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TORRES STRAIT ORIGIN OF SOME STONE-HEADED CLUBS FROM THE TORASSI OR BENSBACH RIVER AREA, SOUTHWEST PAPUA NEW GUINEA

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Petrological examination of a collection of Torres Strait stone-headed clubs concluded that all were manufactured from local Torres Strait stone (McNiven, 1998). This finding overturned previous thought, based on early historical sources and diffusionist assumptions, which held that such clubs were of Papuan origin. This short note reports the results of a similar analysis of 3 stone club heads from the Torassi or Bensbach River area, in the extreme SW corner of Papua New Guinea adjacent to Torres Strait. This is an area devoid of stone, and local people have no knowledge of the original source of these items. Analysis indicates that these artefacts are also of Torres Strait origin. They are the first Papuan stone club heads to be sourced to the islands of Torres Strait. □ *Stone club trade, sourcing studies, headhunting, raiding, Torassi or Bensbach River, Torres Strait.*

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McNiven (1998) surveyed the literature relating to Torres Strait stone-headed clubs (*gabagaba*) and presented the results of a petrological analysis of 26 ethnographic and archaeological examples collected from 7 islands in the region. Contrary to most historical sources relating to trade in this area, which have posited a Papuan origin for these weapons, he has demonstrated that the raw material source and manufacturing site of the clubs was the granitic islands of central and northern Torres Strait: Dauan in the Top Western group of islands, and Mabuia, Badu and Mua (Moa) in the Central Western group.

This paper presents the results of a surface petrological examination of 3 stone-headed clubs collected from the Torassi or Bensbach River area in the Morehead District of Western Province, Papua New Guinea (PNG) (Fig. 1). This area is located NW of Torres Strait, in the nearby lowlands SW PNG. Further ethnographic, documentary and linguistic evidence relating to the origin and trade into PNG of Torres Strait stone-headed clubs is also presented.

TORASSI RIVER CLUBS

The people of the Torassi are part of the Morehead linguistic-cultural group, who speak dialects of the Upper Maro and Morehead River language family and share a common kinship system, customs and material culture (Ayres, 1980, 1983; Williams, 1936; Wurm & Hattori, 1981). Clubs in this area functioned primarily as

weapons of war, but, as in Torres Strait and elsewhere in the Papuan lowlands, they feature significantly in local mythology and history (e.g., Ayres, 1983: 54; Tapari, 1977: 84).

In the *Thuntai* dialect of the Wartha (also known as the Toro in colonial reports) people of the middle Torassi, disc clubs are called *kirikiri* and ovoid clubs *bef*. Local people have no knowledge of the raw material source or manufacturing methods of these weapons, and state that they obtained them through trade with neighbouring groups, or in warfare, in particular with their old foes the *Parma* (the Marind-Anim of SE West Papua). The Morehead District, like the rest of the lowlands of central-southern New Guinea, is devoid of suitable hard stone (Blake, 1971: 60-61, 1972: 1190; Pretty, 1965: 124-125; van Baal, 1966: 16)¹.

I am not aware of any past use of clubs for ritual on the Torassi, but it seems possible given the association of one of the Torassi clubs with an important story², and documentation of the use of broken or incomplete examples in ritual contexts on the Morehead River (see below). For the Marind-Anim, clubs were also status markers, being given to young men during the feast to celebrate their promotion to the *éwati* (late adolescence) age-grade. In this connection, van Baal (1966: 151 citing Wirz, 1922/25: 50) stated that it 'is the most valuable present he receives on this occasion', and that 'the young man is very proud of the club and always carries it about with him, because he knows his weapon to be an

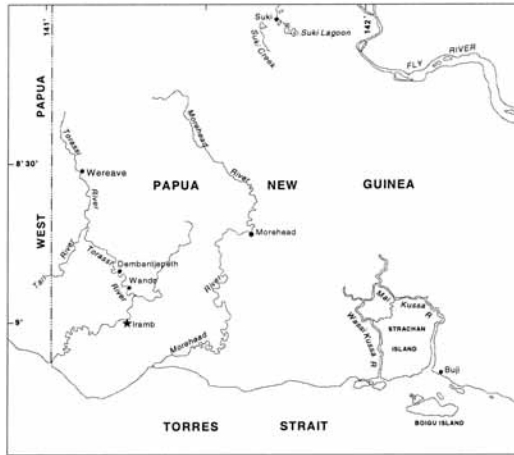


FIG. 1. Northwest Torres Strait and adjacent lowland Papua.

heirloom'. Following the establishment of a Dutch post at Merauke in 1902, Chinese traders capitalised on the rarity and importance of clubs by trading Asian-made sandstone, iron and brass clubs to Marind communities (see Appendix 1 for a detailed metallurgical analysis of a recently collected brass disc club)³.

Among the Marind-Anim, the Morehead people, and their northern neighbours the Suki, ceremonial clubs featuring decorated fretwork surmounting the head of the shaft, appear to have had particular magico-symbolic significance in headhunting raids⁴ (Grottanelli, 1951; Kooijman, 1952: 97; Williams, 1936: 266-268).

British anthropologist C.G. Seligman visited the Wartha people in 1904 during the Cooke-Daniels Ethnographical Expedition to British New Guinea, less than a year after this people's first contact with Europeans. He noted that the clubs he saw were 'few and extremely rough, and were certainly imported' (Seligmann & Strong, 1906: 228). In a letter to colleague Herbert Jonas reflecting on his visit, Seligmann (1904: 2) noted further: 'stone implements were

few, their clubs amazingly rude & I suspect traded slowly from folk far beyond their or our knowledge'. One hafted club was collected during the visit, and donated to the British Museum (Figs 2, 3). This is described in the Daniels collection catalogue as 'Stone headed club – rough globular rattan handle, L. [length] 41½ [inches]' (Anon., n.d.: 139). The club also features a length of cord, allowing the club to slide along the shaft when swung and therefore increasing its force on impact (Kooijman, 1952: 97). Cords also enabled clubs to be carried, slung over the shoulder (Nevermann, 1939: 34; Wirz, 1922/25: 112).

DESCRIPTION

During 1995-98, I was shown 3 unhafted stone club heads owned by people in the middle Torassi River area — 2 bi-convex or disc clubs (Figs 4, 5) and an ovoid club (Fig. 6). A Korombo villager found 1 of the disc clubs in the vicinity of Werewave village, while a resident of Dembantjepeth (Wando Patrol Post) discovered the other disc club at Iramb to the south (Fig. 1). The ovoid club has been in the keeping of a Torassi family for generations, and is associated with the activities of mythological storybeings. It is called *teuwiteuwi bef*, after the *teuwiteuwi* (Goshawk, *Accipiter* sp.) storybeing.

METHODS AND RESULTS

Local village people kindly allowed me to borrow the clubs for geological assessment by Friedrich von Gnielinski (Geological Survey of Queensland, Brisbane) in 1999. Mr Gnielinski is familiar with the geology of Torres Strait (von Gnielinski et al., 1998) and also undertook assessment of the Torres Strait clubs discussed by McNiven (1998) and McNiven & von Gnielinski (this volume) and Kiwai axes described in McNiven, von Gnielinski & Quinnell (this volume). The Torassi club heads were examined macroscopically and with the aid of a ×10 hand lens. Raw material comparisons were made with an extensive collection of sectioned samples of Torres Strait rock types. Results suggest strongly



FIG. 2. Stone-headed club (Oc1906, 1013.381) collected by C.G. Seligmann on the middle Torassi, 1904. © The British Museum.

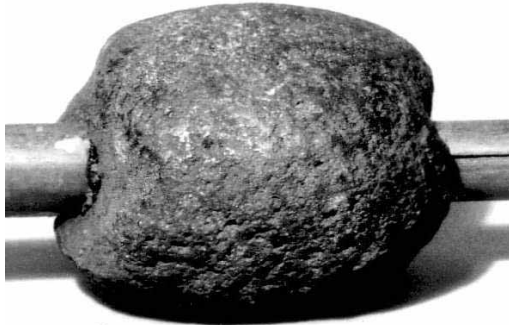


FIG. 3. Detail of stone-headed club (Oc1906, 1013.381). © The British Museum.

that the raw material for all 3 club heads originates in Torres Strait to the south, on the granitic islands of Dauan, Badu, Mua and Mabuia (Table 1).

DISCUSSION

While the raw material results point strongly to sources in Torres Strait, the findings cannot be considered unequivocal until all possible Papuan sources for these raw material types have been discounted. Williams (1936: 102, 415-416) reported that Morehead clubs originated through trade and raiding with the Wiram (Suki) people to the north, who in turn obtained them from their northern neighbours. There have been a number of studies that consider known trade in New Guinean stone artefacts (e.g., Burton, 1984; Haddon, 1900; Hughes, 1977; Rhoads & Mackenzie, 1991; Swadling, 1983). Few, however, have conducted detailed comparative geochemical or petrographic analyses of artifacts and stone outcrops. McNiven, von Gnielinski & Quinnell (this volume) discuss known stone quarry sites in the highlands of West Papua and PNG in the course of their analysis of 'Kiwai' type axes. Several of these could also be potential sources of stone for Torassi people, in particular a black-brown basalt quarry on the Digul River. Here it is important to point out that the Marind-Anim people, in addition to a large home territory, raided (and traded) for hundreds of kilometres to the north, east and west of their territories, including the Digul River area, coastal and inland Trans-Fly, and the NW islands of Torres Strait (Van Baal, 1966: 695-710; Knauff, 1993: 154-159; Serpenti, 1968; van der Kroef, 1952: 224; Wirz, 1933).

Wirz (1922/25: 112) described Marind clubs as either ball-shaped or flat, and called *kupa* and

woganeh, respectively. Most appear to have come from the Digul River and were stolen during headhunting expeditions or obtained by trading. Interestingly, he noted that star-shaped and pineapple clubs were found exclusively among inland Marind communities and originated from the upper Fly River.

Among the Kanum⁵ peoples, living between the eastern boundary of the Marind territories and the Torassi River area, Nevermann (1939: 33-4) reported that disc and ovoid stones were obtained from the Marind-Anim, who in turn obtained them from the Digul River area. Nevermann also noted that the Marind-Anim possibly obtained clubs from the N'gowugar (Yei language speakers [Wurm, 1971: 168]) of the Waroe River, a tributary of the Maro River⁶.

Stone from other sites, such as the Wario River quarries in PNG, is known to have been traded down to Trans-Fly peoples such as the Gidra-speaking people of the Oriomo River. Pretty (1965: 127) contended that the 'major direction of entry of stone implements into the ...Wonia [an Oriomo village] area would seem to be from the north-west along the length of the Fly River'. Ohtsuka (1983: 4) noted that he found stone axes and grinders in this area, but that their origin was unknown to local people. However, with regard to the clubs under consideration, the Wario stone material is entirely different (McNiven, von Gnielinski & Quinnell, this volume).

The 3 Torassi River clubs are almost certainly from the Top Western and/or Western Islands of Torres Strait. In the Torassi River area, which is totally devoid of suitable stone, these weapons were (and continue to be) prized, and to judge from Seligmann's remarks regarding the crudeness of Bensbach clubs, were possibly conserved until worn and broken. It may also be the case that less perfect and/or broken examples were actively traded to inland areas by coastal groups on the S coast of New Guinea living close to stone sources in Torres Strait. Beaver (1920: 108-109), for example, reported how the Mawatta people benefited from their key position in trade between New Guinea and Torres Strait with regard to access to, and disposal of, European trade goods:

In the yam season, those aristocrats of Western Papua, the Mawatta, make trips as far as Buji for trading purposes. But they go up to the Beer tribe as a rule, whom they reach by ascending a small creek some fifteen miles east of Buji and then travelling by road ... The goods taken for barter included old tools, knives, axes, old print dresses, in fact all the rubbish they could find no use for themselves ... In exchange for all this rubbish palmed off on the



FIG. 4. Disc club 1, Torassi River.



FIG. 5. Disc club 2, Torassi River.

unsophisticated bushmen they brought back some tons of fine yams and much other miscellaneous gear such as women's dresses, bows, orchid root bags in two or three colours and the so-called Tugeri arrows. These arrows are sold again to Europeans in New Guinea or, by way of the Torres Strait Islanders, reach Thursday Island, where they are disposed of to curio-hunting tourists. The Buji and Wassi Kussa people carry on some trade with Boigu [Island in Torres Strait], selling belts and boars' tusks and manufactured stone clubs, although on the Wassi Kussa I was told that the stone for clubs was obtained from Boigu and Dauan.⁷

While Boigu is a sedimentary island lacking tool stone, McNiven (1998), McNiven & von Gnielinski (this volume) and this study have identified Dauan as a key source for club stone. Andesitic/basaltic dyke quarries have been identified on the island (McNiven, Fitzpatrick & Cordell, this volume; Vanderwal, 1973). McNiven & von Gnielinski (this volume) document partially made stone club heads found on Dauan. Villagers' belief that some clubs originated from Boigu probably reflects the fact that clubs from Dauan entering the Buji/Wassi Kussa area would in many cases have been traded via Boigu. It is also interesting to note reports of grinding grooves for sharpening clubs at Mabaduan, the only outcropping of granite on the lowland New Guinean south coast (Landtman, 1927: 287; Lyons, 1916, II: 129). Hence the possibility that some clubs were manufactured in southern PNG using imported raw material from Torres Strait cannot be discounted (McNiven, 1998: 106). For example, some stone club heads may have moved from Torres Strait into southern PNG as unground blanks, and finished at Mabaduan, or on portable grinding stones or tables such as those reported for the Oriomo and Morehead River areas, and among the

Marind-Anim (Ohtsuka, 1983: 4; Pretty, 1966: 127; Williams, 1929: 384; Wirz, 1946: 80 cited in Pretty, 1966: 127).

The Thoro people traded with their neighbours, including their eastern allies the Bavir (*Ranjer Tjokwasef* dialect speakers, usually referred to as the Bapir or Bapiri in early colonial reports), who live between the Bensbach and Morehead Rivers. Bavir people traded with their neighbours to the east, who included the Wassi Kussa and Mai Kussa peoples who had a long history of customary exchange with the northern Torres Strait Islanders (Lawrence, 1994). Thus, it is entirely plausible that at least some Torassi clubs — including those under consideration here — came from Torres Strait, given raw materials



FIG. 6. Ovoid club, Torassi River.

TABLE 1. Torassi stone-headed club raw materials.

Artefact Provenance	Type	Raw Material Type	Raw Material Source
Iramb	Disc	Very fine-grained andesite – possible dyke within the Badu granite. (Very hard heavily altered microdiorite. Fine grained. Seems to be hornfelsed. Dominant plagioclase-feldspar component creamy-white, quartz invisible. Possibly silicified).	Western Islands of Torres Strait (Badu, Mua, or Mabuia)
Wereave	Disc	Fine-grained microdiorite/quartz-gabbro dyke within the Badu granite. (Equigranular, grain size fine. Minerals of hornblende, biotite, plagioclase-feldspar and quartz. Fairly evenly grained. Rock is possibly altered and silicified).	Western (Badu, Mua, or Mabuia) or Northern (Dauan and Gebar) Islands of Torres Strait
middle Torassi	Ovoid	Basalt – possible dyke within Badu granite. (very fine-grained matrix, dark grey to black, coherence very hard).	Dauan Island

similarities and historically recorded trade links between these areas.

Morehead people did not possess many clubs, and better quality clubs may have been prized and hoarded by those communities closest to the source of Torres Strait stone. F.E. Williams only recorded broken or unfinished clubs being used in ritual contexts in the Morehead District. Among the ritual equipment at the fertility shrine of *inifiak* at Kuramangu, were 2 broken stone clubs, as well as other broken stone implements and unworked stones (Williams, 1936: 104-105, pl. 6). Furthermore, at Gulijebgund, the rain-making laboratory of Wengu of Bebedeben, a ritual item called *besa* was described as ‘a fragment in which a hole was bored to the depth of half an inch, apparently with the original intention of making a club-head’ (Williams, 1929: 386). Several granite blocks with axe (or possibly club) sharpening grooves were also seen by Williams at the rain-making shrine of Yawes, near Bebedeben (1929: 382). Wirz (1946: 80 cited in Pretty, 1965: 127) also reported Marind-Anim reverence of grinding stones as cult objects⁸. It is relevant here to note Ayres’ (1983: 9) observation that ‘stone or rock (except lateritic gravel) is extremely rare in the Morehead area’, and that ‘the very few outcrops of bedrock or small conglomerate boulders that I saw in two years were all at sacred story-places’. With regard to other stone artefacts in the Morehead District, Williams (1936: 428) noted that:

The celt [axe/adze], *turika*, like the club, has to be imported into a stoneless country: some examples come from the Wiram, others from Bugi on the sea-coast. Although nowadays stone of any kind may be hoarded and tend to assume a religious or magical importance, there are nevertheless remarkably few to be found in the district. All the examples of celts that I have seen are very inferior and appear to be merely pebbles ground down.

For Morehead peoples, living in a stoneless region of endemic headhunting, and unaware of the source of stone artifacts, clubs were not only weapons of war. They also embodied

mythological and ritual values, although it may have been martial pragmatism that saw only broken examples enter ritualistic contexts. Williams’ comments, and Seligmann’s observations of worn clubs on the Torassi in 1904, may also point to the effects of the cessation of trade in Torres Strait stone, following the large-scale introduction of iron into the islands from the 1860s and 1870s. Local loss, breakage and theft over time, would have seen a decline in stone in the area and this, together with later government pacification and collecting of objects, may have resulted in a further increase in the ritualised usage of these and other stone artifacts.

The known distribution of clubs and other stone artifacts could suggest that New Guinean communities closest to the sources of Torres Strait stone benefited, like the example of Mawatta above, in terms of disposing of poor quality examples and blanks, and presumably commanding high trade values for well finished items within defined patterns of customary exchange. For example, the fact that no Kiwai type axes are known from the Morehead District may reflect their particular association with a specific trade cycle, i.e. the production of, and trade in canoes, as discussed by McNiven, von Gnielinski & Quinnell (this volume). The apparent scarcity of clubs well away from known source areas, such as in the Torassi River area, is also of interest, as is Murray’s (1914: 23) observation that as one descended the Fly River, stone blades became smaller in size and more highly valued by their owners. Sir William MacGregor (1890a: 54) noted that the local people 630 km up the Fly River ‘value very highly the most worthless remnant of a stone adze, and with these they will not part under any consideration’. MacGregor (1890b: 74) also found that people in the lower reaches of the Morehead River had more clubs than those further upstream. This could perhaps reflect the

fact that the people of the lower Morehead were closer to PNG communities trading with Torres Strait Islanders for clubs. More attention to the ethnographic literature pertaining to known trade routes may account for these observed differences. For example, it would be useful to map those clubs in museum collections with known provenances, in conjunction with analysis of differences in various trade routes in terms of stone sources, artefact types, relevant dynamism (e.g., communities controlling stone sources or local trade routes, as opposed to 'backwater' areas), taking into account disruptions such as raiding and the introduction of iron.

Linguistic evidence supports in part the view that Torres Strait was a key source of stone-headed clubs for the PNG lowlands. The word for club in Torres Strait — a known source of these weapons — is *gabagaba*, in both indigenous Torres Strait languages (*Kala Lagaw Ya* and *Meriam Mir*); the word for star club in Meriam Mir is *seuriseuri* (Lawrie, 1970: 301). The Kiwai word for stone club is likewise *gabagaba*, and the word for hammerstone is *gubakura* (McNiven 1998; McNiven, von Gnielinski and Quinnell, this volume). Patrol Officer L.A. Flint visited the Wartha people in 1916 and his English-*Thuntai* vocabulary lists *gungaba* for club stone, *kirikiri* for star club, and *dimbiko* for pineapple club. In the *Nama-yem* (was) dialect of Mibini villagers of the east bank of the middle Morehead, '*songgaba* is a round disc stone club; *tembithko* is a 5 point stone club; and *tengafu* is a wooden club' (Ayres, 1983, 54, n.1). This dialect shares a border with the Bavir (*Ranjer Tjokwasef* dialect speakers), for whom *songgaba* or *songgapa* also means a type of club (Mark Bize, Bula village, pers. comm., 2002). Williams (1936: 416), working among *Nambu* dialect speakers, states that 6 pointed clubs are *girigiri*, and 4 pointed clubs *susa*. In Suki, club is *girigiri* (Martin in Swadling, 1983: 141). Analysis of the words for stone and clubs in source societies to the north, and their intermediary trading communities, may further elucidate linkages between the peoples of central-southern New Guinea and the origin of their stone artefacts⁹.

CONCLUSION

Further details on the trade of Torres Strait stone artefacts into the PNG lowlands await future research. These 3 clubs do not constitute a meaningful sample upon which to base wide-ranging assertions about club stone sources or trade and the results of surface analysis must

be treated with caution in the absence of more knowledge of regional geology and more detailed petrological analysis of artefacts. However, significant collections of clubs from this area exist in Australian, British, and Dutch museums (G. Hitchcock, pers. obs.). This includes the Morehead District where Sir William MacGregor obtained a number of clubs in May 1890 and again in January 1896 (MacGregor, 1890b: 74, 1896: 42); 9 of these are in the Queensland Museum. MacGregor also collected a number of disc and ovoid clubs when he defeated a Marind-Anim raiding party on the Wassi Kussa in May 1896¹⁰ (MacGregor, 1896: 56); 4 of these are at the Queensland Museum and 3 at the National Museum of Papua New Guinea. Additionally, the Australian Museum holds 2 Morehead River stone-headed clubs and the South Australian Museum holds 2 from the Morehead, and 2 from the Wassi Kussa River. Petrological analysis of these collections would be very interesting, in particular the Marind-Anim examples collected on the Wassi Kussa, in light of the extent of Marind-Anim raiding/trading parties. This, together with examination of potential quarry sources of stone to the north of the PNG lowlands and sites in Torres Strait (including the hill of Mabaduan), will shed further light on the provenance and trade in these artefacts.

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ENDNOTES

1. The only hard stone in the region occurs at the granitic outcrop at Mabaduan. Laba (1975: 35) noted that Gizra people of the Pahoturi River most likely obtained stone tools from rocks at Mabaduan and 'rocks in local creeks which are probably re-excavated beach or terrace deposits'. Given the scarcity of stone in central-southern New Guinea, rough wooden clubs, and various substitutes for stone club heads, appear to have been common. Club heads made of wood and dried clay have been reported among the Marind-Anim (Nevermann, 1941: 13; 1939: 33; Speiser 1932: 78) and fungal club heads from the Gogodala (Price et al., 1978).
2. For discussion of the terms 'story' and 'storybeing', see Ayres (1983: 44-9).
3. Nevermann (1939: 33; 1941, 12-3) and Wirz (1922/25: 112) discuss trade in these clubs, and Swadling (1983: pl. 41, no. 7) depicts an example collected from Bosset. Ian McNiven has recently acquired a brass disc club, provenanced to the Marind-Anim (Appendix).
4. Not all such clubs comprised stone headed clubs, e.g. the *parasi* described by Williams (1936: 267); see also Kooijman (1952: 97).
5. The Kanum peoples speak dialects of the Kanum language, a member of the Upper Maro and Morehead Rivers Family (Wurm & Hattori, 1981).
6. Wirz (1922/25) and Nevermann's (1939, 1941) informants did not mention Torres Strait or adjacent lowland New Guinea as a source for stone clubs.
7. Caution must be exercised when interpreting the trade reported by Beaver, as headhunting and migration movements were dynamic at and before contact, and no doubt impacted on trade cycles in the region, as did the introduction of iron. Bugi was established by the British New Guinea administration in 1897-98 as a refuge for so-called 'broken tribes' who had suffered from Marind-Anim depredations, and it appears that only a few villages existed on the Trans-Fly or Daudai coast at the time of first contact in the 1860-1870s, such as Mawatta (or Katau) on the mouth of the Binaturi River, and nearby Tureture (Lawrence, 1994). McNiven, von Gnielinski & Quinnell (this volume) make the point that the symbiotic relationship between stone tool and canoe hull trade was integral to the settlement of Torres Strait and continuation of the maritime lifestyle, which is known to extend back two and a half millennia.
8. Wirz (1933: 121) documented the profound impression the hills and boulders of Mabaduan and Dauan had upon visiting Marind-Anim raiders, whose own lands were devoid of stone.
9. Care must be exercised when comparing wordlists for such terms, as errors of translation and

transcription appear to be common in early government reports, and local knowledge of the specific names for the various clubs appears to have become attenuated in the decades following pacification. For example, I have heard Wartha people refer to disc clubs as *songgapa*, as well as *kirikiri*. Flint's listing of star club as *kirikiri* may reflect a time when these objects were more

common, and knowledge of the various types more precise. I have not seen any star or pineapple clubs in the Torassi area; pacification and the trading of such items to Europeans over the years may in part account for this situation.

10. One of these clubs was made from 'fossiliferous whitish stone' (MacGregor, 1896: 56).

APPENDIX

NUCLEAR MICROPROBE ANALYSIS OF A MARIND-ANIM BRASS CLUB HEAD

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DESCRIPTION. The club head collected from the Marind-Anim in 1989 is in the possession of Ian McNiven (Monash University). It has a biconvex shape with a large central hole for hafting a handle (Fig. 7). Traces of red paste up to 1mm thick around the surface of the central hole reveal the impression left by a hafted handle. It is likely this red paste functioned as a hafting adhesive. Smudges of this red paste also occur across the surface of the club. The red paste indicates that the club head was hafted recently. The surface of the club has a smooth finish with no macroscopic mould marks. A series of scratches and impact marks can be seen across the club's surface. The symmetrical club has a diameter range of 94.0-94.3mm, hole diameter that slightly tapers from 32.0-31.5mm, maximum thickness of 19.5mm, and weight of 647.9g. The almost perfect symmetry of the club head indicates that it was not cast from a mould originally formed by taking an imprint of an 'original' stone club head. A heavy dark green patina across the surface of the club head indicates manufacture from either brass or bronze. To settle this metallurgical ambiguity, the club head was subjected to detailed elemental analysis.

ELEMENTAL ANALYSIS. To measure the elemental composition of the club head, Proton Induced X-ray Emission (PIXE) was performed with the Melbourne Nuclear Microprobe (Jamieson, 1998). Normally a small fragment for analysis would be removed from such a large artefact. This is because the specimen for analysis must be loaded into a high vacuum chamber for irradiation with a focused, high

energy, ion beam. However, to preserve the integrity of the artefact, we adopted the unusual strategy of loading the entire artefact into the specimen chamber. Being made from metal, no damage to the artefact was likely from having been exposed to vacuum.

Owing to the rough surface oxide and other materials on the surface, the ultimate vacuum achieved in the chamber under these conditions was not good, but better than 1×10^{-6} Torr was achieved. This was adequate for the present purposes. PIXE spectra and images were obtained with a 3 MeV H^+ microbeam using a Canberra UltraLeGe 100mm² Ge x-ray detector, with a nominal solid angle of 100 msr fitted with a filter (including the detector window) of 145 microns Be. The purpose of this filter was to attenuate x-rays from minor elements that might otherwise overload the x-ray detector and reduce sensitivity to heavy elements of interest here. To



FIG. 7. Marind-Anim brass club head.

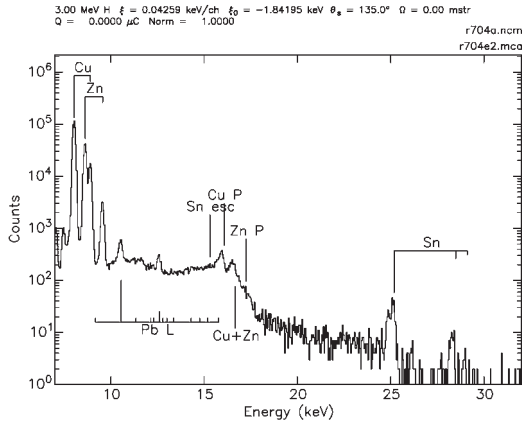


FIG. 8. PIXE spectrum of region 1 of brass club head.

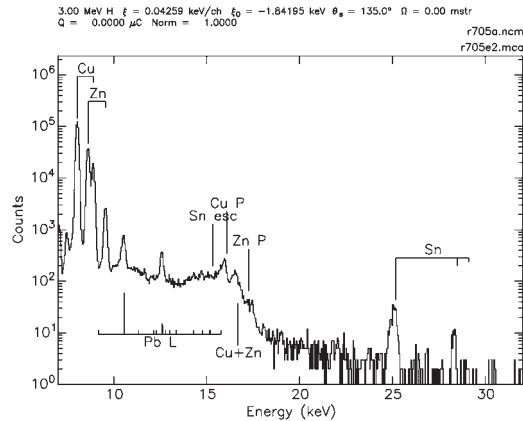


FIG. 9. PIXE spectrum of region 2 of brass club head.

obtain a representative sample of the elemental composition of the club head, two different regions, 600×600 micron square, were irradiated to obtain PIXE spectra for the analysis of the elemental composition. The elemental composition of the club head was then determined from quantitative analysis of the PIXE spectra using the CSIRO GEOPIXE analysis code (Ryan et al., 1995). An important consideration is that the PIXE spectrum in itself does not readily provide sufficient information for a complete analysis of a specimen consisting of several layers with different composition. This is the case here where the surface oxide/dirt layer will have a different composition to the bulk. The ion beam will penetrate a nominal 50 microns into the specimen and excite x-rays from a similar depth. Therefore the composition figures obtained from analysis of the PIXE spectra will be the weighted average over the ion range.

Little difference between the regions was observed suggesting that the spectra (Figs 8, 9) were indeed characteristic of the artefact. Elemental compositions obtained from the two spectra (Figs 8, 9) are shown in Table 2.

The elemental composition shows that the artefact is most probably made from brass with a Cu (copper) to Zn (zinc) ratio of 3:1. The low level of Zn (18-14%) contrasts with Zn levels of

28% and 33% achieved by European smelters after 1450 and 1675 respectively (Henderson, 2000: 240). However, Sn (tin) was also detected at around the 1%. This is much lower than expected for the alternative possible composition, which was bronze, especially when compared to published spectra (Climent-Font et al., 1998) for known ancient bronze artefacts where PIXE does not reveal Zn and shows a much stronger Sn signal consistent with the much greater Sn composition. Note that the Sn composition of the present artefact could be obtained from both the K and L characteristic x-rays with similar results, as expected (Table 2). Pb (lead) was also present at 1%.

It was surprising to see such a large concentration of Si (silicon), at around 13%. As discussed previously, the PIXE spectrum represents the average composition along the entire ion range. It is likely that the Si signal arises only from a surface coating of the artefact. Further analysis of a cleaned region of the surface would be necessary to determine if this is the case or if instead the Si is located within the bulk.

The distribution of Cl (chlorine), Ca (calcium), Fe (iron) and possibly also Ni (nickel) may be similar to that of Si but again could be resolved by analysis of a cleaned surface.

TABLE 2. Elemental composition of brass club head (% weight). Si = silicon; Cl = chlorine; Ca = calcium; Fe = iron; Ni = nickel; Cu = copper; Zn = zinc; Sn = tin; Pb = lead.

Region	Si K	Cl K	Ca K	Fe K	Ni K	Cu K	Zn K	Sn K	Sn L	Pb L
1	13.8%	8%	3.3%	1.7%	0.3 %	44 %	18%	1.5%	2.4%	1.0 %
2	13.0 %	19%	1.6%	1.8%	0.3%	42%	14%	1.1%	0.8%	1.2%

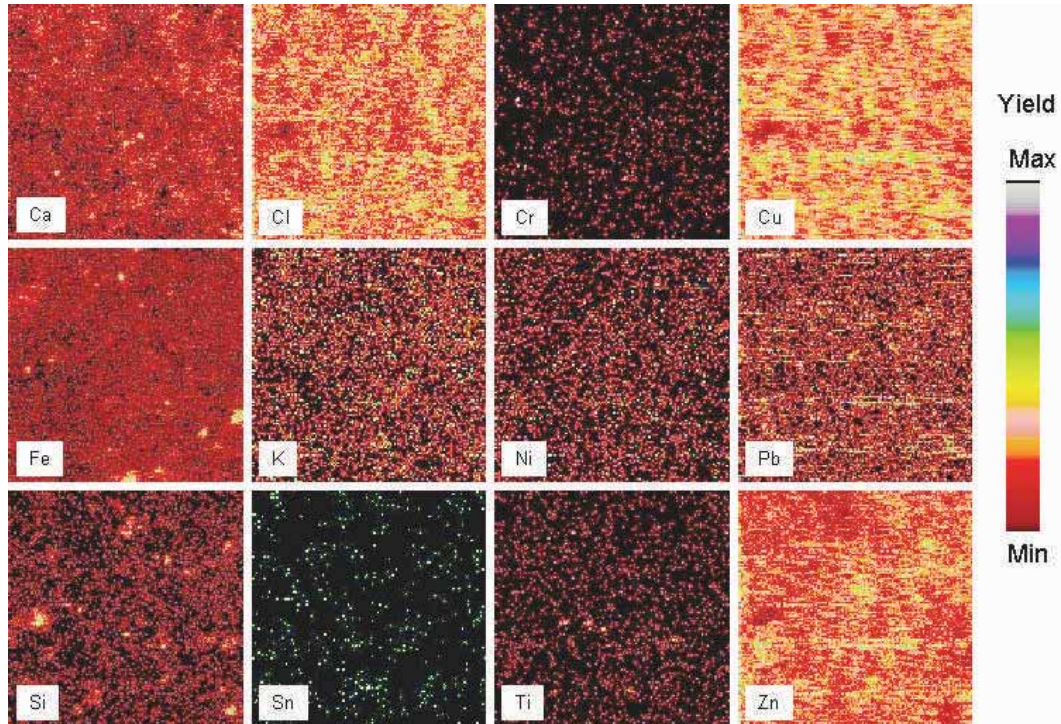


FIG. 10. Elemental maps for region 2 of brass club head.

Although the depth distribution of the elements could not be obtained from the PIXE spectra, the use of a nuclear microprobe meant that the lateral distribution of the elements could be mapped. Representative elemental maps (Fig. 10) were from region 2 (Table 2), but the features observed in region 1 were very similar. These maps reveal the uniform distribution of Zn and Cu, as expected for the bulk of the artefact. The distribution of Cl is also uniform. As Cl is unlikely to be component of the bulk, this is consistent with a surface layer. This may also be the case for Ca. However, the trace metals and Si are quite different. Cr (chromium), Fe, Si, Ti (titanium) and possibly also Ni are randomly distributed in small inclusions with a diameter less than about

20 microns in the case of the metals. Si appeared as larger inclusions. This suggests that the metal elements appear in the bulk, since similar distributions of 'intermetallics' also appear in modern aluminium alloys. If this is the case, the pattern of these trace elements is likely to be a signature of the factory from which the artefact originated. Note that the concentration of Sn (1%) was too low to construct an elemental map with meaningful statistics.

This work has shown that nuclear microprobe analysis provides a convenient method of measuring the elemental composition of metal artefacts, with the additional potential of providing the provenance from the elemental distribution.

