploeckl, 2020). Such a high value reflected the dramatic presence and technical artistry of the canoe.

In the Western Solomons it was the single most economically valuable item possessed by chiefs and their people, and technically the most complicated. It was also central to the politico-religious complex which underlay head-hunting and formed the cultural focus of the societies of the region. As such it played a pivotal role, both in the expansion of the head-hunting complex in the 19th century and the struggle between chiefs and settler colonialism wishing to create an environment more receptive to western capitalism. The donation of such a canoe by the son of Australian trader Frank Wickham and a Solomon Island mother, Ameriga, from Buin in Bougainville (Osmond, 2013), symbolises the development of this new colonial Solomon Island identity.

Solomon Island Canoes

In the sheltered lagoons and short passages between islands in the Solomon Islands, paddle canoes are efficient means of travel and are the most common form of water transport. Haddon and Hornell, in their wonderful study of *Canoes of Oceania* (Haddon and Hornell, 1936), note only a few small outrigger canoes made by various groups in the main Solomon Islands. Nowhere do we find large sea-going outrigger sailing canoes built on dugouts such as found in the Polynesian Outliers, or to the north and west in New Guinea. Throughout the Solomons, large paddle canoes are commonly used for inter-island trade and raiding, while many smaller canoes are used for fishing or local transport. The large canoes are plank-built and follow a similar general design throughout the Solomons, with variation in details such as the height of the peaks at the bow and stern and in the presence of washboards. All would appear to have had some form of a keel as a specially designed plank or set of planks onto which plank strakes were attached. Haddon and Hornell (1936 vol. 2: fig. 56) describe four types of plank-built canoes characteristic of different regions along the

Figure 4. Roviana *tomoko* at Sisieta Munda, Roviana Lagoon. Photo John Thurston 1894 (Amherst and Thomson, 1901: 566).

Solomon chain. Their type 1 *mon* canoe is found throughout the Western and Northern Solomons.

> The typical *mon* is a plank-built canoe of which the edges of the topstrakes are continued in an uprising curve to form a peak of variable height at each end of the canoe (figs. 66, 70). This type is characteristic of the central islands: New Georgia, Mandegesu [Simbo], Ganongga [Ranongga], Vekevekela [Vella Lavella] and Choiseul. It extends to a gradually decreasing degree as far north as Nissan and is also found in Northwest Ysabel [Santa Isabel] and to some extent in Florida [Ngella] (Haddon and Hornell, 1936 vol 2: 82, names in square brackets added).

In their figure 56 Haddon and Hornell extend the distribution of this *mon* form into the Shortland Islands, Bougainville and Buka, and report its presence in the Bismarck Archipelago as having a limited southerly distribution: 'The *mon* of south New Ireland occurs in small numbers from Lamassa at the southwest end to the whole of the Kandass district, in the Duke of York Islands and is found sporadically in neighboring [*sic*] areas' (Haddon and Hornell, 1936 vol 2: 123). They cite Powell (1884) as to the opinion that the natives must have learnt the art of building them from the Solomon Islanders. This distribution of the *mon* form follows closely the distribution of the Northwest Solomonic language family (Ross, 1988), which today divides the Western and Northern Solomons from the Southeast Solomons between Isabel and Malaita. This division is also seen in modern human DNA evidence which maps onto this linguistic pattern (Pugach *et al*., 2018). A similar pattern is seen in the archaeological evidence with a distinctive Late Lapita age (c. 2600 cal. BP) ceramic tradition found from New Ireland south through the Western Solomons where it ends on Santa Isabel (Sheppard and Walter, 2006; Sheppard and Walter, 2009; Walter and Sheppard, 2017; Garling, 2007). It is possible that the plank-built canoe tradition spread throughout the Solomons in the late-Holocene where it subsequently diversified over time. It was certainly present by 1568 AD, the time of the Spanish exploration of the Solomon Islands under Alvaro de Mendaña. At Estrella Bay, on the northeast coast of Santa Isabel where the Spanish expedition first landed, they had several encounters with crescent-shaped canoes which the people called *mola*, meaning in Roviana a built canoe as opposed to a dugout (Waterhouse, 1949: 75).

> Their canoes are very well made and very light; they are shaped like a crescent, the largest holding about thirty persons. They are so swift that although our ships under sail started two leagues ahead of them, with a good wind and all sails set they caught us up within the hour. Their speed in rowing is marvelous; they row in the fashion of the people of Cartagena (Amherst and Thomson, 1901: 109).

> As soon as the natives saw us a great many canoes began to come off. They were long, and pointed at the ends in the shape of a crescent moon, and full of Indians equipped for war, with their bows and arrows and clubs and lances of palm (Amherst and Thomson, 1901: 227).

Within the *mon* category, there is considerable variation in decoration and it is the subgroup characteristic of the New Georgia Group (New Georgia, Rendova, Simbo, Rannonga, Ghizo, Kolombangara, Vella Lavella, Vangunu) which is the most highly decorated and carries various forms of the *nguzunguzu* (Roviana) figurine at the water line on the bow (Fig. 2b). While surveying New Georgia on board HMS *Penguin* in 1893–1894, Lieutenant Somerville was the first to describe these canoes in detail:

> The canoes of New Georgia are built, as in the rest of the Solomon Islands, on the Malay model, with high prow and stern post. Nothing can exceed the beauty of their lines, and carefulness of build—considering the means at disposal—or their swiftness when properly propelled. They are a most astonishing revelation of scientific art in a people little removed from complete savagery. These graceful boats are of all sizes, from that of the one-man, of 8 feet long, to the great war canoe, or *tomako* [*sic*], of 40 to 50 feet, which will hold perhaps thirty-five men. Whatever the size, they are all built on the same lines, and in the same manner (Somerville, 1897: 369).

Somerville described in detail the decoration of the canoes and especially the distinctive figurine mounted at the bow.

> The function of this *Totoishu* [Marovo] is to keep off the *Késoko*, or water fiends, which might otherwise cause the winds and waves to overset the canoe, so that they might fall on and devour its crew. This figure (*Totoishu*) has a more or less human face, of malevolent, and extremely prognathous countenance; the nose and chin being almost at a right angle to the curious pointed head, the chin resting on his two closed fists (Somerville, 1897: 371, square bracket added).

The anthropomorphic dog-like head is characteristic of the large raiding canoes of the New Georgia Group. Known as *toto ishu* in Marovo Lagoon, *nguzunguzu* in Roviana and *nujunuju* in Vella Lavella, these figurines are found on canoes constructed by all the language groups in the region including the non-Austronesian speakers of Vella Lavella and Rendova. In Vella Lavella the entire cultural complex associated with head-hunting was adopted directly from their Austronesian neighbours (Sheppard *et al*., 2010). I have argued (Sheppard, 2019) that the head-hunting complex spread throughout the New Georgia group sometime after 1600 AD, when the Nusa Roviana hillfort was constructed, and the shrines associated with late-period Roviana appear. Such shrines were constructed in the last several hundred years in Vella Lavella and head-hunting seems to have primarily impacted islands outside the New Georgia Group (e.g., Choiseul and Santa Isabel) in the 19th century, when it intensified under the effects of access to European weapons and the desire to obtain commodities such as turtle shell used in European trade, that was abundant in the straits between Choiseul and Isabel. However, in 1768 Bougainville reported seeing a canoe in Choiseul Bay bearing a *nguzunguzu,* although the canoe might have crossed from Vella Lavella (Forster, 2000: 319).

Manufacture

The first detailed account of *tomoko* manufacture is provided by Somerville:

> The planks are planed down to about half an inch in thickness or even less, but leaving in the centre of each a strengthening rib, which projects about three-quarters of an inch along the whole length. The two corresponding planks of opposite sides of the future canoe are placed together and bent between posts struck into the ground at the necessary curve, and when each pair of planks has thus received its proper bend, the whole boat is stitched together with a three-plait of coconut fibre, or of some bush material, through holes bored about 2 inches apart, along the sides of the planks. The seam is then caulked with a white sticky substance (*Tita*, obtained from the egg-shaped fruit of the *Parinaria Laurinum* [sic]) by rubbing its surface with a rough piece of stone. This substance, at first white and sticky, becomes when dry, black, and nearly as solid as pitch, and makes the boat watertight. It must be kept under shelter from rain during the hardening process, which takes from a week to ten days, according to weather. The shape of the boat is preserved by half a dozen strong ribs, each cut from a single piece of wood, the central one being much stronger than the remainder. At the places where the ribs are to be secured, the mid rib of the planks is left much thicker for a few inches, and, by means of a stout cane lashing, passing round the rib and through two holes in this extra piece, the sides of the boat are kept together. (Somerville, 1897: 369–370).

Charles Woodford, the first Resident Commissioner of the Solomon Islands Protectorate (Woodford, 1909), provides essentially the same description although he reports: ‘The planks, after being roughly adzed out, are lashed tightly together, the corresponding planks from each side of the future canoe, outsides together, and placed in the canoe houses to season before being finally assembled’ (Woodford, 1909: 509–510). This would allow the wood to bend and cure to shape. Recent descriptions of canoe construction and decoration are provided by Edvard Hviding (2014) based on interviews with elders in Marovo Lagoon at the eastern end of New Georgia, and Shankar Aswani (1999) based on interviews with elders in Roviana (see also Officer, 2012[1901]). Hviding (2014: 106) notes that the tall, straight growing lightweight wood of the *toba* tree was favoured for the planks of the canoe and that although somewhat brittle when dry, *toba* wood is durable and also easy to bend. The same wood was used in Roviana and called *tobo* (Waterhouse, 1949: 184). The planks of the Australian Museum canoe are probably of this wood. A variety of other woods, chosen for their mechanical properties, are used for other parts of the canoe and are described by Hviding (2014) and Aswani (1999).

Early writers describing the construction of these canoes marvelled at the ability of the New Georgia people to create such fine woodwork with ‘stone-age tools’ of stone and shell. Woodford (1909: 508) comments: ‘It is difficult to understand how the natives were able, before they became acquainted with iron tools, to adze down the canoe planks to the requisite degree of thinness and shape them with the aid only of stone implements’, although he also reports that: ‘For boring the holes the natives make use of a pump drill, tipped with a flake of chalcedony, and they appear to adhere to this primitive tool in preference even to an ordinary awl or gimlet’ (Woodford, 1909: 509). It is generally assumed that the appearance of iron tools in the 19th century greatly increased the efficiency of economic activity in the Pacific. Hviding (2014: 105, 108) suggests local traditions indicate it would take five to six years or more to make a war canoe using stone and shell technology, and that the appearance of metal tools sped up the production of canoes and intensified head-hunting. Somerville (1897: 371) reported it took two years in 1893, while Woodford reported it took 18 months to have a 24-foot scale model built.

Even though people built high-quality *tomoko* before the arrival of metal, one widespread assumption was that earlier tools were inefficient. Experimentation in the manufacture and use of stone tools for adzing planks in New Zealand has shown that the cutting edge of stone adzes can be very sharp and maintain their edge with re-sharpening (Turner, 2000). In the hands of a skilled craftsman who knows how to haft and re-sharpen a stone adze head, it seems there is little improvement in cutting efficiency with metal. What metal does allow is much easier hafting, reuse and sharpening, perhaps reducing the expertise needed in these tasks? The skill in canoe manufacture would appear to have always been in the design, layout and execution of cutting. What tools were used before the introduction of metal is unknown, as by Somerville's time he was unable to procure any stone tools other than the chert pump drill bits that seem to have lasted well into the 20th century. Some stone adze heads have been recovered in Roviana (Felgate, 2003) although the most common discovery in areas such as the surface of the slopes of Nusa Roviana is shell adze or axe heads made from giant clam (*Tridacna* sp.).

The speed and ease of manufacture relates to the economics of canoe production and the greater head-hunting economy. The economy of the New Georgia group made use of a shell money exchange system, which allowed the near commodification of goods and facilitated inter-island trade in food, material culture and services (Aswani and Sheppard, 2003; Sheppard, 2019). The shell rings of varying value used in these exchanges were known in Roviana generically as *poata*, with the highest valued ring, called *bakiha*, made of fossil *Tridacna* shell showing a distinctive yellow stain. These were commonly mounted in fibre supports (*medaka*) and worn around the neck by chiefs and wealthy individuals.

Other *poata* included the often-smaller forms without the yellow stain, known simply as *poata,* and *hokata*, which were narrow arm rings of semi-circular cross-section worn above the elbow, seemingly made of fresh shell (Sheppard and Walter, 2014). A. M. Hocart (MSS*a*), an anthropologist conducting research in Roviana and Simbo in 1908, provides a table of value and commodity equivalences for the different forms of *poata*. In 1908 a large *bakiha* was worth 15 *hokata* and a large *poata* worth five. A basket of taro could be purchased for one *hokata* and a *tomoko* was valued at one *poata* per rib, with the average canoe seating 30 men having 11–13 ribs and costing 4 *bakiha*. A large *bakiha* might take up to 12.5 days work to manufacture if we use the equivalence of 1500 copra to one *bakiha* and the time required to produce that copra (Bennett, 1985: 87). A large *tomoko* might, therefore, cost the equivalent of 6000 copra, or 50 days of labour. Chiefs (*mbangara*) in Roviana could call upon the labour of ritual and technical specialists in their *mbutubutu* or cognatic corporate group, and increasingly in the 19th century, the labour of captives taken in head-hunting raids, such as shown by the shell ring manufacturer from Choiseul photographed in Nusa Roviana in the late 19th century (British Museum Oc,ca44.61). Again, it is possible that the introduction of metal wire for sawing shell, and quartz sandstone for grinding, may have sped up the process of shell ring production and the financing of *tomoko* construction.

The construction and decoration of the canoe (Waite, 1990; Hviding, 2014) was not a simple commodity transaction but a social event, and an ongoing relationship between the artisans and the chiefs sponsoring construction. As such, it was surrounded by ritual and feasting. Hocart (MSS*b*) in 1908 reported on the production of a large plank-built bonito fishing canoe in Simbo, based on observation of construction of a model, canoes in progress and discussions with specialist artisans called *tioni roverove*, that is men with an eye for measurement, perhaps equivalent to the Roviana specialist *matazonga*, capable of envisaging and executing designs of houses, canoes, shell valuables and discovering through ritual the location of the fossil shell used in *poata* manufacture (Aswani and Sheppard, 2003: 65; Waterhouse, 1949: 150). Both canoes used in trolling for bonito and in raiding needed to be fast, and both activities were viewed as similar forms of hunting (Hocart, 1935; Barraud, 1972). In the following quotation Hocart notes the making of taro and ngali nut (*Canarium* sp.) puddings for feasts at different stages of canoe construction, as well as the payment of the workers with shell money.

> The keel, which is sometimes in two parts, is first prepared. Then the end garboard strakes (*onda*) are stitched on. Then puddings are made. This is the consecrated description of a small feast for which no pig is killed. Then come the middle garboard strakes (*lokuana*); then the end second strakes, after which puddings are made. The middle second strakes are put in next, followed by the end third strakes (kimo), then the middle third strakes. Then the ends are given a rest while the fourth strakes and the gunwale strakes are added to the middle part. Then there are puddings.
>
> The caulking either comes in here, or after the large planks which form the raised ends, and are called *kapukapu*, have been added. These raised ends require much skill, and an expert has to be called in in the case of the finer canoes. About half a dozen men were mentioned as being such experts [*tioni roverove*]. The art is not taught, but a man just watches another. These planks are stitched together along the whole of their join. …. For caulking they put the canoe on a platform. The caulking is a paste obtained from the fruit of the *Tita* tree (probably *Parinarium laurinum* A. Gray) and is itself called *tita*. Puddings are eaten on the day of caulking. The canoe is painted next, and ribs are put in. An ordinary canoe is then complete. The finer ones have to be inlaid. There is often a little prognathous figure at the prow which is familiar in museums. It is called *Aunju?unju*. *Nuzhu* in Roviana means mouth (Hocart, 1935: 98; additional notes on this can be found in Hocart, MSS*b*).

Both the caulking and provision of shell pieces for inlay decoration generally called for a group effort. As described to Aswani in Roviana, the caulking required preparation of the *tita* paste from seeds and rapid application, inside and out, with men assigned different segments of the canoe. When dry, after three to seven days, the canoe was painted black with paint made of charcoal from the *domu* tree (*Bischofia javanica* Blume) and then varnished with the sap of another plant *lalusu* (Aswani, 1999). The elaborate pearl shell inlay required another large group effort to produce the great number of pieces required for the highly decorated *tomoko*. When describing the decoration of canoes on Nggela or Isabel, Penny reported that:

> When a chief had a canoe built, he requisitions his dependants for these prepared pieces—1000 or 2000 per village—which the artist fashions into devices and patterns on the sides of the canoe. I have heard of 50,000 of these pieces being used to inlay one canoe. This entails considerable expense in food and native [shell] money (Penny, 1888: 79–80).

Head-hunting and Tomoko

The completion of a new canoe or new canoe house (*paele*) required an inauguration through the taking of heads. The canoe needed to be 'wetted' or *vapenja*, which Hocart interpreted as moistening or wetting, presumably with blood. The occasions of *vapenja* are new canoes, new communal houses (*paele*, *njelepande*), new skull-houses, the death of a chief, and the release from confinement of a widow (Hocart, 1931: 303). Each of these events were to be organised and financed by the chief or chiefs resident in the hamlet or hamlets in which lived the *mbutubutu* over which the chief had influence and responsibility.

Figure 5. Food preparation trough (*hao*) taken from a canoe house on Nusa Roviana (Vuragare?) on 25 September 1891 by Captain Edward Davis, HMS *Royalist*. British Museum Oc1903,1007.1. Courtesy of the © Trustees of the British Museum.

This new canoe bearing a new name (e.g., *Kiso* shark, *belama hite* little frigate bird (Waterhouse, 1949: 127) could be sent out alone, but most often with a group of canoes belonging to the *mbutumbutu*, each manned by 24 or more men. The object of the raid in the 19th century was to obtain heads, but also captives (*pinausu*) (McDougall, 2000) for sacrifice, or to serve as captive labour, although ultimately such captives were potentially able to marry into and strengthen the *mbutubutu.*

The object of the raid was to enhance the *mana* of chiefs who provided the canoes and financed the activity and in whose canoe house any heads would be displayed, lining the rafters. The political power of the chief, and his efficacy or *mana* (Dureau, 2000), derived from powerful ancestors from whom he descended, was made manifest by success in taking heads and captives. The size of these raids is debated (Lawrence, 2014: 92), with some early commentators talking of hundreds of canoes going out from New Georgia during the calm weather of December and January to raid Isabel and Choiseul. Such very large fleets seem unlikely, however large numbers could well have been assembled. Chiefs called upon chiefs, often relatives, in neighbouring hamlets to join together in raids and provide additional canoes (Hocart, 1931). How many canoes might be found in a small village or Roviana hamlet is unknown. At the time Woodford visited in 1887, Jackson (1978: 96) reports that Sisieta had five *tomoko*, some English-built whaleboats and a 'large arsenal'. The elders of Pienuna village in Rannonga recalled in 2003 the names of seven canoes from their village in the early 20th century (Richards, 2012: 208). Before the impact of European disease, the population of Roviana was easily more than the 3–4000 estimated by Somerville in 1893 (1897: 359) in the villages visible to him in the open western end of the Lagoon. The coasts of Nusa Roviana are today mostly uninhabited, but the former hamlets recorded by Hocart display the remnants of large stone wharves, probably associated with canoe houses and with a chief in that hamlet or section (Nagaoka, 2011). In one village on Nusa Roviana, Woodford (1888: 360) reported in 1886 five war canoes in the principal canoe house, with the entire male population away on a raid. Adding together the potential number of canoe houses in the western end of the lagoon with those in villages in the Kalikoqu or eastern end of the lagoon, those in Vonavona Lagoon to the west of Munda and those from the Roviana people in north Rendova, the total number of war canoes is potentially more than 30. Woodford (1888) reported 38 heads brought back from separate raids to five different villages in Roviana during a fortnight, while he visited in 1886. The fleet of 20 canoes and 500 men reported to have been led by Hingava against Santa Isabel during the latter end of Somerville's (1897: 399) first season in 1893 in New Georgia does not seem impossible. In 1859, the crew of the *Clarence Packet,* upon leaving Rendova Harbour, came upon what may have been a returning raid, or an attempt on the ship, which seems to have included canoes from Nusa Roviana. The report of the visit to Rendova, written by a passenger and published in the Sydney paper, the *Empire* of Dec 26th, 1859 exclaimed:

> … we were thunderstruck to see an immense number of canoes (estimated at from 150 to 200), hiding behind these two islands, and when they saw us coming out of the harbor, they began paddling towards us; many of these canoes had from thirty to forty men in each… (Empire, 1859).

The departure and return of the head-hunting canoes were associated with considerable ritual and feasting, designed to ensure the success of the expedition, and celebrate and reward success with both feasts and shell money being given to the warriors by chiefs (Hocart, 1931). In each large canoe house, there appears to have been a large food preparation bowl or trough used in ceremonies associated with head-hunting, possibly the launching of a raid. In 1887, Charles Woodford witnessed at Sisieta part of the inauguration of a 30-foot long bowl (*hao*) in Hingava's canoe house, where 22 warriors arranged along the sides of the bowl, in full war regalia, rhythmically pounded the taro and ngali nuts to make feasting pudding for half an hour, after being vigorously addressed by Hingava (Woodford, 1888; Edge-Partington, 1903). A very similar trough (Fig. 5) was taken from a canoe house on Nusa Roviana, by Captain Edward Davis of HMS *Royalist* in 1891, before the villages were burnt as part of a punitive raid. This elaborately ornamented trough is decorated at its head with a crocodile swallowing a human head. The ritual pounding sounds like a *tomoko* being paddled with rhythmic strokes by its crew of 22 warriors (see also Waite, 2000: 122; Were, 2019).

Raiding may have been mostly within the New Georgia Group before the 19th century, but by the mid-19th century raiding for heads, as opposed to local revenge attacks (Hocart, 1931), was regularly moving out into neighbouring islands, with raids as far east as the Russell Islands and western Guadalcanal (Bathgate, 1985), a distance of 280 km from Roviana. *Tomoko* were regularly reported outpacing European vessels, with top speeds up to ten knots and speeds of six knots maintained for long periods without rest (Officer, 2012[1901]; Somerville, 1897). Regular raids took place into Choiseul and Santa Isabel where the collection of hawksbill turtle shell in the Arnavon Straits for European trade was combined with head-hunting. This combination allowed chiefs to both acquire *mana* and the means to engage with European traders, using the most highly valued commodity available, through chiefly sponsored activity (Sheppard, 2019). By the time Woodford sailed along the coasts of Choiseul and Santa Isabel in 1887, the coast appeared abandoned with populations having moved to the interior or to the east or west, away from the activities of the head-hunters (Woodford, 1922). This time in Santa Isabel was known as the time of flight when entire villages were destroyed and often there were not enough people left living to bury the dead (White, 1991).

Tomoko and Western Trade

> They were there before the missionaries came and it was not because of the missionaries that head-hunting stopped. It was the time when the *Pagan* [possibly HMS *Penguin* 1894] returned with Mi Gereka looking for those who still went out head-hunting. They went to Malaita and took Kamkamea and forty other Malaitans. They carried guns and when they came to Batuna just inside Marovo Lagoon they were lowered down to a small rowboat. Then Kamkamea started to order the people in the village, telling them that head-hunting must stop. (Silas Oka video interview Patmos (Ndora Island, Roviana Lagoon) Sept. 1997; translated from Roviana by Kenneth Roga).

In the mid to late 19th century, a number of traders established stations under the patronage of Roviana chiefs on the small islands in front of modern Munda, making the region the centre of European trade in the Western Solomons. In the decades before the establishment of the Protectorate in 1893, traders complained regularly through the Sydney papers about attacks on their stations and assistants by what they described as cannibal head-hunters. They requested that the British Navy do something to make trade safe and profitable. A regular request was for the destruction of the *tomoko*, which seems to have been general British navy policy, but of little effect as the navy was reluctant to pursue canoes hidden in the lagoons and bush.

In the Sydney Morning Herald, of 29th March 1889, Mr. Peter Pratt [Edmunds] a French trader with a station on Hombuhombu Island opposite Munda listed a series of 'outrages' committed against him and others in the Roviana region and demanded stronger action.

> Sir, it is the opinion of all the traders right throughout the group that an example ought to be shown these natives, especially around this part of the group [New Georgia Group] where the inactivity of H.M. ships is very keenly felt. The cutting of their fruit trees or destroying their canoes, which was done in all the aforementioned cases does not seem to affect them in the least. (Edmunds, 1889).

The outcome of this letter, and additional attacks, was a raid on Roviana on Sept. 25th 1891 lead by Captain Edward Davis of HMS *Royalist*. The goal was ostensibly to find the men guilty of the murder of Mr. Pratt's assistant William Dabelle, but in effect was an attempt to destroy the base of the Roviana people at Nusa Roviana by destroying canoes, canoe houses and shrines. This was accomplished by burning all the villages on Nusa Roviana, and along the Munda coast up to Sisieta where they left Hingava's canoe houses intact as he was their main interlocutor in Roviana. Although great destruction was wrought on the thousands of people who lived in the region, Davis did not find it a complete success. In total, Davis reported they had destroyed 400 houses, 150 canoes and a thousand heads. This would have included many large canoe houses, containing the skulls of head-hunting victims and ancestral skull shrines as well as residences:

> In one house I found twenty-four heads ranged along one side, but it was too dark to see the rest of the house. In Goolie's house, the Chief who murdered Dabelle, I found several guns, spears &c and from ten to fifteen heads. … Suspecting punishment, the natives had removed their large war canoes before my arrival, and I regret I was unable to destroy them, as these boats, used on their head-hunting expeditions, are primarily the cause of most of the trouble at this end of the group … this severe punishment will not be lost on the noted Rubiana head-hunters, who for many years have considered themselves perfectly safe in their strongholds (Davis, 1892: 21).

One of the items looted from Nusa Roviana, probably from a canoe house in the Vuragare section of the island where the killers of Dabelle had been living, is the ritual food trough shown in Fig. 5, donated to the British Museum by Rear Admiral Lord Charles Scott, then Commander in Chief of the Australian Station of the British Navy.

During the cruise of 1891 Captain Davis lead many raids where canoes were targeted and destroyed, and regularly shelled canoe houses and canoes on the beaches of the New Georgia Group (Davis, 1892). The ultimate effect was limited, however, as within a few years Hingava was reported leading a large fleet of canoes against Santa Isabel (Somerville, 1897: 399). In 1893 the British Protectorate was formed and in 1896 Charles Woodford took up his post as the first Resident Commissioner. One of his earliest acts was the establishment of a government station at Ghizo where the primary goal was the suppression of head-hunting and the seizure and destruction of *tomoko*.

After his earlier tour of the Solomons as a naturalist, Woodford had recommended that efforts should be made to end head-hunting, including by destruction of canoes (Lawrence, 2014: 97). In 1900 he appointed Arthur Mahaffy Resident Magistrate and Deputy Commissioner at Ghizo. As described by Silas Oka above, Mahaffy created an armed police force of 25 men from Malaita, Savo and Santa Isabel which aggressively raided throughout the Group seizing and destroying canoes. One of these canoes, *Mbatu-mbatu* from Rannonga, was ultimately sent to the National Museum of Victoria (Richards, 2012: 207). Another canoe seized in 1910 from the Kalikogu or inner lagoon side east of Nusa Roviana, probably from the old village at the western end of Honiavasa Island, was regularly used, as described by Silas Oka, to patrol throughout the Group, including into the shallow lagoons where previously the *tomoko* were hidden. The effect of this close policing, as well as depopulation through European diseases and the benefits of the European copra trade—which could be carried out without the intervention of chiefs—was the end of head-hunting and the decline in the power of chiefs (Sheppard, 2019). In Ghizo, on 27 July 1901, Mahaffy held a great feast to celebrate the coronation of King Edward VII and the end of head-hunting. The celebration

Figure 6. Canoes at Mbilua, Vella Lavella in 1921 as part of a re-enactment of a head-hunting raid filmed by E. Salisbury and M. Cooper (Nicholson, 1924: 48).

was attended by 1,892 people from throughout the Group. Mahaffy wrote that it was a 'picturesque sight to see the great canoes all decorated with streamers and each with its full complement of men, coming up the [Ghizo] harbour at full speed' (O'Brien, 2011: 204). The canoes had now taken on their central role in 20th-century colonial celebrations.

Tomoko in the 20th Century

In the 20th century, *tomoko* were regularly incorporated into both government and mission celebrations. The Australian Museum canoe was used in 1912 in races to celebrate the 10th anniversary of the Methodist Mission at Munda which had been established in 1902. Visitors in 1902 reported Hingava's canoe house empty but saw many small canoes including small *tomoko* in construction as well as shell money in manufacture (Western Grazier, 1902). Manufacture of *tomoko* probably declined rapidly with the ending of the raiding for which they were designed, as they required considerable skill in manufacture and regular maintenance. They rapidly became leaky and needed to be stored in elaborate canoe houses which themselves were associated with head-hunting and chiefly *mana*. As an informant told Hocart in 1908 'now chiefs hem stop nothing'. The power of traditional chiefs had diminished significantly and was now more likely to be associated with connections to the church. One, perhaps final construction of a traditional *tomoko* was by the people of Mbilua Vella Lavella in 1910, who, encouraged by a junior colonial officer at Ghizo, R. Broadhurst-Hill, built the 11.3 m *tomoko* now held by the British Museum (Hviding, 2014: 113, Hess *et al*., 2009).

One of the most widely publicised events displaying *tomoko* was the filming of a fleet of war canoes at Mbilua in south Vella Lavella in 1921 (Fig. 6). As part of a tour by yacht around the world, the entrepreneur Edward Salisbury, working with the cinema photographer Merian Cooper (of *King Kong* 1933 fame), wanted to film Solomon Island 'head-hunters' and use the footage in the production of a series of movies. Working with Rev. Reginald Nicholson, the Methodist missionary at Mbilua, a re-enactment of a raid was carried out with *circa* nine large, aging *tomoko* recruited from Vella Lavella and Rannonga. The resulting footage was used in the production of the films *Black Shadows of the South Seas* [1923] and *Gow the Head Hunter* [1928] (Lindstrom, 2016). Several publications featuring still photographs of the canoes were also made (Salisbury, 1922; Salisbury and Cooper, 1924). Nicholson had agreed to assist with the project if in turn Salisbury would donate copies of the footage to the Methodist Society, to be used in fund-raising. Salisbury did not keep the bargain and as a result Nicholson went to Los Angeles and pursued his case in the courts, finally obtaining the footage (Roberts, 2004). The result of this was the production of the film, *The Transformed Isle* (Nicholson, 1921(?)), which contrasted the violent head-hunting past with the peaceful Christian present. The one-hour long silent film was shown widely through Australia and New Zealand. It is now available on-line through the New Zealand Nga Taonga Film and Sound archive and includes footage of *tomoko* at sea as well as a sequence of shell money production in Malaita.

Throughout the 20th century, the photogenic *tomoko* became an important symbol of the Western Province and the Solomon Islands, appearing on stamps, starting in 1939, and on banknotes and coins, including the *nguzunguzu* on the one-dollar coin today. The *nguzunguzu* became a major subject for the creation of wood carvings in the Western Solomons, supplying the growing tourist market from the late 19th century. Today it can be found filling the shelves of Honiara souvenir shops. The canoes themselves have generally become simplified in construction as the skill and time required to manufacture and assemble the thin planks and procure the material for ribs has diminished.

At some point, the canoes commonly used in celebrations became embellished dugouts. With the advent of mechanised commercial logging, large logs from the interior forests could be more easily acquired. Recently in Roviana agreements with logging companies have included the felling and transport of logs suitable for large dugouts down to work areas near the coast, where these vessels were produced using chain saws and metal adzes.

Canoes with raised prow and stern, and decorated as *tomoko*, were regularly used for celebrations during the colonial period. In March 1959, a fleet of *tomoko* from

Figure 7. (*a*) Canoe construction at Moli, Choiseul in 1958. (*b*) Sewn canoe at prow, Choiseul. Photo Harold Scheffler 1959. Harold Scheffler Papers, MSS 481. With the courtesy of © Jan Simpson and Special Collections & Archives, University of California, San Diego.

throughout the Western Solomons and Choiseul were photographed in Ghizo harbour (https://library.ucsd.edu/dc/collection/bb08204951) by the anthropologist Harold Scheffler, where they had assembled to greet Prince Philip aboard the royal yacht *Britannia.* In 1958 Scheffler had photographed the construction of plank-built canoes at Moli in southwest Choiseul (Fig. 7a,b) and he may have accompanied them to Ghizo for the celebration. A newsreel film of the Prince being transported to shore in a large *tomoko* called *Kaliva*, in which a throne had been constructed, can be viewed on-line (https://www.youtube.com/watch?reload = 9&v = iZnSVAIcuvs).

Figure 8. (*a*) CFC *Tomoko* arriving for a Western Province festival at Ghizo on 7 December 2007; (*b*) details of the interior of the CFC canoes. Photos: P. J. Sheppard.

In 1968, it was decided to start an Annual Festival of the Solomon Seas to promote interest and pride in the arts of seamanship and in the traditional customs of the seagoing peoples of the Solomon Islands (Pacific Islands Monthly, 1968). Therefore, on Easter Monday 1968 an inaugural event was held in Honiara at which three war canoes participated, including one from Roviana. This canoe, *New Life*, which won the race, was criticised for not being a 'real' *tomoko* but rather a smaller *gopu* or trading canoe, possibly an embellished dugout. Because of the interest it raised, it was reported that Roviana villages were keen to build two real *tomoko* under the guidance of the last man with the requisite knowledge, 70-year-old Opero Sasabule. It is not clear if this attempt at revitalisation was successful. In August of the same year, a 16 m canoe from the Western Solomons called SDA was delivered to the Seventh Day Adventists South Sea Islands Museum in Cooranbong in NSW Australia (Wikipedia, 2019). Presumably, decorated dugouts were increasingly used in races and displays throughout the colonial period and after the establishment of the independent Solomon Islands in 1978 (Hviding, 2014). It was not until 2004 that the next major attempt at revitalisation occurred under the auspices of the Christian Fellowship Church.

The Christian Fellowship Church (CFC) was established as a breakaway from of the Methodist Church in the 1950s by Silas Eto (Tuza, 1977). The leadership of what is now a very successful church in New Georgia passed to his son Reverend Sir Ikan Rove in 1984. In 2004 the CFC decided to stage its own 100th Anniversary celebrations of the founding of the Methodist Church at Munda (actually in 1902) and Sir Rove requested that every CFC village in New Georgia that was able, should build a *tomoko* to create a fleet for racing and display (Hviding, 2014). The result was a fleet of 15 canoes assembled at Madou village in Vonavona Lagoon west of Munda in June 2004 (Fig. 8a). These were, in fact, large dugouts with a few upper strakes sewn on and with prow and stern posts and traditional decorations including *nguzunguzu* (Fig. 8b). The very active commercial logging on CFC land in Roviana and north New Georgia at the time would have facilitated this activity. The fleet, which toured throughout the Group and was active in provincial celebrations in later years, demonstrated the success and power of the CFC and their spiritual leader in the Western Province and the Solomons more generally.

The *tomoko* remains a powerful symbol for people in the Western Solomons and the country, even though many, if not most young people have never seen one. There are none curated and displayed in the country today. People from the Western Solomons might see a model of one at a wedding, where it is filled with gifts and food used in exchange, then symbolically attacked and broken by men from the next family to have a wedding. Some large dugout *tomoko* appear to be in operation in the Western Solomons for special events, with one called *Roguana* from Lambu Lambu village in south Vella Lavella recently (2017) photographed transporting a wedding party. Unfortunately, despite there being many plank-built *tomoko* in museums around the world, most, and possibly all except for the *tomoko* in the Vatican Museum, the SDA museum in Cooranbong (NSW) and the National Museum of Victoria, are in storage and not visible to the public or Solomon Islanders, except as part of commendable attempts by museums to make their collections available to the original communities through special visits. Display of these large objects is, of course, difficult and efforts to digitise and make them available online for the people of the Solomon Islands and the world is encouraging (Hess *et al*., 2009).

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References

Amherst, L., and B. Thomson. 1901. *The Discovery of the Solomon Islands by Alvaro de Mendaña in 1568*. 2 vols. London: Hakluyt Society.

Aswani, S. 1999. *Tomoko*: The Roviana War Canoe. In *New Georgia Archaeological Survey (NGAS) Roviana Lagoon Year 4: Annual Report 1999*, ed. P. Sheppard, S. Aswani, M. Felgate, T. Nagaoka, R. Walter, J. Dodson, and S. Grimes, pp. 26–39. Auckland: Dept. of Anthropology, University of Auckland.

Aswani, S., and P. Sheppard. 2003. The archaeology and ethnohistory of exchange in precolonial and colonial Roviana: gifts, commodities and inalienable possessions. *Current Anthropology* 44 (supplement): S51–S78.
https://doi.org/10.1086/377667

Barraud, C. 1972. De la chasse aux Têtes á la pêche à la Bonite. *L'Homme* 12: 67–104.
https://doi.org/10.3406/hom.1972.367239

Bathgate, M. A. 1985. Movement processes from precontact to contemporary times: the Ndi-Nggai, west Guadalcanal, Solomon Islands. In *Circulation in Population Movement: Substance and Concepts from the Melanesia Case*, ed. M. Chapman and R. Prothero, pp. 83–118. London: Routledge and Kegan Paul.

Bennett, J. A. 1985. *Wealth of the Solomons: A History of a Pacific Archipelago, 1800–1978*. Pacific Islands Monograph Series 3. Honolulu: University of Hawaii Press.

Davis, Captain E. 1892. *Australian Station, Solomon Islands, 1891: Correspondence respecting Outrages by Natives on British Subjects and other matters, which have been under inquiry during the Year 1891, being continuation of reports of cases dealt with in former years, together with other cases which have since arisen.* Western Pacific Archives 2003/1.WPHC 8. Series III. File 20. Special Collections, University of Auckland Libraries and Learning Services.

Dureau, C. 2000. Skulls, *Mana* and Causality. *Journal of the Polynesian Society* 109(1): 71–97.
https://www.jstor.org/stable/20706908

Edge-Partington, J. 1903. Food trough from Rubiana, New Georgia. *Man* 3: 161–162.
https://doi.org/10.2307/2839833

Edge-Partington, T. W. 1907. Ingava, Chief of Rubiana, Solomon Islands: died 1906. *Man* 7: 22–23.
https://doi.org/10.2307/2788122

Edmunds, P. 1889. Atrocities at Rubiana. *Sydney Morning Herald (NSW: 1842–1954)*, 29 March 1889, 5.
http://nla.gov.au/nla.news-article13719207

Empire. 1859. Massacre of the crew of the schooner *Pearl*. 1859. *Empire (Sydney, NSW: 1850–1875)*, 26 December 1859, 5.
http://nla.gov.au/nla.news-article64095003

Felgate, M. 2003. *Reading Lapita in Near Oceania: Intertidal Shallow-Water Pottery Scatters, Roviana Lagoon, New Georgia, Solomon Islands*. Unpublished PhD thesis, Department of Anthropology, University of Auckland.

Forster, G. 2000. *A Voyage Round the World*, ed. N. Thomas and O. Berghof. Honolulu: University of Hawai'i Press.
https://doi.org/10.1515/9780824861308

Garling, S. 2007. Post-Lapita Evolutions or Revolutions? Interaction and Exchange in Island Melanesia: The View from the Tanga Islands. Unpublished PhD thesis, Department of Archaeology and Natural History, Australian National University, Canberra.

Haddon, A. C., and J. Hornell. 1936. *Canoes of Oceania*. 3 vols. Honolulu: Bernice P. Bishop Museum.

Hess, M., S. Robson, F. S. Millar, G. Were, E. Hviding, and A. C. Berg. 2009. Niabara—The Western Solomon Islands War Canoe at the British Museum—3D Documentation, Virtual Reconstruction and Digital Repatriation. 15th International Conference on Virtual Systems and Multimedia, 9–12 Sept. 2009.
https://doi.org/10.1109/VSMM.2009.12

Hocart, A. M. 1931. Warfare in Eddystone of the Solomon Islands. *Journal of the Royal Anthropological Institute of Great Britain and Ireland* 61: 301–324.
https://doi.org/10.2307/2843922

Hocart, A. M. 1935. The Canoe and the Bonito in Eddystone Island. *Royal Anthropological Institute of Great Britain and Ireland* 65: 97–111.
https://doi.org/10.2307/2843843

Hocart, A. M., MSS*a*. Trade and Money. In *Hocart Manuscripts*. Wellington: Alexander Turnbull Library, National Library of New Zealand.

Hocart, A. M., MSS*b*. The Canoe. In *Hocart Manuscripts*. Wellington: Alexander Turnbull Library, National Library of New Zealand.
https://www.ngataonga.org.nz/collections/catalogue/catalogue-item?record_id = 77046

Hutchinson, D., and F. Ploeckl. 2020. Five ways to compute the relative value of Australian amounts, 1828 to the present. *Measuring Worth* online.
https://www.measuringworth.com/calculators/australiacompare/index.php

Hviding, E. 2014. War canoes of the Western Solomons. In *The Things We Value: Culture and History in the Solomon Islands*, ed. B. Burt and L. Bolton, pp. 103–115. London: Sean Kingston Publishing.

Jackson, K. B. 1978. Tie Hokara, Ties Vaka: Black Man White Man, a Study of the New Georgia Group to 1925. Unpublished PhD thesis, Department of Anthropology, Australian National University, Canberra.

Lawrence, D. R. 2014. *The Naturalist and his 'Beautiful Islands': Charles Morris Woodford in the Western Pacific*. Canberra: ANU Press.
https://doi.org/10.22459/NBI.10.2014

Lindstrom, L. 2016. Shooting Melanesians: Martin Johnson and Edward Salisbury in the Southwest Pacific. *Visual Anthropology* 29 (4–5): 360–381.
https://doi.org/10.1080/08949468.2016.1191929

McDougall, D. 2000. Paths of 'pinauzu': captivity and social reproduction in Ranongga. *Journal of the Polynesian Society* 109(1): 99–114.
https://www-jstor-org/stable/20706909

Mitchell, S. 2015. Australia Day and the war canoe. Australian Museum online.
https://australian.museum/blog-archive/explore/australia-day-and-the-war-canoe/

Nagaoka, T. 2011. Late Prehistoric-Early Historic Houses and Settlement Space on Nusa Roviana, New Georgia Group, Solomon Islands. Unpublished PhD thesis, Department of Anthropology, University of Auckland.

Nicholson, R. 1921(?). *The Transformed Isle*. [Moving Image]. Nga Taonga Sound and Vision.
https://www.ngataonga.org.nz/collections/search?utf8 = %E2%9C%93&text = The+Transformed+Isle

Nicholson, R. C. 1924. *The Son of a Savage: The Story of Daniel Bula*. London: Epworth Press.

O'Brien, A. 2011. Collecting the Solomon Islands: Colonial Encounters & Indigenous Experiences in the Solomon Island Collections of Charles Morris Woodford and Arthur Mahaffy (1886–1915). Unpublished PhD thesis, School of World Art Studies and Museology, University of East Anglia, Norwich.

Officer, G. 2012 [1901]. The Art of Canoe Making. Reproduced in *Head Hunters Black and White*, R. Richards, pp. 211–217. Wellington: Paremata Press.

Osmond, G. 2013. Wickham, Harry (1882–1962). *Solomon Islands Historical Encyclopaedia 1893–1978.* http://www.solomonencyclopaedia.net/biogs/E000750b.htm

Pacific Islands Monthly 1968. They're the new pride of the Solomon Seas. *Pacific islands Monthly*, 1 May 1968: 27.

Penny, A. 1888. *Ten Years in Melanesia*. London: Wells Gardner, Darton & Co.

Powell, W. 1884. *Wanderings in a Wild Country, or, Three Years Amongst the Cannibals of New Britain*. London: Sampson Low, Marston, Searle, & Rivington.

Pugach, I., A. T. Duggan, D. A. Merriwether, F. R. Friedlaender, J. S. Friedlaender, and M. Stoneking. 2018. The gateway from Near into Remote Oceania: new insights from genome-wide data. *Molecular Biology and Evolution* 35(4): 871–886. https://doi.org/10.1093/molbev/msx333

Richards, R. 2012. *Head Hunters Black and White*. Wellington: Paremata Press.

Roberts, D. 2004. From Hollywood to Vella Lavella. The Methodist Church of New Zealand. http://www.methodist.org.nz/touchstone/lead_articles/2004/november_2004/methodist_archives_11_04

Ross, M. 1988. *Proto Oceanic and the Austronesian Languages of Western Melanesia*. *Pacific Linguistics C-98*. Canberra: Australian National University.

Salisbury, E. A. 1922. A Napoleon of the Solomons. *Asia: Journal of the American Asiatic Association* 22: 707–720.

Salisbury, E. A., and M. C. Cooper. 1924. *The Sea Gypsy*. New York: Putnam's.

Sheppard, P. 2019. Four hundred years of niche construction in the western Solomon Islands. In *Archaeologies of Island Melanesia Current approaches to landscapes, exchange and practice*, ed. M. Leclerc and J. Flexner, pp. 117–133. Canberra: ANU Press. https://doi.org/10.22459/TA51.2019.08

Sheppard, P., and R. Walter. 2006. A revised model of Solomon Islands history. *Journal of the Polynesian Society* 115(1): 47–76. http://www.jstor.org/stable/20707321

Sheppard, P., and R. Walter. 2009. Inter-tidal Late lapita Sites and Geotectonics in the Western Solomons. In *Lapita: Ancestors and Descendants*, ed. P. Sheppard, T. Thomas, and G. Summerhayes, pp. 73–100. Auckland: New Zealand Archaeological Association.

Sheppard, P., and R. Walter. 2014. Shell valuables and history in Roviana and Vella Lavella. In *The Things We Value: Culture and History in the Solomon Islands,* ed. B. Burt and L. Bolton, pp. 32–45. London: Sean Kingston Publishing.

Sheppard, P., R. Walter, and T. Nagaoka. 2000. The archaeology of head-hunting in Roviana lagoon, New Georgia. *Journal of the Polynesian Society* 109(1): 9–37. https://www.jstor.org/stable/20706906

Sheppard, P., R. Walter, and K. Roga. 2010. Friends, relatives, and enemies: The archaeology and history of interaction among Austronesian and NAN speakers in the Western Solomons. In *A Journey through Austronesian and Papuan Linguistic and Cultural Space: Papers in Honour of Andrew Pawley*, ed. J. Bowden, N. Himmelmann, and M. Ross, pp. 95–112. *Pacific Linguistics PL 615*. Canberra: Pacific Linguistics.

Somerville, B. T. 1897. Ethnographical notes in New Georgia, Solomon Islands. *Journal of the Anthropological Institute* 26(4): 357–413. https://doi.org/10.2307/2842009

Sydney Daily Telegraph 1915 Head Hunters Canoe. *Daily Telegraph (Sydney, NSW: 1883–1930)*, 31 July 1915: 12. http://nla.gov.au/nla.news-article238920597

Sydney Morning Herald 1915a. Native War Canoe. *Sydney Morning Herald* (NSW: 1842–1954), 22 July 1915: 8. http://nla.gov.au/nla.news-article15590530

Sydney Morning Herald 1915b. Island War Canoe. *Sydney Morning Herald (NSW: 1842–1954)*, 31 July 1915: 13. http://nla.gov.au/nla.news-article15579906

Sydney Sunday Times 1915. Head-Hunting Canoe. *Sunday Times (Sydney, NSW: 1895–1930)*, 1 August 1915: 8. http://nla.gov.au/nla.news-article120804330

Thomas, T., P. Sheppard, and R. Walter. 2001. Landscape, violence and social bodies: ritualized architecture in a Solomon Islands society. *Journal of the Royal Anthropological Institute* 7(3): 545–572. https://doi.org/10.1111/1467-9655.00077

Thorpe, W. 1921. A Tomako, or Head-Hunters' Canoe, from the Solomon Islands. *Australian Museum Magazine* 1(10): 289–292. https://doi.org/10.3853/j.0155-3496.1923.1.10

Turner, M. T. 2000. The Function, Design and Distribution of New Zealand Adzes. Unpublished PhD thesis, Department of Anthropology, University of Auckland.

Tuza, E. 1977. Silas Eto of New Georgia. In *Prophets of Melanesia*, ed. Garry Trompf, pp. 65–88. Port Moresby: Institute of Papua New Guinea Studies.

Waite, D. 1990. Mon canoes of the Western Solomon Islands. In *Art and Identity in Oceania*, ed. A. Hanson and L. Hanson, pp. 44–66. Honolulu: University of Hawaii Press.

Waite, D. 2000. An artefact/image text of head-hunting motifs. *Journal of the Polynesian Society* 109(1): 115–133. https://www.jstor.org/stable/20706910

Walter, R., and P. Sheppard. 2017. *Archaeology of the Solomon Islands*. Dunedin and Honolulu: Otago University Press and University Press of Hawai'i.

Waterhouse, J. H. L. 1949. *A Roviana and English Dictionary, with English-Roviana Index and List of Natural History Objects and Appendix of Old Customs Revised and enlarged by L M Jones*. Sydney: Epworth Printing & Publishing House.

Were, G. 2019. *How Materials Matter: Design, Innovation and Materiality in the Pacific*. New York: Berghahn Books. https://doi.org/10.2307/j.ctv12pns8c

Western Grazier 1902. Among the Headhunters of the Solomon Islands. *Western Grazier (Wilcannia, NSW: 1896–1951)*, 12 July 1902, 1. http://nla.gov.au/nla.news-article133604425

White, G. M. 1991. *Identity Through History: Living Stories in a Solomon Islands Society*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511621895

Wikipedia. 2019. South Sea Islands Museum. *Wikipedia*. [Accessed 28 Oct 2019]

Woodford, C. M. 1888. Exploration of the Solomon Islands. *Proceedings of the Royal Geographical Society and Monthly Record of Geography* 10(6): 351–376. https://doi.org/10.2307/1801372

Woodford, C. M. 1909. The canoes of the British Solomon Islands. *Journal of the Royal Anthropological Institute of Great Britain and Ireland* 39: 505–516. https://doi.org/10.2307/2843216

Woodford, C. M. 1922. The Solomon Islands. In *Essays on the Depopulation of Melanesia* ed. W. H. R. Rivers, pp. 69–77. Cambridge: University Press.

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Barkcloth from the Solomon Islands in the George Brown Collection

Rhys Richards[1] and Peter J. Matthews[2]

[1] 174 Paremata Road, Porirua, 5024, New Zealand

[2] Department of Social Research, National Museum of Ethnology,
Senri Expo Park 10-1, Suita City, Osaka, 565 8511 Japan

Abstract. Historically, barkcloth in Southeast Asia and Oceania has been made using diverse plant species, mostly in the fig plant family (Moraceae). Despite the general use of woven textiles today, barkcloth is still made in some cultural contexts. Here, based on a previously undescribed ethnographic collection from the Solomon Islands, we report new information on an enigmatic local tradition of barkcloth decorated with a blue plant dye. Our immediate aim is descriptive, and to raise awareness of the tradition, but we also note difficulties for identifying the plants used to make barkcloth. Historical questions concerning the origins and spread of barkcloth traditions cannot be answered without better knowledge of their material foundations.

Over three decades, from 1879 to 1911, the missionary George Brown visited the Solomon Islands five times and collected 631 ethnographic items that are now stored at the National Museum of Ethnology, Japan. The items include 12 sheets of barkcloth from the western Solomon Islands, most of which appear to be made from fig (*Ficus* sp.) or breadfruit (*Artocarpus* sp.). Six from the island of Isabel have distinctive motifs painted with the indigo-blue dye. Only ten examples of blue-dyed barkcloth have been found previously in other museum collections, and these also came from Isabel. In other areas of Southeast Asia and Oceania, paper mulberry (*Broussonetia papyrifera*), is the most commonly used bast fibre source for barkcloth and is associated with the spread of Austronesian-speaking peoples. This plant appears to have had a minor role in the Solomon Islands.

Introduction

Barkcloth is an ancient form of textile production that may have predated the use of woven cloth, since barkcloth can be made from a wide variety of plant sources and involves relatively simple techniques for its production. However, there is wide scope for refinement in both the production of the cloth, its decoration, and in its uses. In many locations today, barkcloth is still made despite the general use of woven textiles. In some locations, continued production may reflect geographic and social isolation as well as the local utility and cultural value of the cloth concerned. More commonly, perhaps, older traditions coexist with new uses and new values in contemporary culture and modern trade (Charleux, 2017).

In Southeast Asia and Oceania, barkcloth is known by a variety of names in Austronesian and other languages, and may be made from the inner bark (bast) of fig (*Ficus* spp.), wild and cultivated breadfruit (*Artocarpus* spp., *A. altilis*), paper mulberry (*Broussonetia papyrifera*), upas (*Antiaris toxicaria*), poison peach (*Trema tomentosa*, syn. *T. amboinensis*), beach hibiscus (*Hibiscus tiliaceus*), the mangrove trees *Barringtonia asiatica* and *Rhizophora* sp., and other trees (Kennedy, 1934; Kooijman, 1963, 1972; Leonard and Terrell, 1981; Aragon, 1990; Hill, 2001; Larsen, 2011; Vargyas, 2016; Moskvin, 2017; Butaud, 2017). Fig, breadfruit and paper mulberry appear to be the most commonly used sources for barkcloth in Southeast Asia and Oceania, but wild upas (*Antiaris toxicaria*) is also used in Africa, making it the most widely-used barkcloth

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Corresponding authors: Rhys Richards rhys.paremata@gmail.com and Peter J. Matthews pjm@minpaku.ac.jp
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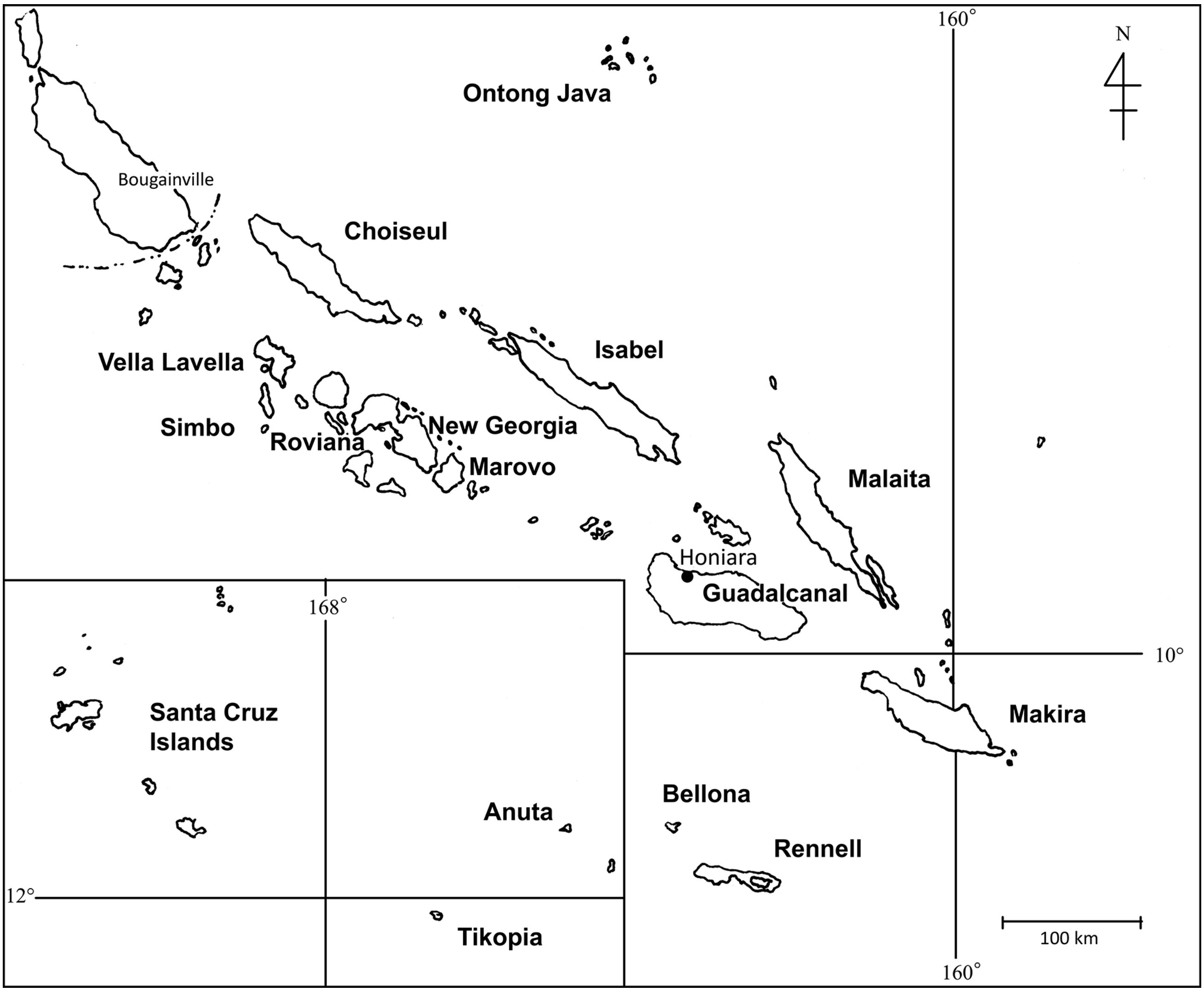

Figure 1. Western Solomon Islands, where George Brown established a mission on New Georgia Island in 1902. The present capital is located at Honiara, and the inset shows islands in the far southeast.

source in the world. All of these bast sources belong to the plant family Moraceae, and are fast-growing softwood trees with thick, fibrous bark that gives the trunks and branches tensile strength (in the absence of the hardwood typically produced by slow-growing trees). This tensile strength is what makes the bast of these trees practically valuable for paper or cloth making. Among them, paper mulberry is the most widespread *cultigen* used for barkcloth. It originated as a natural species in mainland Asia and was carried by people through island Southeast Asia to most island groups in Remote Oceania, including Hawaii, Society, Rapanui, and New Zealand (Matthews, 1996; Larsen, 2011; Chang *et al*., 2015; Peñailillo *et al*., 2016; Seelenfreund *et al*., 2017; Olivares *et al*., 2019).

In Remote Oceania, *tapa* (barkcloth) is most often made from paper mulberry, and is commonly made for gift-giving, ceremonies, and for modern craft, art and trade (Kooijman, 1972, 1977; Larsen, 2011; Addo, 2013; Seelenfreund, 2013; Charleux, 2017; Veys, 2017). Throughout its range in cultivation, paper mulberry is prized above other plants as a source of white or near-white bark that can be processed into many different grades of molded paper, beaten bark paper, or barkcloth, from coarse (thick sheets, uneven thickness) to very fine (thin sheets, even thickness). White barkcloth has positive symbolic connotations throughout Polynesia (Ewins, 2017) and is also favoured as a medium for pigments used to create designs that have decorative and/or symbolic value and meaning. From the late 18th century onwards, decorated barkcloths from Oceania became popular items for collection by European visitors.

One of many 19th century collectors of barkcloth was Rev. Dr. George Brown (1835–1917), a Methodist missionary and self-taught ethnographer (Brown, 1908, 1910; Gardner, 2006; Reeson, 2013) who assembled a collection of approximately 3000 artefacts that form the George Brown Collection held at the National Museum of Ethnology in Osaka (Ishimori and Hayashi, 1999; Hayashi and Matthews, 2017). Some items from the original collection are also held by other institutions, mainly in the United Kingdom, but these do not include sheets of barkcloth (though they do include small pieces of barkcloth incorporated into masks).

Here we offer initial descriptions and tentative interpretations of 12 sheets of barkcloth and two barkcloth beaters collected by Brown in the western Solomon Islands (Fig. 1), and then relate the materials to historical questions concerning the origins and spread of barkcloth traditions in Oceania. Within the Solomon Islands, barkcloth production on Santa Isabel Island (henceforth referred to as Isabel) is perhaps best known ethnographically (Waite, 1987; Richards and Roga, 2005), and the island is one of the few locations where barkcloth production has been more-or-less continuous from the time of George Brown to present.

Figure 2. Group A: barkcloth with blue dye over entire surface. George Brown Collection, Solomon Islands (i = H138297, ii = H138303). Photography: both sides (a, b) are shown, each in mirror position with respect to the other, with narrow, upper end of each piece at left (a) or at right (b). Scales vary; see text for measured dimensions. Photos courtesy National Museum of Ethnology, Osaka.

Barkcloths from the Solomon Islands represent only a small proportion of Pacific cloths in the George Brown collection, most of which are from Fiji, Samoa and Tonga. Cloths from the latter island groups were mostly made from paper mulberry (*Broussonetia papyrifera*), while those from the Solomon Islands were mostly made from either fig (*Ficus* sp.) or breadfruit (*Artocarpus* sp.) and are relatively coarse, light brown cloths that have been dyed with a blue plant dye of uncertain origin, similar in colour to indigo blue. Of the 12 cloths, eight are dyed blue, including two that are plain-dyed, and six with distinct designs or 'decoration'. Two undyed white cloths in the collection may be made from breadfruit, or possibly paper mulberry, though the latter tree is not widely found in the Solomon Islands today. The bast plants used to make barkcloth are of interest because the Solomon Islands is a Near Oceanic region of contact between Austronesian and non-Austronesian language speakers. Is a mixing of younger (AN) and older (non-AN) traditions apparent in the plants used? We will return to this question later.

The use of a blue dye on barkcloth is rare globally, and is exceptional in Oceania, where barkcloth is typically coloured using black, brown, yellow, orange, and red pigments (Larsen, 2011; Charleux, 2017; Flowers *et al.,* 2019). A previous survey of collections in 16 museums located 52 cloths with blue decorations from the Solomon Islands. Among these, 36 had secure provenances, with 12 attributed to Isabel (including H138296 from the George Brown Collection, Fig. 3 iv), 13 to Simbo, five to Roviana, and smaller numbers to other locations (Richards and Roga, 2005: 72). In addition to H138296, the George Brown Collection includes five more blue-decorated cloths from Isabel, bringing the global total of blue-decorated cloths to 57, with 17 now attributed to Isabel. In addition, a small number of blue-dyed cloths, with and without decoration, have been located in museums or private collections since 2005, but details and photographs are not available for all of these (in Appendix 1, we note just the more accessible items).

The 12 barkcloths

George Brown passed through the Solomon Islands in 1875, on his way to New Ireland and the Duke of York Islands, but later stated, 'my acquaintance with the great Solomon Islands group began in the 1879, and since then I have visited the group on several occasions' (Brown, 1910). In 1902 he stayed on New Georgia for nearly two months to help establish a new Methodist mission (Reeson, 2013). It is likely that he obtained many or most of the Solomon Island materials (approximately 652 objects) during the 1902 visit. In a typed letter to Mr R. Etheridge Jnr of the Australian Museum (AM) on Feb. 3, 1903, Brown (1903) stated that 'the blue tinted native cloth which you saw in my collection is from the island of Ysabel, and I think the same kind is made throughout New Georgia, and probably some of the other islands.' The same letter is annotated with AM collection numbers E. 11229–30 and stamp indicating that these were exhibited on 3rd March 1905 (AM archive seen by Matthews, courtesy R. Torrence). These two cloths were purchased from the Board of the Melanesian Mission in December 1902 (Richards and Roga, 2005), soon after the date of Brown's return from New Georgia to Sydney on the *SS Titus* (Reeson, 2013: 270). In 2016, Brown attempted to sell the entire George Brown Collection to the Bowes Museum in Barnard Castle, northern England, and after he passed away in 1917, his family attempted to sell it to the AM, without success. At that time, the Collection was housed in a purpose-built room at the family home in Gordon, Sydney. The Collection was sent to the home of Brown's aunt in Barnard Castle, from where it was eventually moved to the nearby Bowes Museum, then to the University of Newcastle upon Tyne, and then (in 1985) to the National Museum of Ethnology in Osaka (Specht, 1987; Ishimori and Hayashi, 1999; Gardner, 2006; Hayashi and Matthews, 2017). Despite the many changes in location, the 12 barkcloths from the Solomon Islands remain in good condition, though kept folded rather than on rolls as is now common museum practice.

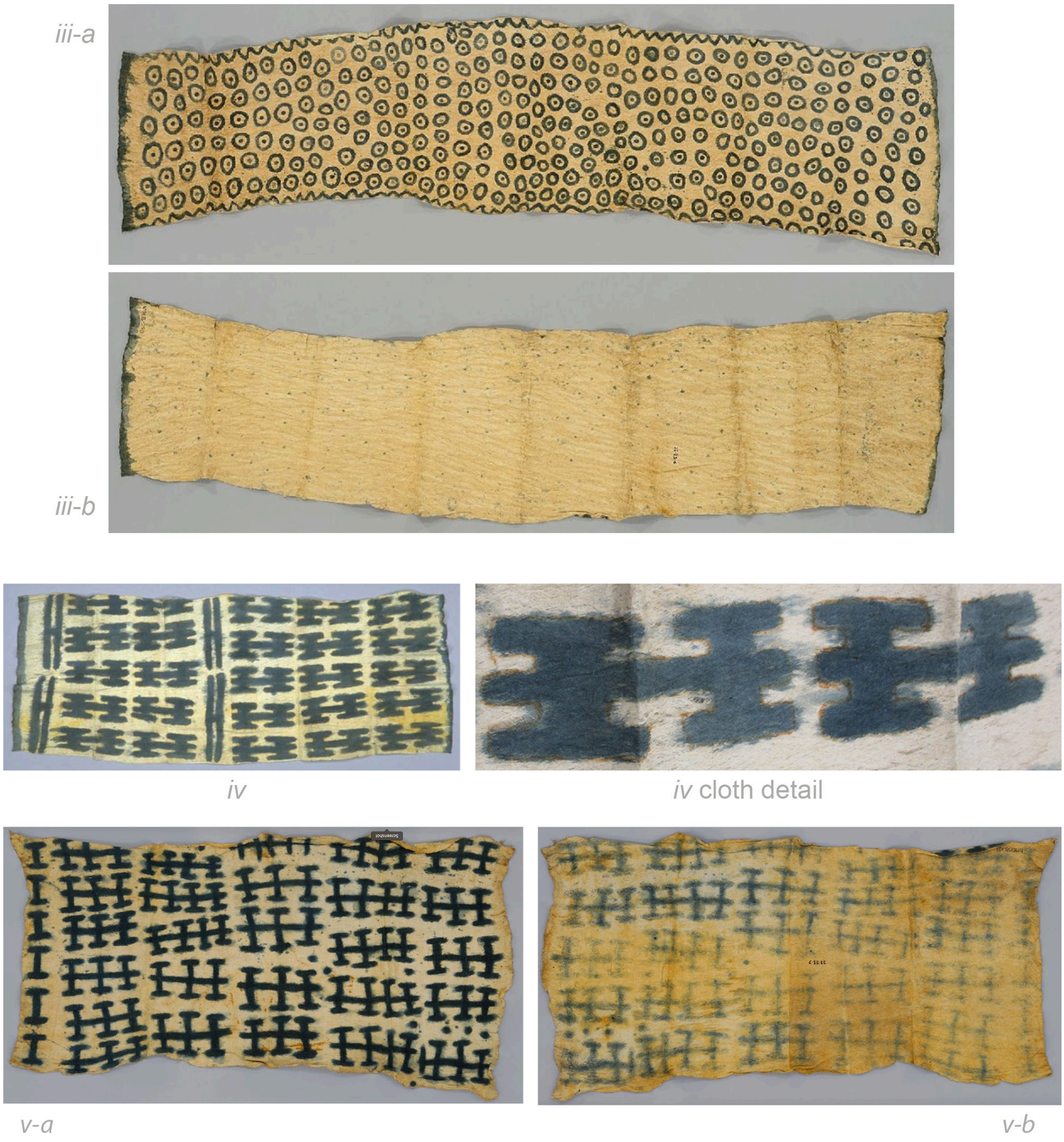

Figure 3. Group B: barkcloth with blue designs. George Brown Collection, Solomon Islands (iii = H138298, iv = H138296, v = H138301). Photos courtesy National Museum of Ethnology, Osaka. Figure 3 continued on facing page …

Identifying bast source plants

The present first author has lived in the Solomon Islands and travelled extensively in the area over many years. During return trips in the years 2002–2004, he carried out intensive fieldwork to study barkcloth traditions, together with Kenneth Roga (Richards and Roga, 2005). In 2015, he was invited to the National Museum of Ethnology, to examine the George Brown Collection. The second author has previously studied the history of paper mulberry in Asia and the Pacific (Matthews, 1996). Our attempted botanical identifications of bast source plants are based on visual observation, heft (weight when held in hand), and touch familiarity with barkcloths known to be made from fig (usually light or reddish brown, coarsely beaten, thick, heavy, and rubbery, with visibly coarse fibres), breadfruit (see further below), or paper mulberry (usually white or near-white, evenly or finely beaten, and relatively thin, light, and flexible, with visibly fine fibres) (see a similar visual comparison in Hill, 2001). Barkcloth made from breadfruit bark appears to have intermediate qualities: it is not as coarse or dark coloured as fig and not as fine or white as paper mulberry. The colour of breadfruit bast used for a cloth may also vary according to the proportional contributions of inner (white) and outer (with a reddish tinge) bark tissues (Richards and Roga, 2005: 27–28). A fourth candidate source, *Antiaris toxicaria*, produces a coarse reddish brown cloth that resembles some *Ficus* cloths. All four plants belong to the same plant family, Moraceae.

Our identifications are tentative. We are not familiar with the full range of potential plant sources for these cloths, and regardless of taxonomic identity, bark from older and younger stems can have different qualities, can vary in

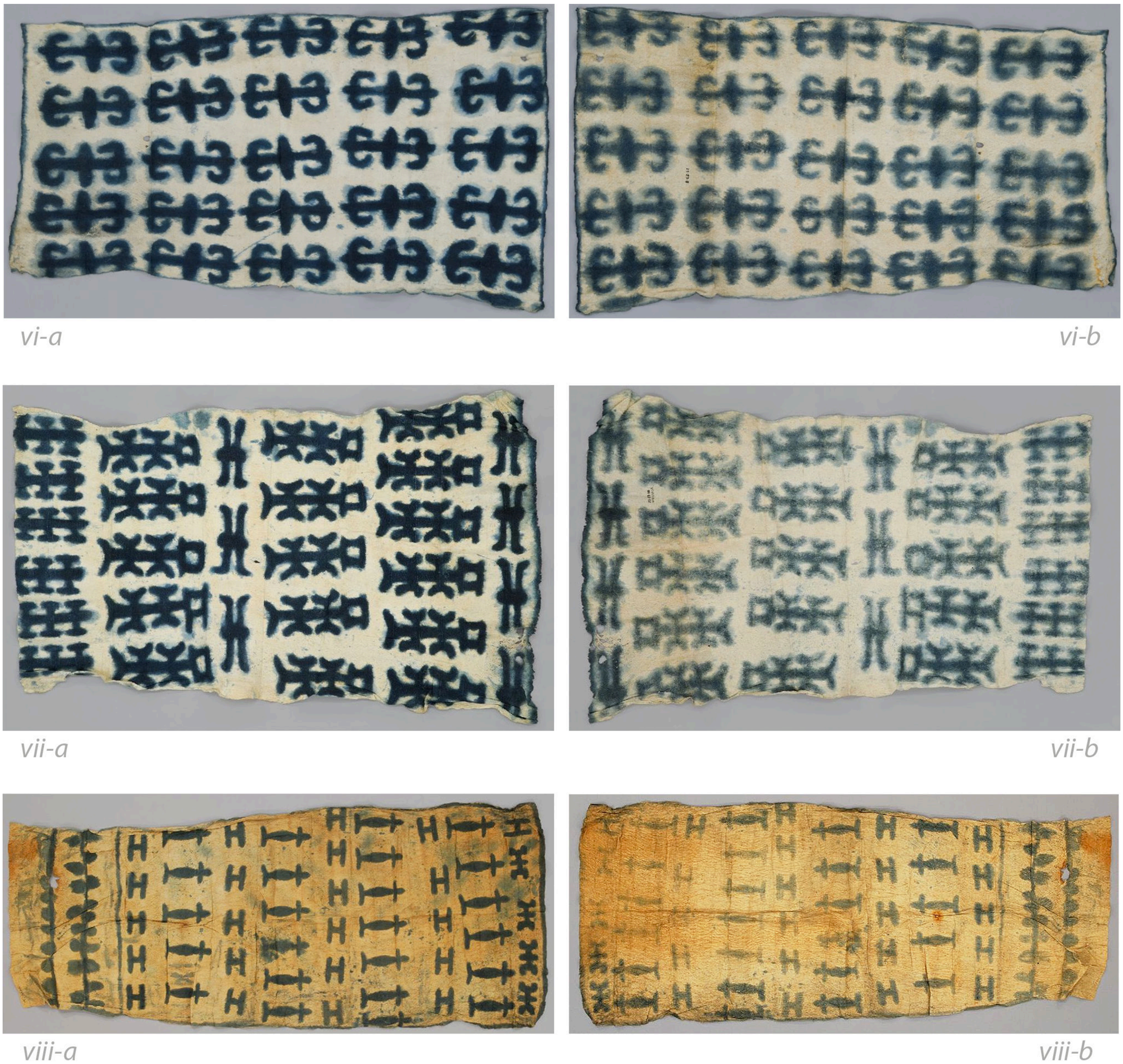

Figure 3 (continued). Group B: barkcloth with blue designs. George Brown Collection, Solomon Islands (vi = H138302, vii = H138304, viii = H139234). Photos courtesy National Museum of Ethnology, Osaka.

colour from outer to inner layers, and can be processed with or without dyeing or bleaching (for detailed analyses of variation in processing methods, see Tolstoy, 2008, and Larsen, 2011). Bleaching, to enhance the whiteness of a cloth, can be achieved by a range of methods. Less commonly, bast from different plant species may be combined in one piece. All these variables add to the difficulty in identifying source plants through simple direct observation of barkcloth. More reliable identification will require examination by experienced barkcloth makers, and comparative microscopic and biochemical studies of bark in all the candidate taxa.

Descriptions of the 12 cloths, and two beaters

Through records in the Museum electronic database, 12 cloths from the Solomon Islands or Melanesia were found in the George Brown Collection, 11 identified as being from the Solomon Islands. One (H139234, Fig. 3 viii) from 'Melanesia' has motifs that clearly indicate an origin in Isabel, in the Solomon Islands. Ten of the 12 are recorded in an original typescript Collection list (inventory) held by the

Figure 4. Detail of H138298, barkcloth made from *Ficus* sp. (?*Artocarpus*), National Museum of Ethnology (see also Fig. 3 iii). Outer diameter of one circle is c. 4 cm. Photos courtesy National Museum of Ethnology, Osaka.

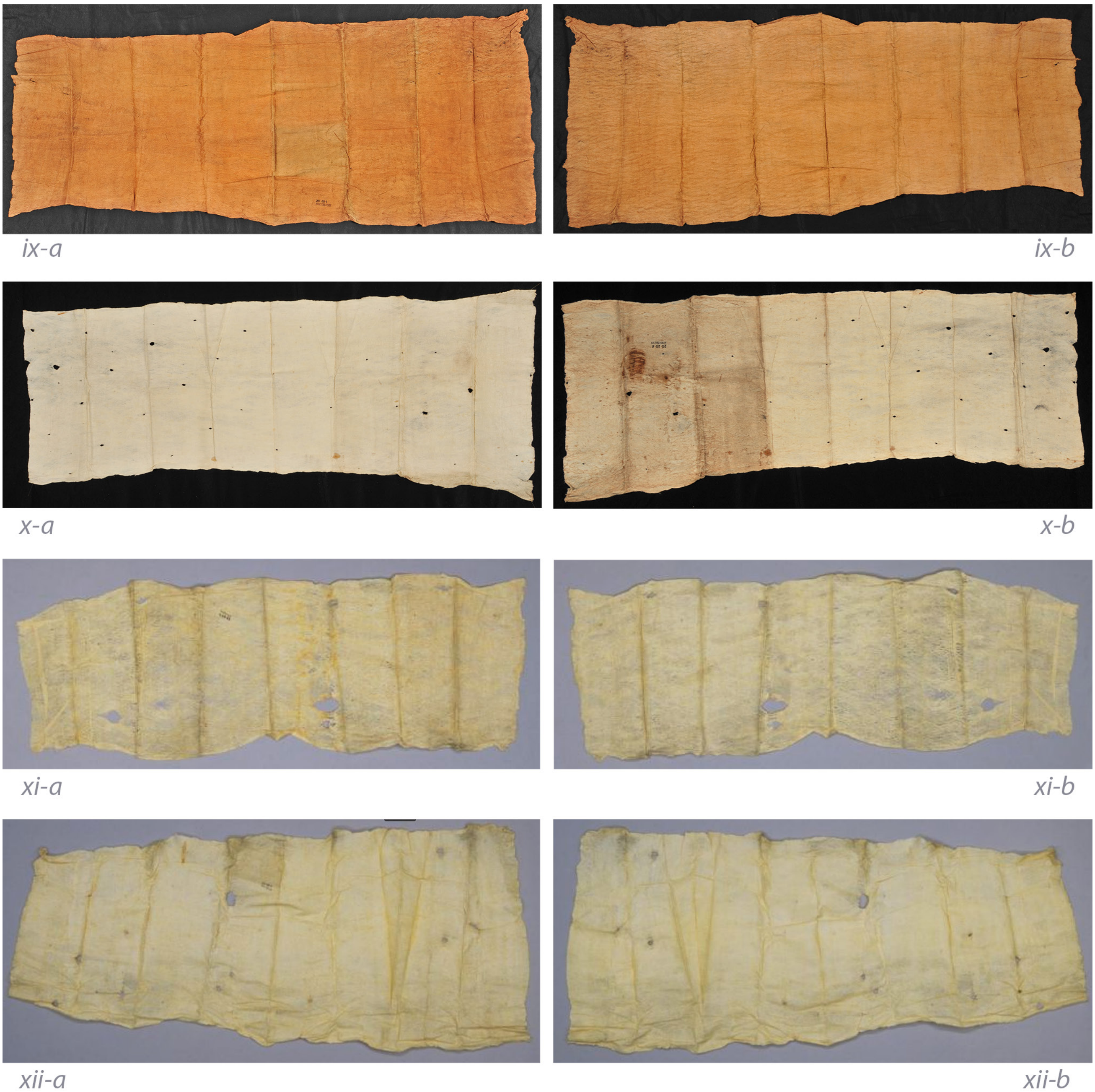

Figure 5. Group C: barkcloth without dye. George Brown Collection, Solomon Islands (ix = H138295, x = H138299, xi = H138300, xii = H138305). Photos courtesy National Museum of Ethnology, Osaka.

Uniting Church Archives (UCA), in Australia (Anon, n.d.), possibly prepared by George Brown's daughter Elizabeth Brown soon after he died in 1917 (Reeson, 2013: 335). The UCA list includes 683 items or groups of items, including 'Item 249: Ten native cloths from Ysabel and Ruviana' (now called Isabel and Roviana). This group could be identified in the George Brown Collection because numbers in a series 23-23-1 to 23-23-10 (henceforth the 'old number' series) are written on the cloths. Original labels in the George Brown Collection are very cursory, and records in the electronic database are correspondingly cursory. Creating a full confirmed inventory of cloths from the Solomon Islands and Melanesia would require physical examination of all 105 cloths in the Collection. Further examples from the Solomon Islands may exist among the cloths not seen by us.

All 12 cloths seen by us were made from single pieces of beaten bark, usually oblong and tapering slightly from the shape of the tree, wider at base and narrower at top. None have joins or repairs, despite many parts having coarse stringy fibres or parts that are very thin or with holes. For the purposes of description, the cloths are grouped below into three groups: (A) with blue dye all over, (B) decorated with blue designs, and (C) without dye. We use the term 'decoration' in a technical sense, to distinguish plain monochrome and undyed cloths from those with abstract or pictorial designs. The possible botanical sources of the blue dye are discussed later.

Descriptions follow for each cloth (i–xii), in three groups (A–C). Each description begins with the current collection number at the National Museum of Ethnology, and concludes with original, old number in the UCA list, if present. Main dimensions and weight recorded in the Museum database are also noted if available, after our own measurements of the main dimensions. To avoid damage, we did not flatten creases. Differences in the two sets of measurements presumably reflect differences in how the cloths were unfolded. The Museum data have been used to calculate an average cloth weight per area (see below).

A. Barkcloth with blue dye all over (Fig. 2)

1 H138297. *Ficus (?Artocarpus),* thick heavy cloth, dyed heavily, dark blue all over 'front' side. Dye has leached through unevenly to 'under-side', where areas with less dye reveal natural, light brown fibre colour. L. 171 cm tapering to 168 cm, W. 90 cm tapering to 68 cm (Museum database gives L. 176, W. 88—possibly based on more complete unfolding and stretching of the cloth—and weight 342 g). Old number 23-23-3.

2 H138303. *Ficus (?Artocarpus),* thick, coarse cloth, dyed blue all over on one side (the 'front'), and leached through unevenly to underside. Natural fibre colour light brown. Holes caused by damage at one edge. Two brown ?stains on front, apparently coming from underside, where they are more obvious. L. 97 cm, W. 76 cm. Old number 23-23-9.

B. Barkcloth decorated with blue designs (Figs 3 and 4)

3 H138298. *Ficus (?Artocarpus),* a long and narrow cloth, light brown, decorated all over in blue circles (approx. 4 cm diameter). Most circles have a blue dot in center, some are empty, one dot has no circle, and there are also some splattered drops of pigment (Fig. 4). Despite fluid application, there is generally little leaching to reverse side, though dots have penetrated. At each end, a narrow edge has blue dye on both sides as if the ends have been dipped. The long sides are marked by long sinuous (wavy) lines. L. 210 cm, W. 56 cm tapering to 40 cm (Museum database gives L. 215 cm, W. 50 cm, weight 342 g). Old number 23-23-4.

4 H138296. *Ficus (?Artocarpus),* light orange brown cloth, some bleaching, some brown staining, some holes. Decorated on one side with 25 double-HH motifs in blue, in two panels. Upper (narrower) panel has 10 motifs, lower panel has 15, and four 'stretched' H motifs frame the upper panel. Each motif was outlined in red on the decorated side, then painted over, leaving some traces of red visible (see detail in Fig. 3 iv-b). The top and bottom edges are also dyed, on the decorated side only. Considerable leaching of dye through to other side from all motifs. Noted by George Brown to be from Kia in northern Isabel. A Solomon Islands expert, Reuben Lilo, has provided a tentative interpretation of the design on this cloth (see Discussion). L. 154 cm, W. 67–63 cm. Old number 23-23-2.

5 H138301. *Ficus (?Artocarpus),* thick, yellow-brown cloth. Decorated with various blue motifs painted on one side: six consist of a single 'I' shape (at narrower 'top' end, derived from narrower upper part of source trunk); 17 consist of three 'I' figures joined by single line; eight consist of four 'I' shapes, joined at the middle by a single line; one consists of five straight lines joined by a single long line; and a few irregularly-distributed blue spots (Museum database gives L. 124 cm, W. 67 cm, weight 198 g). Old number 23-23-7.

6 H138302. *Ficus (?Artocarpus),* pale orange-brown cloth, decorated with 25 blue motifs in a single panel on the front side, regularly aligned in five rows and five columns. Much dye has leached laterally on front and through to the other side. Motifs composed of two 'anchor' shapes, each with three 'flukes' and joined by a thick line. L. 138 to 135 cm. W. 80 tapering to 68 cm (Museum database gives L. 137 cm, W. 78 cm, weight 231 g). Old number 23-23-8.

7 H138304. *Ficus (?Artocarpus),* pale orange-brown cloth, not rectangular. Painted with blurred blue motifs that have leached through to back side. Four rows of unfamiliar motifs each with square 'box' at top, a vertical 'spine' with two short 'legs' like an arrow head, and near middle, two horizontal lines with an arrowhead at each end. Between those four rows are two more rows with an unfamiliar motif of a vertical line crossed by two horizontal lines, both with one end bent up or down. L. 146 cm. W. 96 cm to 80 cm (Museum database records L. 145 cm, W. 94 cm, weight 341 g). Old number 23-23-10.

8 H139234. *Ficus (?Artocarpus),* orange-brown cloth, large and thin. Some holes, and some tears at narrow (upper) end. At wide (lower) end and lower sides, a narrow blue margin. Painted with crisp blue motifs with four rows of five to seven dugongs, all facing in one direction (towards lower end). Each row of dugongs alternates with a row of H motif, except for the lower-most row which has a single H alongside four wide H shapes with serifs and a small vertical line through the horizontal bar of each H. At the narrow (upper) end of the cloth there are three long blue lines, one plain, one with 18 alternate or opposite rounded 'leaves' attached (a vine motif?), and one (at upper end of the cloth) with nine rounded 'leaves' attached on one side. L. 296 cm tapering to 262 cm. W. 117 cm tapering to 96 cm (Museum database gives L. 265 cm, W. 109 cm, weight 625 g). No 'old number' found. Provenanced only to 'Melanesia' but clearly from Isabel, as similar motifs occur on at least ten other cloths seen by R. Richards, including items 804-40, 805-41 and 806-42 in the Brenchley Collection, Maidstone, UK, and item Oc1981,Q.1572 and BM 6622 at the British Museum, London, UK; item E.11230 in the Australian Museum, Sydney, Australia, item A2000 in the Macleay Museum (now part of the Chau Chak Wing Museum), Sydney, Australia; and item 1802.3.9 at the Whanganui Museum, NZ, and item E181.1092 at Canterbury Museum, Christchurch, NZ.

C. Barkcloth without dye (Fig. 5)

9 H138295. *Ficus (?Antiaris toxicaria),* reddish (terra cotta) brown, thick, no dye, and undecorated. L. 200 cm, W. 90 cm tapering to 72 cm. Old number 23-23-1.

10 H138299. *?Artocarpus,* off-white to light brown, no dye, undecorated. Finely, evenly beaten, from a single stem, with no patches or joins. None of the holes have been mended. The many small holes mark branch attachment points and are more abundant towards the narrow, upper end (corresponding to the upper end of the source stem). Cloth thicker at the wider lower end. L. 142 cm, W. 55 cm. tapering to 50 cm. Old number 23-23-5.

11 H138300. *Artocarpus (?Broussonetia papyrifera),* white, no dye, undecorated; possibly bleached. Very thin, from a single stem, with no patches or joins, and some areas almost transparent. Few branch holes, not patched and apparently stretched open by beating. L. 165 cm, W. 65 cm. Old number 23-23-6.

12 H138305. *Artocarpus (?Broussonetia papyrifera),* white, no dye, undecorated; possibly bleached. Thin, evenly beaten; twelve holes, no patches or joins. L. 115 cm, W. 96 cm. Not included in the old number 23-23- series, but provenanced to 'Solomon Islands' in the George Brown Collection records.

For six of the putative *Ficus (?Artocarpus)* cloths (measurements of main dimensions (width and length) and weight (g) are given in the Museum database. With these we can make an approximate estimate of cloth area (based on the assumption of rectangular shape), and areal density (g/m^2). The resulting average and standard deviation is 260±60 g/m^2 (similar to the weight of a multilayered Bristol art paper).

Beaters

Two wooden barkcloth beaters (Fig. 6) were also collected by Brown in Roviana, and are held at the National Museum of Ethnology: Item H138245 (old number 363) is a large heavy beater (36 cm long, including cylindrical handle; 1.08 kg), with cylindrical head (7.5 cm diam.), deep longitudinal grooves, and a longitudinally-convex striking face. Item H138246 (also old number 363) is smaller and lighter (28 cm long, including cylindrical handle; 600 g) with cylindrical head (6.4 cm diam.), deep longitudinal grooves and a longitudinally-concave striking face. Both are made from a dark reddish-brown hardwood (possibly *Manilkara* sp. or *Casuarina equisetifolia*), and appear designed to beat and spread bark into a coarse sheet or the early stages of a fine cloth (neither has the narrow grooves needed to make fine cloth). Both seem new and unused, but close examination is needed to look for residues of bark fibre, which would confirm use and perhaps allow identification of the fibre source. Whether or not they were replicas made for sale, they might represent a technically complementary (concave /convex) working pair, with concave form spreading the force of the heavier beater (assuming use of a convex anvil surface; see 1908 photo of concave beater on carved anvil with flat and rounded parts, in Richards and Roga, 2005: 13), and convex form focusing the force of the lighter beater (assuming that the anvil used was flat or convex; see 1992 photo of convex beater on flat anvil in Richards and Roga, 2005: 20).

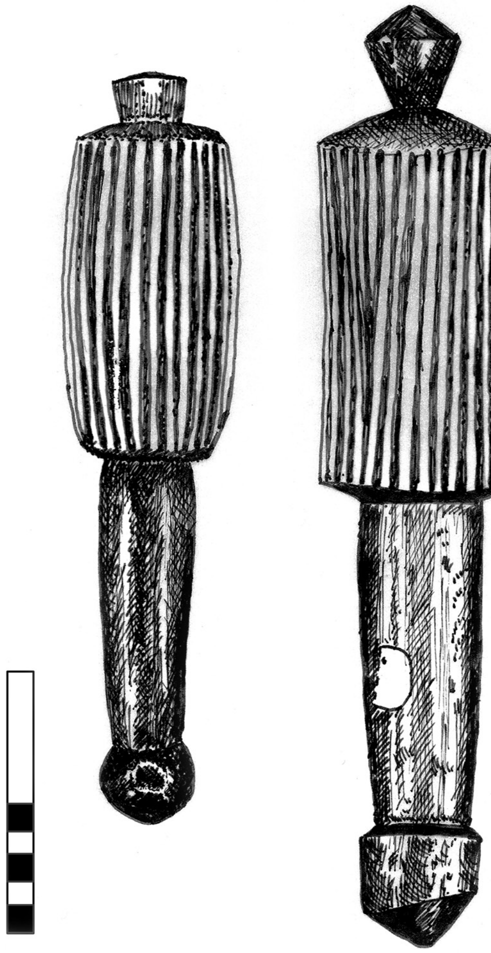

Figure 6. Barkcloth beaters collected by George Brown at Roviana, New Georgia. Left, convex, H138246. Right, concave, H138245. Scale bar 10 cm (sketch by P. J. Matthews).

Discussion

Analysis of motifs

While graphic motifs are generally considered to be designs set in a larger field, or elements of an image, a completely monochrome field can be regarded as a 'motif' when it is used as a symbolic element of a full costume. Bond (1996: 45) found that plain blue barkcloth was previously used in several language groups in the western Solomons 'at crucial stages of the life cycle including the ritual procedures associated with marriage, death and possibly birth'. In certain contexts, 'bark cloth was considered to have great potency, perhaps equivalent to life itself', and represented connections 'between the living and the dead, decay and growth.' This may have been the case in some localities, but whether it was so among the people on Isabel who made blue-dyed barkcloth has not been established from the written records seen by us.

Richards and Roga (2005) found a wide range of abstract and pictorial motifs on decorated cloths from the western Solomon Islands in museum collections, and two broad style categories were noted. Decorated cloths from Simbo Island and Roviana are large and long with abstract and pictorial motifs that help tell 'kustom storis'. Decorated cloths from Isabel have different motifs, especially variations of single and multiple HHH, III and TTT shapes, some single and some joined together. Several cloths from Isabel show fish, dugong (apparent from the forward-placed flippers, long bulging body, and wide horizontal tail, on same plane as the flippers when viewed from above), frigate bird and anthropomorphic motifs, as well as simple grids and 'boxes'. The abstract motifs are difficult to interpret in any direct manner, but they are unlikely to have been purely decorative. On the six decorated cloths in the George Brown Collection, the main motifs are shaped like capital letters H or I in various combinations and with various embellishments. These motifs are very regularly formed on cloth H138296 (Fig. 3 iv) which is the only one that George Brown provenanced specifically, as from 'Kia' in northern 'Isabel'. He probably collected it when he visited Kia in 1911. The simple H and I figures on cloth H138301 (Fig. 3 v) are like cloths in other collections that are securely provenanced to Isabel. The more embellished motifs on cloths H138302 (Fig. 3 vi), and H138304 (Fig. 3 vii) are similar to those on Isabel cloths in the British Museum (all illustrated in Richards and Roga, 2005: 51–65). The cloth H139234 (Fig. 3 viii) is not in the UCA list group, and is known only as 'from Melanesia', but combines alternating rows of H shapes and dugong images and is very similar to another cloth from Isabel in the Macleay Museum, Sydney (Richards and Roga, 2005: 56) and cloth Oc1981,Q.1572 in the British Museum (probably from Isabel, Richards and Roga, 2005: 60). Dugongs are sea mammals traditionally accorded respect for being 'nearly human,' but today dugongs are quite scarce. So far, no cloths from Simbo have been found with dugongs, which suggests that the dugong motif is indicative of a cloth origin on Isabel. The dots within circles on cloth H138298 (Figs 3 iii and 4) are not known in such profusion on other decorated cloths from the western Solomon Islands. In summary, none of the motifs on the six decorated cloths in the George Brown Collection casts any doubt on their common provenance to the island of Isabel.

Some further comments can be made regarding the interpretation of decorated cloths. As recounted by Richards and Roga (2005). Mr Lilo, a former school-teacher, Member of Parliament and Premier of Western Province, was trained by his grandfather in the pre-Christian traditional lore and religion of Simbo Island, sometime before the 1950s. Mr Lilo interpreted readily and confidently several decorated cloths collected on Simbo in 1901, explaining that they convey simple stories and fables about fishing, hunting and life events generally. He also explained that a difference in perspective, namely that density of design indicates nearness, while open spaces convey distance and time. In recent correspondence regarding the abstract designs on H138296 from Isabel (Fig. 3 iv-b), Mr Lilo noted cautiously that he was not brought up in Isabel, but on Simbo some 220 to 360 km and at least five major language groups distant from Isabel. However, he considered that '(t)his cloth [H138296] is the chief's or a paramount leader's cloth for wearing and depicts unity, togetherness and people-based leadership.' This interpretation suggests that the abstract designs on this Isabel cloth had a symbolic rather than narrative function. The cloth H139234 (Fig. 3 viii), presumed to be from Isabel (see above), includes both abstract and 'pictorial' motifs. This cloth might have both narrative ('kustom stori') and symbolic functions. More work is needed—both in the field and through literature study—to understand the narrative and symbolic meanings of pictorial and abstract elements in all these cloths.

Historical records from the late 19th to early 20th centuries (Richards and Roga, 2005: 83–92) refer to the trading of cloth from Isabel to Roviana in New Georgia where, it was said, the dying process was unknown. Such trade may have made it possible for George Brown to obtain his cloths in New Georgia. Trading from Isabel (plus looting and thefts) probably spread cloths to other areas, so that Isabel motifs were known in Roviana, Ranongga and Simbo Islands, but perhaps only as decorations, not as meaningful symbols conveying 'kustom storis.'

Identifying dye plants

All but one of the brown or orange brown cloths made from *Ficus sp*. (?*Artocarpus*) have applications of an indigo-blue dye. What may be the earliest collection of blue-dyed barkcloth in the Solomon Islands was made by Julius Brenchley in 1865 (Richards and Roga, 2005: 56–58; Phelps, 1976: no. 1136, pp. 248, 436), while the earliest description of production method is from New Georgia in 1897:

> Bark cloth was usually made by women, but men could make it if necessary… The tapa was made from several sorts of bark; *kalolo*, *berekoto*, being the two most usual. These two have a naturally reddish colour. Another sort is white, and this one is often died entirely blue with wild indigo. This is done in Ysabel, the New Georgia women being said not to understand the colouring process… A bright blue dye is obtained from the wild indigo which is bruised up with lime [powder] and water, and is used for dying bark-cloth (Somerville, 1897: 361, 375).

The source of the blue dye is a plant in the pea family (Fabaceae) and was described Charles Woodford (first British Commissioner in the Solomon Islands) as:

> … still in use by the natives of Ysabel as late certainly as 1910. It is a vegetable dye resembling indigo and is used for colouring bark cloth… the leaves are first wilted then sprinkled or soaked in salt water. They are then chewed by the women which produces a blue saliva that they then spit or smear on the cloth… The plant was identified for me by the Kew authorities as *Desmodium brachypodum.* The native name of the plant in Isabel is pau. (Woodford, 1926: 484).

Kew Herbarium holds two Isabel plant specimens, one collected by Rev. R. B. Comins in 1893 (K000264036), with a specimen label stating: 'a dye plant used by natives for staining blue their tappa [sic] cloth. Apparently an indigo', and the other by Woodford in 1907 (K000264035) (collection dates recorded on herbarium specimen labels). There is also a Solomon Islands specimen collected by 'Officers of the H. M. S. Penguin' in 1894 (most likely in the vicinity of New Georgia), with a specimen note: 'Indigo, used for making blue dye by natives' (K000264037).

Bond (1996) noted that *Desmodium* is not known among indigo (blue dye) source-plants in other parts of the world, and the only related report we have found is a brief note that the seeds of *Desmodium multiflorum* can be used to prepare a purple dye, in India (Senthilkumar *et al.,* 2015).

In 1595, at Graciosa Bay in Santa Cruz (Nendo Island), in the southeastern Solomon Islands, the Spanish explorer Quiros recorded a 'tall branching shrub... from which indigo dye is made' (Yen, 1973). Yen interpreted this as being *Sophora tomentosa* (also in the pea family), noting further that 'dark blue dye is still occasionally extracted from the bark and roots of this shrub found wild in Graciosa Bay'. *S. tomentosa* is a pan-tropical beach shrub that is widespread in the Pacific Islands, and was collected on Isabel in the Solomon Islands by P. F. Hunt in 1965 (Kew Herbarium, specimen 32393.000 kept in spirit). No other record of its use as a dye plant has been found, but *S. japonica* is well known as a source of yellow dye (Brunello, 1968). Regardless of the specific plants used as dye sources, the reports by Quiros and Yen suggest that blue-dyed barkcloth was previously widely made in the Solomon Islands, and already long before the period of intensive contact and trade with Europeans that began in the 1800s (Richards, 2012; Thomas, 2019; Bayliss-Smith *et al*., 2019). Yen (1974) recorded *Antiaris toxicaria* as cultivated in Santa Cruz, and previously used for barkcloth in the Solomon Islands generally, including the islands Anuta and Tikopia. He did not report paper mulberry or *Ficus* in Santa Cruz, but noted that *Artocarpus altilis* was previously used as an alternative to *Antiaris* for barkcloth. We cannot know which of these bast plants was used with the blue dye in Santa Cruz, but *Artocarpus* is the better candidate, as *Antiaris* generally produces a coarse and darker, brown or reddish-brown cloth (not well-suited for painted designs).

The last known local mention of dyeing cloth on Isabel was by Bogesi (1948: 227):

> Pohe: bark cloth made of *punga* bark pounded thoroughly. After pounding the bark is laid out and dried. It is dyed blue with the leaves of *fute*, a clover like grass, by chewing and spitting the liquid over the cloth. The cloth is used for barter, especially with the western Solomons.

'Grass' can be understood as a gloss for 'herb', and *fute* likely refers to *Desmodium*, a clover-like herb. Several names were used for barkcloth in Isabel including *pohe aroaro* for barkcloth with designs, *pohe bao balo* for partially coloured barkcloth, *pohe buubulu* for partly dyed barkcloth and *pohe domu* for darkly coloured cloth (Ivens in Waite, 1987: 59). The only colours mentioned were light or dark blue.

When blue dying ceased is not clear. Eight women from Isabel wore blue cloths as dance skirts at the Third South Pacific Festival of Arts in Papua New Guinea in 1980 (Richards and Roga, 2005: 90). After repeated enquiries among people from Isabel, mainly in Honiara but also on southern Isabel, Richards found no-one could recall how to make the blue dye. A light blue 'traditionally dyed tapa cloth' was sent to him from Pogalo village in southern Isabel in 2008, but without any further information as to how, or when, it was made and dyed. Some plain bark cloth is still made in northern Isabel and elsewhere as loin cloths (*kabilato*) for men who dance to pan pipes, but it seems that now no-one knows of any blue dyed cloth made in the last thirty years. The trajectory of loss of this knowledge has parallels in Indonesia, where a variety of plants were previously used to produce dyes for barkcloth, including a blue-purple colour derived from an unnamed species of the Papilionaceae [an old name for the pea or bean family, now known as Fabaceae] (Aragon, 1990: 41).

Identifying bark sources

Moskvin (2017) noted the lack of any method that allows non-experts to identify bast plant sources for barkcloth, and numerous difficulties for identification with light microscopy or scanning electron microscopy. Identification matters for understanding the history of barkcloth because (a) every species used has different requirements for growth, harvest, and processing, and (b) the barkcloth made from each species has different qualities that affect practical use, aesthetic qualities, and symbolic value. Identification also matters for understanding how bast plants have been used and moved by people in the past, and for future selection and use of the plants.

Historical collections of blue-dyed barkcloth from the Solomon Islands are rare, widely scattered in museum collections, and poorly documented. The 12 examples found in the George Brown Collection are relatively well provenanced, in geographical and chronological terms, but as in most collections, source plants were not recorded at the time of collection. For us, the source plants for all 12 cloths are ambiguous. *Ficus variegata* was recorded by Richards and Roga (2005: 19) as the source of a 'dark red' cloth that appears similar to that shown in Fig. 5 ix, but *Antiaris toxicaria* is also a candidate, as it produces a similar colour, a 'terracotta' like that of cloths made from *Antiaris toxicaria* and *Ficus natalensis* in Uganda (Rwawiire *et al.*, 2013). *Ficus variegata* is common throughout the Solomon Islands, has a 'pinkish brown' bark, and is a reported source for barkcloth (Corner, 1967). Cloths identified in Group B as *Ficus* (?*Artocarpus*), are ambiguous because cloth made from *Artocarpus* can have a reddish tinge (like some *Ficus*) if some of the outer bark layer is kept when preparing the bark for beating, and bark from *Ficus* spp. may also approach the lighter colour of bark from *Artocarpus*. Both of these genera belong to the family Moraceae, and the bark fibres in beaten cloth appear similar when viewed by eye, though the fabric made from *Ficus* may be thicker or coarser.

The last two cloths (Group C, Fig. 5 xi, xii) are comparable to those recently made from *Artocarpus* and photographed in the western Solomons (Richards and Roga, 2005: 11–22), and may be the first plain, white, undyed cloths recorded in museum collections from this region. Three sections of barkcloth made from *Artocarpus communis* were collected at Roviana in 1929 by J. H. L. Waterhouse (no. H2202/29 in Kew 2020), but no image or other data are shown in the Kew online database. The two cloths are also comparable in appearance to cloth made from paper mulberry (*Broussonetia papyrifera*), a tree recorded in 1966 on Bellona Island (Fig. 1) and in 2005 on Lauru Island (also known as Choiseul, Fig. 1) in the western Solomon Islands (McClatchey *et al*., 2005). However, the lack of historical reports of paper mulberry barkcloth in the Solomon Islands, and the scarcity of botanical records of the plant (Yen, 1974; Henderson and Hancock, 1988; and other negative records cited in Matthews, 1996), suggest that paper mulberry was not commonly used for barkcloth in the Solomon Islands in the past. Following modern introduction of male and female plants, and establishment of a breeding population near Honiara, paper mulberry has started to spread spontaneously (Marten, 1975). If the plants reported in locations other than Honiara were not modern introductions, they may be living, clonally-propagated relicts of interactions with Austronesian-speakers involved in the spread of paper mulberry into Remote Oceania. If so, archaeologists may find special interest in archaeological sites in the vicinity of such plants.

Difficulty in identifying plant sources for barkcloths from the Solomon Islands is compounded by the presence of multiple candidate species within *Artocarpus* and *Ficus*, and the presence of further taxa that are known sources elsewhere in the western Pacific (including paper mulberry; see Introduction). Few published records of Melanesian barkcloth in museum collections include secure identification of the plants used to make individual pieces. Currently, the Economic Botany Collection at Kew Gardens (Kew, 2020), lists 32 cloths (as 'tapa') with known geographical provenance are identified as being made from paper mulberry, and all are from Polynesia or 'South Sea' islands, the exception being a patterned cloth, no. 73928, from New Caledonia, collected by P. Cribb in the 1980s. No other source taxa are recorded for cloths listed as 'tapa'. In the same Kew catalogue, listed as 'bark cloth', there are cloths made from *Antiaris* (six, from Ghana, Malaysia, Uganda, India), *Artocarpus* (five, from Borneo, Indonesia, Solomon Islands and unknown), and *Ficus* (16, from India, Papua New Guinea, Tanzania and Uganda). None of these online records are accompanied by photos, but the Kew collection has been a valuable starting point for preparing physical descriptions of bark cloth made from known plant sources (Lennard and Mills, 2020).

The ethnographic collection of the National Museum of Ethnology, Netherlands, includes a large collection of cloths from Oro Province, Papua New Guinea, where the paper mulberry is commonly used (Hermkens, 2005; Barker, 2008). A plantation of paper mulberry is clearly shown in an early photograph from the lower Musa River, Oro Province, alongside a woman wearing barkcloth (Mosuwadoga, 1977). Hill (2001) links the use of different kinds of bark in Papua New Guinea to environmental preferences of the trees: Paper mulberry is predominant in coastal locations with well-drained soils. In coastal areas with limestone soils, *Artocarpus altilis* is most popular and also makes 'a whitish cloth', and in coastal swampland, mangrove trees may be used. Further inland, *Ficus* is the 'next most popular choice', providing cloth that is 'generally darker in colour than that from paper mulberry or breadfruit', in 'various shades of beige, yellow or grey depending on the species.' Thus, the ecology of a location may also be a clue to the likely source plant for a given example of barkcloth. A confounding historical factor is the spread of early (19th century) missionary stations in coastal Melanesia, including those established by George Brown: many stations employed South Pacific islanders trained for missionary work, and Solomon Island missionaries were also trained in Fiji, so the possibility of modern, coastal introductions of paper mulberry from Polynesia must also be considered.

Yen (1974: 258) noted that *Antiaris toxicaria* was previously used for barkcloth on Santa Cruz Island, that it was still the main plant used for barkcloth in Anuta and Tikopia, and that it may have been used in the main (western) Solomon Islands. He also noted that the status of this tree as part of a natural distribution of the species in Melanesia is uncertain. In the Solomon Islands seeded forms of breadfruit (*Artocarpus altilis*) predominate, and were previously used for barkcloth in Santa Cruz, and for food. Yen (1974: 260) noted that breadfruit is 'unimportant' for subsistence in the western Solomon Islands, and was used for barkcloth on Kolombangara Island in the New Georgia group.

What were the main uses of barkcloth in the past? George Brown included a wide range of utilitarian objects in his collection, which was created over many years, and often in close interaction with the communities he entered as a missionary. Nevertheless, most of the Pacific island barkcloths collected by him, including those from the Solomon Islands, are large decorated sheets, not plain undyed pieces used for daily wear. For everyday use, plain undyed barkcloth may have been the most important product in most barkcloth-making regions of the world, before the spread or dominance of woven textiles. As Vargyas (2016) showed, a simple perishable barkcloth can be quickly made using wooden tools that are also simple, quickly-made and perishable. Barkcloth and wood are materials that are rarely preserved archaeologically, though preservation of the dense woods used for beaters like those shown here (Fig. 6) would be favoured in continuously-waterlogged sites. In Southeast Asia and Melanesia, for most of the prehistoric period, non-Austronesian and Austronesian traditions of barkcloth production and decoration may have employed many different wild or cultivated plants for barkcloth and dye making, without leaving any obvious physical traces.

The likely deep antiquity of barkcloth production may have been significant for selection and spread of plants used as bast and dye sources. This does not appear to have been given any direct consideration in botanical and historical discussions of *Antiaris*, *Artocarpus* or *Ficus*. In recent years, extensive and detailed studies have been carried out on the taxonomy of *Artocarpus* and the origins and spread of domesticated breadfruit, *Artocarpus altilis*, documenting the transition from a fertile, seeded wild species (*A. camansi*) to vegetatively-propagated seedless forms of *A. altilis* (Zerega *et al*., 2004, 2005; Jones *et al*., 2013). In these studies, breadfruit is discussed almost entirely in relation to its use as a food crop. We suggest that the present distribution and diversity of *Artocarpus* spp. may also reflect past uses of wild and cultivated species for barkcloth production. Yen (1974) also observed that seedlings of *Antiaris toxicaria* were transplanted to establish new self-propagating stands of the tree next to breadfruit trees, in order to provide 'living ladders'. Throughout its range, from Africa to Asia and the Pacific, *Antiaris toxicaria* has a wide range of uses, including use as a source of latex for poison and adhesive in hunting and warfare (PlantUse, 2020). Given their many uses, it is possible to imagine breadfruit and upas being actively propagated as complementary trees in many areas of overlapping distribution in the western Pacific.

In Oceania, most historical research has focused on traditions related to barkcloth made from paper mulberry, the symbolic meanings of barkcloth designs, and the social importance of barkcloth. The use of paper mulberry for barkcloth has a likely antiquity of several thousand years, as the natural distribution of paper mulberry in eastern Asia and mainland Southeast Asia (Matthews, 1996) coincides geographically with numerous archaeological sites yielding early stone barkcloth beaters dated to between 7900 and 3000 years BP (Li *et al.,* 2014, 2017; Howard, 2017; Tang and Tang, 2017). Yet, the story of paper mulberry may be a relatively young branch of the story of barkcloth. Vargyas (2016) made this point very clearly in his discussion of the use of *Antiaris toxicaria*, and simple wooden tools to make barkcloth in a mountain region of central Vietnam: identifying the origins of barkcloth per se cannot depend on the evidence of stone tool technology, which is far better preserved than wooden technology. Vargyas (2016) also emphasised that historical-linguistic approaches need to be applied to all the wild and cultivated plants used for making barkcloth. Historical-botanical approaches are also much needed. Is a mixing of younger (Austronesian) and older (non-Austronesian) traditions apparent in the plants used in the Solomon Islands? Systematic analyses of barkcloth traditions in Oceania have been attempted in order to trace the origins, development and spread of barkcloth culture (Tolstoy, 2008; Larsen, 2011), but such attempts are limited by the lack of clear botanical identification in most historical records available for analysis. The barkcloth traditions of Sulawesi, Micronesia and Fiji were treated by Larsen (2011) as taxonomic outgroups for an analysis focused on Polynesian barkcloth traditions (the taxonomic ingroup), but the entire analysis seems to have ignored the possibility of Melanesian (and potentially non-Austronesian) contributions to the diversity of traditions studied—despite citing widespread use of *Artocarpus altilis* (breadfruit, a Melanesian domesticate) in the Cook Islands, Austral Islands, Mangareva, Hawaiian Islands, Marquesas, Rapa Nui-EI, Samoan Islands, Tonga, Society Islands, Sulawesi (east Indonesia), and Ponape (Micronesia). In principle, it is now possible to link historical and botanical records directly through DNA analysis of barkcloth, as has been demonstrated with an archaeological sample of barkcloth that was found to be made from paper mulberry (Seelenfreund *et al.,* 2016), despite the presence of contaminating DNA. (To avoid contamination effects, species-specific primers can be used to amplify DNA regions that are taxonomically informative).

Blue-dyed barkcloth appears to be rare globally, and is no longer made in the Solomon Islands. From Africa to Southeast Asia, however, the use of plant-based, indigo-blue dyes for woven textiles is widespread, and still continues, despite the arrival of modern chemical dyes. Aniline dyes were produced industrially in Europe by the 1860s (Garfield, 2000), and in 1917–1920 aniline blue dye was seen on barkcloth in Sulawesi, Indonesia, by the Swedish ethnologist Walter Kaudern (Howard, 2017). Although aniline dyes could have reached the Solomon Islands during the same period as George Brown's visits, the early Spanish record of an indigo (blue) dye in Santa Cruz (see dye plants above) pre-dates the invention of aniline dyes, and the more recent historical records reviewed above confirm that the blue dye was plant-based and locally made.

The blue-dyed barkcloth of the Solomon Islands is an enigmatic tradition in material and historical terms. Natural indigo dye is made from various species of *Indigofera*, a genus that is closely related to *Desmodium* and that is also present in Melanesia. Did the use of *Indigofera* spp. as a source of blue dye predate the woven cloth traditions with which it is universally associated today? Did the blue dye tradition in the Solomon Islands arise independently, or did it reach the Islands as part of an early spread of barkcloth and dye making in Southeast Asia and the western Pacific, surviving only in relative isolation from the weaving traditions that later appeared in Southeast Asia? Dye plants can be used to colour many kinds of non-woven fibre product, including plaited mats and bags, rope or string, and string bags (*bilum*). To learn more about the range of plants that produce indigo-blue dyes, we must study the dyes used for all plant fibre products.

Conclusion

This review and discussion of barkcloths from the Solomon Islands reveals how little is known about barkcloth collections and their plant sources generally. To learn about the history and meaning of material objects we must look far beyond the boundaries of a museum. George Brown—along with many others—was surely instrumental in the cultural changes that led to the adoption of new textiles and modes of dress in the Solomon Islands, and decline in barkcloth use. He assembled his collection while expecting that changes would come to the Islands, but of course without knowing exactly what the changes would be. We hope that the present article will help bring barkcloth from the Solomon Islands back to light, so that others can return meaning to collected examples, and find new meanings and uses for them.

Barkcloth traditions associated with plants such as *Antiaris, Ficus*, and *Artocarpus* must have origins and trajectories very different from those associated with paper mulberry. Each of these plants, and many others, have their own special qualities as bast fibre sources and have unknown antiquity as useful plants. To recognise their significance for distant ancestors, we must first learn to recognise the plants.

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References

Addo, P.-A. 2013. *Creating a Nation with Cloth: Women, Wealth, and Tradition in the Tongan Diaspora*. New York and Oxford: Berghahn Books.

Anonymous. 1917. *Ethnological Collection of the Late Rev. Dr. G. Brown*. Unpublished typescript kept with Will of the collector (d. 1917), Uniting Church Archives, North Parramatta (courtesy D. Moore).

Aragon, L. V. 1990. Barkcloth production in central Sulawesi: a vanishing textile technology in outer island Indonesia. *Expedition* 32: 33–48.

Barker, J. 2008. *Ancestral Lines: The Maisin of Papua New Guinea and the Fate of the Rainforest*. Peterborough, Ontario: Broadview Press.

Bayliss-Smith, T., M. Prebble, and S. Manebosa. 2019. Saltwater and bush in New Georgia, Solomon Islands: exchange relations, agricultural intensification and limits to social complexity. In *Archaeologies of Island Melanesia*, ed. M. Leclerc and J. Flexner, pp. 35–52. Terra Australis 51. Canberra: ANU Press. https://doi.org/10.22459/TA51.2019.03

Bogesi, G. 1948. Santa Isabel, Solomon Islands. *Oceania* 18(3): 208–232. [Article continued in issue no. 4, see below] https://doi.org/10.1002/j.1834-4461.1948.tb00476.x

Bogesi, G. 1948. Santa Isabel, Solomon Islands. *Oceania* 18(4): 327–357. [Article continued from issue no. 3, see above] https://doi.org/10.1002/j.1834-4461.1948.tb00488.x

Bond, V. 1996. *A Study of Barkcloth from the Solomon Islands: With Particular Reference to the Use of Indigo in the North-Western Region*. Unpublished MA thesis, University of East Anglia, Norwich.

Brown, G. 1903. Letter to Mr Etheridge, 6th Feb. 1903, with letterhead of the Methodist Missionary Society of Australasia, 381 George Street, Sydney. Australian Museum Archives (date stamp 9 Feb. 1903, no. B.6, reply to 681; handwritten no. E. 11229–30).

Brown, G. 1908. *Pioneer-Missionary and Explorer: An Autobiography.* London: Hodder and Stoughton.

Brown, G. 1910. *Melanesians and Polynesians: Their Life Histories Described and Compared*. London: Macmillan and Co.

Brunello, F. 1968. *The Art of Dyeing in the History of Mankind*. Cleveland: Phoenix Dyeworks.

Butaud, J.-F. 2017. Les plantes à tapa de Polynésie orientale. In *Tapa, de l'Écorce à l'Étoffe. Art Millénaire d'Océanie. De l'Asie de Sud-Est à la Polynesie Orientale/Tapa, From Tree Bark to Cloth. An Ancient Art of Oceania. From Southeast Asia to Eastern Polynesia*, ed. M. Charleux, pp. 496–503. Paris: Somogy Éditions d'Art.

Chang, C.-S., H.-L. Liu, X. Moncada, A. Seelenfreund, D. Seelenfreund, and K.-F. Chung. 2015. A holistic picture of Austronesian migrations revealed by phylogeography of Pacific paper mulberry. *Proceedings of the National Academy of Sciences of the USA* 112(44): 13537–13542. https://doi.org/10.1073/pnas.1503205112

Charleux, M., ed. 2017. *Tapa, de l'Écorce à l'Étoffe. Art Millénaire d'Océanie. De l'Asie de Sud-Est à la Polynesie Orientale/Tapa, From Tree Bark to Cloth. An Ancient Art of Oceania. From Southeast Asia to Eastern Polynesia*. Paris: Somogy Éditions d'Art.

Corner, E. J. H. 1967. *Ficus* in the Solomon Islands and its bearing on the post-Jurassic history of Melanesia. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 253: 23–159. https://doi.org/10.1098/rstb.1967.0033

Ewins, R. 2017. The red barkcloth of Fiji—*na masi damu ni Viti*. In *Tapa, From Tree Bark to Cloth: An Ancient Art of Oceania. From Southeast Asia to Eastern Polynesia,* ed. M. Charleux, pp. 165–170. Paris: Somogy Éditions d'Art.

Flowers, T. H., M. J. Smith, and J. Brunton. 2019. Colouring of Pacific barkcloths: identification of the brown, red and yellow colourants used in the decoration of historic Pacific barkcloths. *Heritage Science* 7(2): e15. https://doi.org/10.1186/s40494-018-0243-9

Gardner, H. B. 2006. *Gathering for* God. *George Brown in Oceania*. Dunedin: Otago University Press.

Garfield, S. 2000. *Mauve: How One Man Invented a Color that Changed the World.* New York and London: W. W. Norton.

Hayashi, I., and P. J. Matthews. 2017. The George Brown Collection. *Minpaku Anthropology Newsletter* 44: 10–11.

Henderson, C. P., and I. R. Hancock. 1988. *A Guide to the Useful Plants of the Solomon Islands*. Honiara: Research Department, Ministry of Agriculture and Lands.

Hermkens, A. 2005. *Painting the Past and the Future. Barkcloth of the Maisin people in Papua New Guinea*. Leiden: National Museum of Ethnology.

Hill, R. 2001. Traditional barkcloth from Papua New Guinea: materials, production and conservation. In *Barkcloth: Aspects of Preparation, Use, Deterioration, Conservation and Display*, ed. M. M. Wright, pp. 24–55. London: Archetype Publications.

Howard, P. M. C. 2017. Southeast Asian barkcloth. In *Tapa, From Tree Bark to Cloth: An Ancient Art of Oceania. From Southeast Asia to Eastern Polynesia*, ed. M. Charleux, pp. 45–52. Paris: Somogy Éditions d'Art.

Ishimori, S., and I. Hayashi, eds. 1999. *Studies on the George Brown Collection*. Senri Ethnological Reports 10. Osaka: National Museum of Ethnology.

Jones, A. M. P., S. J. Murch, J. Wiseman, and D. Ragone. 2013. Morphological diversity in breadfruit (*Artocarpus*, Moraceae): insights into domestication, conservation, and cultivar identification. *Genetic Resources and Crop Evolution* 60(1): 175–192.
https://doi.org/10.1007/s10722-012-9824-8

Kennedy, R. 1934. Bark-cloth in Indonesia. *Journal of the Polynesian Society* 43(4): 229–243.
https://www.jstor.org/stable/20702569

Kew. 2020. *Economic Botany Collection*. United Kingdom: Kew Gardens. [Accessed 6 May 2020]
https://tinyurl.com/kew-ebc

Kooijman, S. 1963. *Ornamented Bark-Cloth in Indonesia*. Leiden: E. J. Brill.

Kooijman, S. 1972. *Tapa in Polynesia*. Honolulu: Bishop Museum Press.

Kooijman, S. 1977. *Tapa on Moce Island, Fiji: A Traditional Handicraft in a Changing Society*. Mededelingen van het Rijksmuseum voor Volkenkunde 21. Leiden: E. J. Brill.

Larsen, A. 2011. Evolution of Polynesian bark cloth and factors influencing cultural change. *Journal of Anthropological Archaeology* 30(2): 116–134.
https://doi.org/10.1016/j.jaa.2010.12.004

Lennard, F., and A. Mills, eds. 2020. *Material Approaches to Polynesian Barkcloth: Cloth, Collections, Communities*. Leiden: Sidestone Press.

Leonard, A., and J. Terrell. 1981. *Patterns of Paradise. The Styles and Significance of Bark Cloth around the World*. Chicago: Field Museum of Natural History.

Li, D., W. Wang, F. Tian, W. Liao, and C. J. Bae. 2014. The oldest bark cloth beater in southern China (Dingmo, Bubing basin, Guangxi). *Quaternary International* 354: 184–189.
https://doi.org/10.1016/j.quaint.2014.06.062

Li, D., W. Wang, and C. J. Bae. 2017. The contribution of Guangxi peoples to Austronesian expansions: what the barkcloth beaters say. In *Tapa, From Tree Bark to Cloth: An Ancient Art of Oceania. From Southeast Asia to Eastern Polynesia*, ed. M. Charleux, pp. 53–57. Paris: Somogy Éditions d'Art.

McClatchey, W. C., M. Q. Sirikolo, H. Boe, E. Biliki, and F. Votboc. 2005. A proposed PABITRA study area on Lauru Island, western Solomon Islands. *Pacific Science* 59(2): 213–239.
https://doi.org/10.1353/psc.2005.0023

Marten, K. D. 1975. *Broussonetia papyrifera—weed tree?* Silvicultural Note no. S/2/75. Honiara: Forest Division, Ministry of Natural Resources.

Matthews, P. J. 1996. Ethnobotany, and the origins of *Broussonetia papyrifera* in Polynesia (an essay on tapa prehistory). In *Oceanic Culture History: Essays in Honour of Roger Green*, ed. J. M. Davidson, G. Irwin, B. F. Leach, A. Pawley, and D. Brown, pp. 117–132. Wellington: New Zealand Journal of Archaeology.

Melandri, M., and S. Revolon. 2014. *L'Eclat des Ombres: L'Art en Noir et Blanc des Isles Salomon*. Musée du quai Branly—Jacques Chirac, Paris: Somogy Éditions d'Art.

Moskvin, I. 2017. Methods for microscopic fiber identification of Polynesian barkcloth. In *Tapa, From Tree Bark to Cloth: An Ancient Art of Oceania. From Southeast Asia to Eastern Polynesia*, ed. M. Charleux, pp. 428–434. Paris: Somogy Éditions d'Art.

Mosuwadoga, G. N. 1977. *Traditional techniques and values in the lower Musa River*. Waigani, Port Moresby: Trustees of the National Museum and Art Gallery.

Olivares, G., B. Peña-Ahumada, J. Peñailillo, C. Payaca, X. Moncada, M. Saldarriaga-Cordoba, and E. Matisoo-Smith. 2019. Human mediated translocation of Pacific paper mulberry [*Broussonetia papyrifera* (L.) L'H'er. ex Vent. (Moraceae)]: genetic evidence of dispersal routes in Remote Oceania. *PLoS One* 14: e1–24.
https://doi.org/10.1371/journal.pone.0217107

Peñailillo, J., G. Olivares, X. Moncada, C., Payacán, C.-S. Chang, K.-F. Chung, and P. J. Matthews. 2016. Sex distribution of paper mulberry (*Broussonetia papyrifera*) in the Pacific. *PLoS One* 11: e0161148.
https://doi.org/10.1371/journal.pone.0161148

Phelps, S. 1976. *Arts and Artefacts from the Pacific, Africa and the Americas: The James Hooper Collection.* London: Hutchinson.

PlantUse English contributors. 2020. *'Antiaris toxicaria* (PROSEA)', *PlantUse English,* 11 March 2016.
https://uses.plantnet-project.org/e/index.php?title = Antiaris_toxicaria_(PROSEA) andoldid = 215155

Reeson, M. 2013. *Pacific Missionary: George Brown, 1835–1917, Wesleyan Methodist Church.* Canberra: ANU Press.
https://doi.org/10.26530/OAPEN_459937

Richards, R., and K. Roga. 2005. *Not Quite Extinct: Melanesian Barkcloth ('Tapa') from Western Solomon Islands.* Wellington: Paremata Press.

Richards, R. 2012. *Head Hunters Black and White: Three Collectors in the Western Solomon Islands 1893 to 1914*. Wellington: Paremata Press.

Rwawiire, S., G. W. Luggya, and B. Tomkova. 2013. Morphology, thermal, and mechanical characterization of bark cloth from *Ficus natalensis*. *ISRN Textiles 2013*.
https://doi.org/10.1155/2013/925198

Seelenfreund, A., ed. 2013. *Vistiendo Rapanui: Textiles Vegetales (Haka'ara O Te Kahu)*. Santiago de Chile: Pehuén.

Seelenfreund, A., M. Sepulveda, F. Petchey, B. Pena-Ahumada, C. Payacan, S. Gutierrez, J. Carcamo, O. Kardailsky, X. Moncada, A. M. Rojas, M. Moraga, E. Matisoo-Smith, and D. Seelenfreund. 2016. Characterization of an archaeological decorated bark cloth from Agakauitai Island, Gambier archipelago, French Polynesia. *Journal of Archaeological Science* 76: 56–69.
https://doi.org/10.1016/j.jas.2016.10.008

Seelenfreund, A., A. Rivera-Hutinel, G. Rojas, I. Riquelme, X. Moncada, and D. Seelenfreund. 2017. On the biology and history of paper mulberry (*Broussonetia papyrifera*) in Oceania. In *Tapa, From Tree Bark to Cloth: An Ancient Art of Oceania. From Southeast Asia to Eastern Polynesia*, ed. M. Charleux, pp. 488–495. Paris: Somogy Éditions d'Art.

Senthilkumar, R. P., V. Bhuvaneshwari, S. Sathiyavimal, R. Amsaveni, M. Kalaiselvi, and V. Malayaman. 2015. Natural colours from dyeing plants for textiles. *International Journal of Biosciences and Nanosciences* 2: 160–174.

Somerville, H. B. T. 1897. Ethnographic notes on New Georgia, Solomon Islands. *Journal of the Royal Anthropological Institute* 26: 357–412.
https://doi.org/10.2307/2842009

Specht, J. 1987. The George Brown affair again. *Anthropology Today* 3: 1–3.
https://doi.org/10.2307/3033212

Tang, C., and M. H. Tang. 2017. Origins of barkcloth: a techno-typological analysis of beaters in South China and Southeast Asia. In *Tapa, From Tree Bark to Cloth: An Ancient Art of Oceania. From Southeast Asia to Eastern Polynesia*, ed. M. Charleux, pp. 58–66. Paris: Somogy Éditions d'Art.

Thomas, T. 2019. Axes of entanglement in the New Georgia group, Solomon Islands. In *Archaeologies of Island Melanesia: Current Approaches to Landscapes, Exchange and Practice*, ed. M. Leclerc and J. Flexner, pp. 103–116. Terra Australis 51. Canberra: ANU Press.
https://doi.org/10.22459/TA51.2019.07

Tolstoy, P. 2008. Barkcloth, Polynesia and cladistics: an update. *The Journal of the Polynesian Society* 117(1): 15–57.
http://www.jstor.com/stable/20702569

Vargyas, G. 2016. Bark-cloth clothing of the Bru of Central Vietnam. In *Nagas, Birds, Elephants. Traditional Dress from Mainland Southeast Asia*, ed. G. Fajcsak and V. Brittig, pp. 194–223. Budapest: Hopp Ferenc Kelet-Ázsiai Művészeti Múzeum.

Veys, F. W. 2017. *Unwrapping Tongan Barkcloth: Encounters, Creativity and Female Agency*. London: Bloomsbury.
https://doi.org/10.5040/9781474283335

Waite, D. B. 1987. *Artefacts from the Solomon Islands in the Julius L. Brenchley Collection.* London: British Museum.

Woodford, C. M. 1926. Notes on the Solomon Islands. *Geographical Journal* (London) 68: 481–487.
https://doi.org/10.2307/1782004

Yen, D. E. 1973. Ethnobotany from the voyages of Mendaña and Quiros in the Pacific. *World Archaeology* 5: 32–43.
https://doi.org/10.1080/00438243.1973.9979551

Yen, D. E. 1974. Arboriculture in the subsistence of Santa Cruz, Solomon Islands. *Economic Botany* 28: 247–284.
https://doi.org/10.1007/BF02861424

Zerega, N. J. C., D. Ragone, and T. J. Motley. 2004. Complex origins of breadfruit (*Artocarpus altilis*, Moraceae): implications for human migrations in Oceania. *American Journal of Botany* 91(5): 760–766.
https://doi.org/10.3732/ajb.91.5.760

Zerega, N., D. Ragone, and T. J. Motley. 2005. Systematics and species limits of breadfruit (*Artocarpus*, Moraceae). *Systematic Botany* 30(3): 603–615.
https://doi.org/10.1600/0363644054782134

Appendix 1

Further examples of blue-dyed barkcloth from the Solomon Islands (located and seen by the first author after those noted in Richards and Roga, 2005). All but the last example can be seen via museum websites.

Museum of South Australia, Adelaide

A8112. A large heavy sheet of *Ficus*, with dispersed pale blue dye on one side only, joined HH and dot motifs, and 20 ‘dugong’ figures in thicker blue dye and outlined in red or black. It has no specific provenance but was probably collected by Rev. Reginald Nicholson who was stationed on Vella Lavella from 1906 to 1920. Its style is definitely that of Isabel. L. 170 cm, W. 83 cm.

Te Papa Tongarewa, the National Museum of New Zealand

FE010611. Solomon Islands, provenance unknown. Plant source not recorded; blue dye applied all over one side, and leaching through to other side. L. 105.5 cm, W. 81 cm.

FE004687. Gift of New Zealand Anglican Board of Missions, 1966, Solomon Islands**.** Very coarse cloth, one piece, with some blue dye showing, thinly dispersed.

OL002309/2. Oldman Collection. Gift of the New Zealand Government, 1992**.** Two separate segments (one cloth cut into two pieces?), orange-brown fibre, with similar mottled, indigo-blue dye all over. L. 90 cm, W. 72.5 cm.

Musée du quai Branly—Jacques Chirac, Paris

72.1992.0.13. From Isabel, early 20th century. Pale brown or off-white cloth, with many branch holes. It includes the dugong motif, long dividing lines across the width of the cloth, H motif, and a curious H motif joined at the cross bar to a third down stroke, so that the whole motif looks like half an H joined to a whole H. Very large. L. 255 cm W. 90 cm. Illustrated in Melandri and Revolon (2014: 207).