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

edited by

Jim Specht, Val Attenbrow, and Jim Allen

Technical Reports of the Australian Museum Online, no. 34, pp. 1–258
12 May 2021

AUSTRALIAN MUSEUM

Tech. Rep. Aust. Mus. Online
Number 34, pp. 119–136, 2021
https://doi.org/10.3853/j.1835-4211.34.2021.1747

Technical Reports of the Australian Museum Online
a peer-reviewed open-access journal
published by the Australian Museum, Sydney
communicating knowledge derived from our collections
ISSN 1835-4211 (online)

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

Keywords: New Britain; mid-Holocene; obsidian; stemmed tools; specialisation; workshop production; social networks
Corresponding author: Paul Dickinson ptd5.pd@gmail.com
Received: 19 November 2020 **Accepted**: 30 November 2020 **Published**: 12 May 2021 (online only)
Publisher: The Australian Museum, Sydney, Australia (a statutory authority of, and principally funded by, the NSW State Government)
Citation: Dickinson, Paul. 2021. Narrow margins: standardised manufacturing of obsidian stemmed tools as evidence for craft specialisation and social networks in mid-Holocene New Britain. In *From Field to Museum—Studies from Melanesia in Honour of Robin Torrence*, ed. Jim Specht, Val Attenbrow, and Jim Allen. *Technical Reports of the Australian Museum Online* 34: 119–136. https://doi.org/10.3853/j.1835-4211.34.2021.1747

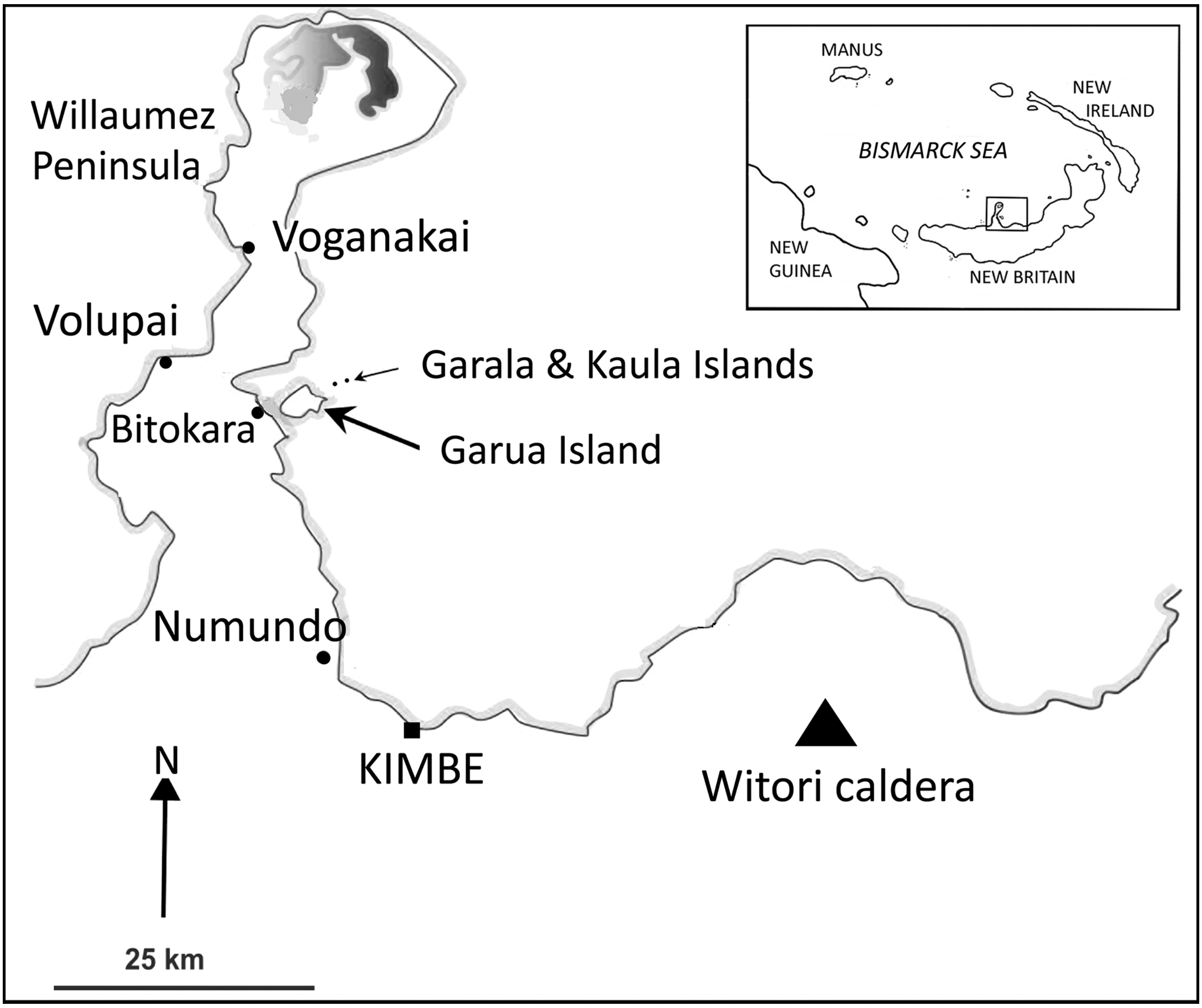

Figure 1. Willaumez Peninsula and Garua Island showing principle locations mentioned in the text (after Summerhayes *et al*., 2010).

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

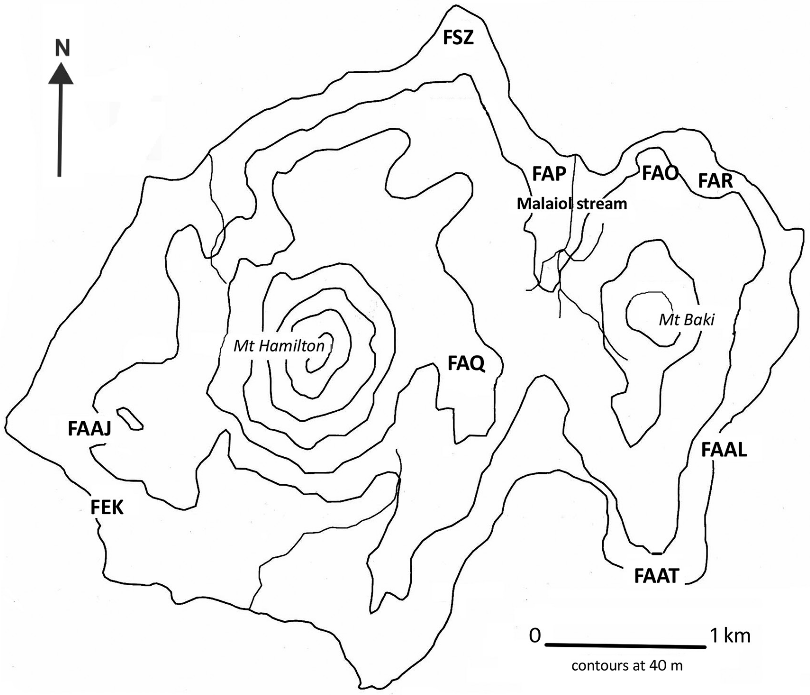

Figure 2. Garua and Kaula Islands showing sites included in the study (Torrence, 1998).

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

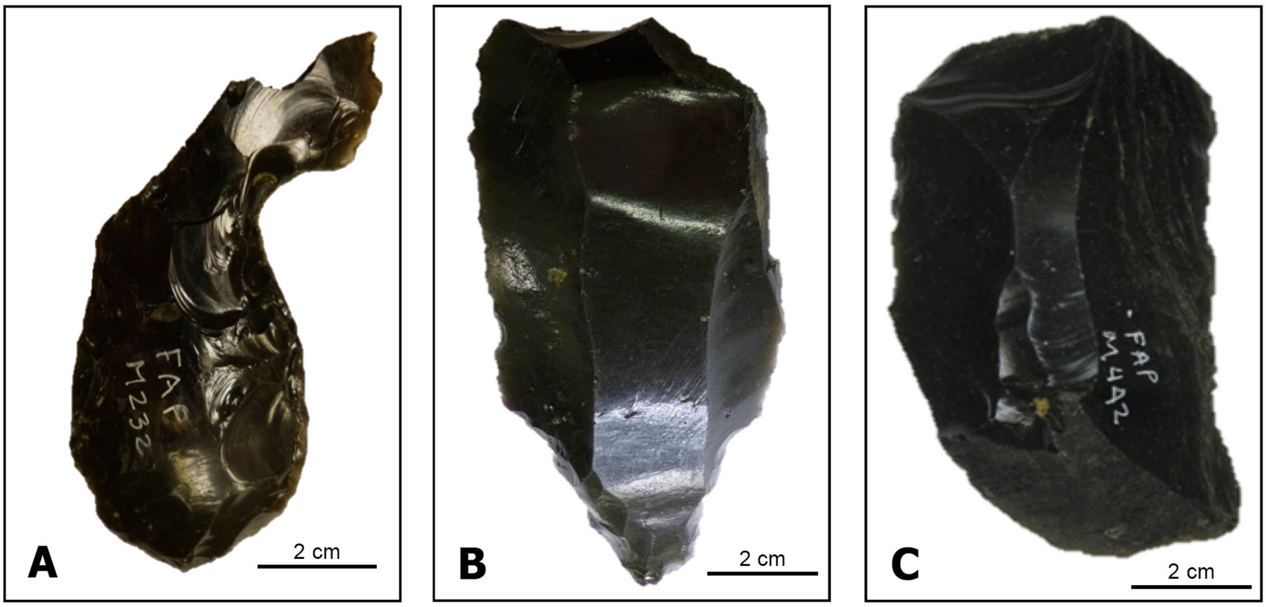

Figure 4. Stem types: (*A*) Type A (FAP M232); (*B*) Type B (FAP 542); and (*C*) Type C (FAP M442)

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

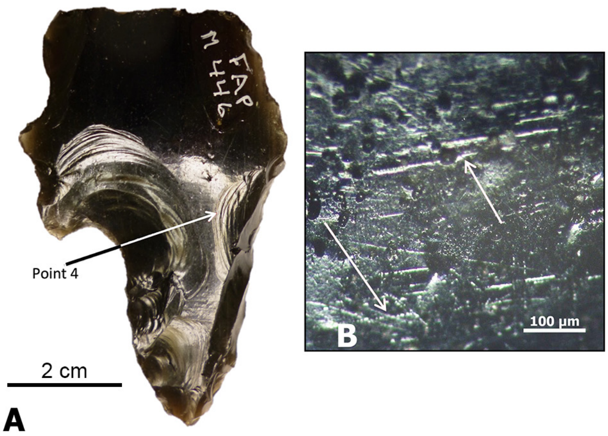

Figure 7. FAP 446: (*A*) ventral face, Point 4; and (*B*) Point 4 ×100; white arrows indicate scatter of transverse intermittent striae at hafting line.

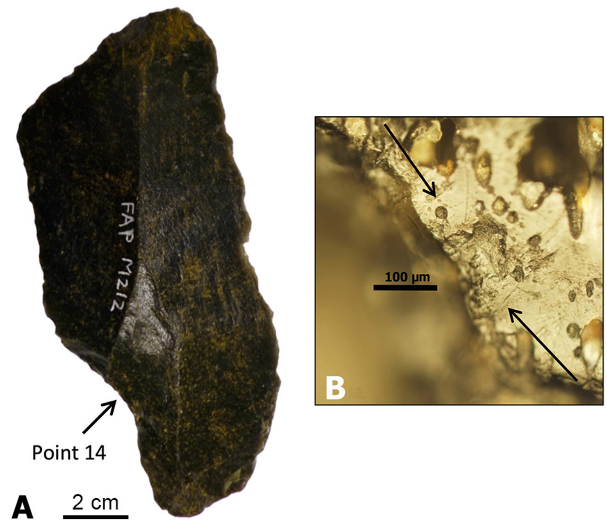

Figure 8. FAP 212: (*A*) dorsal face, Point 14; and (*B*) Point 14 ×200; black arrows indicate a rounded edge with short striae from hafting.

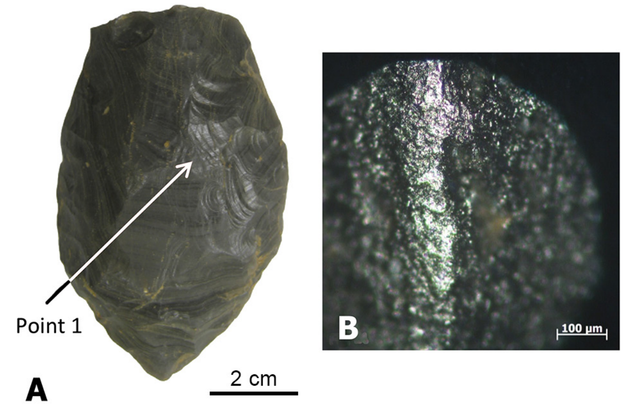

Figure 9. FAP 481: (*A*) dorsal face, Point; and (*B*) Point 1 ×100; line of well-developed polish on elevated edge of scar.

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

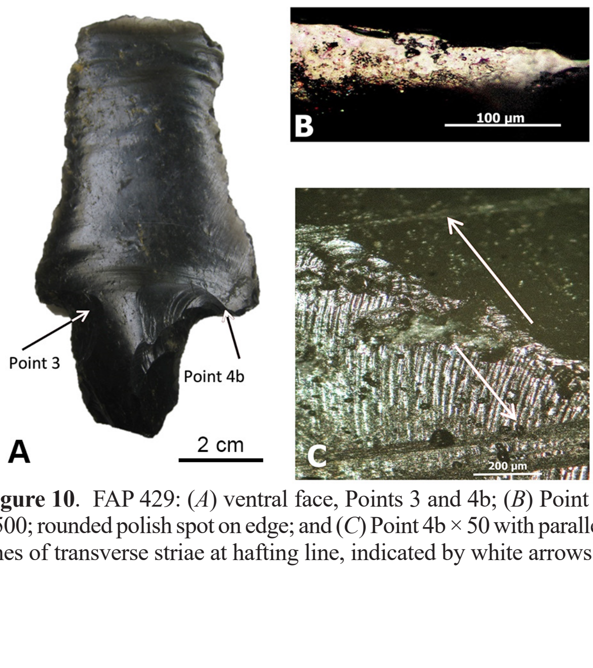

Figure 10. FAP 429: (*A*) ventral face, Points 3 and 4b; (*B*) Point 3 ×500; rounded polish spot on edge; and (*C*) Point 4b × 50 with parallel lines of transverse striae at hafting line, indicated by white arrows.

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

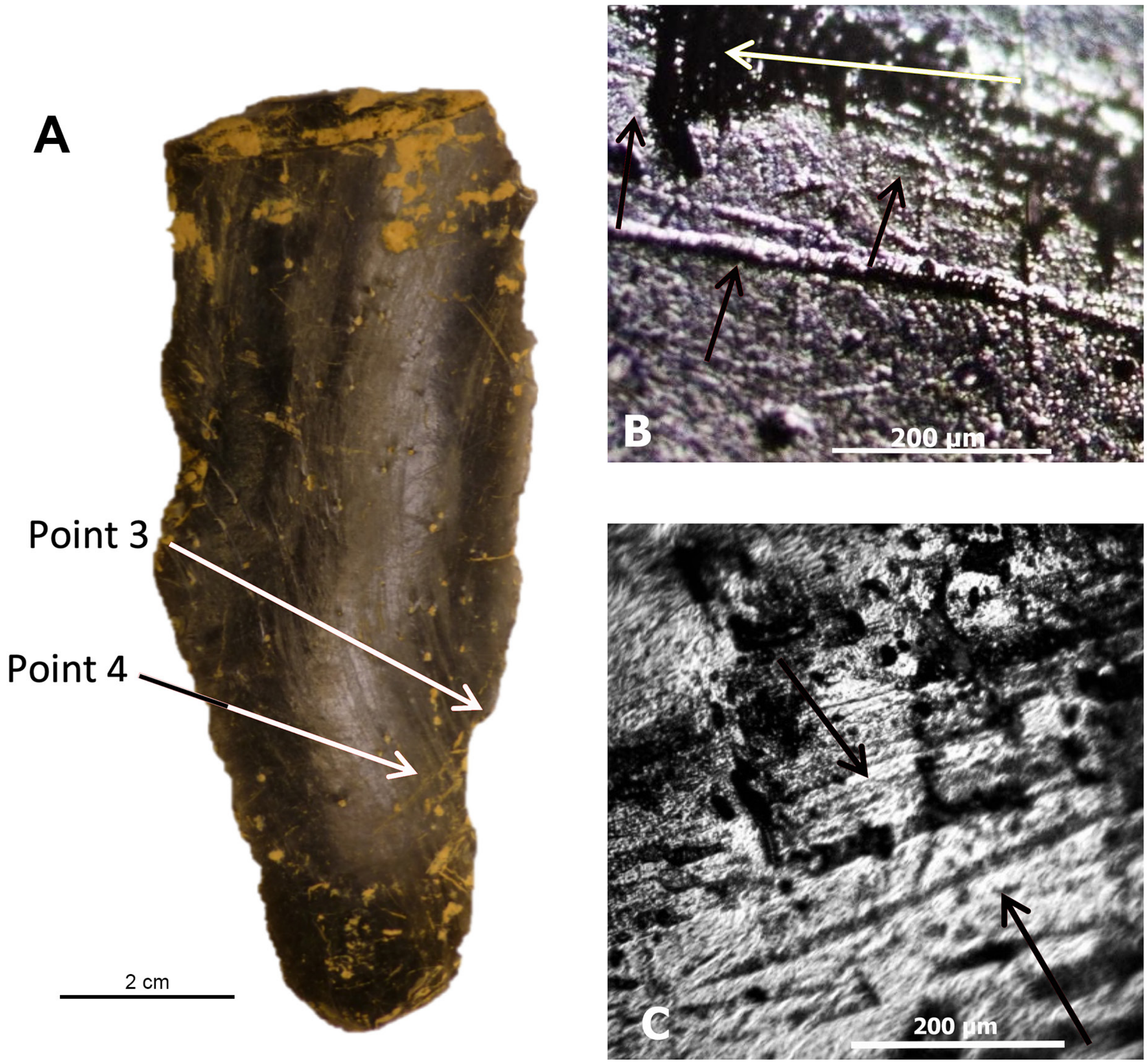

Figure 11. FRL 183: (*A*) ventral face, Points 3 and 4; and (*B*) Point 3 ×200 with scatter of transverse rough-bottomed striae indicated by black arrows. These are on a slightly different alignment to the dense crescent row striae, indicated by a white arrow, which overlies them. (*C*) Point 4 of FRL 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

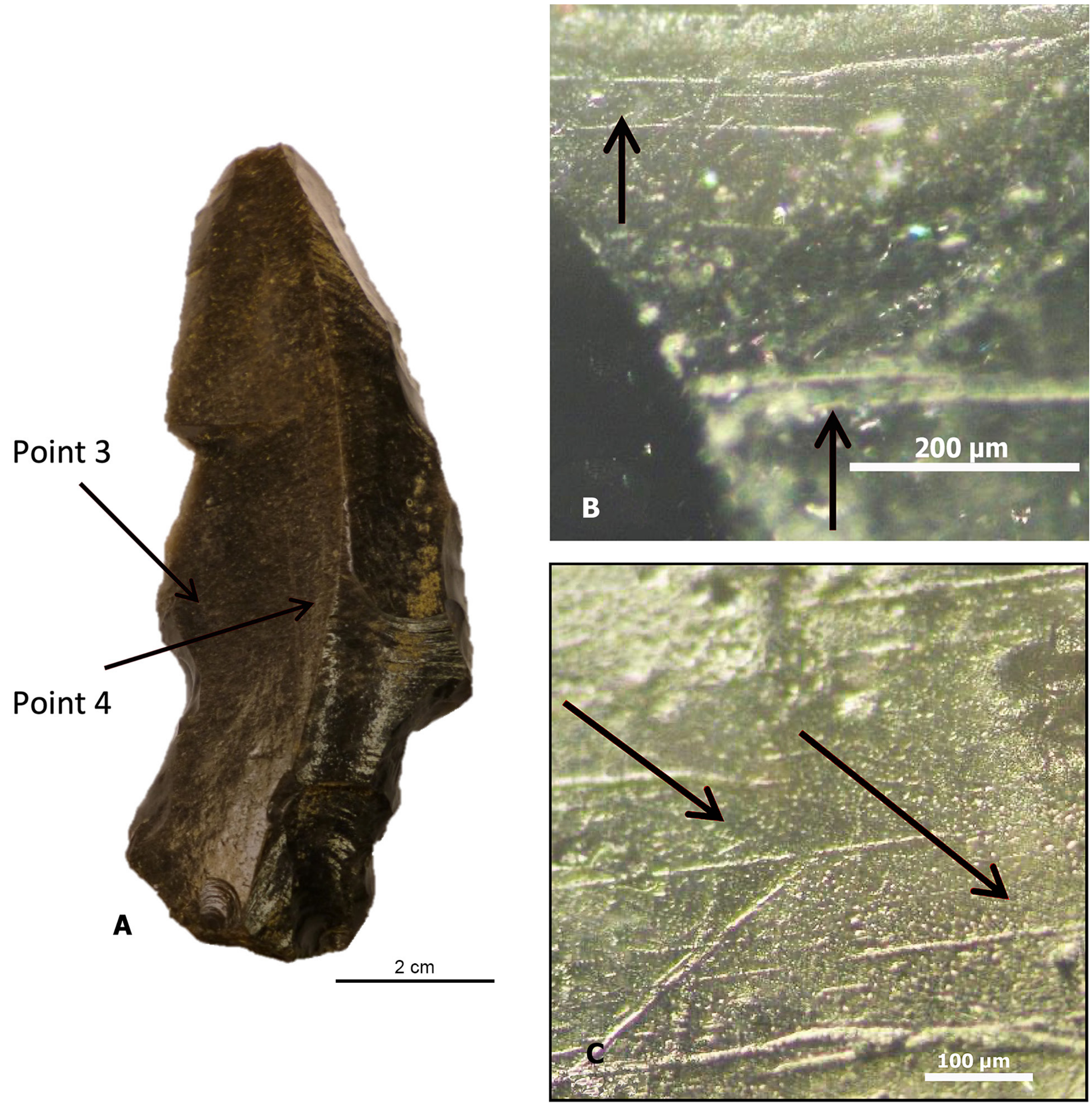

Figure 12. FEK 109: (*A*) dorsal face; Points 3 and 4; (*B*) Point 3 ×100 with transverse rough-bottomed striae indicated by black arrows; and (*C*) Point 4 ×100 with scatter of transverse striae indicated by black arrows.

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

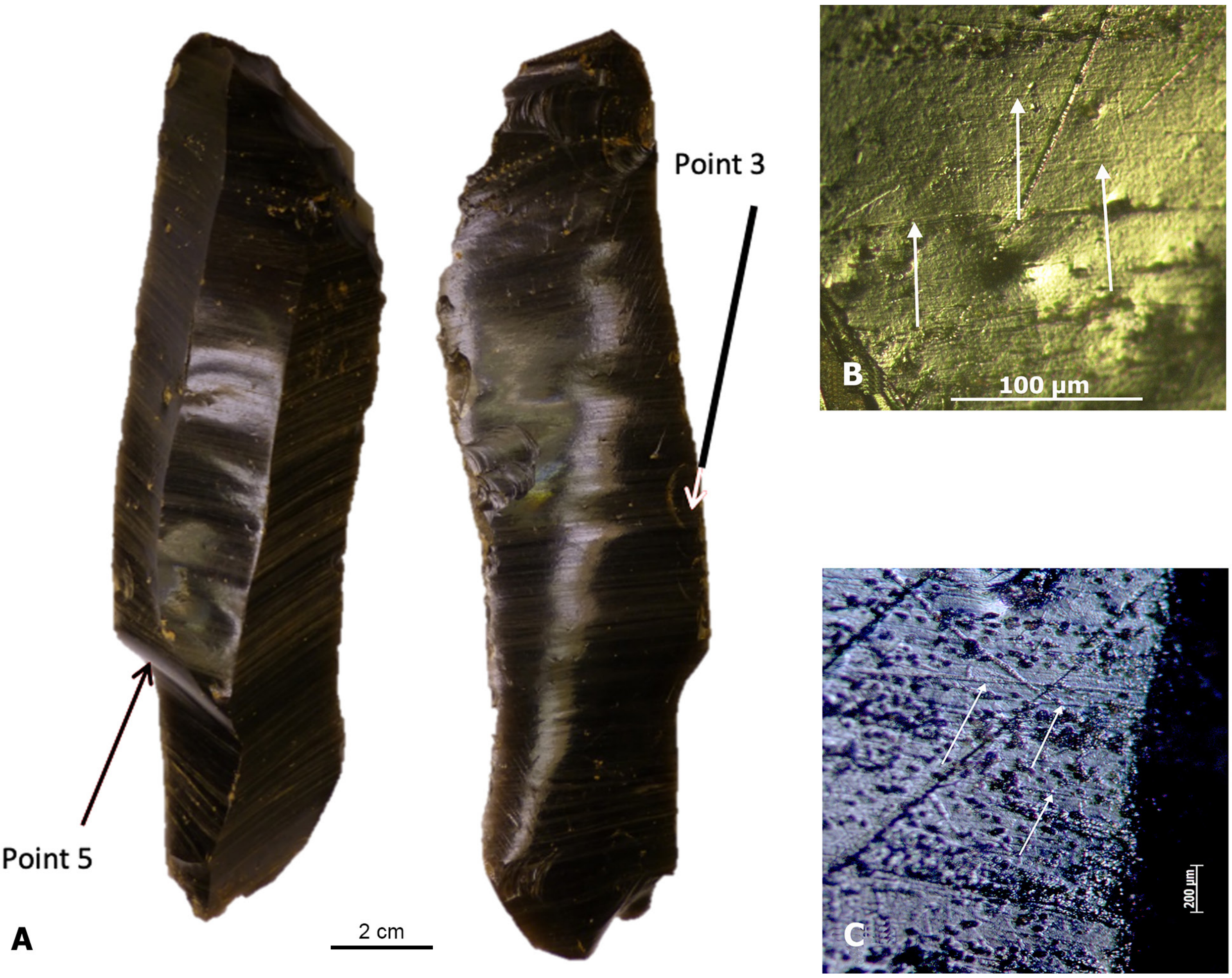

Figure 13. FRL 428: (*A*) dorsal and ventral faces, Points 3 and 5; (*B*) Point 5 ×100 with transverse striae indicated by white arrows; and (*C*) Point 3 ×200, white arrows indicate edge rounding and moderate dense transverse striae.

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

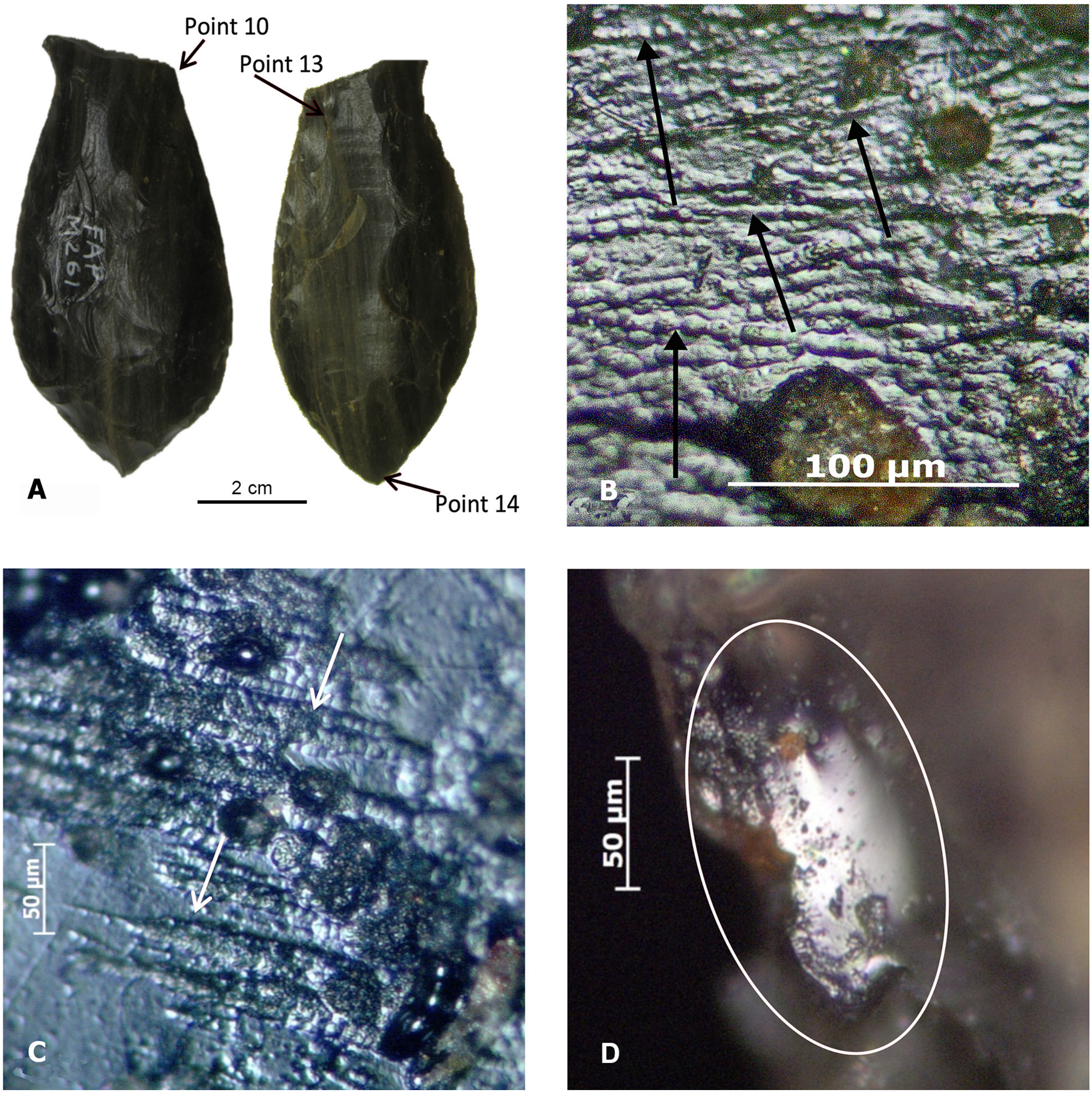

Figure 14. FAP 261: (*A*) Type A stem, dorsal and ventral faces, Points 10, 13 and 14; (*B*) Point 10 ×200 with black arrows indicating dense transverse striae across neck of stem; (*C*) Point 13 ×200, with white arrows indicating a dense patch of very short striae; and (*D*) Point 14 ×200, the white 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.

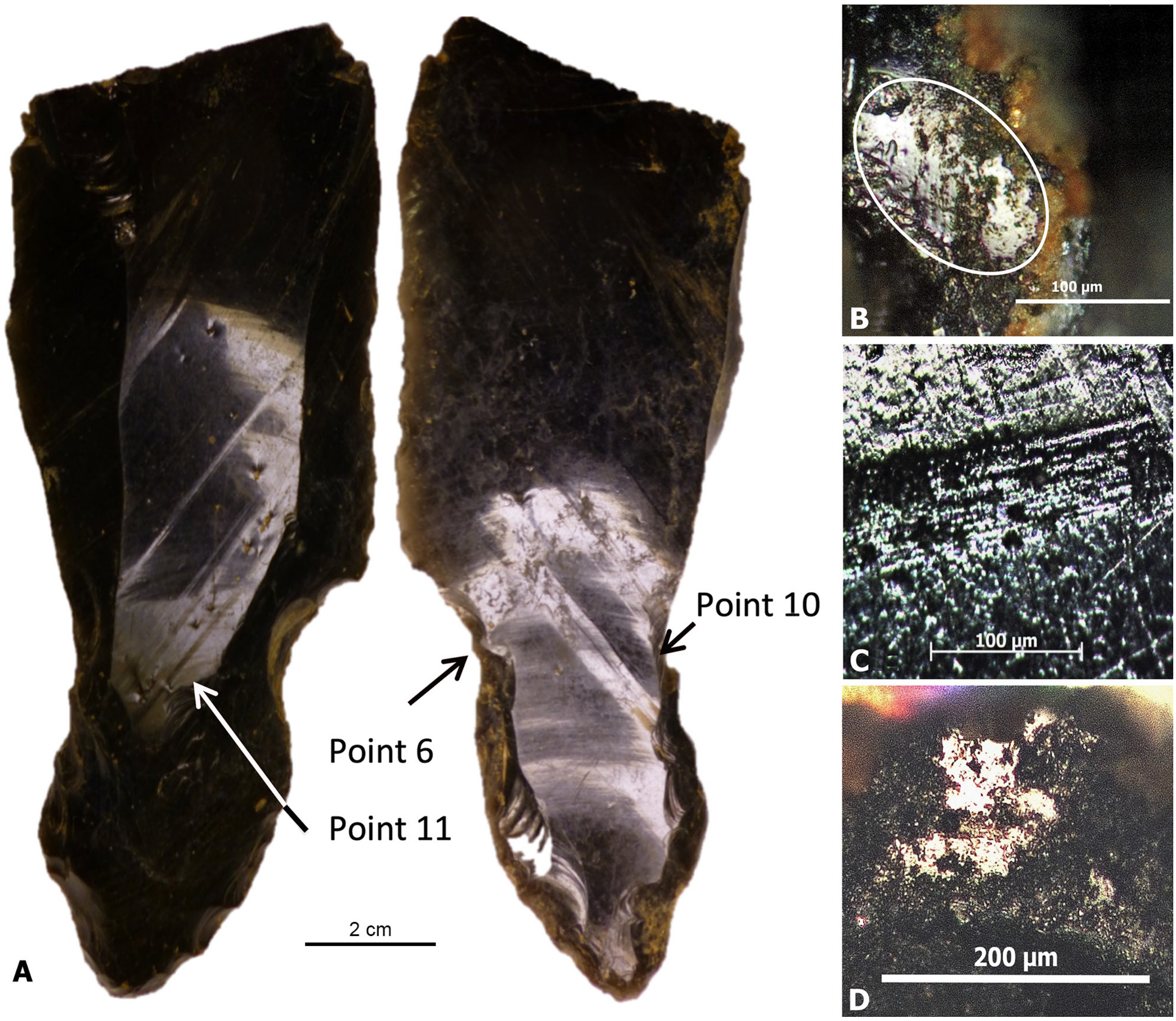

Figure 15. FAP 705: (*A*) Type A stem, dorsal and ventral faces, Points 6, 10 and 11; (*B*) Point 6 ×200 with developed polish patch on edge indicted by white oval; (*C*) Point 11 ×100 with dense transverse rough-bottomed striae at hafting line; and (*D*) Point 10 ×100 showing 'bright spot' on edge.

ACKNOWLEDGEMENTS. This paper is drawn from my PhD research for which Robin Torrence was a tremendously supportive, generous, and tireless co-supervisor who, in addition to supplying the artefact sample, encouraged, challenged and helped me to complete my research and my thesis. Great thanks are also due to Huw Barton, co-supervisor of my PhD, for an immense amount of help and encouragement over several years, including his guidance on this paper. I also thank Nina Kononenko who so generously gave up her time to teach me the fundamentals of use-wear analysis and allowed me to make use of the reference collection of obsidian tools that she had spent much labour and many hours compiling. Without her expertise, patience, guidance and support I could not have completed this study. I also thank an anonymous reviewer. Any errors or shortcomings in this work are mine alone.

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

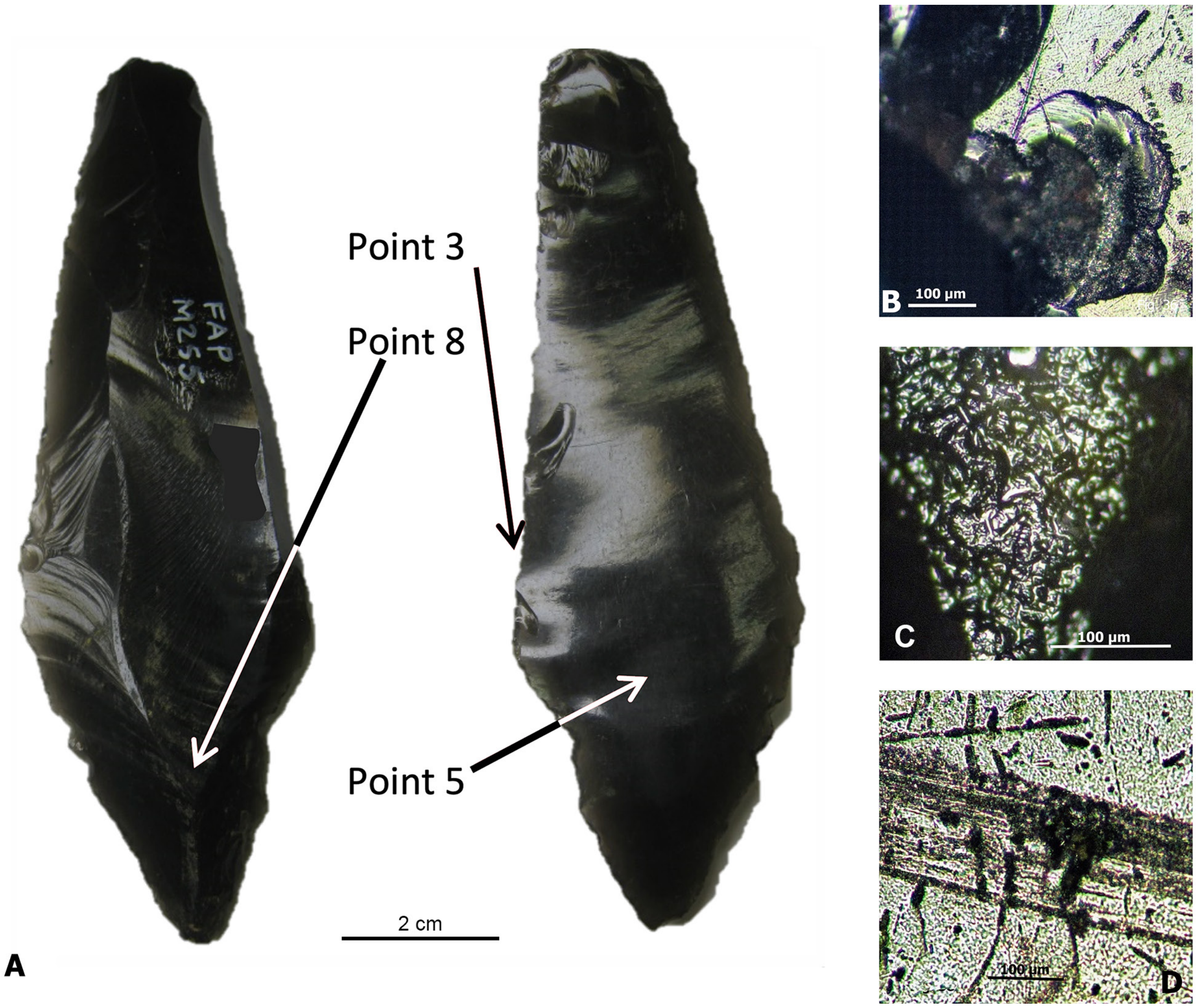

Figure 16. FAP 255: (*A*) dorsal and ventral faces, Points 3, 5 and 8; (*B*) Point 3 ×100 with feather scars on edge; (*C*) Point 8 ×200; well-developed polish patch; (*D*) Point 5 ×100 with transverse rough-bottomed striae.

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

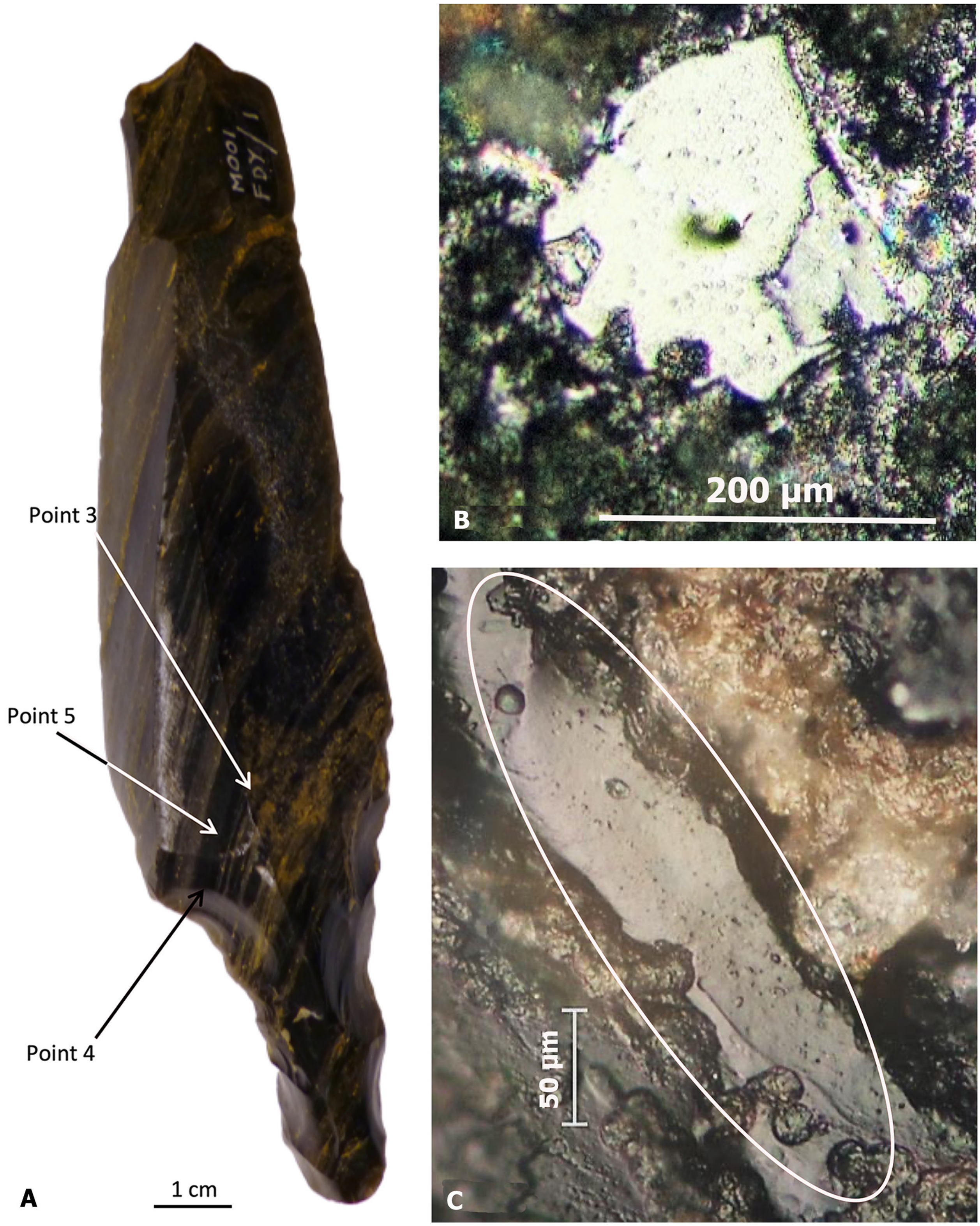

Figure 17. FDY 001: (*A*) dorsal face; Points 3, 4 and 5; (*B*) Point 3 ×100 'bright spot'; and (*C*) Point 4 ×500 with 'bright spot' indicated by white oval.

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

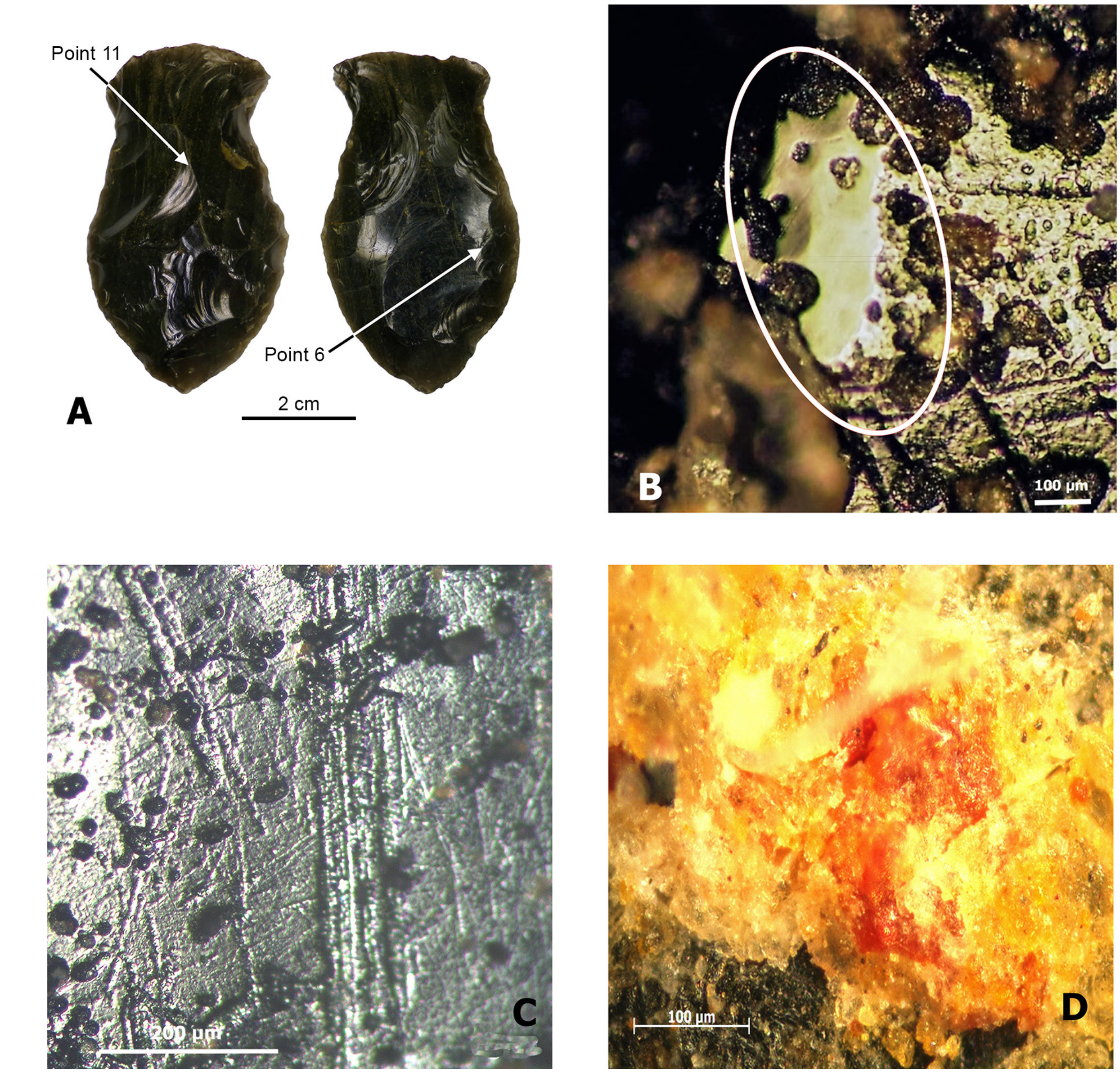

Figure 18. FAP 400: (*A*) dorsal and ventral faces; (B) Point 11 ×200, with 'bright spot' indicated by white oval; (*C*) Point 6 showing transverse rough-bottomed striae. FDM 002: (*D*) Point 4 ×200 showing orange and red residues on stem.

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