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Negotiating Social Identity through Material Practices with Stone

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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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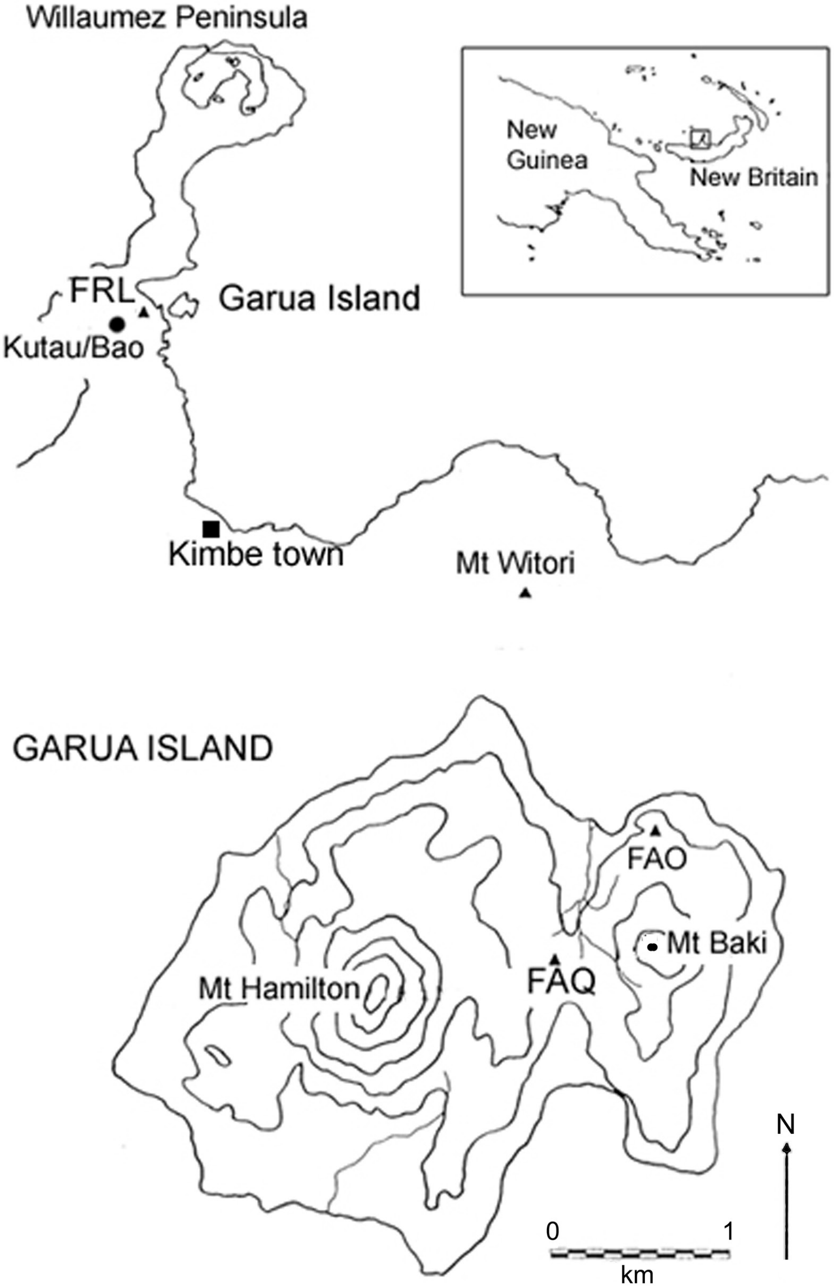

Figure 1. Map of West New Britain, showing location of excavated sites and the Kutau-Bao and Baki obsidian sources.

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.

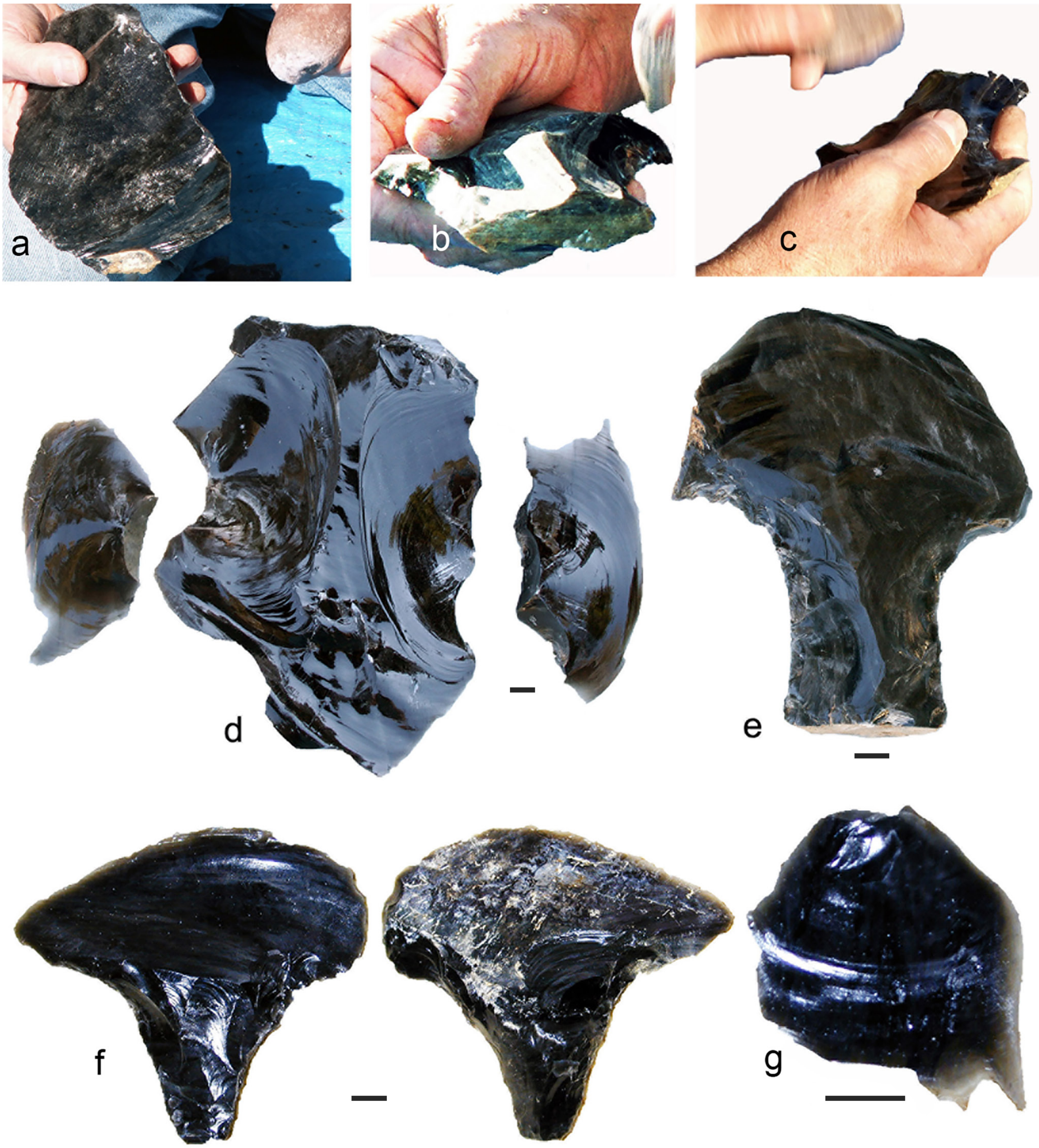

Figure 2. Experimental replication of stemmed tools: (*a*) massive blank knapped from the core; (*b, c*) percussive shaping the stem; (*d*) flakes and blank with notches from percussive strokes; (*e, f*) finished stemmed tools with unretouched edges; and (*g*) negative of flake from flaking the stem. 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

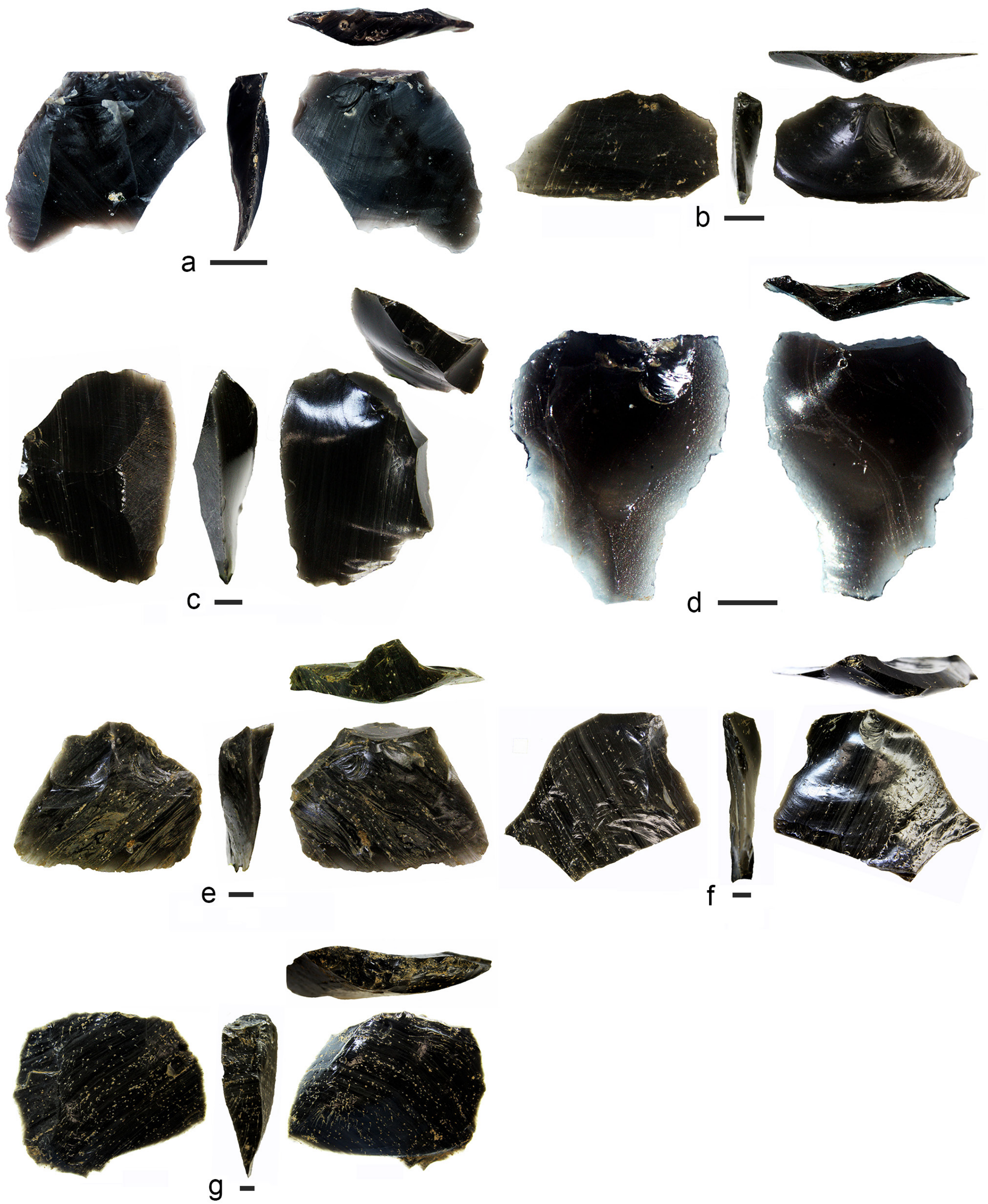

Figure 3. Flakes from excavated sites showing characteristic attributes: (*a)* FAO 1000/1010 Level 5 spit 1; (*b*) FRL NEb 12; (*c*) FRL NEb 12; (*d*) FAO 1000/1010 Level 5 Spit 1; (*e*) FRL NEb 12; (*f*) FRL SEa 12; and (*g*) FRL SEc 12. Scale 1 cm.

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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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.