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Raided and traded: Sourcing Marind-anim exotic stone objects, south-east Papua (Indonesia)

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Abstract

The Marind-anim of the south-east corner of Papua, Indonesia, live in a stoneless world but venerate stone objects. As expected, stone objects of the Marind, such as axes, club heads and 'spearthrower' attachments, are exotic, with ethnographic information pointing to acquisition through a complex portfolio of trading and raiding (headhunting) relationships with multiple neighbours who had either direct or indirect access to tool stone. Ethnographic and geological information indicates that the two closest sources of tool stone to the Marind are located over 100 km away—the southern flanks of the Central Ranges (especially the Upper Digul River) to the north and Torres Strait to the south-east. These two source options are consistent with our petrographic assessment of a sample of three Marind stone club heads and three 'spearthrower' stones. Beyond ethnographically documented trading and raiding processes of stone implement provisioning, we hypothesise that the Marind may have manufactured their own stone implements by accessing igneous outcrops at Mabaduan on the northern mainland coast of Torres Strait during headhunting expeditions.

Introduction

Chemical fingerprinting and petrographic analysis of raw materials have been fundamental to archaeological understandings of past stone artefact movements and associated exchange networks in New Guinea for half a century (e.g. Gaffney and Summerhayes 2019; Key 1968; McNiven et al. 2004; Mialanes et al. 2016; Rhoads and MacKenzie 1991; Shaw et al. 2021; Summerhayes 2009; Summerhayes et al. 1998; Sutton et al. 2015). For over 30 years, Glenn Summerhayes has had a critical role in innovative methodological and analytical developments in these sourcing studies, particularly in understanding obsidian exchange systems over the past 20,000 years, and especially over the past 3300 years in tandem with sourcing of Lapita and Post-Lapita ceramics (e.g. Summerhayes 2000; Summerhayes and Allen 1993). In marked contrast to the importance of these studies for understanding Papua New Guinea's past, little stone artefact sourcing research has been undertaken across the western half of New Guinea in Indonesian Papua (e.g. Harlow et al. 2012;

Pétrequin and Pétrequin 1993a, 1993b, 2020; Torrence et al. 2009). This chapter provides the first published account of the raw materials and potential geological sources of ground stone implements (club heads and 'spearthrower' attachments) used by the Marind-anim of south-east Papua. These ground stone implements had an exotic origin as the Marind inhabit a stoneless world. Ethnographic records from the early twentieth century invite discussion of the relative roles of headhunting raids and exchange in the provisioning of these exotic objects.

Marind-anim

The Marind-anim are hunter–forager–agriculturalists who inhabit tropical coastal lowlands of the south-east corner of Indonesian Papua (van Baal 1966). Usually, their name is shortened to Marind as *anim* = people/person/human in Marind language (Chao 2021:248; Olsson 2017; Usher and Suter 2015). The territorial domain of the Marind stretches 200 km eastwards along the coast from Selat Muli (Muli Strait, formerly known as Princess Marianne Strait) in the west to 25 km east of Merauke (a town located 100 km along the coast from the Indonesian – Papua New Guinea border). It extends 200 km inland, taking in the drainage basins of the Bian and Kumbe Rivers and the lower reaches of the Merauke (Maro) River (van Baal 1966:10–11; see Figure 12.1). A linguistic division exists between the (inland) Bian Marind (of the upper Bian River) and the Coastal and Central Marind (Olsson 2017:25; Usher and Suter 2015). The stoneless world of the Marind is mostly elevated <40 m above sea level and comprises Quaternary sediments (Reynders 1961; Schroo 1964). Much of this low-lying area was probably inundated following higher sea levels associated with the end of the postglacial sea level rise c. 6000–7000 years ago (Chappell 2005:Fig. 4; see also Dougherty et al. 2019; Woodroffe et al. 2000).

Population estimates of the Marind at the start of the twentieth century and before depopulation (see below) range from c. 15,000 to c. 20,000, divided between the coast (c. 10,000–13,000) and inland (c. 5000–7000) (Kooijman et al. 1958:44–45; see also van Baal 1966:710). In reality, the Marind 'world', especially the region taken in by large-scale headhunting expeditions that could last for months, encompassed a much larger area than the region defined by the extent of the Marind language. As pointed out by Dutch colonial anthropologist Jan van Baal, these 'extra-regional' domains included Yos Sudaro (formerly Frederik Hendrik) Island to the west/south-west, the Digul River to the north/north-west, and the Trans-Fly and northern Torres Strait to the south-east (van Baal 1966:348). These areas had cosmological referents in numerous mythological narratives where the creative activities of *dema* spirit beings extend from the Digul River to the Fly River (van Baal 1966:348).

Sustained colonial occupation and pacification of the Marind commenced in 1902 with the establishment of the Dutch settlement of Merauke on the lower Merauke (Maro) River and the establishment of Okaba in 1908 (Kooijman et al. 1958:103; van Baal 1966:681). Roman Catholic (Sacred Heart) missionaries established major missions at Merauke (1905) and Okaba (1910) (Boelaars 1969; Kooijman et al. 1958:104–105; Steenbrink 2007). Diseases (e.g. donovanosis), influenza epidemics, Dutch government administrative control, and missionisation resulted in radical changes to Marind culture and society (Kooijman et al. 1958:53; Kooijman 1959:19; Richens 2022; van Baal 1966:25–26). In 1962, the peoples of western New Guinea (including the Marind) became part of Indonesia and what are known today as the various provinces of Papua.

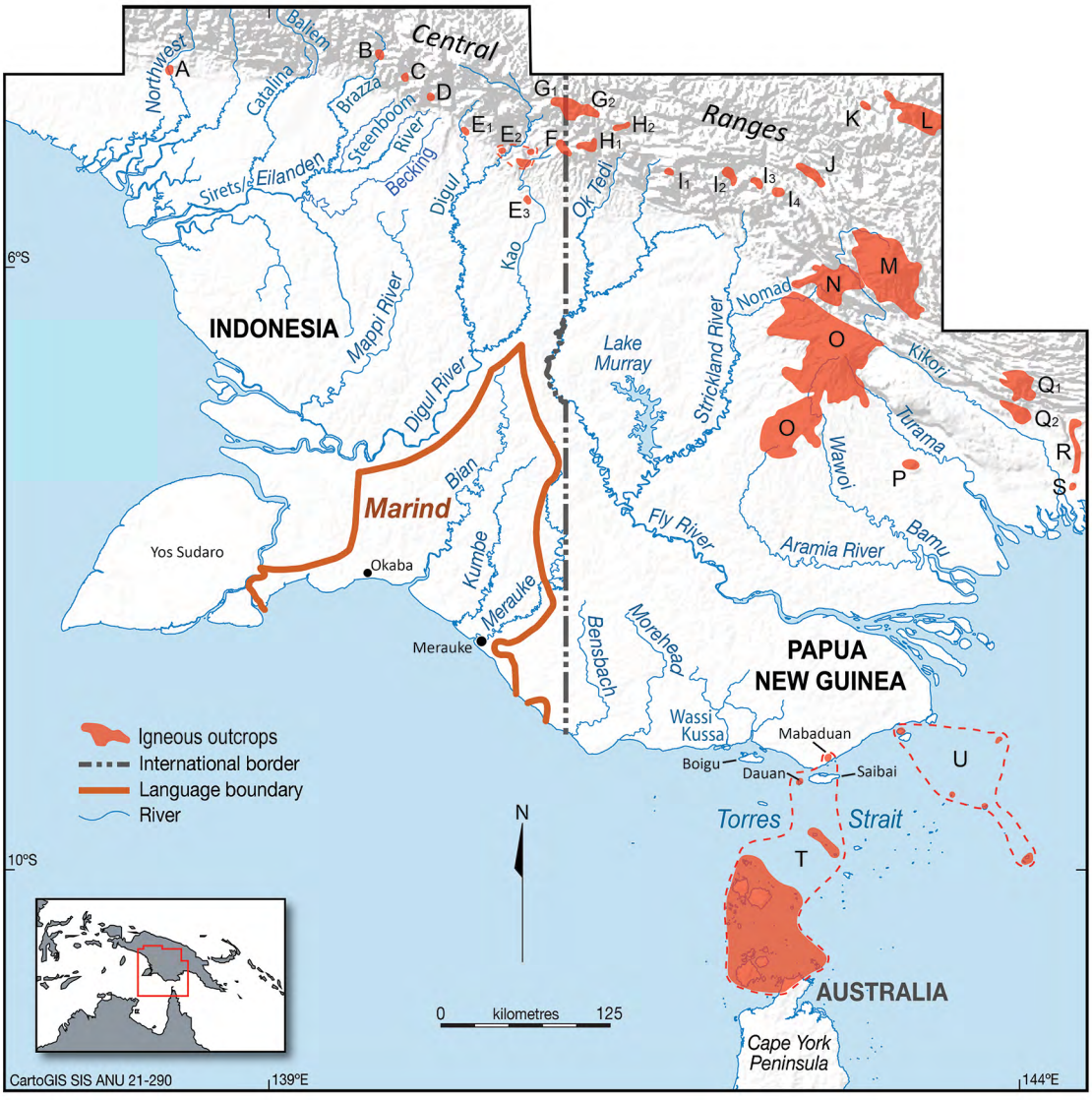

Figure 12.1: Map of central-southern New Guinea showing Marind territory (brown line) and igneous rock outcrops.

Note: For details on igneous rock outcrop locations/zones labelled A to U see Table 12.2.

Sources: After van Baal (1966); Kooijman (1959:12); Voorhoeve (1983); Bain and Haipola (1997); D'Addario et al. (1976); Dow et al. (1986).

Archaeological understandings of the Marind past are essentially non-existent, as they are for most of the southern lowlands of Indonesian Papua (Simanjuntak 1998; Wright et al. 2013). It is likely that archaeological evidence of settlement sites (e.g. villages) is relatively recent and concentrated within fossil beach ridges aligned parallel to the coast (Reynders 1961; see also McNiven 2010). These fossil beach ridges extend up to 100 km inland according to Heldring (1910:Pl. III), and probably track the progressive fall in sea level over the past c. 6000–7000 years (see also Paijmans et al. 1971:67, Fig. 8). Archaeological evidence of older village sites is likely to be found on elevated relict river terraces located further inland (see Visser and Hermes 1962:188). Following Swadling (1983:23–29), the newly formed coastal lowlands of Papua were likely colonised by inland peoples, a hypothesis consistent with genetic evidence for similarities between both regions and an absence

of an influx of coastal (Austronesian) peoples (Purnomo et al. 2021; Tommaseo-Ponzetta et al. 2002:59; see also van Baal 1966:944; Djami and Suroto 2023). The Asmat, who occupy lowlands to the north-west, hold a myth recounting how their ancestors migrated southwards from inland mountains (Konrad and Konrad 1996:268).

Stone use by the Marind: Ethnographic picture

The limited number of published references to the use of stone by the Marind is due in large part to the simple fact that Marind territory is 'completely devoid of stony matter except for loose concretions of sand or weathered loam' (van Baal 1966:16; see also Heldring 1910). In 1905, Austrian anthropologist Rudolf Pöch travelled across Marind territory, noting that 'Nowhere in this region did I notice any stone' (1907:614; see also van Baal 1966:8). Living in a stoneless environment, stone had a special meaning for the Marind, as all stone artefacts had to be obtained externally (see below). Despite an absence of locally available stone, the Marind used stone for tools (e.g. axes, club heads, and 'spearthrower' attachments—see below), while references to stone objects and features occur in a number of *dema* mythological narratives (e.g. Kooijman et al. 1958:73; van Baal 1966:279, 299, 461, 880). Ethnographic records say nothing about the use of flaked stone cutting or scraping tools. Such tasks were performed by tools manufactured from bamboo, marine shell, bone and boar's tusk (Kooijman et al. 1958:46; van Baal 1966:313, 907). The rarity of stone is reflected also in the use of pieces of termite nest as heat retainers in Marind ground ovens, and not stones as occurred across most other parts of New Guinea (van Baal 1966:16, 799–800, 847–848). It is likely that clay ball heat retainers were also used, as seen in neighbouring groups (Owen et al. 2008).

The earliest published record of Marind stone objects is by William MacGregor, Lieutenant-Governor of British New Guinea, who collected a number of stone objects from a Marind raiding camp on the Wassi Kussa (river) in the Trans-Fly region of south-west Papua New Guinea in 1896 (MacGregor 1897) (see Figure 12.1). The objects include a Marind 'pounding stone' with 'a fossil shell in one end of it', and a series of stone objects with possible ritual functions (MacGregor 1897:56). Despite the existence of stone implements (e.g. axes and club heads—see below), the majority of the admittedly limited published information on Marind stone objects concerns spiritual/ritual stones. Van Baal noted that stones can have spiritual power in Marind society as 'many' *dema* 'changed into stones' (1966:182–185, 209, 223, 229–230, 233, 237, 267, 392, 461; see also Wirz 1946). More generally, 'déma stones' were a 'preoccupation' of 'medicine-men' (*messav*) (van Baal 1966:883). These stones often took the form of a 'peculiar pebble' that was obtained through ritual interactions by *messav* at locations where *dema* reside. *Dema* stones were associated with rituals to heal sick people, increase the fertility of gardens, including coconuts, assist with hunting of crocodiles and help bring rain (van Baal 1966:803, 873–874, 881–882, 894, 899–900, 926).

Stone axes

Marind stone axes were hafted into a single piece of wood with a slot to accommodate the axe head (van Baal 1966:22, 230) (Figure 12.2A). This distinctive form of socketed hafting has a restricted distribution in New Guinea, centring on the southern lowlands of Indonesian Papua (Le Roux 1950, 3:Map III; Pétrequin and Pétrequin 2020:Figs 32–37). The Marind also possessed a variant of socketed hafting using a section of bamboo with a root node, known as *hong-ti* (van Baal 1966:230; see also Wirz 1946:85) (Figure 12.2B).

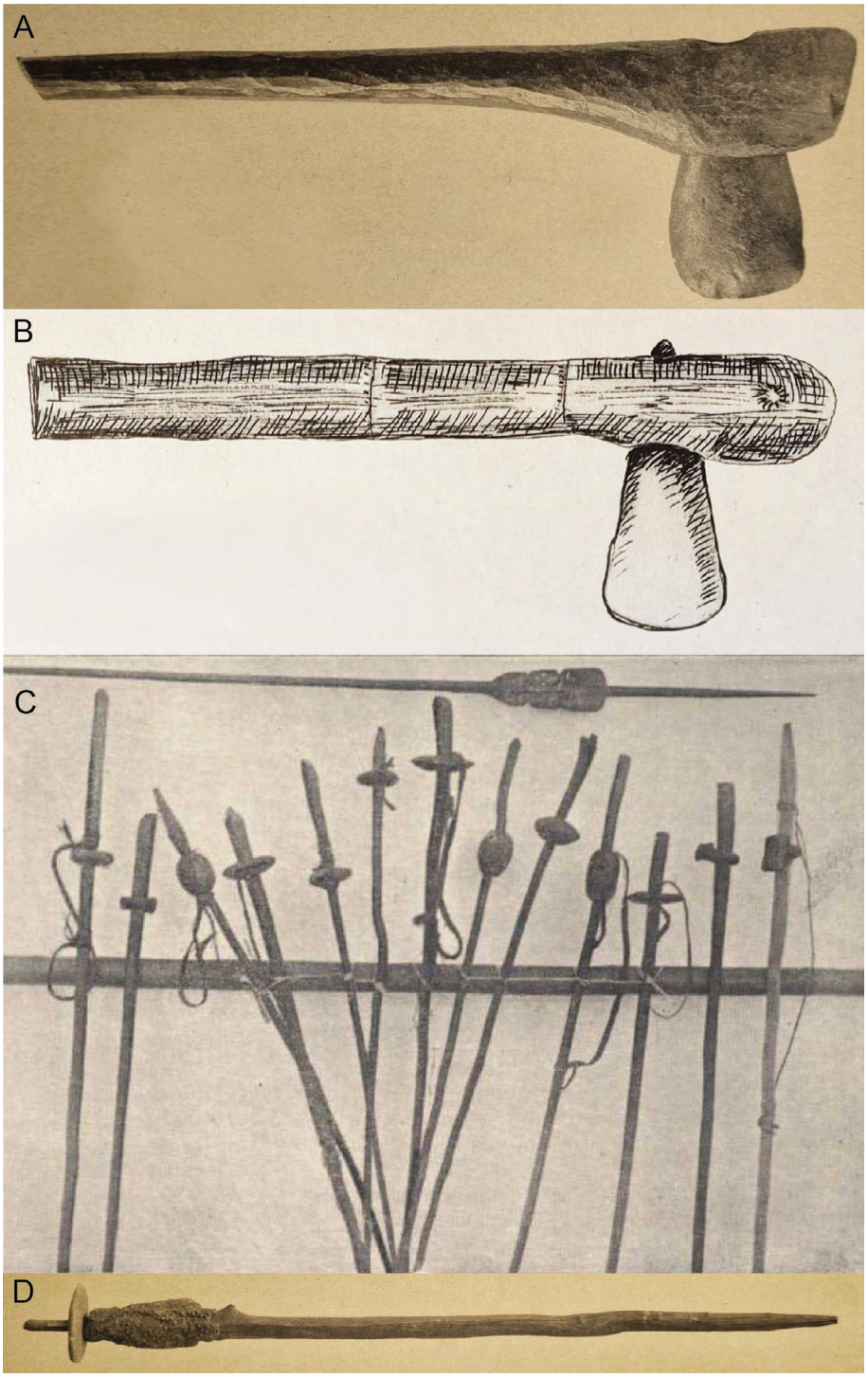

Figure 12.2: Marind stone axes and stone-headed clubs.

Notes: (A) Marind hafted stone axe from Merauke, collected 1904–05; (B) Marind stone axe hafted to the 'root end of a bamboo stalk'. Length of haft = 60 cm; (C) stone-headed clubs (ovoid and disc-shaped), metal-headed clubs, and a spear collected by William MacGregor from a Marind raiding camp on the Wassi Kussa (river), Trans-Fly region, south-west Papua New Guinea, 1896; (D) Marind stone-headed club from Merauke, collected 1904-05. Piece of spiky skin of a stingray wrapped around wooden haft. Weight = 1.5 kg, Length = 1.32 m.

Source: (A) from Expedition (1908:Plate VI, No. 183); (B) from Wirz (1922, I:Plate 37.1, English translation); (C) MacGregor (1898:Plate 6, Fig. 11); (D) from Expedition (1908:Plate VII, No. 179).

Similar bamboo hafts were used by the Asmat and Kamoro (Mimika) to the north-west (Konrad and Sowada 2002:369; Kooijman 1984:117; Le Roux 1950, 3:Map III; Pétrequin and Pétrequin 2020:Figs 34–36) and in the Morehead River area to the south-east (Williams 1936:429). These status/wealth objects had a range of secular uses within Marind society, such as chopping down sago trees, and ceremonial functions, and were inherited from father to son (van Baal 1966:466, 771, 861). Van Baal (1966:841) noted that 'stones axes, birds of paradise and other ornaments' are attached to a platform made of arrows (*tanggé*) upon which pigs are butchered for feasts. Stone axes are mentioned in a range of Marind mythological narratives (van Baal 1966:227, 255, 466). One mythological narrative refers to a time when 'nobody knew how to go about' chopping down sago trees 'to prepare the pith … because at the time stone axes were unknown' (van Baal 1966:337). The first axe was one of the 'very big teeth' of the *dema* Monubi who 'had come from far away' (van Baal 1966:337; see also Wirz 1922, II:153, 1946:85).

Stone club heads

Stone-headed clubs were highly prized objects possessed by many Marind men (Figure 12.3; see also Corbey 2010:37). As with stone axes, this implement type is found across much of Papua New Guinea and the southern lowlands of Indonesian Papua (Haddon 1900; Höltker 1940–41:Fig. 1; Pétrequin and Pétrequin 2020; Pretty 1965:Fig. 2; Soukup 2020). In common with other parts of New Guinea, they were used as raiding weapons (e.g. headhunting raids) and as status/ceremonial objects. They came in two main forms (ovoid or egg-shaped, and disc-shaped), and two rare forms (star-shaped, and knobbed/'pineapple'-shaped) (van Baal 1966:22, 273; Wirz 1922, I:112). The earliest recorded Marind examples are by MacGregor (1897:56) who at a raiders camp on the Wassi Kussa observed no 'stone axes' but a number of stone-headed clubs that were 'either of the thick disc type or shaped nearly like a turkey's egg. One at least is made of a fossiliferous whitish stone' (Figure 12.2C).

Of the 38 stone club heads (13 hafted) depicted in the online catalogue of the Tropen Museum in Amsterdam, most (79 per cent) (N = 30) are disc-shaped and eight are ovoid-shaped. The ovoid-shaped club (*waganê*) was a symbol of the male sex and the disc-shaped club (*kupa*) a symbol of the female sex (van Baal 1966:273, 732, 742). Van Baal (1966:730) was emphatic: 'Stone discs are rare'. Such rarity may explain in part the manufacture of wooden 'imitation' stone discs (Grottanelli 1951:106; van Baal 1966:734, 736) and the acceptance of imported brass imitation stone club heads in the early twentieth century (McNiven and von Gnielinski 2004; see also MacGregor 1897:56) (see below). Men obtained their first stone-headed club at the important age-grade ceremony when boys change status to young single men (*ewati*) and are presented with an 'heirloom' stone-headed club (van Baal 1966:151; 1994:135). They continued to be status/wealth objects until at least 1919 (Alder 1922:24; Alder and Bailey 1921; van Baal 1966:861). Adventurist and filmmaker William Alder (1922:110) claimed he observed a man 'fashioning a rattan handle for a stone war-club head' in 1919. They are mentioned in numerous mythological narratives (van Baal 1966:284, 292, 315, 317, 464) and were held by participants in a range of ceremonies (e.g. van Baal 1966:483, 904, 906). A *kupa* club was used to kill a pig for a feast associated with a ceremony (van Baal 1966:567) and Alder (1922:102) observed a stone-headed club used to break open coconuts. In some cases, club heads were hafted loosely such that they could slide down the wooden haft to increase impact (Kooijman 1952:97). In at least one case, spiky stingray hide was attached to the haft under the stone club head to increase the severity of impact (Figure 12.2D).

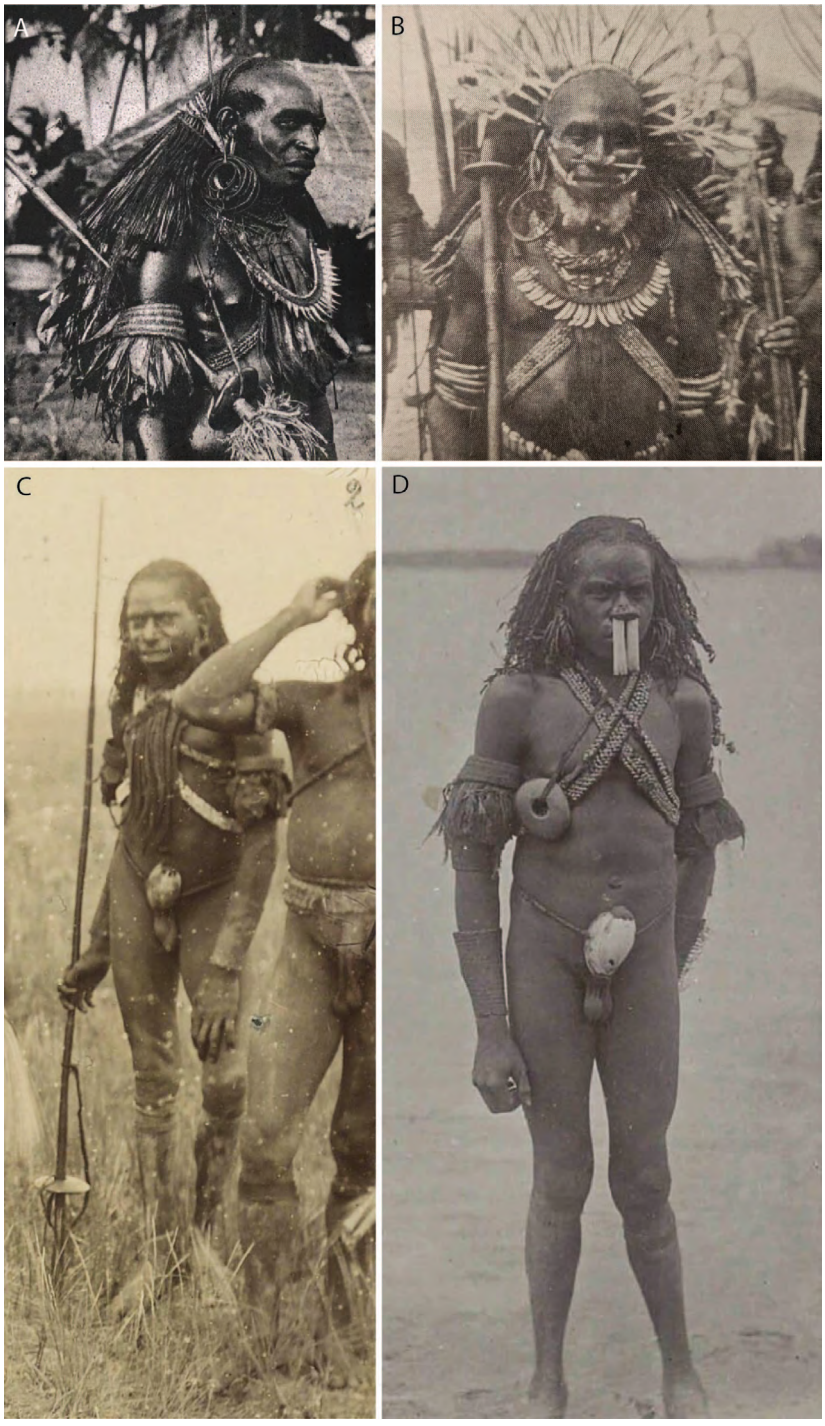

Figure 12.3: Marind men and stone-headed clubs.

Notes: (A) Marind man holding a stone-headed club, Merauke, c. 1906–1909; (B) Marind man holding a stone-headed club, c. 1902–1920; (C) Marind man holding a stone-headed club; (D) Marind man with a stone club head hanging around his neck.

Source: (A) photography by Father Henricus Nollen and published in Nollen (1909:Fig. H IVc); see also Reichgelt (2016:24) (collection of the University of Leiden library, KITLV D6224); (B) from Alder (1922:opp. p. 161); (C) photograph taken during the 'De Zuidwest Nieuw-Guinea-Expeditie 1904/05' (collection of the Museum Volkenkunde, Leiden, RV-A30-23); (D) photograph by Nicholas at Merauke in 1904 and published in Expedition (1908:Fig. 142) (collection of the Museum Volkenkunde, Leiden, RV-A30-25).

‘Spearthrower’ stones

The Marind used wooden (bamboo) spearthrowers (e.g. Geurtjens 1949; Wirz 1922, I:Plates 32.3 and 36.3). However, ethnographically collected objects in the form of wooden shafts with hafted stones that were beautifully crafted with a shaped hook feature (known as *imbassum*) are unique to the Marind (Figure 12.4).

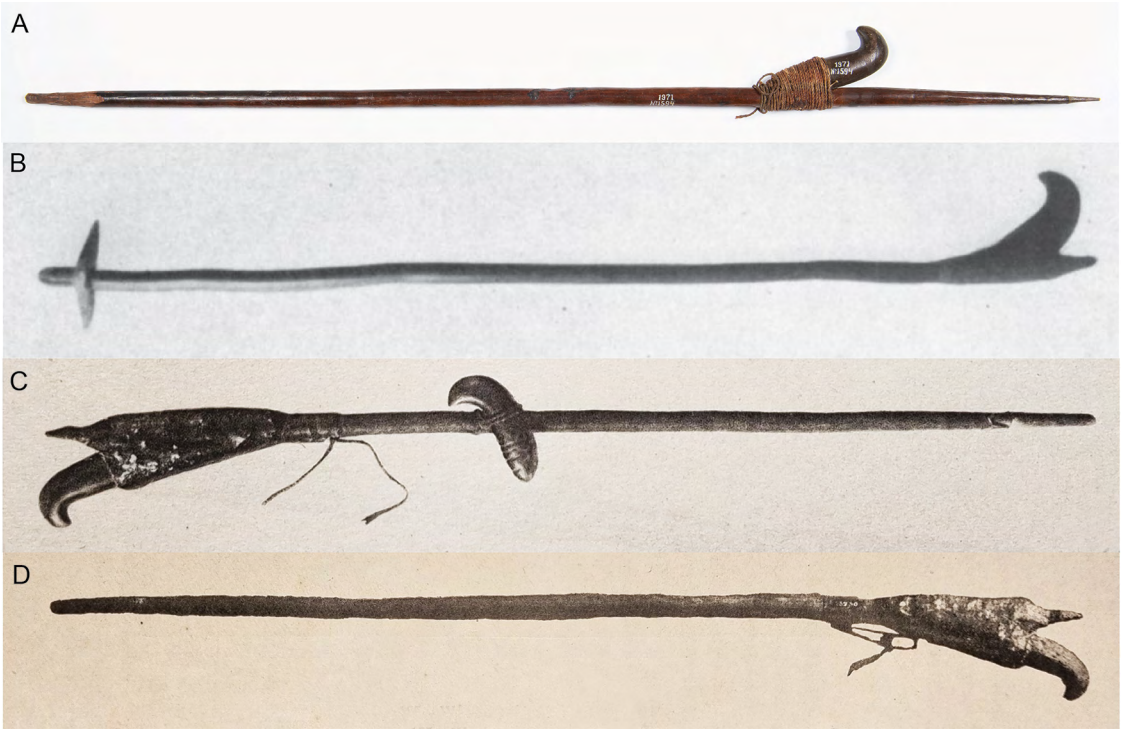

Figure 12.4: Various hafted *imbassum*.

Notes: (A) Marind hafted *imbassum*, Sanggase coastal village, collected c. 1913 by A.J. Gooszen. Length = 116 cm; (B) hafted *imbassum* at one end and ‘bone plate’ at the other end. Provenanced to the Digul River. Length = 80 cm; (C) Marind hafted *imbassum* (with two shaped stones); (D) ‘ornamental weapon or symbol’ comprising a hafted *imbassum* and cassowary toenail, Okaba coastal village, collected 1907–1915.

Source: (A) Geurtjens (1949:Figs 1–2) (collection of the Museum Volkenkunde, Leiden, RV-1971-1594); (B) Geurtjens (1949:Fig. 4) (collection of the Nederlandsch Volkenkundig Missiemuseum, Tilburg); (C) Wirz (1922, I:Plate 36.12); (D) Expedition (1920:345–346, Fig. 155, English translation).

According to Swiss ethnologist Paul Wirz (1925 cited in van Baal 1966:413), *imbassum* ‘combines the functions of spear-thrower, striking weapon and thrusting weapon’. The spearthrower function of *imbassum* was supported by Geurtjens (1949:221) and van Baal (1966:413–415). Anthropologists agree that *imbassum* also had an important ceremonial/ritual function. Wirz (1925, III:20) noted that *imbassum* were carried by *kapiog* (black cockatoo) performers in *mayo* cult initiation ceremonies, adding that the hooked form of the stone ‘has some resemblance to the beak of a cockatoo’ (Wirz 1925, IV:138, English translation) or more generally ‘the shape of a bird’s head’ (Wirz 1946:88, English translation). Father Henri Geurtjens (1949) argued that the rarity of *imbassum* is consistent with a restricted, ceremonial use. Van Baal (1966:414) was adamant that ‘there is ample reason to accept that the *imbassum* is a ceremonial spear-thrower. It fits in perfectly with the ritual performance’ of the *kapiog*. Marind mythological narratives refer to *dema* using *imbassum* to facilitate hunting of wallabies (e.g. van Baal 1966:286, 328, 412). At Senégi village, missionary Father Jan Verschueren

(cited in van Baal 1966:415) recorded a large (12-cm-long) *imbassum* (stone) said to be a banana *dema*. The rarity of hafted *imbassum* (see Figure 12.4) and unhafted *imbassum* stones in museum collections is consistent with their apparent rarity among the Marind and their restricted ceremonial use (Smidt 2006:429). The combined online catalogue of the Tropen Museum (Amsterdam), Rijksmuseum voor Volkenkunde (Leiden), and World Museum (Rotterdam) lists seven Marind *imbassum* stones (one with a haft), with a length range of 6.5–14.5 cm. Length measurements made by Wirz (1946:88) of five *imbassum* stones in the Museum für Völkerkunde (Basel) range from 9.5 to 16.2 cm (Figure 12.5).

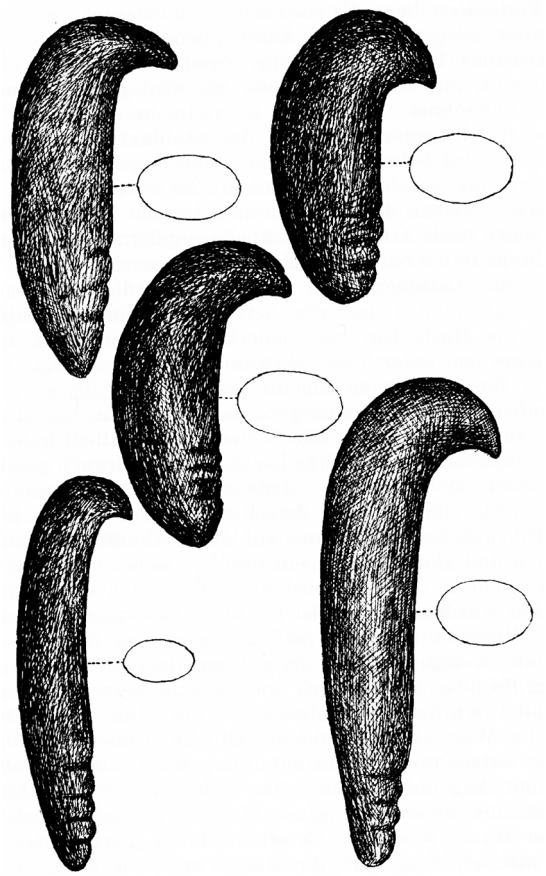

Figure 12.5: Marind *imbassum* stones collected by Paul Wirz between 1915 and 1922 and housed in the Museum für Völkerkunde (now Museum of Cultures), Basel, Switzerland.
Source: After Wirz (1946:Fig. 9–13).

Potential sources of stone implements

All stone implements used by the Marind must originate from beyond their territory, given the absence of local stone. Less consensus exists within anthropological literature on specifically where and how stone implements were obtained by the Marind. Van Baal suggested:

> stone axes as well as the stone clubs had to be obtained through trade or robbery during one of their frequent headhunting expeditions. The fact that there are different types of axes and clubs points to a diversity of origin (van Baal 1966:23; see also Wirz 1946:85)

Three regions external to the Marind have been identified ethnographically (based on interviews with elderly Marind during the first half of the twentieth century) as known and potential sources of stone implements—inland regions to the west and north (Digul River) and to a lesser extent the north-east (Fly River) and south-east (Torres Strait) (see Figure 12.1).

Upper Digul River

Wirz (1922, I:114, English translation) was informed by the Marind that their stone axes originated in the 'upper Digul and the Fly river'. Dutch anthropologist Simon Kooijman and colleagues (1958:46) noted that the Marind obtained stone axes and club heads from 'inland peoples … by barter or otherwise by robbery'. Archaeologist Pam Swadling (1983:85–86, Fig. 35) hypothesised that stone axes manufactured in the Upper Digul River ('Red Digul River quarry') 'were traded southwards as far as the Marind-anim'. Ethnoarchaeologists Pierre Pétrequin and Anne-Marie Pétrequin (2020:18, 143–144, 184–185) argued that most basalt stone axes traded down the Digul River originated from ethnographically documented quarries to the immediate north-west across the headwaters of the Eilanden (Sirets) River system located c. 200 km north-west of the Marind (see also

Hampton 1999:Chap 7). For example, Langda andesite/basalt axes (Eilanden River headwaters) have been documented among stone axes collected from the Digul River (Pétrequin and Pétrequin 2020:172). Axes manufactured from andesite/basalt (possibly from Langda) were also used by the Kombai of the Upper Mappi River (Konrad and Ligabue 1996:58) located immediately west of the Digul River, and the Marind on the Merauke River (Pétrequin and Pétrequin 2020:16, 18).

Wirz (1922, I:112) also recorded that the Marind obtained most ovoid- and disc-shaped stone club heads from the Digul River through trading and raiding. German ethnologist Hans Nevermann (1939:33) was informed that the Marind obtained stone club heads from the Digul River area. Similarly, Verschueren (cited in van Baal 1966:730) was informed in 1936 that disc-shaped stone club heads were 'traded, being passed down from the Star Mountains [Digul River headwaters] to the south'.

The hafted *imbassum* collected from the Marind coastal village of Okaba during the 1907–1915 'Verslag van de Militaire Exploratie van Nederlandsch-Nieuw-Guinee' was said to have come from 'Jamboeike in the interior' (Expedition 1920:345, English translation) (see Figure 12.4D). Jamboeike is located 90 km north-east of Okaba and 25 km south-east of the Digul River. Geurtjens (1949:223) was of the opinion that *imbassum* originated from the Digul River region.

Upper Fly River

Wirz (1922, I:112) recorded that Marind star- and pineapple-shaped stone club heads were obtained through headhunting and were thought by the Marind of the Upper Bian River to come from the Upper Fly River. He also noted that the 'Fly river' was a source of some Marind stone axes (Wirz 1922, I:114). Swadling (1983:79–84) added that Wirz's Fly River source may have been the Boazi people of the Lake Murray area who imported stone axes from the Upper Fly River, including gneiss axes from the Upper Wario River within the Sepik River system.

Torres Strait

Van Baal (1966:699) observed that the 'stone-headed clubs' of the Marind:

> are very much like some of the stone clubs of the Torres Str. islands and it is a fair guess that they obtained them from the Fly River district as well as from the interior.

Wirz (1933:121) was of the opinion that while the Marind visited the granite outcrops at Mabaduan on the Trans-Fly south coast, they only viewed the granite hill of Dauan, the northernmost rocky island of Torres Strait, from a distance. He added: 'Even on the calmest sea the crossing [10 km] in their canoes would have been a foolhardy venture' (Wirz 1932:285). The Marind informed Wirz (1933:120) that Dauan, a close but unreachable hill of stone, 'occupied their imagination more than anything else they had got to know on their journeys'. McNiven (in press) hypothesises that the Marind likely obtained stone objects manufactured by Torres Strait Islanders through trading and raiding after they had passed northwards into the hands of Trans-Fly peoples similarly through raiding and trading. Preliminary sourcing studies of stone club heads from Torres Strait and the Torassi or Bensbach River area of the Trans-Fly indicate manufacture from Torres Strait stone (Hitchcock 2004; McNiven 1998; McNiven and von Gnielinski 2004). Although *imbassum* ('spearthrower' stones) have never been recorded in Torres Strait, Swadling (1983:103) suggested that Torres Strait may have been the source of raw materials.

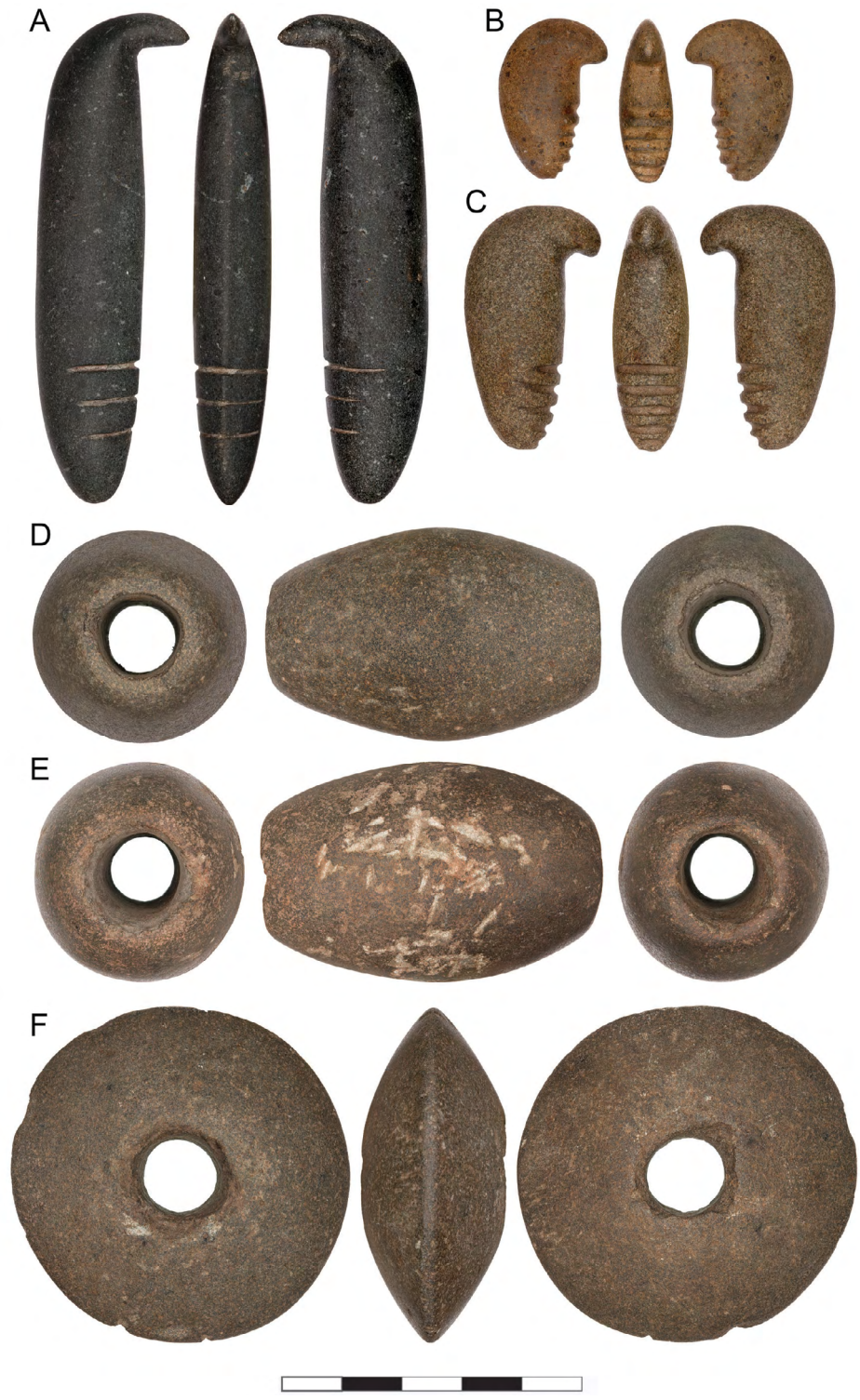

Figure 12.6: Marind *imbassum* and stone club heads, examined by IM and FvG.

Notes: (A) Marind *imbassum*, Okaba area (#498); (B) Marind *imbassum*, Merauke area (#541); (C) Marind *imbassum*, Merauke area (#542); (D) Marind ovoid stone club head (*wagané*), Merauke area (#479); (E) Marind ovoid stone club head (*wagané*), Merauke area (#480); (F) Marind discoid stone club head (*kupa*), Merauke area (#463). Scale in 1 cm units.

Source: All objects in private collection. Photographs by Steve Morton, Monash University.

China

Wirz (1922, I:112) recorded that Chinese traders introduced brass copies of stone club heads to the Marind in the early twentieth century. Similarly, Nevermann (1939:34, English translation) noted that 'recently' (i.e. early twentieth century) 'club discs made of stone or iron' were introduced to the Marind by Chinese traders. He observed that in contrast to the 'hourglass pierced shape' of the hafting shaft in 'old stone knobs', the hafting shaft of the Chinese imports was 'smoothly pierced' (Nevermann 1939:34). However, Swadling (1983:103–104), following Wirz (1922, I;112), rightly pointed out that straight-sided hafting shafts on stone club heads from south-western Papua New Guinea predate the arrival of Chinese traders at Merauke after 1902. Furthermore, ethnographic observations indicate the indigenous production of straight-sided hafting shafts in stone club heads in Papua New Guinea using cylindrical drills of bamboo (Austen 1923:344; McNiven and von Gnielinski 2004:298).

Six Marind stone implements: Manufacture and raw materials

To shed further light on the source(s) of Marind stone objects, one of us (IM) gained access to three 'spearthrower' stones (*imbassum*) and three club heads (ovoid and discoid) (Figure 12.6). Provenance information on the six objects is based on personal communication by IM with three ethnographic artefact 'dealers' in Australia, the Netherlands and Germany. Objects 463, 498, 541, and 542 were obtained by two of the 'dealers' directly from Marind in Okaba and Merauke. Objects 479 and 480 were part of an old missionary collection from Merauke taken back to the Netherlands. All six objects are in the custodianship of IM in Melbourne.

'Spearthrower' stones (*imbassum*)

The three 'spearthrower' stones (*imbassum*) (Objects A to C) vary considerably in weight (42, 112, 238 g), maximum length (55, 81, 164 mm) and maximum thickness (18, 25, 27 mm) (Table 12.1, Figure 12.6A–C). All exhibit the characteristic hook feature at one end and a series of three to six abraded grooves at the opposite end. The three *imbassum* have ground and highly polished surfaces and reveal no evidence of earlier stages of manufacture and shaping such as flaking or pecking. Rock types represented by each implement were described by one of us (FvG) by visual inspection of the surface with the aid of a 10× hand lens. Object B is manufactured from extrusive igneous rock, specifically rhyolite or rhyodacite. Objects A and C are manufactured from intrusive igneous rocks, specifically diorite/microdiorite (Object A) and microdiorite (Object C). Object A, though, has a fresh, very coherent, and crystalline appearance, different from any other objects observed in McNiven (1998) and McNiven et al. (2004). These characteristics may indicate a different provenance for Object A. That Object A may have been obtained from Chinese traders in the early twentieth century is a hypothesis for future testing.

Stone club heads

The three stone club heads represent examples of the two major forms of ethnographically known Marind stone club heads—ovoid (*wagané*) (Objects D and E) and discoid (*kupa*) (Object F) (Table 12.1, Figure 12.6D–F). The range of weights (540, 614, 669 g) and maximum diameter of the hafting shafts (25, 26, 27 mm) is similar for all three club heads, and the two ovoid club heads have near-identical lengths (99, 106 mm) and maximum diameters (66, 71 mm). All three club heads exhibit ground and polished surfaces (with scattered pits indicative of a prior manufacturing phase of shaping by pecking) and reasonably straight-sided hafting shafts. Numerous deep impact marks across the surface of Object E are consistent with secondary use as a hammerstone and/or anvil. All three club heads are manufactured from intrusive igneous rocks, specifically microdiorite (Object D) and microdiorite or micromonzodiorite (Objects E and F).

Table 12.1: Descriptions of Marind stone objects.

Fig. 12.6 ref. (private coll. #) collection location	**Size** Wt = weight L = length Th = thickness D = diameter HS = hafting shaft	**Object type** Method of manufacture	**Rock type** Raw materials
A (498) Okaba area	Wt: 237.5 g Max. L: 164 mm Max. Th: 27 mm	**'Spearthrower' stone (*imbassum*)** The entire surface of the implement has been ground and polished smooth, thus obliterating evidence of prior stages of shaping/manufacture (e.g. flaking, pecking). The three parallel (straight-sided) grooves were created using a thin-bladed saw (probably metal). In contrast to the other objects, the polished surface appears fresh with little or no patination.	**Diorite/microdiorite** Black equigranular (0.01–2.2 mm) microdiorite (intrusive igneous), with fresh biotite flakes (mostly weathered on surface), white plagioclase, translucent fine quartz/silica, dark green to black augite, dark grey pyroxene/hornblende. There also is a dark blue mineral, that is not yet identified.
B (541) Merauke area	Wt: 42.0 g Max. L: 55 mm Max. Th: 18 mm	**'Spearthrower' stone (*imbassum*)** The entire surface of the implement has been ground and polished smooth, thus obliterating evidence of prior stages of shaping/manufacture (e.g. flaking, pecking). The six parallel (U-shaped) grooves were created by abrasion.	**Rhyolite or rhyodacite** Brown-oxidised greenish-grey crystal and lithic-rich rhyolite or rhyodacite. Common euhedral plagioclase laths and less common larger volcanic quartz crystals, which are translucent, but appear dark grey (up to 2 mm). The matrix is aphanitic and quartz-feldspar–dominant—hence an extrusive/volcanic rock, possibly a lava or an ignimbrite.
C (542) Merauke area	Wt: 111.7 g Max. L: 81 mm Max. Th: 25 mm	**'Spearthrower' stone (*imbassum*)** The entire surface of the implement has been ground and polished smooth, thus obliterating evidence of prior stages of shaping/manufacture (e.g. flaking, pecking). The five parallel (U-shaped) grooves were created by abrasion.	**Microdiorite** Altered very fine to fine-grained (0.01–1.2 mm) intrusive rock, even-grained equigranular microdiorite with distinctive euhedral-shaped crystals of plagioclase (white-cream), smaller brownish K-feldspar, less distinct translucent to buff-coloured quartz-silica and dark grey-green hornblende (chloritised).

Fig. 12.6 ref. (private coll. #) collection location	**Size** Wt = weight L = length Th = thickness D = diameter HS = hafting shaft	**Object type** Method of manufacture	**Rock type** Raw materials
D (479) Merauke area	Wt: 539.8 g L HS axis: 99 mm Max. D: 66 mm Max. D HS: 25 mm	**Ovoid club head (*wagané*)** Most of the outer surface is ground smooth with scattered small pits indicative of a prior manufacturing phase of shaping by pecking. Central hafting shaft is largely parallel-sided, suggesting creation by drilling augmented by abrasion. Minor chipping on the inside circular edge of both entrances to the hafting shaft possibly reflects impact from a wooden handle during use. Both hafting shaft entrances have been ground flat.	**Microdiorite** Altered very fine to fine-grained (0.03–1.1 mm) intrusive rock, fairly even-grained equigranular microdiorite with distinctive euhedral-shaped crystals of plagioclase (cream-brown), less distinct translucent to buff-coloured quartz-silica, very fine black flakes of biotite. Some rare aggregates of biotite and other mafic minerals were observed, but this rock has less hornblende compared to #480. Also, some rare K-feldspar laths (up to 3 mm) were observed. The rock appears to be hardened by silica alteration.
E (480) Merauke area	Wt: 669.0 g L HS axis: 106 mm Max. D: 71 mm Max. D HS: 27 mm	**Ovoid club head (*wagané*)** Most of the outer surface is ground smooth with scattered small pits indicative of a prior manufacturing phase of shaping by pecking. Central hafting shaft is largely parallel-sided, suggesting creation by drilling augmented by abrasion. Minor chipping on the inside circular edge of both entrances to the hafting shaft possibly reflects impact from a wooden handle during use. Both hafting shaft entrances have been ground flat. One half of the implement exhibits multiple impact pits, suggesting use as an anvil and/or hammerstone.	**Microdiorite or micromonzodiorite** Altered very fine to fine-grained (0.05–1.2 mm) intrusive rock, fairly even-grained microdiorite with distinctive euhedral-shaped crystals of plagioclase (cream-brown), less distinct translucent to buff-coloured quartz-silica and dark grey-green hornblende (possibly chloritised), also some altered pseudomorphs after pyroxene. The rock appears to be hardened by silica alteration.
F (463) Merauke area	Wt: 614.2 g L HS axis: 45 mm Max. D: 111 mm Max. D HS: 26 mm	**Discoid club head (*kupa*)** Most of the outer surface is ground smooth with scattered small pits indicative of a prior manufacturing phase of shaping by pecking. Central hafting shaft is largely parallel-sided, suggesting creation by drilling augmented by abrasion. Minor chipping on the inside circular edge of both entrances to the hafting shaft possibly reflects impact from a wooden handle during use. Outer edge of implement exhibits a series of flake scars from impact.	**Microdiorite or micromonzodiorite** Fresh very fine to fine-grained (0.05–1.2 mm) intrusive rock, fairly even-grained microdiorite with distinctive euhedral-shaped crystals of plagioclase (cream-brown), less distinct translucent to buff-coloured quartz-silica and dark grey-green hornblende (possibly chloritised), also some altered pseudomorphs after pyroxene. The rock appears to be hardened by silica alteration.

Source: Authors' summary.

Discussion

Characterised implements: Potential sources

All six Marind implements are made from igneous rocks. No outcrops of igneous stone occur within an area of ~100,000 km^2 across the vast lowlands of Quaternary sediments located south of the Central Ranges between the Digul River (west) and the Fly River (east) and north of the south coast and Torres Strait (D'Addario et al. 1976; Dow et al. 1986; Willmott 1972) (Figure 12.1). On the eastern side of the Fly River, igneous outcrops do not occur across ~40,000 km^2 of Quaternary lowlands located south of the Central Ranges, taking in the Strickland and Aramia Rivers, and north of the south coast (Dow et al. 1986) (Figure 12.1). As such, the nearest sources of igneous tool stone to the Marind are located to the south-east across northern Torres Strait and to the north and north-east in the Central Ranges and associated southern foothills. As discussed below, some of the identified raw materials for the six Marind implements are known to outcrop in the Central Ranges, while others occur in Torres Strait. That is, microdiorite and microdiorite/micromonzodiorite (intrusive igneous) are available in the Central Ranges and Torres Strait, while rhyolite/rhyodacite (extrusive igneous) are available in Torres Strait. The diorite/microdiorite (intrusive igneous) of Object A is of a form currently unknown in Torres Strait.

Torres Strait

The Torres Strait takes in the northern (Papua New Guinea) and southern (Cape York, Australia) mainland coasts and intervening islands (mostly within Australia). The geology of Torres Strait islands is divided into the Torres Strait Volcanic Group of rhyolites, ignimbrites and andesites (western Torres Strait); the Badu Suite of granites (western Torres Strait) and the Maer Volcanics of basalts and tuffs (eastern Torres Strait) (von Gnielinski 2015; von Gnielinski et al. 1997; Willmott et al. 1973). On the south coast of Papua New Guinea forming the northern boundary of Torres Strait, igneous outcrops are limited to the settlement of Mabaduan and nearby islets (e.g. Marakara Island) which feature boulders of Badu Suite granites and small areas of Torres Strait Volcanics, which, due to their proximity to the 'hot' Badu Suite granites, were hornfelsed and silicified. Across the northern section of Cape York Peninsula (within the area delimited in Figure 12.1), igneous outcrops are restricted to the immediate surrounds of Cape York (Powell and Smart 1977; Willmott and Powell 1977).

Except for the form of diorite/microdiorite of Object A, the other identified raw materials of rhyolite/rhyodacite, microdiorite and microdiorite/micromonzodiorite are known to outcrop in western Torres Strait. Rhyolite/rhyodacite is part of the Torres Strait Volcanic Group, especially the Goods Island Ignimbrite and the Muralug Ignimbrite of south-west Torres Strait. Microdiorite and micromonzodiorite are very fine-grained intrusive rocks that possibly derive from dyke outcrops within the Badu Granite, especially in north-west Torres Strait. Previous research has similarly identified Torres Strait as the likely source of ground stone implements (stone axes and club heads) collected from Torres Strait and the Trans-Fly region (Hitchcock 2004; McNiven 1998; McNiven and von Gnielinski 2004; McNiven et al. 2004).

Central Ranges

In Indonesia, the Central Ranges covering the area taken in by Figure 12.1 are dominated by marine sedimentary rocks, limestones, sandstones and mudstones (Dow et al. 1986). Metamorphic rocks such as mica-schist metadiorite and slate occur across the northern flanks of the ranges. In Papua New Guinea, the Central Ranges covering the area taken in by Figure 12.1 are similarly dominated by marine sedimentary rocks and limestones (Bain et al. 1972). However, a range of locations within the Central Ranges located to the north (within Indonesia) and north-east (within Papua New Guinea) of the Marind exhibit igneous rock outcrops and potential sources of raw materials matching the rock types used to manufacture the characterised Marind implements. That is, localised igneous outcrops with diorite and microdiorite are found across the upper (headwater) catchments of the Digul, Sepik, Fly and Strickland Rivers (Figure 12.1, Table 12.2). None of the characterised Marind implements were made from lavas (e.g. basalts) and ash (tuff) deposits associated with the Dome Peaks, Mt Sisa and Mt Bosavi volcanoes located to the east of the middle Strickland River, or gneiss from quarries of the Upper Wario River of the Sepik River system.

Erosion of igneous outcrops extended the availability and potential source locations of tool stone raw materials to include secondary deposits of boulders, cobbles and pebbles in rivers draining the southern flanks of the Central Ranges (see Swadling 1983:89). Visser and Hermes (1962:177) note that 'Torrential rivers flowing down the range have laid down extensive boulder beds in foothills and adjoining plains'. For example, average annual rainfall exceeds 10 m in the Ok Tedi River area of the Upper Fly River catchment (Pickup and Marshall 2009:5). Most riverine pebbles of the eastern Central Ranges in Indonesian Papua 'can be fitted into the groups of igneous rocks known from outcrops' (Visser and Hermes 1962:122). The size of these eroded rock fragments decreases from boulders to fine sands as they travel down towards the sea. Löffler (1977:133) pointed out that 'gravel banks and bars' occur up to 100 km downstream from where the Strickland River leaves the mountains (i.e. c. 700 km from the Fly River mouth). Cobbles and boulders occur down to 120 km from the source of the Ok Tedi River (i.e. c. 900 km from the Fly River mouth) (Bolton et al. 2009:54–56). Austen (1926:438) noted that the Ok Tedi River contains 'volcanic gravels … in great quantities'.

In Indonesian Papua, Saulnier and Bisiaux (1963:147, 159–160, 163) documented pebble banks along the Steenboom River where it leaves the Central Ranges and enters the lowland plains. In lowlands to the immediate east of the Upper Eilanden River, extensive cobble banks occur along the Upper Becking River (Raffaele 2006:55; van Enk and de Vries 1997:274 n. 16). 'Cobbles' are well documented for the mountainous headwaters of the Digul River in elevations above 400 m above sea level (e.g. Reijnders 1964:27–28, 33, 81–83, 103, 119, 138–139). Schroo (1964:14) noted that 'gravel terraces' begin occurring c. 460 km upstream from the Digul River mouth, along both the main Digul River channel and the Kao (Oewimmerah) River tributary. Whether cobbles occur within these gravels, or are restricted to further upstream (e.g. Schoorl 1993:72), is unknown. Van den Bold (1942) noted that many of Heldring's (1913) samples from 'pebble banks' of the Upper Digul River were diorite.

The downstream extent of cobbles is complicated further by transport within the roots of dislodged and floating trees. For example, people of the stoneless Middle Fly River region would 'pick stones out of the roots of trees that were floating down the river to obtain stones for axe blades' (Busse 1987:50; see also Swadling 1983:89). The Asmat (located > 200 km north-west of the Marind) used stones recovered from roots of floating trees along the lower Sirets (Eilanden) River as 'grinding tools, as they are not ordinarily suitable for processing into ax blades' (Konrad and Ligabue 1996:56; see also Trenkenschuh 1982:83).

Table 12.2: Outcropping igneous rock units across central New Guinea (Indonesia and Papua New Guinea) and Torres Strait (Australia). Rock types in bold match identified raw material types for sampled Marind stone objects (Table 12.1).

Fig. 12.1 reference	Geographical location	Geological unit (Unit map code)	Rock types/Comments	References
A	Upper Mumugo (Northwest) River valley	Unmapped geologically	Schist, greywackes, sandstone. Known mostly from ethnographic descriptions of the Mumugo tool stone quarry sites	Pétrequin and Pétrequin (2020:189–190); Swadling (1983:88)
B	Sela/Phu Valley and headwaters of the Brazza River (Eilanden River catchment)	Unmapped geologically	Metabasalt/andesite; metamorphosed igneous, formerly dolerite; andesite dykes Known mostly from ethnographic descriptions of the Sela tool stone quarry sites	Hampton (1999:85, 276); Pétrequin and Pétrequin (2020:168–169); Terpstra (1939); van der Wegen (1966:258)
C	Langda area Ey/Mumyeme/Heime Rivers, headwaters of the Steenboom River (Eilanden River catchment)	Unmapped geologically	Andesite/basalt, meta-andesite/basalt; biotite-muscovite granite, quartz-biotite-cordierite schist. Known mostly from ethnographic descriptions of the Langda tool stone quarry sites	Hampton (1999:85, 252, 274); Pétrequin and Pétrequin (2020:143–144); Toth et al. (1992:88); van den Bold (1942:850); van der Wegen (1966:259)
D	Suntamon Valley/Yamyhi River and headwaters of the Eilanden River	Unmapped geologically	Metavolcanics, metamorphosed basalts, probably a dyke (possibly dolerites); biotite-muscovite granite, hornblende granodiorite. Known mostly from ethnographic descriptions of the Suntamon tool stone quarry sites	Pétrequin and Pétrequin (2020:15, 175, 182–186); van der Wegen (1966:259)
E_1–E_3	Headwaters of the Digul River and its multiple tributaries—E_1 (Red/West Digul), E_2 (East Digul and Kao) and E_3 (Kao) Rivers	Timepa Monzonite (Tpt)	Tpt: Quartz **diorite**, minor monzonite, porphyry **diorite**, quartz andesite, biotite-muscovite granite E_1 = corresponds to location of Red Digul ('basaltic rock'?) tool stone quarry	Bär et al. (1961:59, Geological map); Soetrisno dan and Amiruddin (1995); Pétrequin and Pétrequin (2020:185); Swadling (1983:85–86, Fig. 35)
F	Headwaters of the Kao River (Digul River catchment) and Ok Mat River (Ok Tedi and Fly River catchment)	Birim Formation	Andesites; **diorite**, augite-hornblende basalt, augite-plagioclase basalt, olivine basalt, basalt-tuff with zeolite or aragonite as cement, chlorite-augite andesite	Bär et al. (1961:59, Geological map); van der Wegen (1966:255, 257)

Fig. 12.1 reference	Geographical location	Geological unit (Unit map code)	Rock types/Comments	References
G_1-G_2	Star Mountains. Headwaters of the Digul River and Kongfale, Fatik and Bun Rivers, Ok Werp Al, Tingeri, Ban, Din and Nong Rivers (Upper Sepik River)	Timepa Monzonite (Tpt) Antares Complex (Tpa) Volcanics (Tpv) Porphyry (Tpp) Ban Quartz **Monzodiorite** (Tpb) Tumfakama **Microdiorite** (Tpt) Stolka Quartz **Diorite** (Tpo)	Tpt: Quartz **diorite**, minor monzonite, porphyry **diorite**, quartz andesite, biotite-muscovite granite (Indonesian side of border) Tpa: Quartz **monzodiorite**, quartz monzonite, **diorite**, **microdiorite**, granodiorite, granite, some porphyry, some volcanics Tpv: Andesitic and dacitic volcanic agglomerate, volcaniclastic sandstone and mudstone, crystal tuff Tpp: Andesitic and dacitic porphyry; phenocrysts are hornblende, plagioclase, minor pyroxene, rare biotite Tpb: Quartz **monzodiorite**, granodiorite, quartz monzonite, equigranular, medium to coarse-grained; characteristically includes pale green clinopyroxene Tpt: **Microdiorite**, some **diorite** and microgranodiorite; medium to fine-grained and equigranular Tpo: Quartz **diorite**, quartz **monzodiorite**, minor porphyry	Bär et al. (1961:53–57, Fig. 4); Davies (1982:28–29); Davies et al. (1983)
H_1–H_2	Headwaters of the Kwirok and Iram Rivers (Upper Sepik River) and Ok Tedi River (Fly River catchment)	Star Mountains Intrusives (Tps)	Tps: Porphyritic micromonzonite, microdiorite, microgranodiorite, minor medium-grained equivalents; magnetite, sulphide and epidotegarnet skarns	Davies et al. (1974); Davies and Norvick (1974:20)
I_1–I_4	Headwaters of the Bol (Upper Fly River) and Strickland Rivers	Intrusives (Tpi) I_1 = Bolivip Stock I_2 = Tabe Stock I_3 = Idawe Stock I_4 = Tumbudu Stock	Tpi: Porphyritic micromonzonite, **microdiorite**	Davies et al. (1974); Davies and Norvick (1974:20)
J	Headwaters of the Strickland River	Kendupwa Volcanics (Tpk)	Tpk: Andesitic agglomerate, tuff and volcanic sandstone, minor marl. Andesite has clinopyroxene and labradorite phenocrysts, and large hornblende xenocrysts, in groundmass of matted plagioclase microlites and much magnetite	Davies and Eno (1983); Davies (1983:51)
K	Headwaters of Nekiei River (Upper April River) (Sepik River catchment)	Nekiei batholith (Tmi)	Tmi: **Diorite**, quartz **diorite**; granodiorite, some porphyry	Davies and Baloiloi (1983); Davies and Hutchison (1982:37)
L	Headwaters of the Karawari River (Sepik River catchment)	Karawari batholith (Tmr)	Tmr: **Diorite**, quartz **diorite**; granodiorite, quartz gabbro, hornblende gabbro, anorthite gabbro, pyroxenite and hornblendite; some **diorite** pegmatite, some **microdiorite** porphyry. Inclusions of hornfelsed and mineralised calcareous sediments	Davies and Baloiloi (1983); Davies and Hutchison (1982:37); Davies and Eno (1983); Davies (1983:53)

Fig. 12.1 reference	Geographical location	Geological unit (Unit map code)	Rock types/Comments	References
M	Headwaters of the Kikori River with three volcanic cones known as the Doma Peaks	Tephra (Qt) Lumu Volcanics (Qiv) Doma Volcanics (Qdn, Qda, Qdb, Qdd, Qde, TQn) Un-named (TQp) Kerewa Volcanics (TQk, Qvk, Qvkl)	Qt: volcanic ash, some coarser pyroclastics: tephra Qiv: Porphyritic olivine tholeiite lava Qdn: Probably trachyandesite lava Qda: Lahar and pyroclastic flow deposits, some coarse volcanogenic sediments: basal volcanics Qdb: Trachyandesite lava, some pyroclastics and volcanogenic sediments: old cone Qdd: Trachyandesite and olivine trachybasalt lava flows Qde: Chaotic deposits of large clasts of lava in finer volcanic debris, clay; pyroclastic flow TQn: andesite lava TQp: Probably pyroclastics TQk: Trachyandesite lava and lava breccia, some agglomerate and tuff Qvk: Fine-grained basaltic lava, lava breccia, andesitic agglomerate, tuff Qvkl: Volcaniclastic andesite and basaltic breccia; reworked agglomerate, tuff minor intercalated volcanically derived conglomerate, sandstone: laharic deposits	Davies and Eno (1983); Davies (1983:41, 48–50); Brown et al. (1983)
N	Headwaters of the Nomad River (Strickland River catchment) with two volcanic cones, one known as Mt Sisa	Sisa Volcanics (TQsl, TQvs)	TQsl: Volcaniclastic andesitic and basaltic breccia, reworked agglomerate, tuff; minor intercalated volcanically derived conglomerate, sandstone; exotic blocks of limestone; laharic deposits TQvs: Andesitic and basaltic agglomerate, tuff lava	Brown et al. (1983)
O	Headwaters of the Rentoul, Tomu and Aiema Rivers (Strickland River catchment); Aramia River; Wawoi and Guavi Rivers (Bamu River catchment); and Turama River. Centres on the Mt Bosavi cone	Sisa Volcanics (TQsl) Bosavi Volcanics (Qvb, Qvbl)	TQsl: Volcaniclastic andesitic and basaltic breccia, reworked agglomerate, tuff; minor intercalated volcanically derived conglomerate, sandstone; exotic blocks of limestone; laharic deposits Qvb: Basaltic (shoshonitic) and andesitic lava, agglomerate, tuff; minor derived volcaniclastic conglomerate, sandstone Qvbl: Volcaniclastic basaltic and minor andesitic breccia; reworked agglomerate, tuff intercalated volcanically derived conglomerate, sandstone: laharic deposits	Brown et al. (1983)
P	Turama River catchment centring on the Biwai Hills cone	Unnamed (Qv2)	Qv2: Basic to intermediate lavas and pyroclastic rocks (shoshonitic and calc-alkaline), lahars, fanglomerate, lacustrine deposits	Bain et al. (1972)

Fig. 12.1 reference	Geographical location	Geological unit (Unit map code)	Rock types/Comments	References
Q_1–Q_2	Lower Kikori River catchment, centring on the Mount Murray cone	Q_1 = Mount Murray Volcanics (Qvm) Q_2 = Mount Murray Volcanics (Qvml)	Qvm: Basaltic (shoshonitic) to andesite lava, agglomerate, tuff, porphyritic **microdiorite** dykes Qvml: Volcaniclastic basaltic and andesitic breccia, reworked agglomerate, tuff; minor intercalated volcanically derived conglomerate, sandstone: laharic deposits	Bain and MacKenzie (1974a:30, 1974b); Brown et al. (1983)
R	Sirebi River (Kikori River catchment)	Duau Volcanics (Qvd)	Qvd: Andesite and basalt agglomerate, tuff, minor lava at central parts of cones; volcanic sandstone, conglomerate and tuff on lower slopes and aprons	Pieters (1980:17–18, 1983)
S	Lower Kikori River (delta)	Aird Hill Volcanics (Qva)	Qva: Aphyric to porphyritic plagioclase-rich, leucocratic andesite or dacite lava and volcanic breccia	Pieters (1980:16, 1983)
T	Western Torres Strait, taking in numerous islands (e.g. Dauan, Gebar, Mabuyag, Mua, Badu and Muralag) and isolated outcrops on the adjacent north coast (Mabaduan, PNG) and south coast (Cape York, Australia)	Badu Suite (Cub) Torres Strait Volcanics (Ct) Muralug Ignimbrite (Cm) Goods Island Ignimbrite (Cg) Endeavour Strait Ignimbrite (Cn) Eborac Ignimbrite (Ce)	Cub: Leucocratic biotite granite, hornblende-biotite granite, porphyritic biotite granite, adamellite, hornblende-biotite adamellite, granodiorite, microdiorite, aplite and numerous quartz veins and dykes of aplite, pegmatite, porphyritic microgranite, dacite (?), hornblende andesite, hornblende-augite andesite and augite andesite. Ct: **Rhyolite** welded tuff, **rhyolite**, hornfels, andesite, siltstone and arenite Cm: Brownish grey **rhyolite** welded tuff; some **rhyolite** volcanic breccia and dacite? welded tuff Cg: Dark grey dellenite to dacite welded tuff; some interbedded siltstone and sandstone Cn: Greenish-grey **rhyolite** welded tuff; some **rhyolite**, andesite, agglomerate and hornfels Ce: Light grey **rhyolite** welded tuff; some **rhyolite** and agglomerate	Maitland (1892:16–17); von Gnielinski (2015); von Gnielinski et al. (1997); Willmott (1972:8); Willmott and Powell (1977:9–12); Willmott et al. (1973:98–106, 113–118),
U	Eastern Torres Strait, taking in the islands of Daru (PNG) and Bramble Cay, Ugar and Erub, and well-preserved cones at Mer, Dauar and Waier (Australia)	Maer Volcanics (Qpm)	Qpm: Basalt lava and tuff	Willmott (1972:9); Willmott et al. (1973:50–53)

Source: See sources listed throughout table. See also Figure 12.1.

Characterised implements: Potential processes of acquisition

Ethnographic information indicates that the Marind obtained stone implements from their immediate neighbours by trading and raiding. These neighbours similarly obtained supplies of stone implements by trading with and/or raiding neighbouring groups who had direct or indirect access to tool stone supplies/quarries. The following discussion of ethnographic information reveals that the Marind were part of trading and raiding networks that linked them directly or indirectly with potential sources of stone implement raw materials (i.e. Upper Digul River, Upper Fly–Strickland Rivers and Torres Strait). Indeed, such links suggest strongly that the Marind strategically positioned themselves with a wide range of stone implement provisioning options involving trading, raiding and perhaps direct stone procurement by quarrying.

Trading

As noted above, elderly Marind informed anthropologists during the first half of the twentieth century that at least some exotic stone implements were obtained from neighbours through exchange (e.g. Kooijman et al. 1958:46; van Baal 1966:23; Wirz 1946:85). The Digul River is the only specific area identified as the source of exchanged stone implements (Wirz 1922, I:112), with the Upper Digul River (Star Mountains) identified as the ultimate source (Verschueren cited in van Baal 1966:730).

A wide range of ethnographic information reveals that stone axes originating from quarry sites scattered along the southern flanks of the Central Ranges in Indonesian Papua were traded southwards along various river systems and across the vast lowlands towards the coast. In each case, and in the broader context of bi-directional movements of a variety of objects, stone axes from the mountainous interior moved downriver and marine shells (used as valuables and body adornments) from the coast moved upriver: Mumugo/Pomatsi–Northwest River system (Eyde 1967:15–16, 25; Pétrequin and Pétrequin 2020:188–190), Eilanden–Catalina–Baliem River system (Hampton 1999:278; Matthiessen 1962:94; Mitton 1972:8; Swadling 1983:87, Fig. 35), Eilanden–Brazza River system (Hampton 1999:278: Pétrequin and Pétrequin 2020:167, 175–176), Eilanden–Steenboom River system (Toth et al. 1992:92), Eilanden River (van Enk and de Vries 1997:11, 48-49) and Digul River (Kooijman 1962:18–19, 31–32, 37; Pétrequin and Pétrequin 2020:167, 172, 186, 253; Schoorl 1993:87, 94; Swadling 1983:86).

For the Fly–Strickland River system in Papua New Guinea, Swadling (1983:82) noted that the Duna of the headwaters of the Strickland River traded (imported) axes (made of glaucophane blueschists, greenschists and metavolcanics—White and Modjeska 1978:279) southwards through various groups to the Middle Strickland River and Lake Murray area (see also Austen cited in McCarthy 1939:185–186). The Boazi of the Middle Fly River (Lake Murray) obtained stone axes from Upper Fly River (Ok Tedi River) people in exchange for marine shells sourced to the Suki and Kiwai (Lower Fly River mouth) and Marind (Busse cited in Craig and Swadling 1983:117). The Samo of the Middle Strickland (Nomad River) obtained stone axes from the Upper Strickland in exchange for marine shells sourced to the Gulf of Papua coast via riverine trade routes (e.g. Bamu and Turama Rivers) (Craig and Swadling 1983:118). People of the Oriomo area at the mouth of the Fly River obtained stone implements 'through the Fly River people, who traded them from up-river' (Pretty 1965:127). Government anthropologist F.E. Williams (1936:416) recorded that the Wiram/Suki of the Lower Fly River obtained stone club heads from 'higher up the Fly River' in exchange for *Melo* shells 'collected on the coast'.

People of Mawata village on the northern mainland coast of Torres Strait apparently obtained stone implements from Torres Strait Islanders, telling Finnish anthropologist Gunnar Landtman (1927:34) that 'Torres Strait islanders obtained the stones out of which axes (or adzes) and club-heads were made principally from the bottom of the sea, by diving'. The upshot of these ethnographically known exchange networks is that the borders of Marind territory abutted supplies of traded stone implements (e.g. axes, club heads) available along the Digul River (western, north-western and northern borders), the Middle Fly River (north-eastern border) and the Trans-Fly/Torres Strait region (south-eastern border). The close linguistic and social relationships between the Boazi and Bian Marind provided considerable potential for Upper Fly River stone implements to enter Marind society (see Busse 1987, 2005; van Baal 1966:110, 706).

Raiding

Elderly Marind also informed anthropologists during the first half of the twentieth century that exotic stone implements were obtained mostly from neighbours during headhunting raids (e.g. Kooijman et al. 1958:46; van Baal 1966:23; Wirz 1946:85). Again, the only area specially mentioned as a source of raided stone implements was the Digul River (Wirz 1922, I:112), with the far northern Marind (Upper Bian River) adding that the Upper Fly River was the ultimate source of stone club heads (Wirz 1922, I:112). Yet Marind headhunting expeditions engaged a wide range of neighbours to the south-west (Yos Sudarso Island), west, north-west and north (Digul River), east (Middle and Upper Merauke River) and south-east (Trans-Fly and northern Torres Strait) (McNiven in press; Schoorl 1993; Swadling 1996:Fig. 39; van Baal 1966). The relationship between headhunting and stone implement procurement was not unique to the Marind, with Busse (1987:50) noting that 'The absence of stone was also one motivation for the head-hunting raids by the tribes of the Middle Fly on the groups to the north of them' (see also Kirsch 1991:22). Marind headhunting expeditions allowed engagement with a wide range of neighbouring groups who had supplies of stone implements sourced either directly (e.g. Torres Strait) or indirectly (e.g. Digul River).

Ethnographic observations from northern Torres Strait during the late nineteenth century reveal extra dimensions to Marind tool stone procurement. Missionary Rev. Samuel McFarlane (1888:106) was informed by people of Boigu that they fought off a Marind attack using spears and stone missiles. Boigu is a stoneless island with the nearest potential stone source being their neighbours and allies on the granite island of Dauan (Figure 12.1). It is likely that retreating Marind kept the stone missiles as a rare and valuable source of tool stone. In another instance, in the 1880s the missionary Rev. Edwin B. Savage observed the Marind trading with Saibai Islanders instead of the usual raiding interaction (Wirz 1933:108; see also McNiven 1998:108).

Quarrying

While not mentioned in the ethnographic literature, it is possible that the Marind directly accessed the Mabaduan stone source located on the northern mainland coast of Torres Strait (opposite the island of Saibai) during south-eastern headhunting expeditions to the Trans-Fly region (Figure 12.1). The process of direct procurement is not without precedent for southern lowland groups of central New Guinea, with some coastal Asmat groups travelling upriver to foothills of the Central Ranges to load up canoes with river cobbles which were ferried back to coastal villages for shaping into axes (Konrad and Ligabue 1996:54). Within the ethnographic context of Marind mobility patterns, Mabaduan provided the only opportunity for the Marind to directly access igneous tool stone and manufacture their own ground stone implements. Whether or not axe-grinding grooves at Mabaduan were used by the Marind is unknown (Landtman 1927:287). Wirz (1933:119) was informed by the Marind that 'occasionally' they established a 'big camp' (including women and

children) at Mabaduan during the headhunting season. Marind access to northern Torres Strait (including Mabaduan) tool stone helps explain the apparent restricted distribution of 'spearthrower' stones (*imbassum*) to the Marind.

Conclusion

In 2009, Glenn Summerhayes pointed out that documenting chronological and spatial dimensions of stone tools and their geological sources provide important insights into trade and exchange systems and the social and economic worlds of New Guinea societies in the past. Indeed, Papua New Guinea was at the centre of the most extensive distributional array of obsidian in the ancient world (Summerhayes 2009:115). The analytical foundation of these studies is accurate characterisation of stone artefact raw materials and detailed understanding of the locations of potential geological sources of these raw materials. Although such studies (especially by Summerhayes) are well developed for some areas of Papua New Guinea, the same is not true for Indonesian Papua across the western half of New Guinea. The major exception is the detailed ethnoarchaeological research by Pierre Pétrequin and Anne-Marie Pétrequin (1993a, 1993b, 2020) on ground-edge axes in the stone-rich regions of the Central Ranges. While that research was focused on axe production at quarry sites, insights into axe distributions was limited largely to examination of selected museum collections of axes obtained from locations away from sources. Our examination of Marind ground stone implements (club heads and 'spearthrower' stones) builds on the foundational work of the Pétrequins but in the stoneless region of south-east Indonesian Papua. The social and cultural relationships that developed between the stone-rich and stoneless regions of Indonesian Papua reveal that processes of provisioning extended beyond trading and exchange to include raiding and headhunting. Indeed, the Marind developed one of the most extreme stone tool provisioning systems in the world. Further research is required to extend our pilot study of six Marind stone implements to include comprehensive petrographic characterisation of museum collections of stone axes, club heads and 'spearthrower' stones. Archaeological excavation of old Marind village sites would furnish further examples of stone implements for sourcing, and shed light on the representativeness of museum collections of Marind objects. In addition, archaeological research at Mabaduan on the northern mainland coast of Torres Strait may reveal its critical role in provisioning tool stone across the southern lowlands of central New Guinea.

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