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The earliest evidence of ocean navigation

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Introduction

There is considerable confusion about the earliest evidence suggesting the human ability to cross the open sea successfully. The issue is important for many topics of Pleistocene archaeology, including global colonization by hominids, the origins of language, and issues concerning technology, social organization and cognitive evolution.

We have no direct physical evidence of water craft from the entire Pleistocene, be it in the form of remains of vessels, oars or other equipment. Similarly, while there are numerous apparent depictions of water craft in Holocene rock art the world over, there are no identifiable images of boats or rafts from the Pleistocene. The earliest archaeological evidence for nautical equipment is all from Europe: the Mesolithic paddles found in peat bogs at Holmgaard (Denmark) and Star Carr (England) (McGrail, 1991; Clark, 1971: 177). The Star Carr remains date from about 9500 years BP. The most ancient boats known are the canoes or dugouts from the peat of Pesse (Holland) (Zeist, 1957), which is 8265 ± 275 years old, according to its now calibrated radiocarbon date; Noyen-sur-Seine (France), at 7960 ± 100 BP; and Lystrup 1 (Denmark), at 6110 ± 100 BP (Arnold, 1996). A worked reindeer antler from Husum, Schleswig-Holstein (Germany) may be a boat rib of a skinboat of the Ahrensburgian, an Epipalaeolithic tool tradition of the early Holocene (Ellmers, 1980). Indirect evidence for ocean navigation in Europe is the occupation of the Greek island of Kefallinía by Middle Palaeolithic people, which involved a sea crossing of perhaps 6 km (Warner & Bednarik, 1996), and the much later presence of obsidian from the island of Melos in the Frachthi Cave about 11 ka (11,000 years) ago (Renfrew & Aspinall, 1990). Islands to the west of Italy may also have been occupied in the Palaeolithic (d'Errico, 1994).

This rather sparse European record is probably attributable to a simple taphonomic factor (Bednarik, 1994): the significantly lower sea levels for much of the Pleistocene Period have rendered the survival of any coastal or maritime equipment almost impossible. Indeed, what can be known about Palaeolithic maritime economies anywhere in the world is severely limited. Knowledge of Pleistocene archaeology is essentially restricted to inland economies. It is also unlikely that Europe would have featured prominently in early marine exploits by hominids. The most significant early sea crossings were most probably those that eventually led to the occupation of Australia and several nearby islands, which clearly occurred during Middle Palaeolithic or earlier times and are assumed to have commenced from mainland South-east Asia. The favoured scenario for first landfall in Australia places this around, or some time before, 60 ka ago, based on a series of secure radiocarbon determinations in the order of 40 ka (Allen & Holdaway, 1995) and a few

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TL (thermoluminescence) and OSL (optically stimulated luminescence) age estimates for sediments containing occupation evidence of around 60 ka (Roberts *et al.*, 1993). Earlier presence of humans in Australia has sometimes been suggested (Singh & Geissler, 1985; Kershaw, 1993; Fullagar *et al.*, 1996) but no credible evidence for it has been presented so far.

It should be of concern that all discussions of the initial colonization of Sahul (Pleistocene Australia), of the beginnings of nautical technology, of the origins of language, and of the expansion of *Homo erectus* have for many years been conducted in a vacuum. Almost all commentators on these and related topics have failed to take into account evidence that has long been available. According to such evidence, *H. erectus* was an accomplished sailor hundreds of thousands of years ago (Bednarik, 1995a, 1997a). The implications of this evidence are considered here.

The setting

According to conventional archaeological wisdom, humans have occupied Java (and presumably Bali, which was connected to Java at various times during the Pleistocene) since the first known emergence of *Homo erectus* in the region. The crossing of Wallace's Line (between Bali and Lombok) took place only when fully modern people arrived in the region and introduced new technology, shortly before the first known occupation of Australia. Bartstra and others (1991) argue that Wallace's Line was first crossed by humans about 50 ka ago. Swisher and others (1994) have provided what they term precision dating for the earliest appearance of *H. erectus* on Java at about 1·8–1·6 Mya, which coincides with the species' advent in Africa. The recent report of what appears to be a mandible of *Homo habilis* or *ergaster* from Longgupo Cave in central China at 1·9–1·8 Mya has added fuel to the debate between multiregionalists and those who favour the repeated dispersion of hominid species from Africa, because, especially in conjunction with the early dates from Java, it raises the possibility that even *H. erectus* did not evolve exclusively in Africa (Huang *et al.*, 1995). Here, however, more evidence is required. The fragmentary fossil from Longgupo Cave could conceivably represent one of the many hominoids of the region (Qian, 1985), especially *Lufengpithecus*. Finally, we have Swisher and others' (1996) dating evidence, which is said to suggest that *H. erectus* survived on Java well into the Upper Pleistocene. But these very late dates (53–27 ka) are contradicted by the unpublished dates Christophe Falguères has secured for this material (in the order of 300 ka), and they are rejected by Indonesian specialists who withdrew their names from Swisher and others' paper before its publication. Moreover, the claim that the Ngandong hominids are *H. erectus* is tenuous; they are similar to Australians.

Thus the hominid history of the catchment region for the people poised to colonize the Wallacean Islands, and ultimately Sahul and Melanesia, remains largely unknown. The region's recent and present biogeography (Fig. 1) is the result of tectonic history in the Tertiary. The northwards movement of the Sahul Plate (Australia's part of Gondwanaland) has led to it making contact with the Sunda section of the Pacific Plate around 15 million years ago, with full engagement during the Pliocene. So far the continental collision has not resulted in a land bridge to the deep-water islands formed. The biogeographical zones are defined by the lines of Wallace and Huxley (limit of Asian faunal complexes), Weber's Line and, furthest to the east, Lydekker's Line (limit of Australian faunas). Wallacea comprises the islands lying between the lines of Wallace–Huxley and Lydekker, thus effectively straddling the Eurasian and Australian continental plates. The faunal as well as

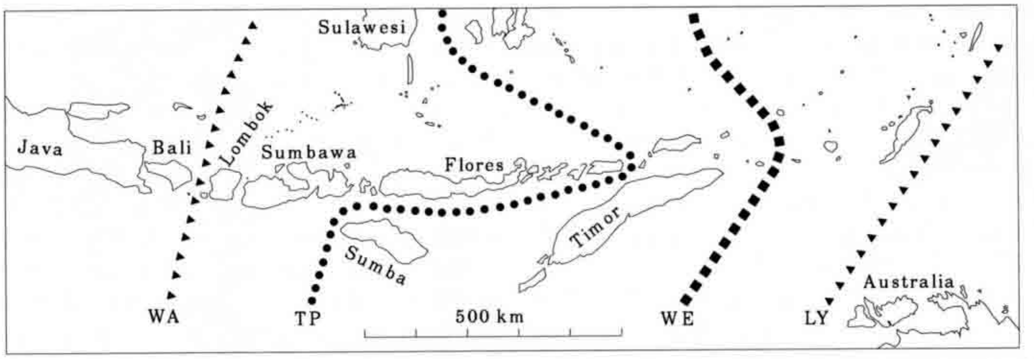

Figure 1. The Lesser Sunda Islands, between Java and Australia: WA=Wallace's line; WE=Weber's Line; LY=Lydekker's Line; TP=the line dividing the Eurasian tectonic plate from the Sahul (Australian) plate.

floral influence gradually decreases from each side, with the various water barriers acting as a series of ecological filters in both directions. A few species (dog, pig and probably macaque) were introduced by humans from the west, while the cuscus may have been carried from Sahul to reach Timor and Sulawesi. Apart from small species (mostly Muridae; Diamond, 1987) and humans, only proboscideans managed to cross unaided to many of the Wallacean Islands, where several species of Stegodontidae and elephants have been found (Koenigswald, 1949; Hooijer, 1957; Verhoeven, 1958, 1964; Glover, 1969; Hantoro, 1996). The deep-water islands have been characterized by distinctive endemism for their entire history, including a trend towards dwarfism among the larger species and rapid speciation. This contrasts sharply with the highly diversified Asian faunas on the large islands west of Wallace's Line. It serves to underline that human colonization of all islands east of Bali would have been impossible without the use of water craft to carry sufficient numbers of males and females, together with adequate supplies of water.

Homo erectus on Flores

A series of important finds in the islands of Wallacea began with Verhoeven's (1958) discovery in 1957 (Hooijer, 1957) of Stegodontidae remains on Flores, near the abandoned village of Ola Bula. Stone implements were noticed to occur together with the fossil bones, and Henri Breuil soon recognized the occurrence of typical Lower Palaeolithic tool forms among these (Verhoeven, 1958: 265). In the summer of 1963, Verhoeven located further stone tools directly in the fossiliferous layer at Boa Leza, and in 1965 at Mata Menge, thus demonstrating their co-occurrence with the Stegodontidae (Verhoeven, 1968). In August of the following year, he located remains of Stegodontidae and stone tools also on Timor, further east (Verhoeven, 1964). He then teamed up with J. Maringer and they began excavating together on Flores in 1968 (Maringer & Verhoeven 1970a; 1970b; 1970c).

Prompted by the presence of tektites, Koenigswald (1958: 44–6) suggested a Middle Pleistocene age, before the stone tools had been securely provenanced. Hooijer (1957: 126) attributed the fauna to the Middle or Upper Pleistocene, while Heekeren (1975: 48–9) placed the fossiliferous and artefact-bearing stratum between 830 ka and 200 ka. Koenigswald preferred a greater age, 830 ka to 500 ka, and eventually nominated 710 ka as the most likely age (Koenigswald & Ghosh, 1973: 3–4). He determined this on the basis of the tektites as well as the geological and palaeontological context (A. K. Ghosh, pers. comm., 1996). Maringer and Verhoeven noted a correspondence of their lithic industry on Flores with the Javan Pacitan tradition attributed to *Homo erectus*. They continued to locate similar artefact material at several sites on Flores (Maringer & Verhoeven, 1972, 1975, 1977; Maringer, 1978).

The Lower Palaeolithic tools found *in situ* together with the Stegodontidae-dominated megafauna all occur in a distinctive geological facies called the Ola Bula Formation. Koenigswald's suggested age for this fossiliferous stratum was confirmed in 1991–1992, when the work of Sondaar (1987) and others led to palaeomagnetic determinations (Sondaar *et al.*, 1994). Among nineteen samples from two sections, the Matuyama-Brunhes reversal to normal polarity (730 ka BP) was found to occur 1·5 m below the artefact-bearing deposit at Mata Menge. At that site, the Ola Bula Formation is 23 m thick, and the magnetic reversal occurs near its base (Aziz, 1993; Morwood *et al.*, 1997). Another fossiliferous stratum, at the nearby site of Tangi Talo, thought to be about 900 ka old (Sondaar *et al.*, 1994), is free of stone tools, perhaps providing a *terminus post quem* indicator for human presence on Flores.

Recent research in the region has confirmed Hartono's (1961) evidence for a great geographical extent of the fossiliferous and tool-bearing stratum, now excavated at Mata Menge, Boa Leza, Dekoweku, Dozo Dhalu, Dozu Sogola, Nagerowe and Ngampa (Lumbanbatu & Aziz, 1994; Aziz, 1996; Morwood *et al.*, 1997). The great number of stone artefacts from several sites implies that, by about 700 ka ago, the island was well occupied by hominids. Globally there is no evidence for archaic sapienoids at that time, so there can be little doubt that the hominids who had established a presumably thriving population on Flores were *Homo erectus*. Lombok and Flores were never connected to Java, nor to each other: this is not only demonstrated by the distinctive endemism of the fauna, but the final uplift of Flores had not yet occurred, so that the water barriers could have been deeper and wider than today, even at the lower sea levels of the Pleistocene. The Ola Bula sandstone formation is overlain by a Pleistocene limestone deposit, the calcareous Gero Formation formed during a period when the area was at or below sea level. This facies, in turn, is covered by more recent volcanic material.

The occurrence of many of the osteal finds from the fossiliferous layer in anatomical articulation excludes the possibility that the sediment is the result of fluvial redeposition of unrelated layers. Many of the artefacts were recently found next to fossil bones, even in direct contact with them (Morwood, *et al.*, 1997). Thus the hominids who made these implements clearly shared the island with the Stegodontidae.

Technological considerations

Examination of both excavated lithics and tools still embedded in their sandstone matrix leaves no doubt that these are artefacts. Indeed, on the basis of the published specimens and those examined it can be argued that, if this assemblage is around 700 ka old as indicated, it represents perhaps the most evolved stone tool industry of its time in the world. Heavily retouched small tools resembling woodworking adzes occur, together with blade tools, flake scrapers and even serrated implements (Fig. 2). Although choppers and pebble/cobble tools are also numerous, the relative technological sophistication of these assemblages is their most salient aspect.

Similar stone tools have been reported from other Wallacean Islands, notably Timor (Verhoeven, 1964: 634; Glover, 1973; Glover & Glover, 1970), Sulawesi (Heekeren, 1957: 47–54) and Ceram (Hadiwisastra & Siregar, 1996). These

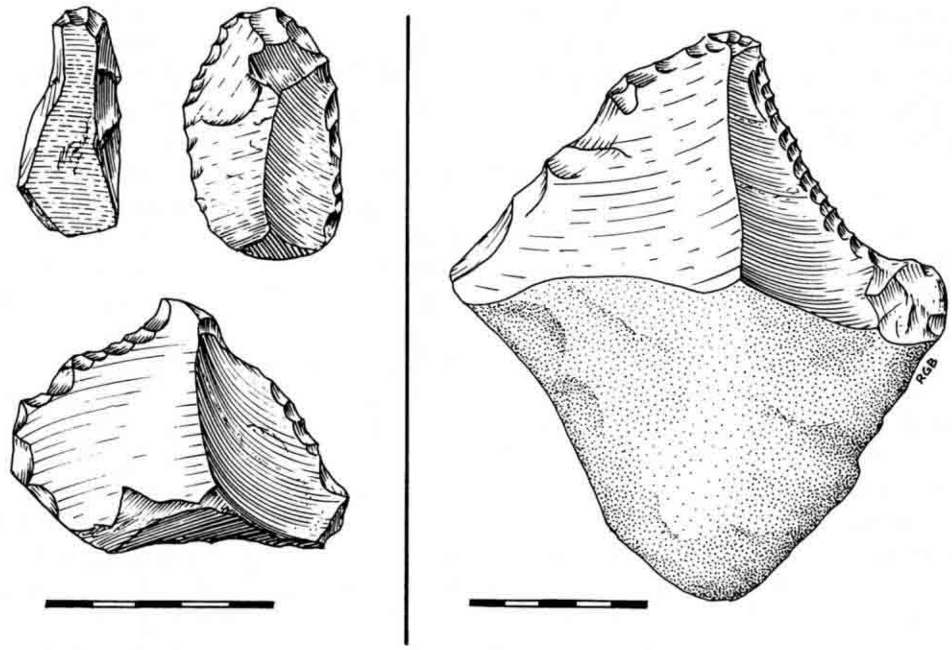

Figure 2. Sample of Lower Palaeolithic stone implements from the fossiliferous stratum in the Ola Bula Formation, Ai Sisa valley, central Flores. Scales in centimetres.

tools, at least in Timor, also seem to occur in stratigraphical contexts together with Stegodontidae and other extinct fauna. In the absence of dating evidence from these islands it cannot as yet be determined whether *Homo erectus* also occupied islands to the east of Flores, but to reach most of them would have been much easier than to cross from Bali to Lombok.

If modern currents were any guide, the crossing of the treacherous Lombok Strait would have been particularly difficult (P. Welch, pers. comm., 1997). While the distance to be crossed was only in the order of 25 km (at any Pleistocene sea level), human colonizers would certainly have required boats or rafts to cross Wallace's barrier. Our knowledge of Middle Pleistocene technology is severely limited, and almost entirely restricted to the use of stone implements. However, the little evidence we do possess points to a rather unexpected sophistication of wooden artefacts. For instance the seven wooden objects from the Lower Palaeolithic of Schöningen in Germany (Thieme, 1995; Bednarik, 1996a) and the fragment of a shaped and polished willow plank from Gesher Benot Ya'aqov in Israel (Belitzky *et al.*, 1991) indicate a high level of craftsmanship, and some of these finds hint at technological complexity. Other wooden implements of the Lower Palaeolithic have been excavated at Bilzingsleben, Lehringen, Clacton-on-Sea and Kalambo Falls. These few items provide no more than a glimpse of the period's non-lithic technology, but they indicate the effectiveness of these hominids in working wood and presumably other perishable materials. The use of beads and pendants during Lower Palaeolithic times (Bednarik, 1992, 1997b) indicates not only that cordage of some form was known and used, it also suggests the ability to produce knots (Warner & Bednarik, 1996).

None of these finds are from South-East Asia, but we have no reason to assume that this part of the world was a technological backwater. Probably the oldest known barbed bone harpoon is from Java, and it is highly possible that bamboo species, so plentiful in supply, provided a major material resource at the time—as they still do today. Most commentators on the subject of the initial peopling of both Wallacea and Sahul agree that bamboo rafts were the most likely craft used (Birdsell, 1977; Thorne 1989). The most obvious source of information concerning the type of rafts used, in the complete absence of any direct physical evidence, would be the ethnographic record. But here, too, there is agreement that none of the water craft known from Australia would have been suitable to cross from Timor, the favoured last bridgehead before reaching that continent (Birdsell, 1957, 1977: 130; Butlin, 1993). Australian ethnographic examples are bark canoes (Massola, 1971: 99, 110), rafts from driftwood, bark bundles (Jones, 1977) or mangrove logs (Flood, 1995: pl. 2). Log rafts, such as those used on the Sepik River, New Guinea, would have been more suitable for major ocean crossings (Jones, 1989). The absence of a major seafaring technology in Australia, a continent reachable only through its use, needs to be explained. Perhaps the material it was based on does not occur in Australia. Thus the lack of large bamboo species in Australia may well explain why a seafaring ability acquired over hundreds of millennia became limited to coastal navigation.

Discussion

Experimental archaeology can solve many practical problems in this discipline, and it has a distinguished history, particularly in nautical archaeology. No Pleistocene ocean crossing in the Wallacean Islands or to Australia has ever been replicated so far, but an expedition attempting this is now being prepared and the author has been appointed its Chief Scientific Adviser. A rudimentary bamboo raft made and equipped entirely with Middle Palaeolithic tool replicas is to be launched from Rote, just off Timor (Bednarik, 1996b). The raft will be 19 m long and carry a crew of twelve. The same project will also consider the level of marine technology possessed by *Homo erectus* when he crossed Wallace's barrier. This project is expected to result in a considerable improvement of our understanding of the conditions under which the first successful ocean navigation by hominids would have been possible.

The evidence summarized in this paper prompts a number of generalizations. Firstly, the present picture of hominid evolution suggests that, at a particular stage (apparently during *Homo erectus*' reign), our ancestors greatly expanded their geographical range, and rather rapidly. If there had been a hominid predisposition to adapt to a great variety of environments, then earlier hominids could have done so. That they did not could suggest that the remarkable expansion of *H. erectus* implies the involvement of a new adaptive tool, an ability not available to earlier hominid species. Colonization by navigation virtually presupposes purpose-specific communication and symboling abilities in the population concerned (Bednarik, 1992, 1995b; Noble & Davidson, 1996). While this does not necessarily include uttered language, the apparent presence of cortical speech centres since *Homo habilis* tends to support such a scenario (Falk, 1987).

Secondly, the model presented here diminishes the out-of-Africa hypothesis of modern human origins, its punctuated equilibria notion, and even the current concept of 'modern human behaviour'. Bearing in mind that most of the information from which the model espoused here is derived has been available for several decades, there is a need to enquire into the ignorance of those who during this time disseminated ill-contrived theories about the very late appearance of language, the inability of archaic *Homo sapiens* and earlier hominids to hunt, erect shelters or use fire, or their supposed lack of metaphysical constructs or self-awareness. Understanding the reasons for these significant misconceptions is not only important in avoiding them in future, it is an integral factor of metamorphology, the scientific version of archaeology (Bednarik, 1995c).

Thirdly, the data related here have a major bearing on our concepts of the initial peopling of Australia, yet for forty years they have never been properly considered in this context. This has given rise to the current belief that Wallacea and Australia were only settled by 'modern' humans of Upper Pleistocene African ancestry. Only after the author canvassed the Flores evidence vigorously did Australian archaeologists begin to take an interest in the issue. Again, this was a question of metamorphology, in the sense that limitations of knowledge about existing data help determine heuristic dynamics in the discipline, and this needs to be studied systematically.

Finally, what has been presented here should affect our thinking about the human past considerably, and particularly our ideas about the beginnings of ocean navigation. The long history of marine technology in the islands of Wallacea not only led to landfall in Sahul, further sea travel followed, to New Ireland, Buka Island and other destinations. Using an essentially Middle Palaeolithic technology, up to 180 km of sea was crossed to reach very small islands. Often these crossings occurred without the opposite shore being visible for much of the journey. It is inconceivable to attribute all of this navigational activity to accidents, to people drifting helplessly at sea, because all knowledge we possess of human occupation of these islands presumably refers to successful colonizations, to well established populations. Since this occurred in dozens of cases, some of which date back hundreds of millennia, Occam's Razor would demand that we view the currently dominant model of technological capacities of Middle Pleistocene hominids as fundamentally false. Not only do we have ample evidence of non-utilitarian activities ('palaeoart') during this time (Bednarik, 1992; 1995b; 1997b), we have considerable evidence of a long history of marine travel south-east of Asia, extending throughout the Middle Pleistocene, which during the Upper Pleistocene developed into systematic sea travel and the confident navigation of vast distances. Thus the Pacific exploits of more recent humans have their roots in the incredible achievements of *Homo erectus*, the greatest colonizer in hominid history.

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