McDONALD INSTITUTE MONOGRAPHS

The global origins and development of seafaring

Edited by Atholl Anderson, James H. Barrett &
Katherine V. Boyle

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Chapter 4

Pleistocene Migration and Colonization in the Indo-Pacific Region

Sue O'Connor

In view of the fact that modern humans reached Sahul (Pleistocene Australia–New Guinea) at least 60,000 years ago it is surprising that more attention has not been paid to the potential of a maritime mode of modern human dispersal upon leaving Africa. A recent paper in *Current Anthropology* (Bulbeck 2007) redresses this situation by arguing that maritime spread was the most likely mode of expansion for early modern humans moving out of Africa and along the Indian Ocean Rim. In view of the arid sections along this coastal stretch, irregularly punctuated by resource-rich estuaries, and open sea crossings during the last leg to Australia/New Guinea, this expansion would necessarily have involved watercraft, potable water and adaptation to estuaries (Bulbeck 2007, 315–21).

Bulbeck's is a 'sweet spot' model — the sweet spots are estuaries. Its parsimony lies in the fact that it does not presume any push or pull mechanisms — other than seeking out the next good fishing spot. Prior to reaching Wallacea there is no need to posit purposeful seafaring or developed watercraft; however, such coastal estuarine strandlooping would have preadapted modern humans for making the longer water crossings required for their first venture into the Indo-Pacific region. The necessary prerequisites were some type of simple watercraft, ability to store potable water and familiarity with the use of inshore marine/estuarine resources.

The evidence for maritime dispersal and maritime adaptations in Pleistocene Wallacea, Greater Australia and Island Melanesia is reviewed here with this model in mind.

Voyaging to Sahul and beyond

Critical to the issue of whether Pleistocene colonization was purposeful and directed, or accidental and the result of drift voyaging is the assumed level of maritime technology possessed by the Pleistocene colonists. Colonization scenarios range from the minimalist position that the crossing to Sahul could have been accomplished by a pregnant woman on a log (Calaby 1976) to those who argue that sophisticated watercraft were employed by Pleistocene colonists (Allen 2000; Irwin 1992). In the absence of any material remains that might throw light on this issue, voyaging capability must be inferred from the distance and difficulty of the route, the rate of spread of the early migrants and evidence for back voyaging or maintenance of contact between the homeland and the founder population.

Dating earliest migration

The rate of spread at which colonization proceeded is critical to whether it is modelled as accidental or purposeful. So far, the required level of chronological control has eluded archaeologists working in the region due to various reasons which include limited regional sampling and the problem with dating events that occur at or beyond the radiocarbon barrier (Chappell *et al.* 1996) — precisely the time that modern humans are dispersing from Sunda.

On the one hand there is a long chronology. Dates of between 50,000 and 65,000 BP for human occupation in northern (Malakunanja, Nauwalabila 1) and southern Sahul (Mungo) have been achieved by the use of dating techniques such as thermoluminescence (TL), optically stimulated luminescence (OSL) and electron spin resonance (ESR) (O'Connor & Chappell 2003; Roberts *et al.* 1990; 1994; 1998; Thorne *et al.* 1999). However, these techniques have not been uniformly applied to sites within Sahul and have rarely been applied in archaeological contexts in Southeast Asia (Roberts *et al.* 2005). Furthermore, some archaeologists doubt whether the dates on sediment grains actually date cultural events (e.g. O'Connell & Allen 1998; David *et al.* 2007).

On the other hand there is a short chronology, or rather several shorter chronologies depending upon which data are preferred. Relying exclusively on radiocarbon chronology, dates in the order of 40,000–47,000 BP have been obtained for occupation sites in northern (Carpenter's Gap 1 and Riwi) and southern Australia (Devil's Lair) (O'Connor & Chappell 2003; Turney *et al.* 2001) and islands to the east of New Guinea required further water-crossings by 40,000 BP (Leavesley & Chappell 2004). Tasmania also appears to have been colonized shortly before 40,000 BP when it was connected to Australia via the Bassian Plain land-bridge. Radiocarbon dates for mainland Sunda sites and settlement of Wallacea are of about the same antiquity. Niah Cave has dates of *c.* 42,000 BP for charcoal in sediments thought to be associated with the 'Deep Skull' (Barker *et al.* 2001). Jerimalai Cave in East Timor has produced archaeological sequences dated to 40,000 BP (O'Connor 2007). Calibration of old dates using best estimate curves such as CalPal and NotCal04 further closes up the gaps and reduces the disparity between the age of the early Australian and Papua New Guinean sites and those from mainland and Island Southeast Asia. When calibrated, the radiocarbon dates from East Timor are of the same order of antiquity as the oldest dates from Papua New Guinea from the Huon Peninsula (O'Connor & Chappell 2003) and only marginally younger than the oldest radiocarbon dates from sites such Carpenter's Gap 1 (McConnell & O'Connor 1999) and Riwi in the Kimberley region of northwest Australia (Balme 2000) (Fig. 4.1). It is also worth bearing in mind that most of the older Australian dates have been achieved using the ABOX wet oxidation stepped-combustion technique which successfully eliminates small amounts of contamination, producing both older and more reliable charcoal age estimates (Bird *et al.* 1999).[1] With few exceptions the dates from Island Southeast Asia are on marine shell, and therefore not amenable to ABOX-SC treatments.[2]

If we use the long chronology provided by OSL/ESR then we have a much longer time frame in which to accomplish the colonization of Wallacea, Greater Australia and Island Melanesia. This potentially allows for gradual or punctuated colonization with movement into Sahul occurring early, but population infilling within most of Island Southeast Asia, Sahul and Island Melanesia taking place much later. The longer chronology however does not rule out rapid migration at an early date. If we accept only the radiocarbon chronology then colonization must by definition have been extremely rapid across this vast region and all water crossings undertaken within two standard deviations of the radiocarbon dates. The latter scenario is favoured by O'Connell & Allen (2006) who contend that colonization occurred 'in less than five thousand years — perhaps much less'.

Which route to Sahul?

The American anthropologist Joseph Birdsell (1977) was the first to try to evaluate passages to Sahul in terms of prospective migration routes and considered distances between islands, size and orientation of island targets and degree of intervisibility (Fig. 4.1). Wind direction and strength of ocean currents also play a vital role in voyaging success (Chappell 2000; Irwin 1992).

Birdsell reasoned that the southern route into Sahul through the Lesser Sundas (including Flores and Timor) was the most parsimonious due to the minimum distances between island and the greatest intervisibility, and others have mostly agreed (Birdsell 1977; Butlin 1993, 15, 44–51; O'Connor & Chappell 2003) (Fig. 4.1). Until recently early dates were not forthcoming from along this route. However, recent research in East Timor at the Jerimalai Cave has produced a dated sequence back to 40,000 BP (O'Connor 2007). Although little hominin skeletal material has been recovered, isolated teeth in the Pleistocene levels are consistent with moderns and the assemblages have been argued to be the end product of modern human behaviour (O'Connor 2007). It seems that modern humans must have passed by or through Flores to reach Timor by 40,000 BP, if colonization proceeded via a southern route.

Contrary to parsimony, some authors have proposed that colonization proceeded via a northern route through Borneo, Sulawesi, and thence into northern Maluku and the Bird's Head of Papua (formerly Irian Jaya) (e.g. O'Connell & Allen 2006). Dates of 42,000 BP have been forthcoming from Borneo on the mainland Sunda Shelf (Barker *et al.* 2001), but excavations in Halmahera and Sulawesi have so far failed to find evidence of settlement earlier than 32,000 and 30,000 years BP,[3] respectively (Bellwood *et al.* 1998; Glover 1981, 16). Sites in the Aru Islands, which the author and colleagues investigated in order to test an alternative northern route onto the Sahul Shelf via Buru, Seram and the Kei Islands (Birdsell's 1977 Route 2B), produced earliest dates for human occupation of 28,000 calendric years (O'Connor *et al.* 2005).

Bird *et al.* (2005) suggest that the presence of a north–south running 'savanna corridor' in late Pleistocene Sundaland would have favoured a southern route (Fig. 4.1). As modelled by Bird *et al.* (2005) this corridor constituted a narrow land-bridge with open vegetation which would have been exposed between Peninsula Malaysia and Sumatra and along the north coast of Java, at all times when sea level was 40 or more

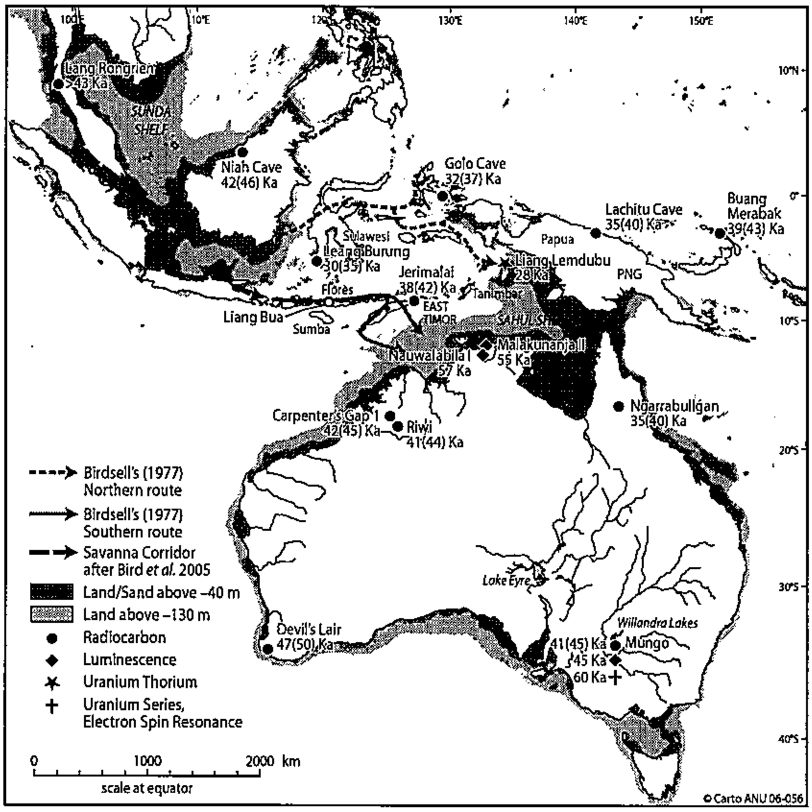

Figure 4.1. *Map of region showing archaeological sites and possible migration routes into Sahul.*

metres below present (Bird *et al.* 2005). Although it is feasible that parts of western Borneo were occupied by tracts of savanna, northeastern and southern Borneo were likely densely forested (Bird *et al.* 2005, 12) creating a barrier to terrestrial dispersal east via the northern route through Sulawesi, before the onset of the much drier conditions of the last glacial maximum (LGM). However, open country facilitating terrestrial dispersal would be less important if the colonists were estuarine hopping as Bulbeck (2007) suggests.

The most recent genetic research also contributes to the Sunda to Sahul migration story. It indicates a time lag of 10,000 years between first occupation of Papua New Guinea and subsequent movement onward into Island Melanesia (Friedlaender *et al.* 2005). As we know that the latter occurred by at least 40,000 radiocarbon years ago it would seem that the genetic data support the longer chronology for first migration into Sahul, such as is reflected by the optical luminescence dates. The genetic data also suggest rapid population dispersal in Sahul followed by almost complete (female) genetic isolation between the populations of Papua New Guinea and Australia (Friedlaender *et al.* 2005, 1514).

One scenario that would accommodate the lack of post-establishment contact between Papua New Guinea and Australia would be a single population that split at a point prior to entry into Sahul, with colonization proceeding independently via both a northern and southern route. The point of split may have occurred in the coastal regions of the savanna corridor between Java and Borneo.

Chappell (1993; 2000) has made a strong case for the long chronology and a southern route based on maritime opportunity. Although it is usually assumed that maritime migrations would have been facilitated by the reduced distance of the sea crossings between land bodies at times of maximum low sea stand (e.g. Birdsell 1977), Chappell argues that distance would have been of less significance in the voyaging equa-

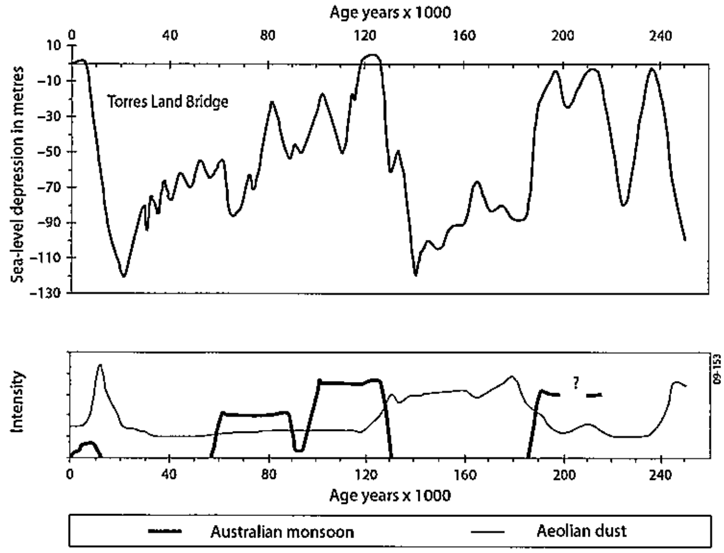

Figure 4.2. *Variations of sea level and the Australian monsoon for the last 250,000 years (after Chappell 2000, 88).*

tion than productive marine environments and wind direction. He points out that rich coastal environments such as mangroves, developed estuaries, backwater swamps and coral reefs that provide the incentive for maritime activities would have been far less common during falling or low sea stands. Tropical coastal populations are therefore more likely to be equipped for, and engaged in, activities requiring watercraft at times of rising sea levels (Chappell 2000, 89–90). Wind regime is also a significant factor. Navigational aids or knowledge would not have been necessary to make the crossings of 80–150 km to reach northern Australia via the southern route. During the north Australian wet season the wind regime at the sea surface is strongly vectored southeastward from Timor and evidence suggests that this would have been the case between *c.* 58,000–90,000 BP (Chappell 2000; Magee *et al.* 1995) (Fig. 4.2). Boats drifting off the coast of Timor or Roti during the months of the summer monsoon would have inevitably washed up somewhere on the expanded Kimberley coastline and in good conditions this would not have taken more than a few days. Chappell therefore reasoned that 'the rising sea level of 62,000 to 59,000 years ago is a likely time for migration across the Timor Sea' (Chappell 2000, 90). After 58,000 BP the absence or reduction of the strength of the northwest monsoon would have made the voyage considerably more difficult (Fig. 4.2).

Voyaging capability: evidence of contact between founder populations and the homeland

The relatively protected waters between Island Southeast Asia, the north coast of Papua New Guinea and Island Melanesia have often been characterized as a voyaging corridor or 'nursery' in which the necessary seafaring skills were built preparatory for the final maritime conquest of the Remote Pacific. Such a position has been espoused by Irwin and Allen who see the acquisition of skills and technological development as incremental. Contrary to this position is that of Anderson (2000) who has argued that there is nothing in the Pleistocene settlement record of Island Melanesia to support the case for the possession of advanced voyaging skills in the Pleistocene or the gradual build-up of technology or capability. Anderson (2000) argues that the record of Pacific colonization attests to a mid to late Holocene quantum step up in maritime technology and voyaging capability that suggests an incursion of new people with new technology, rather than *in situ* incremental development. The merits of these counterposed positions are examined below, but first it is necessary to acknowledge the very small data base of archaeological evidence.

There are 17,000 islands in Indonesia alone. Of the thousands of potentially habitable islands in Island Southeast Asia less than a dozen have been archaeo-

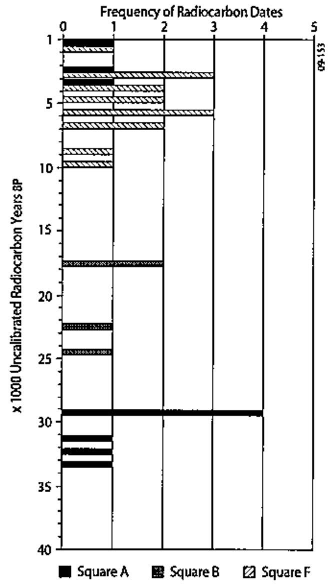

Figure 4.3. *Histogram showing radiocarbon data sets from four test pits at Lene Hara Cave.*

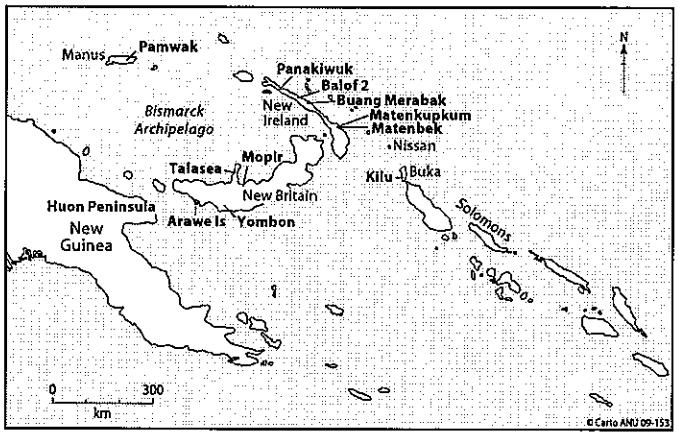

Figure 4.4. *Archaeological sites and obsidian sources in New Britain and New Ireland.*

logically investigated using modern techniques and dating and intra-island sampling has been sparse. Sampled islands or island groups are, Flores, Roti and Timor on the southern route and the Philippines, Sulawesi, Halmahera, Gebe, Banda and Ambon, on the northern route. All bar Ambon and Banda have produced Pleistocene-aged sites. Hundreds of islands of a size that could support permanent habitation remain uninvestigated so assessing the degree of population infilling along potential Pleistocene migration routes is not yet feasible.

Further, most excavations in Island Southeast Asia are small scale and many sites have been minimally sampled with a few test pits. Variable dating of test pits within single cave sites emphasizes the need for greater intra-site sampling. For example at Lene Hara Cave in East Timor a series of test pits carried out over two field seasons produced non-overlapping date sets that would result in the formulation of completely different colonization scenarios (Fig. 4.3) (O'Connor & Aplin 2007, 85).

Purposive voyaging might be indicated by species translocations between homeland and founder region, or by the demonstration that regular movement of non-perishable exotic materials such as obsidian took place. Evidence for back voyaging at an early date is absent throughout Island Southeast Asia. Species translocations are few, and the earliest occur at the Pleistocene/Holocene transition. The first evidence of human translocations in Island Southeast Asia prior to the mid-Holocene comes from East Timor where we have evidence that the cuscus *Phalanger orientalis* was translocated from Papua New Guinea to Timor approximately 10,000 years ago (O'Connor 2006). Halmahera has evidence of the translocation of a wallaby from nearby Misool I and a bandicoot from mainland Papua New Guinea, but not prior to the Holocene (Bellwood *et al.* 1998).

The earliest evidence for translocation in the Pacific comes from New Ireland in the Bismarck Archipelago at c. 20,000 BP with the first appearance of the New Britain cuscus in the New Island sites Buang Merabak and Matenbek (Allen 2000, 154). At the same time the first pieces of New Britain obsidian also appear in the archaeological record. In an adjacent cave, Matenkupkum, obsidian and cuscus are also present from 16,000 BP (Fig. 4.4). However, the water gap between New Britain and New Ireland, St Georges Channel, is a mere 30 km across so the case for humanly assisted movement of the cuscus, let alone a deliberate one, is problematic. The obsidian must have been humanly transported. Be that as it may, Allen's (2000, 153) statement that the obsidian in New Ireland demonstrates 'continuous links between sites and sources between 300 km and 350 km apart' is hard to credit. Buang Merabak contained only eight pieces of obsidian in the Pleistocene levels and Matenbek 37. Even the much larger excavations at Matenkupkum yielded only 200 pieces in levels dating between

16,000 and 10,000 BP (Allen 2000, 153). Analyses of the obsidian suggest Mopir as the probable source (Summerhayes & Allen 1993). As obsidian is 'most plentiful in the southern New Ireland sites at this time, present but less plentiful in the central New Ireland site of Buang Merabak and absent in the Pleistocene layers of Balof and Panakiwuk in the north' which were first occupied about 14,000 BP (Allen 2000, 154) (Fig. 4.4) Allen admits this would favour a hypothesis of 'down-the-line' movement of obsidian along the east coast and northwards, thence across the Vitiaz Strait, rather than direct movement by canoe from the Mopir source to the sites.

Perhaps the best case that the early colonists had advanced voyaging capabilities might be the settlement of the island of Buka, in the northern Solomon Islands chain, by 28,000 BP (Wickler 2001, 239), and Manus Island by 21,000 BP (Fredericksen *et al.* 1993). Buka is 180 km south of the southern tip of New Ireland. Although it is possible that this voyage was made in stages via Nissan and Feni, it is not certain that Nissan had emerged at this time, and Irwin (1991) argues that Feni was such a small target that a direct route from New Ireland to Buka is equally probable. That the voyage to Manus required travelling out of sight of land is less equivocal. This was a 230 km single one-way trip no matter whether attempted from the Papua New Guinean north coast or the northwestern tip of New Ireland. Of this crossing, 60–90 km would have been out of sight of land which makes this the earliest example of Pleistocene settlement beyond the range of visibility. At the site of Pamwak in Manus we also see translocations with a cuscus (*Spilocuscus kraemeri*), a bandicoot (*Echymipera kalubu*) and the important tree crop *Canarium* all introduced from Papua New Guinea (Spriggs 1997, 54). Here again there is a significant time lag between the date of first settlement of Manus and the first translocations in the terminal Pleistocene/early Holocene (Allen 2000, 155), that argues against two-way voyaging and maintenance of contact between the homeland and founder populations. A case could even be made that settlement on Buka was not sustained from the time of settlement. There are major gaps in the Pleistocene occupation sequence at Kilu cave, with sparse cultural material between 28,000 and 20,000 BP followed by a hiatus in occupation lasting from 20,000 to 10,000 BP (Wickler 2001, 240). There is sparse cultural material after 10,000 BP until the late Holocene, possibly indicating that the island was unoccupied during the terminal Pleistocene and recolonized in the early Holocene.

As it stands at the moment it would seem that evidence for maintenance of contact between the homeland and founder populations following on from first settlement is non-existent. Intra-regional contacts do occur, but only 10,000 to 20,000 years after settlement and prior to the Holocene such evidence is too minimal to uphold claims for continuous links or regular two-way voyaging. Allen (2000) is correct in his assessment that the crossing of the Vitiaz Strait required adjustment to a depauperate fauna and flora. However, as Specht (2005, 259) has ironically noted, if translocation was a response to this, then the surprise is not that some species were successfully translocated, but rather how few were, and how long after initial settlement this occurred.

Voyaging capability: distance and direction

We might also ask 'why if the region between eastern Maluku and Papua New Guinea/Island Melanesia was a maritime nursery where the skills necessary for the colonization of the remote Pacific were being incubated', did the Pleistocene colonists of Sahul not venture further than the northern Solomons? Gibbons & Clunie (1986) made a claim for Pleistocene voyaging between what is now the eastern edge of the Australian Great Barrier Reef and New Caledonia. Their argument was two-pronged, resting firstly on the reduced ocean crossings that would have been required for maritime migration during lower sea levels and secondly on the reported human derivation of a series of 'tumuli' or artificial mounds on the interior plateau of the Isle of Pines, off the coast of New Caledonia (Gibbons & Clunie 1986, 65). The latter, dated to *c.* 12,000 BP, have been shown as built by megapodes (Chappell pers comm. 2007).

Leaving aside the lack of evidence for human occupation, Gibbons & Clunie (1986, 73) argued that Pleistocene colonization would have been facilitated by a substantial island between New Caledonia and the east coast of Australia exposed during the LGM low sea stand. However, the –150 m drop they postulate for the LGM low stand would not be generally accepted today. Using the low stand of –120 m to –130 m, a watercrossing of 400 km is needed to get colonists to New Caledonia (Fig. 4.5).

The single most important factor overlooked in Gibbon and Clunie's assessment of oceanic voyaging in the southwest Pacific is wind direction. Southeasterly winds blow all year round and even today sailing from Australia to New Caledonia is a challenging task. Conversely, Anderson (2000) makes the case that while Manus might have been over 200 km from the mainland and required seafaring out of sight of land it nevertheless 'could have been reached by a drifting or paddled raft from New Hanover. There is a strong current (1–3 knots) which sets in that direc-

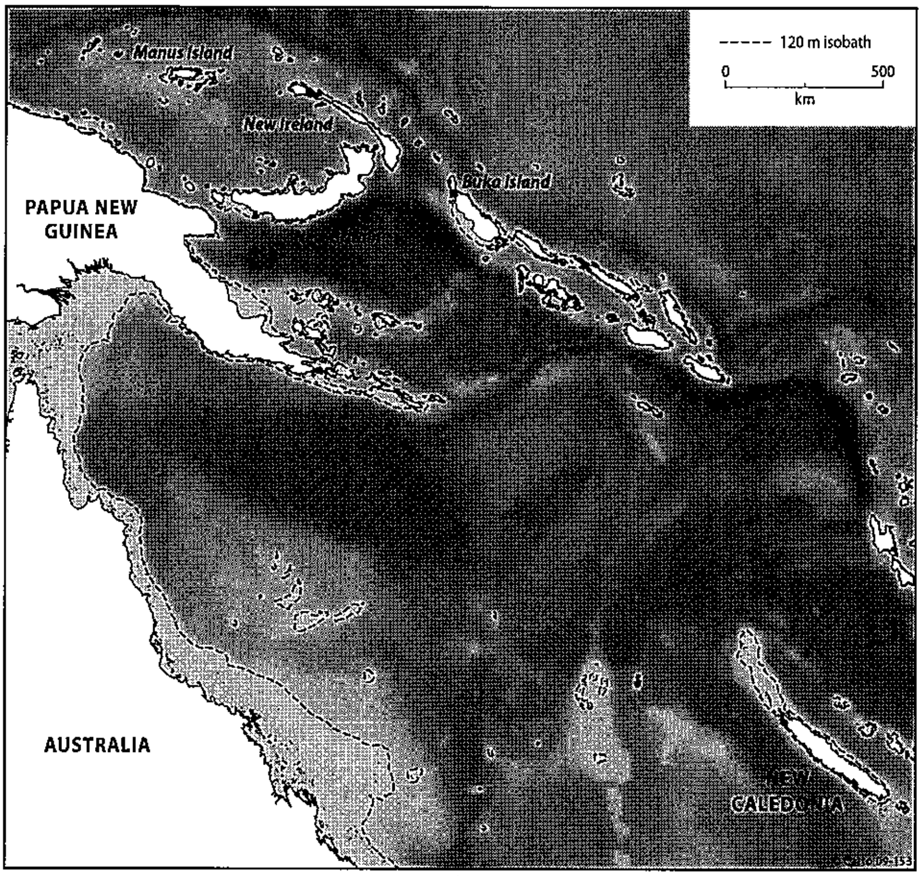

Figure 4.5. *Map showing water crossings necessary to reach New Caledonia from the eastern edge of the Australian Great Barrier Reef today and at –120 m sea-level stand.*

tion and which often brings drifted material from New Hanover to Manus' (Anderson 2000, 18). Once Manus was settled there is no indication that contact was maintained between it and the mainland — 'no obsidian from Manus sources was taken out of the archipelago until the late Holocene' which Anderson (2000, 18) infers as proof that the Pleistocene settlers who reached Manus 20,000 years ago were not capable of controlled and systematic seafaring at this time.

Technology

No remains of early boats have been found in archaeological contexts in Island Southeast Asia or in Australia. It is presumed that the earliest water crossing would have involved simple craft such as rafts made of lashed bamboo (Anderson 2000; Clark 1991), or logs with outriggers to stabilize them, however even transportation on floating trees or mats of vegetation has been mooted as a possibility. Graeme Walsh (2000, 32) argues that some boats, which appear to be of reed-bundle construction with high upswept prows and sterns, are crewed by Bradshaw-style figures, which elsewhere have a minimum age of 17,000 years BP (Roberts *et al.* 1997). At the time of European voyaging to Australia bundle boats were only known from Tasmania, and were not seaworthy for long water crossings (Jones 1977).

Whether or not rafts or other craft in use over 40,000 years ago could have been equipped with navigational aids, such as sails, has also been debated (Anderson 2000, 15–16). Thorne suggested that large

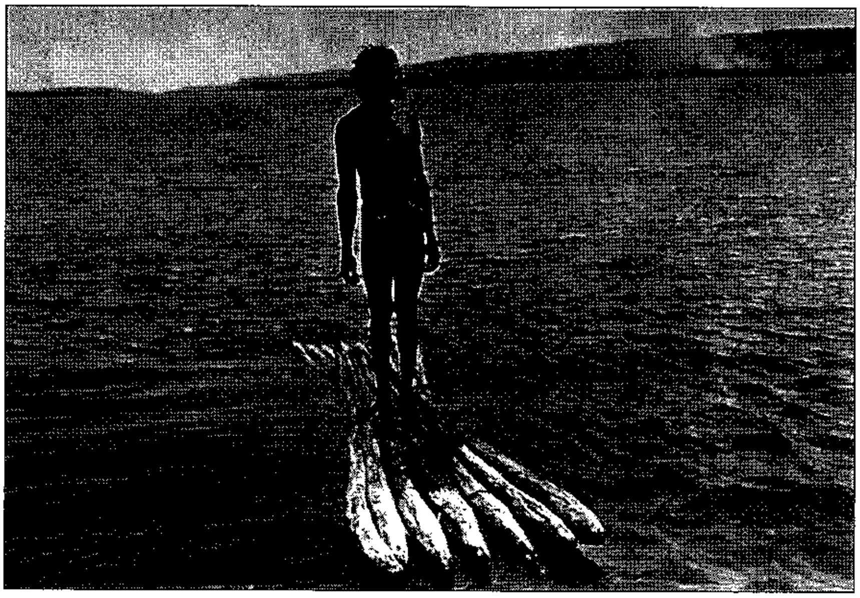

Figure 4.6. *Double raft known as* kalwa *used in the Kimberley into historic times (photo by William Jackson, 1917 Northwest Scientific Expedition (Stuart 1923). The distribution of this type of craft appears to have extended from Cape York to the Kimberley but to have been replaced on the Arnhem Land coast by the dug-out canoe following Macassan contact in the 1600s.*

platform rafts akin to those used today on the wide river mouths in southern China would provide a suitable model for early craft and demonstrated the effectiveness of such a craft in light weather conditions, by experimentation (Thorne & Raymond 1989). As mentioned above, Chappell (2000, 90) argues that simple craft useful for exploiting rivers and estuaries would be all that was required for the water crossings from Timor to northern Australia as the strong northwest monsoon would have provided both momentum and direction. Certainly bamboo has great buoyancy and will stay afloat indefinitely. Large flat rafts are also reasonably stable, i.e. less likely to capsize than single-hulled craft such as canoes, and can support a good number of people/goods.

The past distribution of large bamboos is poorly known. Large diameter varieties such as *Dandrocalamus asper* are naturally occurring in mainland Asia but their natural distribution outside the mainland is uncertain. Although O'Connell & Allen (2006) have proposed the extension of large bamboos along the northern route as one of the reasons why they believe colonization is more likely to have proceeded along this path, there is no evidence for this. Large bamboos occur today in Island Southeast Asia on the northern and southern routes and most abundantly in high rainfall regions, but this may not reflect their natural distribution. Bamboos propagate easily from cuttings and it would be surprising if the large useful species were not an early human introduction along both routes.

Large bamboo would, of course, have been unavailable when the colonists reached Sahul and were not introduced in prehistory. Once inland, the first settlers of the northern Sahul would have been faced with unfamiliar hardwoods, but along the coastal margin some species of mangrove could have substituted for bamboo. Mangrove logs were used in the construction of the single and double-pegged rafts that were common in the Kimberley region of northwestern Australia in ethnographic times (Fig. 4.6). Made of a light soft species of mangrove (*Camptostemon schultzii*) held together with short hardwood pegs, the rafts were about 3 m in length (10 ft). They were very buoyant and were used for journeying out to offshore islands up to 15 km offshore. A short hardwood paddle could be used to propel them, but most journeys utilized tides and currents to travel from the mainland to the islands and between islands (O'Connor 1999, 10). However it is doubtful if such rafts would have been sufficiently stable and durable for back voyaging to Island Southeast Asia.

Whereas bamboo was easily split with a simple sharp flake wedge, more robust tools were required for fashioning and trimming mangrove timbers and making the hardwood pegs and paddles. Cutting and working these resistant timbers required hatchets or axes (Love 1936, 7). Australian Pleistocene stone artefacts assemblages are usually characterized as simple flake and core industries evidencing no specialization or standardization. While this is true, the simplicity of the flaked assemblages belies the fact that edge-ground axes or hatchets occur alongside the flakes in the early assemblages. The use of grinding and polishing a flaked preform to create a sharp robust cutting edge which was then inset into a wooden haft occurs as early in northern Australia as anywhere in the world (Anderson & Summerhayes 2008). Edge-ground hatchets or small flakes of volcanic raw material with intersecting ground facets detached from the polished cutting edge, have been recovered from Pleistocene contexts dating back to 30,000 BP and possibly earlier in Arnhem Land (Nawamoyn and Malangangerr, Nauwalabila I) (Jones & Johnston 1985, 217; White 1967), Cape York (Morwood & Trezise 1989) and the Kimberley site of Widgingarri 1 (O'Connor 1999, 75). The few intact examples indicate that at least some hatchets were centrally grooved for hafting (White 1967). The absence of such technology in Island Southeast Asia at such an early date suggests that this was an adaptation that arose independently and in response to new conditions/timbers following settlement in Sahul.

In the uplifted Huon Peninsula region of New Guinea waisted axes also appear at >40,000 BP but these are much larger, heavier and unground (Groube *et al.* 1986). Their form and size suggest no close relationship with the smaller edge-ground Australian hatchets. Groube (1989) has proposed that the Huon axes were utilized for creating small open patches in the forest canopy to foster more diverse environments for plants and game.

Although few sites have been published in detail the excavated Pleistocene stone artefact industries from Island Southeast Asian sites lack any specialized tools. The assemblages look very similar to the Pleistocene Australian assemblages, composed of small flakes and cores; but without the addition of the ground or waisted hafted tools found in Australia (e.g. O'Connor 2007; O'Connor *et al.* 2002). Flexibility and risk minimization seem to be the key to production choice in the Pleistocene stone artefact industries of Wallacea and Sahul.

Economic strategies

Despite the short water crossings required to reach New Britain from the Papua New Guinean mainland, Allen (2000, 144–5) has argued that the crossing of the Vitiaz Strait represents a new threshold in human maritime colonization and adaptation and the first step towards the settlement of the remote Pacific. This is due to the depletion of land-based fauna that had to be accommodated by the settlers of the Bismarcks.

Crossing the Vitiaz Strait forced the human colonizers of the Bismarck Archipelago to confront the same fundamental subsistence problem that all subsequent moves further into the remote Pacific met. In the beginning, people were forced to establish themselves while largely or wholly dependent upon a restricted range of natural resources, the majority of which were coastal (Allen 2000, 144–5).

Mainland New Guinea has a total of 52 terrestrial mammals of sufficient size to represent potential game, whereas New Britain has only four marsupials and two rats, and as mentioned above two were likely humanly transported tens of thousands of years after first settlement. Bird species also diminish dramatically and drop from 265 on the mainland to between 80 and 100 species, depending on which source is used (Fig. 4.7) (see Allen 2000 and Specht 2005 for discussion of the different estimates). 'The great dietary constants for the move across the Vitiaz Strait were the fish and shellfish and other marine animals and seabirds, together with many familiar tropical food plants'(Allen 2000, 144). Allen believes that the first settlers put in place a strategy to compensate for the reduced level of land-based game species and to support sustainable subsistence, and this strategy involved high mobility across large territories with a focus on marine resources. This in turn was predicated on 'safe, durable and manoeuvrable inshore watercraft from the beginning' (Allen 2000, 145). Ultimately this strategy provided the driver for improvements in watercraft and voyaging capacity and eventually led to a change of strategy; one where resources such as obsidian and animals were moved to people, rather than the reverse (Allen 2000, 146). As noted above, however, there was a time lag of 20,000 years between first crossing of Vitiaz Strait and any evidence for the operation of the latter strategy.

A further flaw in Allen's argument and one that he acknowledges but does not pursue, is that all of these adaptations had been made by the colonists who settled Wallacea by 40,000 BP or earlier. Both land-based and avian fauna were far more depauperate in Wallacea than in New Britain — and yet in Wallacea there is no indication that the initial populations were

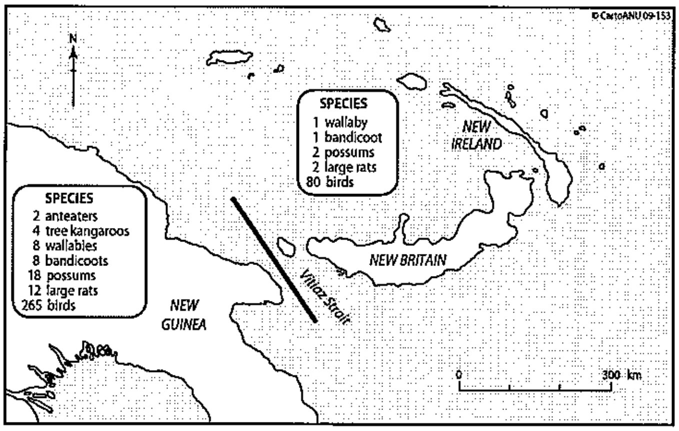

Figure 4.7. *Fauna available on both sides of the Vitiaz Strait (after Allen 2000, 145).*

never have been further than 5 km in straight line distance from the coastline, although between 30,000 and 18,000 BP it would have been higher above the time-equivalent shorelines than is the case today — by up to 120 m (O'Connor 2007). The fauna from the Pleistocene horizon at Jerimalai Cave indicates a heavy reliance on marine turtle, fish and shellfish, although rat, bat and reptile make a steady contribution (O'Connor & Aplin 2007, 85). Marine shell is found throughout the sequence and is almost exclusively rocky platform taxa (O'Connor 2007).

Fish accounts for a large proportion of the bone by MNI and NISP and includes jaws and vertebrae from large individuals of pelagic species such as tuna, as well as a wide variety

small or particularly mobile. Rather it would appear from the range and density of faunal material in the lowest levels of the uplifted limestone Pleistocene caves investigated in East Timor, that the first settlers were already competent at exploiting a range of inshore marine resources throughout the year, supplemented by an opportunistic strategy of acquiring the limited land-based fauna such as bats, rats and reptiles (O'Connor & Aplin 2007).

The only terrestrial species available to the inhabitants of Timor 40,000 years ago were large and small rodents, lizards and snakes (O'Connor & Aplin 2007). While two species of pigmy *Stegodon*, a giant extinct land turtle *Geochelone atlas* and a Komodo dragon-sized monitor have been recovered from Pleistocene-aged deposits in Timor (Hooijer 1969a,b; 1971), there is no evidence, like that now established for Flores, that these extinct taxa ever coexisted with the first human colonists in Timor (O'Connor 2002; O'Connor & Aplin 2007). It appears that the megafauna of the Lesser Sunda group had different extinction histories on the different islands where they occurred, and that those on Timor had vanished by 40,000 BP, although this issue warrants further investigation (O'Connor & Aplin 2007, 89).

Like the north coast of New Guinea, New Britain and New Ireland, the north coast of East Timor drops steeply to the continental shelf and the caves in the uplifted limestone terraces that step up from the coast to 350 m above sea level preserve an excellent faunal record. Today the Jerimalai Cave which is dated to 40,000 BP is less than 1 km from the shore. During the time span of human occupation, Jerimalai would

of inshore reef species. I have suggested elsewhere that the pelagics would have been captured in the deeper waters offshore and are indicative of a high degree of planning, the use of boats and complex technology (O'Connor 2007).[4] Two partial fish-hooks have been recovered at Jerimalai and the earliest occurs in the early Holocene. This is consistent with the single piece fish hook from nearby Lene Hara Cave dated to 9741±60 BP (NZA-1700) (calibrated range 10,205–11,128 BP, 2 sigma, 100 per cent of area) (O'Connor & Veth 2005).

There are no other sites in Wallacea which have records of this age and preserve a window into coastal subsistence following first settlement. Outside Wallacea in mainland Sahul there are only a few places where uplift outstrips sea-level rise or where the offshore profile drops away steeply enough that we can study the types of coastal adaptations made following settlement. The Huon Peninsula site on the north coast of New Guinea dates to >40,000 BP but is an open context and preserves no fauna. The Lachitu Cave also on the rapidly uplifting north coast of Papua New Guinea has a long sequence containing marine fauna, however, recent dating indicates that this begins no earlier than 25,000 BP. The subsistence story from lowland coastal New Guinea is quite disparate from that in the Bismarck Archipelago. Coastal sites such as Lachitu indicate continuous coastal resource use over 20,000 years of occupation, but little in the way of maritime specialization. All levels have evidence for the systematic exploitation of shell beds and inshore fish and urchins and crabs were also exploited throughout, however turtle and large fish are absent in the Pleistocene levels. The emphasis is on land-based game such as wallabies, tree kangaroo, echidna, bandicoots, bats, rats and reptiles.

The only region which provides a window into Pleistocene coastal landscape use within Australia is Northwest Cape on the Pilbara coast. This peninsula is uniquely positioned at the extreme western extent of the Australian coastline at the point where it is closest to the Continental Shelf. Dates as early as 35,000 BP have been obtained from two small limestone shelters which are today within a few kilometres of the coast, Mandu Mandu Creek (Morse 1993a) and C99 (Przywolnik 2002). Despite the dramatic variation in sea levels over the period of occupation these sites were never more than 10 km from the Pleistocene shoreline. They therefore have the potential to preserve early evidence of marine exploitation. One of these shelters, Mandu Mandu Creek, contains the earliest evidence for social symbolic behaviour in the form of personal adornment to have been found in Australia; shell beads from a strung necklace (Balme & Morse 2006; Morse 1993b). Although this demonstrates familiarity with inshore coastal resources Mandu Mandu and C99 contain little evidence for a maritime subsistence focus. Despite the proximity of the sites to the shore no fish or turtle bone are found in the earliest occupation levels — the emphasis is on terrestrial resources from the arid sand plains surrounding the sites, such as small macropods, bandicoots, reptiles and emu eggs (O'Connor & Veth 2000, 111–13).

Conclusion

What can we say about timing and routes of migration to Sahul? As the radiocarbon dates stand at the moment the southern route appears a slightly stronger candidate for first passage to Sahul with dates of 40,000 BP recovered from East Timor. If the longer chronology is accepted, however, then sites in Sahul are 20,000 years older than the oldest known sites on any prospective route and far older sites remain to be discovered in Island Southeast Asia. Without resolving the chronology we are left with little to choose between the northern and southern routes.

Assuming at least some time for the spread of the first migrants south into Sahul, and onwards into Island Melanesia, it would seem probable that 50,000 BP is a minimum age for successful colonization of Greater Australia, even assuming a very rapid rate of spread and population infilling. The genetic data also fits more comfortably with the long chronology as it indicates a lag of at least 10,000 years occurred between the colonization of Papua New Guinea and the Bismarck Archipelago. The dates for the Bismarcks are *c.* 40,000 BP so this would indicate that mainland Papua New Guinea must have been occupied by 50,000 BP or earlier.

If the southern route through Wallacea and onto the expanded Kimberley coast was taken, then a passage before 58,000 BP is likely as the northwest monsoon was weak or absent after this time. Rising sea levels also suggest opportunity would have been greatest before 60,000 BP.

Spatial sampling is critical to resolving the timing and spread of modern humans throughout the region. The early dates from Australia are the result of more intensive fieldwork and the application of a variety of dating techniques to early assemblages. As Roberts *et al.* (2005, 296) emphasize, there is a crying need for the application of 'new and improved dating strategies' and 'a variety of techniques that are founded on different physical principles' at sites in Island Southeast Asia. Many of the site records we currently have, speak to the need for greater inter- and intra-site sampling. In particular, 'evidence', or the lack of it, for human occupation may simply be a result of inadequate sampling of stratigraphically complex cave deposits (e.g. O'Connor & Aplin 2007, 85). Regional sampling across a variety of altitudes and vegetation zones to obtain long local sequences is essential. Replication of sites within single regions is also critical to demonstrate the generality of observed cultural and environmental sequences.

The faunal evidence while sparse also hints tantalizingly at a longer human occupation record for parts of Island Southeast Asia. Human impact on small Pacific islands was rapid and devastating (Steadman & Martin 2003). However, on many of the islands in Island Southeast Asia there is surprisingly little evidence for human impact on endemic faunas following first colonization. Is this because we are dealing with small, low-density, mobile early colonizing groups whose hunting and/or forest burning practices did not have any significant impact on the endemic biota? Or alternatively, could it be that our earliest archaeological records post-date the colonization phase and associated rapid changes? In Timor, for example, the stegodons and giant reptiles appear to have gone extinct before the earliest human occupation levels dated to 40,000 BP, whereas on Timor's neighbouring island, Flores, stegodons co-occur with non-modern hominins, *Homo floresiensis*, in deposits dating to the terminal Pleistocene (in the apparent absence of modern humans) (Morwood *et al.* 2005). The only recorded extinctions of endemic fauna during the period of human occupation on Timor involve a number of small murids and all the giant murids — and this does not occur until the late Holocene. Could it be that these species only survived in Flores until the terminal Pleistocene because of the absence of an effective predator; modern humans? Is there an early colonization phase so far undiscovered in the chronostratigraphic record of Timor that documents human impact on the large fauna? Here again sampling is critical to resolving this problem. Deliberate targeting of sedimentary deposits spanning key periods for which there is no evidence for human occupation records should be a priority. To fully understand the impact of people on the fauna of Island Southeast Asia, we also need to seek non-humanly derived bone accumulations against which to compare the cultural assemblages.

It has to be concluded that there is absolutely no evidence for back-voyaging or the maintenance of homeland/founder group interaction spheres in the Indo-Pacific following first settlement. There is some evidence for animal and plant translocations in the Pleistocene, but it is minimal, and the earliest evidence post-dates first settlement by a minimum of 10,000 to 20,000 years, and in most cases far more. Obsidian is moved from New Britain to New Ireland, but again 20,000 years after first settlement, and then we are looking at less than 250 pieces in the Pleistocene levels of the richest sites. Even allowing for the vagaries of taphonomy and small populations, this is at such a low level that it is hard to sustain an argument for regular maintenance of contact between communities of the two islands. The amount of obsidian in the Pleistocene levels of most of the New Ireland caves could be accounted for by the reduction of a few large cores brought in the bottom of a single canoe travelling the 30 km across St Georges Strait, between New Britain and New Ireland. Sourcing studies in Island Southeast Asia are in their infancy and in the future may throw more light on post-settlement contacts to the west of the Bismarcks.

There is little technological or subsistence data in the archaeological record to suggest any type of maritime specialization for the 20,000 years following first colonization of the Indo-Pacific region. The water crossings made did not require developed watercraft or knowledge and the short crossings that did result in successful migration could have been wind or current assisted. Only when we look at the faunal records from Timor and Island Melanesia where terrestrial resources were in very short supply, do we get the feeling that we are looking at economies with any level of marine specialization, and we may presume that the settlers of these areas had little choice. Conversely, in the north coast Papua New Guinean site of Lachitu and on the mainland coast of northern Australia where terrestrial resources were diverse and abundant, they were far more significant in the diet than coastal resources. In Island Southeast Asia contexts such as Timor, where economic emphasis was by necessity focused on marine produce, stone artefacts were extremely simple — sharp flakes appear to have fitted the bill. Fish-hooks appear in the terminal Pleistocene in Timor and may be earlier, based on the fish capture records, however in the absence of definite hooks or preforms this is speculative. In the dense rainforests of northern New Guinea, huge flaked axes were produced for creating patch clearances and to sponsor habitat diversity. In short, flexibility and adaptability in terms of technology and subsistence appear to be the prime hallmarks of the modern humans who colonized the Indo-Pacific region in the Pleistocene.

Acknowledgements

I would like to thank Atholl Anderson for many provocative discussions about all things maritime.

Notes

1. As recently pointed out by Mellars (2006) a mere one per cent of modern carbon in a sample which is actually 40,000 years old would reduce the measured age of the sample by more than 7000 years and this effect doubles with every additional half-life (5730 years) in the age of the sample.
2. The 42,000 BP age estimate for the Deep Skull context at Niah Cave was produced by the ABOX step combustion method.
3. This age estimate is based on the conventional age of the oldest sample from Leang Burung 2 of 31,260±330 BP (Gr-N-8649) with a freshwater shellfish correction factor of 1350 years subtracted (29,910±330 BP) (Glover 1981, 16). Calibrated using CalPal this gives a calendric age of 35,166±409 cal. BP with a 68 per cent range of 34,757–35,575 cal. BP.
4 Atholl Anderson disagrees with me on this point and says that, prior to over-fishing, tuna could be successfully caught from the shore edge along the eastern seaboard of Australia.

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