The maritime dispersal of Pleistocene humans

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Summary

The global evidence presently available for Pleistocene maritime navigation is comprehensively reviewed, and considered within the context of the relevant technologies. It reveals a pattern of widespread island colonisation during the Late Pleistocene, and of much earlier seafaring abilities in two world regions, south-eastern Asia and the Mediterranean. Sea barriers have acted as technological filters for hominids, in the sense that their crossing was only possible at specific technological thresholds. This principle is similar to the filtering effects of the same barriers on animal species, which relate to the distance a breeding population was able to cross by one means or another. To better understand the technological magnitude of these many maritime accomplishments, expeditions are currently engaged in a series of replicative experiments. The theoretical conditions of these experiments are examined. The paper concludes with the proposition that hominid cognitive and cultural evolution during the Middle and early Late Pleistocene has been severely misjudged. The navigational feats of Pleistocene seafarers confirm the cultural evidence of sophistication already available in palaeoart study.

Introduction

One of the key topics in the area of human migration and diffusion is the subject of hominid locomotion. Human locomotion can be divided into two basic forms: autonomous or self-propelled locomotion, which includes walking, running, crawling and swimming; and assisted locomotion, in which the energies of nature are harnessed by hominids or humans. We can also observe the same dichotomy by dividing such abilities into those that are either culturally or non-culturally transferred. As there is no capacity in the human genes for assisted locomotion to transfer such capabilities genetically, they can only be passed on culturally.

The principal importance of the hominid maritime navigation capability is not that it enabled Homo erectus and later hominids to settle a number of islands as well as some continents, it is very much greater than that. There can be no doubt that what marks the human ascent more than any other development is what I have called the 'domestication of natural systems': the evolution of technologies that have succeeded in harnessing the energies of nature. The first spectacular demonstration of what humans are capable of by harnessing the energies of wind, wave action, current and buoyancy was when they first broke sea barriers. This was the greatest single achievement in human history, rather than the invention of the wheel, of agriculture, or writing, or flying machines. By comparison to the monumental importance of the first ocean crossing, Neil Armstrong's first step onto the lunar surface was indeed no more than a small step for mankind. The entire destiny of humanity was decided around a million years ago, when hominids made a conscious decision to entrust themselves, their very existence, to a contraption they themselves had built, and to seek their future in an unknown land. Since that moment in time, the destiny of the planet Earth has become closely intertwined with the destiny of the human species, because it led to the irreversible and ever-accelerating technological spiral that now transforms the biomass of our planet, and heralds human capacity to affect other objects in space. The ongoing extinction catastrophe on Earth has developed alongside this technological ascent of our species, which mushrooms at a rate massively outstripping our physical, cognitive or intellectual evolution. Therefore it is of considerable scientific interest to determine just how the hominid domestication of natural forces began.

It is also one of the most important aspects of any serious study of hominid expansion, of migration and diffusion of our species to every corner of this planet-and lately beyond its limits. Human expansion in the Pleistocene was assisted to a much greater extent by seafaring than orthodox and outdated archaeology is capable of absorbing. The fringe literature of archaeology is full of claims of seafaring feats that lack any scientific justification: crossings of the Atlantic, of the Pacific, and to various lost continents. The real story of the origins of maritime navigation is much more exciting than that, but it is a topic nobody had ever seriously contemplated before I began to do so, hence nearly all academic literature we possess on this topic is written by me. All material evidence we possess of navigation is from the Holocene, generally less than 8500 years old. Hence the traditional view has been that planned maritime locomotion commenced in the Mesolithic period and became common in the Neolithic. This idea has always found it difficult to absorb the fact of first Australian colonisation. In earlier years it conjured up images of individual humans helplessly drifting out to see, clinging to a log or some other floating vegetation matter, in the way rodents have succeeded in crossing many sea barriers. Until 1962 it was widely assumed that Australia was only settled in the Holocene, but since then the accepted time of the first occupation of this continent has been relentlessly pushed back in time. It now stands at more than 60 000 years ago, and may be forced back further still. Moreover, before these people could embark on the major sea journey to reach an unseen continent, they had to cross several lesser sea barriers, ranging in width from a few kilometres to 40 or 50 km. The traditional model explained this by claiming that seafaring was invented by fully modern Homo sapiens after arriving in Java, as if in response to not being able to proceed on land any further. But with first landfall in Australia perhaps between 60 000 and 80 000 years ago, that would demand an almost impossible, and certainly implausible timetable.

As far as the Anglo-American version of the past is concerned, this is where we stand currently: we have a paradigm that becomes increasingly incongruous as research proceeds. But most importantly, it has remained unaffected for forty years by the knowledge that the Wallacean presence of hominids together with a stegodont-dominated fauna had been demonstrated by Dr Theodor Verhoeven. The reason, very simply was, that this evidence had not been published in English. The matter was still ignored after Sondaar et al. (1994) dated this hominid occupation to around the beginning of the Middle Pleistocene, over 700 000 years ago, by palaeomagnetic analysis. They demonstrated that this hominid must have been Homo erectus, and that he had crossed several stretches of sea to reach Flores. Indeed, it is fair to say that at the present time, most archaeologists of the world remain unaware of this fact, and of the very significant implications it has for Pleistocene archaeology.

To begin with, the issue of how modern humans could have reached Java so rapidly and set about inventing navigation as if in order to immediately travel to an unknown Australia becomes irrelevant. With a locally developed seafaring tradition of many hundreds of millennia in the region it is pointless to invoke the arrival of a newly arrived, more intelligent but entirely hypothetical kind of human. Moreover, all the main claims of the African Eve model collapse now. Aspects of 'modern human behaviour' as defined by this model had existed in South-east Asia for the best part of a million years, and included language and symbolic production. Complex social systems and technologies must certainly have been available to the seafarers, because without them it would have been entirely impossible to organise and execute such courageous exploits. Initially, all of these sea journeys were made with the opposite shore within sight, but in the case of the final crossing to Australia, almost certainly from either Roti or Timor, the target coast only became visible after completing at least nine-tenth of the journey. The indirect presence of a land mass, however, can be predicted by a variety of signs, such as smoke from major forest fires, specific types of cloud formations, wave and current directions, and the movements of birds and sea creatures in consistent directions. Such signs, however, had to be understood not just by automatic response circuitry, they had to be consciously understood. They had to be communicable, in order to be effective and to convince the members of a group that this was a worthwhile effort that had a reasonable chance of success.

For such a colonisation effort to be successful, it had to have a minimum number of male and especially female participants of reproductive age, perhaps around a dozen individuals. To transport a number of humans and their supplies, a vessel of certain minimum requirements needed to be constructed, and to do this with stone tools involved a considerable investment of effort and material. Common sense tells us so, but it does not provide any further details.

The Indonesian background

In January 1957, seven years after commencing his research on Flores (Verhoeven 1968: 395; see Verhoeven 1952, 1953, 1956, 1958b, 1958c, 1959; Verhoeven and Fuchs 1959; Verhoeven and Heine-Geldern 1954), Dr Theodor Verhoeven discovered the island's first reported remains of Stegodontidae from an exposure near the abandoned village Ola Bula, on the Soa plain of central Flores (Hooijer 1957; Verhoeven 1958a). In the previous month, the Governor of Flores had shown him a large fossilised bone found by the Radja of Boawae, Joseph Dapangole, on a hunting trip. A few years earlier, similar faunal remains had been located on southern Sulawesi (Heekeren 1957). In March 1957, Verhoeven found stone flakes and blades eroding from the fossiliferous deposit at Ola Bula (Verhoeven 1968: 400). After notifying the Indonesian authorities of these finds, he was joined in his search by A. M. R. Wegner and A. S. Dyhrberg from the Museum Zoologicum Bogoriense, and a collection of fossil bones and stone tools they assembled over three days was sent to Dr Hooijer in Leiden for a more detailed examination. Henri Breuil recognised among these initial finds a number of typical Lower Palaeolithic stone implements (Verhoeven 1958a: 265), while Koenigswald initially assigned Verhoeven's finds to the Middle Pleistocene.

In mid-1963, Verhoeven succeeded in demonstrating the contemporaneity of the fossil remains and the artefacts, when he excavated the latter directly in the thin fossiliferous stratum at the nearby site Boa Leza (Verhoeven 1968). The condition of the finds in the silty upper part of this layer showed that they had not been subjected to fluvial repositioning: edges were sharp and fresh, and osteal remains occasionally occurred in articulation. Moreover, this concurrence of the Stegodon-dominated megafauna and the archaic stone tools was not limited to a single site, Verhoeven demonstrated it also at nearby Mata Menge, where he excavated in 1965. In 1968, while in Europe, he teamed up with Professor Johannes Maringer of the Anthropos-Institut, Germany, and the two excavated together later in the same year at Boa Leza, Mata Menge and Lembah Menge, with three large excavation teams. Maringer confirmed the validity of all of Verhoeven's crucial observations, and their collaboration led to a series of publications about the early pre-History of Flores (Maringer and Verhoeven 1970a, 1970b, 1970c, 1972, 1975, 1977; Maringer 1978).

In the meantime, Verhoeven worked briefly also on other Wallacean islands, Sumba and Timor (Fig. 1), and in August 1964 he succeeded in discovering Stegodontidae in the north of West Timor (Verhoeven 1964). He found no stone tools with them, and in the subsequent decades there were no attempts to follow up this work (cf. Glover and Glover 1970). I commenced field studies in Timor and Roti in 1998, the latter being a small island to the immediate south-west of Timor (see below).

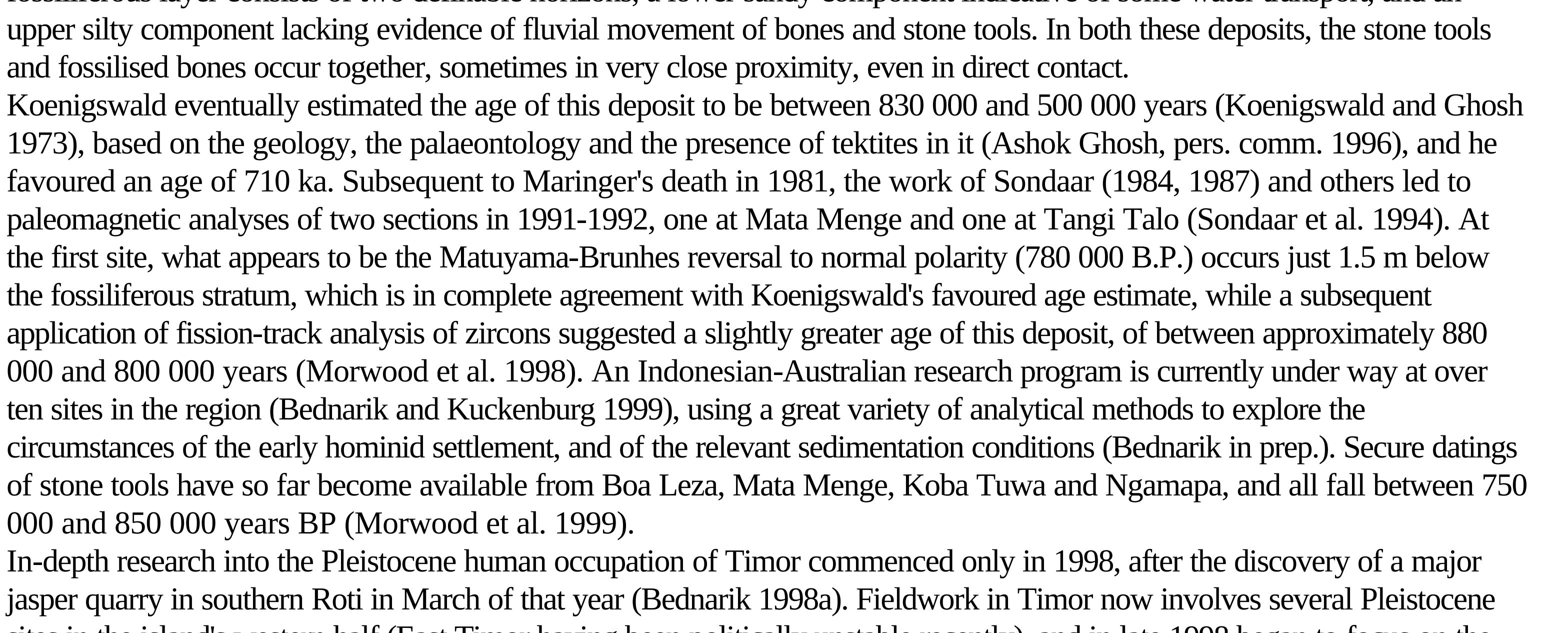

Fig. 1. Map of Southern Wallacea (Nusa Tenggara), Indonesia. The presumed dividing line between the Eurasian and Australian continental plates is shown between Flores and Sumba. Wallace's biogeographical line runs between Bali and Lombok. The locations of known hominid occupation evidence of the Lower and Middle Pleistocene are indicated.

The Soa plain on Flores consists of four distinctive rock facies (Ehrat 1925; Hartono 1961). These are dissected to various degrees by deep fluvial erosion of the Late Pleistocene. The sloping volcanic Ola Kile deposit is overlain by the horizontal Ola Bula Formation, a facies of poorly consolidated mudstone layers averaging about 80 m thickness at some sites, 120 m at others. The fossiliferous band, usually measuring from one to three metres, occurs in its lowest part, just above a distinctive white tuffaceous sediment forming its base. The overlaying Gero limestones, up to 40 m thick, were according to early research formed at or slightly below sea level, as shown by their fossil foraminifera (Morwood et al. 1999, however, suggest that the fossil fauna indicates freshwater conditions), and are in turn capped by a comparatively recent volcanic deposit. The fossiliferous layer consists of two definable horizons, a lower sandy component indicative of some water transport, and an upper silty component lacking evidence of fluvial movement of bones and stone tools. In both these deposits, the stone tools and fossilised bones occur together, sometimes in very close proximity, even in direct contact.

Koenigswald eventually estimated the age of this deposit to be between 830 000 and 500 000 years (Koenigswald and Ghosh 1973), based on the geology, the palaeontology and the presence of tektites in it (Ashok Ghosh, pers. comm. 1996), and he favoured an age of 710 ka. Subsequent to Maringer's death in 1981, the work of Sondaar (1984, 1987) and others led to paleomagnetic analyses of two sections in 1991-1992, one at Mata Menge and one at Tangi Talo (Sondaar et al. 1994). At the first site, what appears to be the Matuyama-Brunhes reversal to normal polarity (780 000 B.P.) occurs just 1.5 m below the fossiliferous stratum, which is in complete agreement with Koenigswald's favoured age estimate, while a subsequent application of fission-track analysis of zircons suggested a slightly greater age of this deposit, of between approximately 880 000 and 800 000 years (Morwood et al. 1998). An Indonesian-Australian research program is currently under way at over ten sites in the region (Bednarik and Kuckenburg 1999), using a great variety of analytical methods to explore the circumstances of the early hominid settlement, and of the relevant sedimentation conditions (Bednarik in prep.). Secure datings of stone tools have so far become available from Boa Leza, Mata Menge, Koba Tuwa and Ngamapa, and all fall between 750 000 and 850 000 years BP (Morwood et al. 1999).

In-depth research into the Pleistocene human occupation of Timor commenced only in 1998, after the discovery of a major jasper quarry in southern Roti in March of that year (Bednarik 1998a). Fieldwork in Timor now involves several Pleistocene sites in the island's western half (East Timor having been politically unstable recently), and in late 1998 began to focus on the Weaiwe valley near Atambua. There, a sequence of Pleistocene sediments occurs above estuarine clay deposits containing a great abundance of marine shells and snails. This demonstrates an uplift of over 300 metres. The Weaiwe Formation, a calcite-cemented Pleistocene conglomerate, has yielded remains of Stegodontidae from six sites by the end of 1998 (Bednarik 1999a; Bednarik and Kuckenburg 1999), and solid evidence of human presence in the fossiliferous stratum occurs at two, Motaoan and To'os (Bednarik 1999a, 2000a). Radiometric and other dating of the sediments is in progress, but there can be no doubt that a Lower Palaeolithic human occupation of Timor has been demonstrated.

General context of the origins of seafaring

The current Indonesian-Australian work has so far confirmed the occurrence of undisputed stone tools together with the stegodon-dominated fauna at six of the localities in Flores, Koba Tuwa, Mata Menge, Boa Leza, Ngamapa, Kopu Watu and Pauphadhi, while Ola Bula, Dozu Dhalu, Dozo Sogola, Tangi Talo and Nagerowe have produced only fossil materials so far. The deposits from Tangi Talo, attributed to the Jaramillo normal polarity period by Sondaar et al. (1994), have been suggested to indicate the absence of hominids by 900 000 years ago, a date squarely confirmed by Morwood et al.'s (1998) zircon fission-track date of 900 000 ± 70 000 B.P. Hominid presence has been dated through stone tools to between 750 000 and 850 000 B.P. at four sites (Fig. 2). One may expect some minor adjustments in these findings, but it seems soundly demonstrated that Homo erectus was well established on the island of Flores by 800 000 B.P. At Timor, similar stone tool technology coincides with a similar fauna in a Middle Pleistocene sediment, and the link between the cultural and the palaeontological evidence is even stronger, because of the recovery of a large shell fragment with signs of massive impact and extensive burning at To'os in the Weaiwe valley (Bednarik 1999a, 2000a).

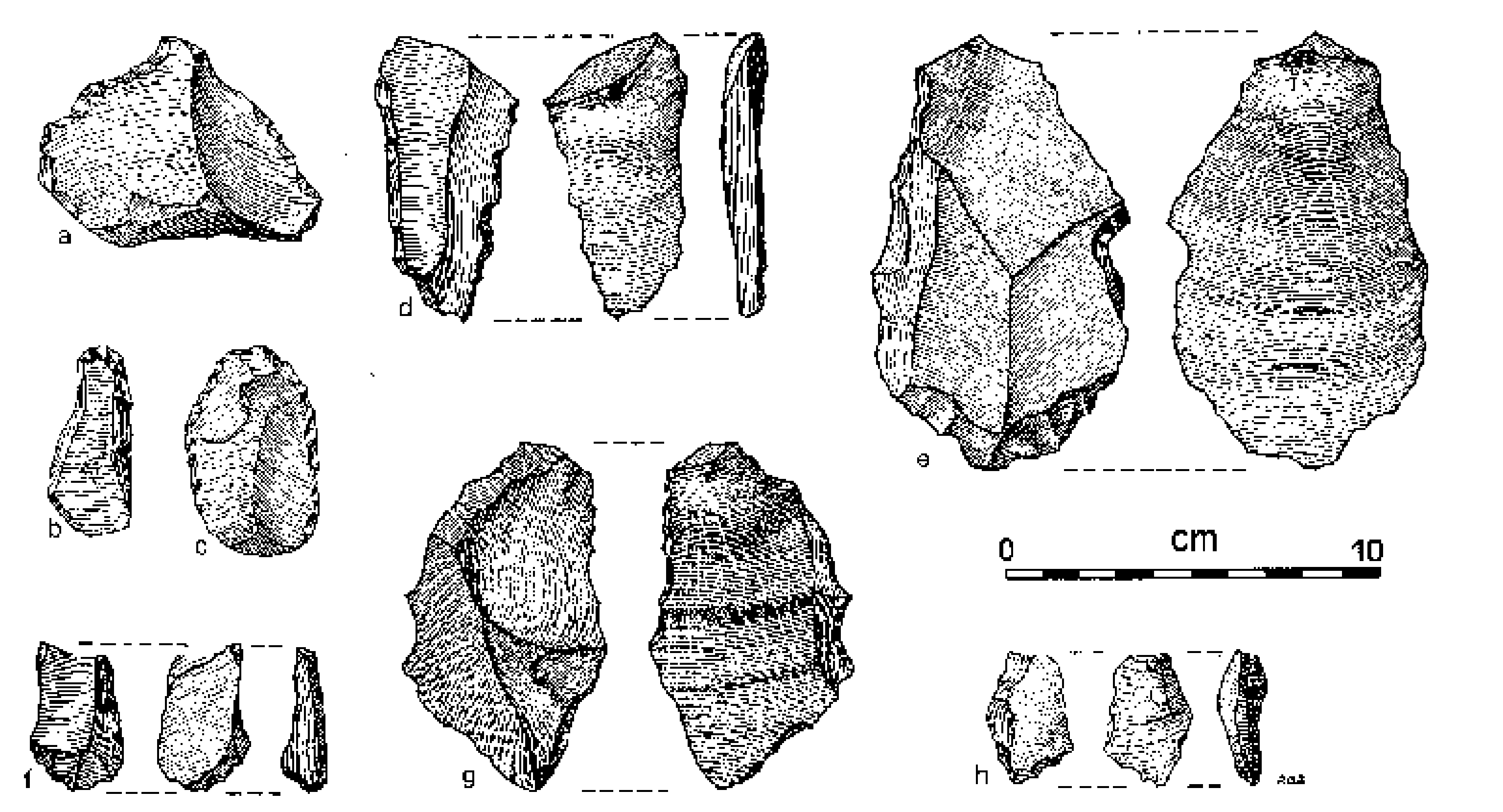

Fig. 2. Stone tools of the final Early Pleistocene of the Soa Basin, central Flores, thought to be between 750 000 and 850 000 years old: Mata Menge (a-e, g) and Boa Leza (f, h).

Flores is separated from Bali, the furthest extension of the Asian mainland during the Pleistocene (at times of low sea level), by two other islands, Lombok and Sumbawa (as well as several smaller islands), and the lack of any land bridge between Bali and Lombok was already recognised by Wallace (1890). While this is based primarily on biogeographical observation, it is supported by the continuing uplift in the 'inner arc' of the Indonesian archipelago, which amounts to several hundred metres over the past million years in this tectonically active subduction zone. Despite the incredibly rich mainland fauna of both extant and fossil terrestrial eutherians that can be found as far east as Bali, few of them ever reached the islands of Nusa Tenggara, or southern Wallacea. Some, such as the dog, pig and macaque, were probably carried by humans, while small mammals, mostly Muridae but including Trachypithecus auratus, probably crossed unaided, perhaps on floating vegetation (Diamond 1977). Proboscideans, however, crossed to numerous of the islands of Wallacea (Hooijer 1957; Verhoeven 1958, 1964; Glover 1969; Groves 1976; Hantoro 1996) and the Philippines (Koenigswald 1949), where they experienced speciation and dwarfism. Elephants are superb long-distance swimmers, having been observed to swim for 48 hours in herd formation across African lakes, and in one reported case swam a distance of 48 km at sea and at a speed of 2.7 km/h (Johnson 1980). In swimming great distances, individuals may tow others to allow them to rest. Their buoyancy is helped by digestive gases in their intestines and their habit of travelling as a herd would facilitate the success of a founding population upon landfall.

Hominids, however, lacked the trunks and swimming ability of elephants. Even deer, pigs, tapirs and hippos, some of the most capable terrestrial long-distance swimmers, apparently never colonised Wallacea. Although some researchers, desperate to save the Bartstra et al. (1991) model of rapid Wallacean and Australian settlement just 50 000 years ago, have suggested that there may have been a land bridge across Lombok Strait, this is highly implausible, and the implication is that the hominid settlement of Flores was preceded by at least two, but possibly three crossings of sea barriers. This conclusion is essential particularly in view of the even more startling evidence that hominids subsequently also reached Timor and Roti, i.e. the southernmost point of the 'outer arc' of the archipelago. As this is separated from the 'inner arc' by a deep graben it would be tectonically absurd to look for a former land bridge between Alor and Timor: the Strait of Ombai is over 3000 m deep. Thus it is demonstrated beyond any reasonable doubt that Homo erectus was the world's first seafarer.

This simple realisation represents several conundrums to traditional archaeology. It seems generally agreed (e.g. Noble and Davidson 1993, 1996) that seafaring ability, particularly when it is used for the successful colonisation of new lands, involves the skilled and standardised use of communication, presumably language or speech. Therefore the Wallacean evidence implies the use of a form of symbolism almost a million years ago. Not only is this in stark contrast to current dogma, it raises the question of how it was possible for conventional archaeology to have so misjudged the 'archaeological record'. Current dogma, particularly in the Anglo-American school of Pleistocene archaeology, emphasises the short-range model of cognitive evolution: language, 'art', social systems, self-adornment and self-awareness, blade tool technology, skilled hunting, shelter construction, forward planning, human interment, or any form of perceived 'modern human behaviour' are the exclusive preserve of that very pinnacle of human evolution, 'anatomically modern humans' (see Tobias 1995 for a pertinent critique of this latter concept), who according to the ideologically closely related 'African Eve' scenario appeared towards the Late Pleistocene in one small region. Generally, these cultural abilities are claimed to have been introduced during the last forty millennia of the Pleistocene, so this model cannot accommodate seafaring ability before 50 000 B.P. without sustaining severe damage (Chase and Dibble 1987; Davidson and Noble 1989). Hence the insistence that Eve's progeny reached Southeast Asia 50 000 years ago, invented watercraft and sailed at once to Sahul (Pleistocene Australia).

The alternative, among archaeologists and palaeoanthropologists rather unpopular model favours a long-range cognitive development, which began perhaps three million years ago (Bednarik 1998b) and led to spectacular changes 900 000 - 800 000 years ago, with the use of mineral pigment and the collection of 'exotic' objects (crystals, fossil casts; d'Errico et al. 1989; Bednarik 1990). The making of excellent wooden artefacts follows (Jacob-Friesen 1956; Howell 1966: 139; Wagner 1990; Belitzky et al. 1991; Thieme 1995, 1996, 1997), and eventually, but still in the Lower Palaeolithic (notably the Acheulian), the production of beads and pendants (Bednarik 1997a), petroglyphs (Bednarik 1995a) and iconographic palaeoart (Goren-Inbar 1986; Bednarik 2001a). Prismatic blade stone tools, burins and backed knives appear before the change from Lower to Middle Palaeolithic industries (Rust 1950; Garrod and Kirkbridge 1961; Copeland 1978; Hours 1982), and the following Middle Palaeolithic period provides ample evidence of human burials, haematite use, palaeoart (Bednarik 1992), bone harpoons (Narr 1966: 123; Brooks et al. 1995; Yellen et al. 1995; Bednarik 1997b: 36), mining and quarrying (Bednarik 1995b), and other forms of evidence indicating cultural complexity. This model favours a multiregional hypothesis of human evolution, because some conspicuously universal features of late 'Lower Palaeolithic' and 'Middle Palaeolithic' culture suggest the existence of cultural contact across much of the Old World. These include the use of iron oxides/hydroxides, the production of cupules and line petroglyphs, the collection of crystals and other unusual objects, beads and pendants, and, in a late phase of this technology, an art based on a surprisingly uniform repertoire of geometric markings (Bednarik 1990/91).

Rather than attributing these and various technological uniformities (which exist across physically different groups, like Neanderthals and modern humans) to independent cognitive evolution, I find it far more likely that the human population of most of the Old World, despite significant technological and ethnic differences, experienced sufficient genetic and cultural exchange to permit a certain level of cultural uniformity. This evidence is in stark contrast to the scenario of genocide or replacement of the African Eve model-and so is the evidence of Lower and Middle Pleistocene seafaring from Indonesia.

Since the first colonisation of Nusa Tenggara by hominids, more recent Pleistocene seafarers have undertaken even more daring sea crossings. The best known is perhaps the journey leading to first landfall in Sahul, which on current evidence is suggested to have occurred in the order of 60 000 years ago (Roberts et al. 1990, 1993; but cf. Allen and Holdaway 1995; the much greater TL dates reported in Fullagar et al. 1996 are attributable to misinterpretation of data). Since southern Wallacea was apparently settled much earlier than any other part of the archipelago, the seafarers who achieved a successful colonisation of Australia probably set out from Timor or Roti. Their essentially Middle Palaeolithic technology continued on in Australia for the rest of the Pleistocene. With this level of technology, numerous more sea crossings were achieved, resulting in the establishment of viable human populations on various islands in the region prior to 33 000 - 27 000 B.P., including Monte Bello Islands (today 120 km from Australia), Gebe Island (west of New Guinea), New Ireland (east of New Guinea) and Buka Island (180 km from New Ireland) (Allen et al. 1988; Wickler and Spriggs 1988; Bellwood 1996; Lourandos 1997). In contrast to the sea crossings in Nusa Tenggara, which were all possible with the target shore in sight, at any sea level of the Pleistocene, the destination was not visible for much of the journey on these much more recent crossings, including the one to Australia. At least some crossings were even made in the alternative direction, for instance the cuscus, a Sahulian marsupial, was probably taken to the Moluccas by watercraft (Bellwood 1996).

Physical evidence of Pleistocene seafaring has not ever been reported, nor have we any credible depictions of watercraft in Pleistocene art. Direct archaeological evidence of navigation peters out between 8000 and possibly 10 500 years ago (Bednarik 1997b, 1997c), consisting of Mesolithic paddles, canoes and a purported reindeer antler of a skin boat of the Ahrensburgian (Zeist 1957; Arnold 1966; Clark 1971; Ellmers 1980; McGrail 1987, 1991; Bednarik and Kuckenburg 1999). Watercraft and paddles of the late first half of the Holocene are also known from two Japanese sites (Aikens and Higuchi 1982: 124; Ikawa-Smith 1986). However, most of this evidence is from the western seaboard of Europe. Indirect evidence of seafaring, in the form of insular obsidian from Melos on the mainland, comes from Frachthi Cave in Greece, being only marginally older, 11 000 B.P. (Perlés 1979; Renfrew and Aspinall 1990). It has also been suggested for the western Mediterranean, but with inadequate proof (e.g. d'Errico 1994). Very much earlier sea crossing and island colonisation is indicated by Mousterian tools on Kefallinía, west of Greece (Kavvadias 1984; Warner and Bednarik 1996), and by the presence of in situ Clactonian-like stone tools in Middle Pleistocene sediments on Sardinia (Martini 1992; Bini et al. 1993; Sondaar et al. 1995). Crete was occupied by humans during Middle Palaeolithic times at the latest (but possibly much earlier), as indicated by the human remains found there which are modern but possess preserved archaic features (Facchini and Giusberti 1992). In Japan, Palaeolithic seafaring is demonstrated at Okinawa (Baba 1998) and Kozushima (Anderson 1987), in North America by the Arlington femurs from Santa Rosa Island (reportedly 13 000 years old). However, in comparison to the seafaring evidence in the seas of Indonesia, New Guinea and Australia, most seafaring evidence from Europe and elsewhere is comparatively recent.

The evidence of hominid presence on Sardinia, although not solidly dated, is in the order of 300 000 years old, but there is a corpus of evidence suggesting much earlier seafaring in the region. It is once again incredible that this has attracted practically no interest so far. It is generally assumed that Europe was initially occupied from the east, either via the Bosporus (or Dardanelles) or via Russia. But there is no archaeological evidence in support of this assumption. Early Lower Palaeolithic occupation evidence and hominid remains are limited to south-western Europe, notably the Iberian peninsula. For instance there is no Early Acheulian in eastern or central Europe, but the trajectories of that industry are entirely identical in north-western Africa (the Maghreb) and in south-western Europe. Moreover, disc beads appear first in these two regions, i.e. north and south of the western Mediterranean, which can hardly be a coincidence. In view of the very short distance to be crossed near Gibraltar, which was even less at lower sea level (and only a fraction of the sea distance Indonesian mariners of the same period managed to cross), I have proposed to test the proposition that Europe was first colonised via the Strait of Gibraltar (Bednarik 1999b, 2001b). If it should be correct, Europeans were sailors before they became Europeans.

Navigation capability was apparently first developed between one million years and 800 000 years ago in Southeast Asia, possibly as a local adaptation to gain access to off-shore marine resources. Humans entrusted themselves for the first time to an artefact that harnessed the forces of nature: the carrying capacity of a floating object, and the currents, waves, and winds at sea. This event determined the direction of human development right up to the present time, as it led to improvements in the skilled application of cultural systems to utilise natural ones. Ultimately it resulted in the unsurpassed seafaring skills of modern Polynesians.

By about 850 000 B.P., an adequate number of males and females to establish a new population had travelled to Flores, probably from Sumbawa. This demands earlier crossings by hominids, most likely from Bali via Lombok to Sumbawa, although the lesser possibility of migration via Sulawesi still does need to be considered. This first geographical and technological Rubicon crossed by the human genus, most probably at the Strait of Lombok, clearly demanded the use of sophisticated communication, most probably in verbal form (speech), or some other suitable mode of language. Chronologically it coincides roughly with the introduction of material evidence suggestive of symbolic behaviour (Bednarik 1990, 1992, 1995a, 1998b), which reinforces the notion of a major cultural watershed at about that time: symbolising abilities acquired an archaeologically visible status, and can perhaps be assumed to have become a major cultural influence.

Replicative experiments

We lack any form of direct physical evidence that would tell us how any of the many Pleistocene seafaring feats were accomplished. The obvious source of ethnographic information, Australia, provides no answers, as all watercraft observed there would be unsuitable for lengthy sea journeys (Massola 1971; Jones 1976, 1977, 1989; Flood 1995). Indeed, this raises the question why these nautical skills would have been lost in coastal Australia, unless the material used in the ocean-going craft was not readily available there. Every commentator on the initial settlement of Australia, from Birdsell (1957, 1977) to the present, seems to agree that the most likely craft were bamboo rafts (e.g. Thorne 1980, 1989), and bamboo occurs only as small pockets of relatively thin-stemmed species in northern Australia (Jones 1989). This may well explain the absence of large, sea-going rafts in Aboriginal Australia.

Although we know that humans reached Australia in Middle Palaeolithic times, we have in fact no material evidence about any aspect of this first landfall: where and when it occurred, at what sea level, where the sailors originated, how many there were, what their vessel was like, how they survived. Did they barely manage the trip, were they swept out to sea against their intention, or were these expeditions well equipped, completing the journey with relative ease? Conventional archaeology cannot ever answer any of these questions, and if they interest us we need to find alternative methods to arrive at credible models. There are basically two approaches available to us. One is to use a carefully designed program of replicative experiments, the other is an intensive study of the technology available to these people, from a pragmatic perspective, and to integrate such knowledge in practical experiments where possible. I have been involved in both of these approaches for well over thirty years, replicating stone and bone implements, fire making, the production of petroglyphs, beads and pendants, the working of wood, bamboo, fibres and resins, and butchering with stone tools (e.g. Bednarik 1997a). This has usually included detailed microscopic studies of the resulting objects (e.g. microwear), by-products or markings. In contrast to Semenov (1964), whose pioneer work in this field concerned particularly Upper Palaeolithic technologies, I have most frequently focused on what are understood to be Middle and Lower Palaeolithic technologies. The most ambitious archaeological replication project I have attempted concerns the earliest sea journeys.

In principle, I perceive two types of replicative work: product-targeted and result-targeted. The easier procedure is the former, in which one copies an archaeologically demonstrated physical result (e.g. an artefact) so as to determine what has to be done in order to arrive at the known product. However, if only the result of a particular strategy is known, and not the physical means by which that result was achieved, the approach is necessarily more complex. One begins by deconstructing the phenomenon to identify as many variables of it as possible, and then constructs multiple scenarios to account for all known and quantifiable variables to test each within a framework of probability. So greater the number of variables or determinants one manages to account for in this fashion, so greater the confidence that the most probable scenario can be identified. It is clear that both these replicative approaches involve uncertainties, but these can be minimised by rigour, and the procedure is still accessible to falsification: one can refute a result by demonstrating a more parsimonious explanation, either of the data available, or by providing additional data. The problem with this approach is that the most logical, most economic, and most sensible course of action is not necessarily the one taken by the pre-Historic people whose activity remains we examine. However, in matters to do with survival, that may not introduce as much uncertainty as perhaps in aspects involving greater individual choice.

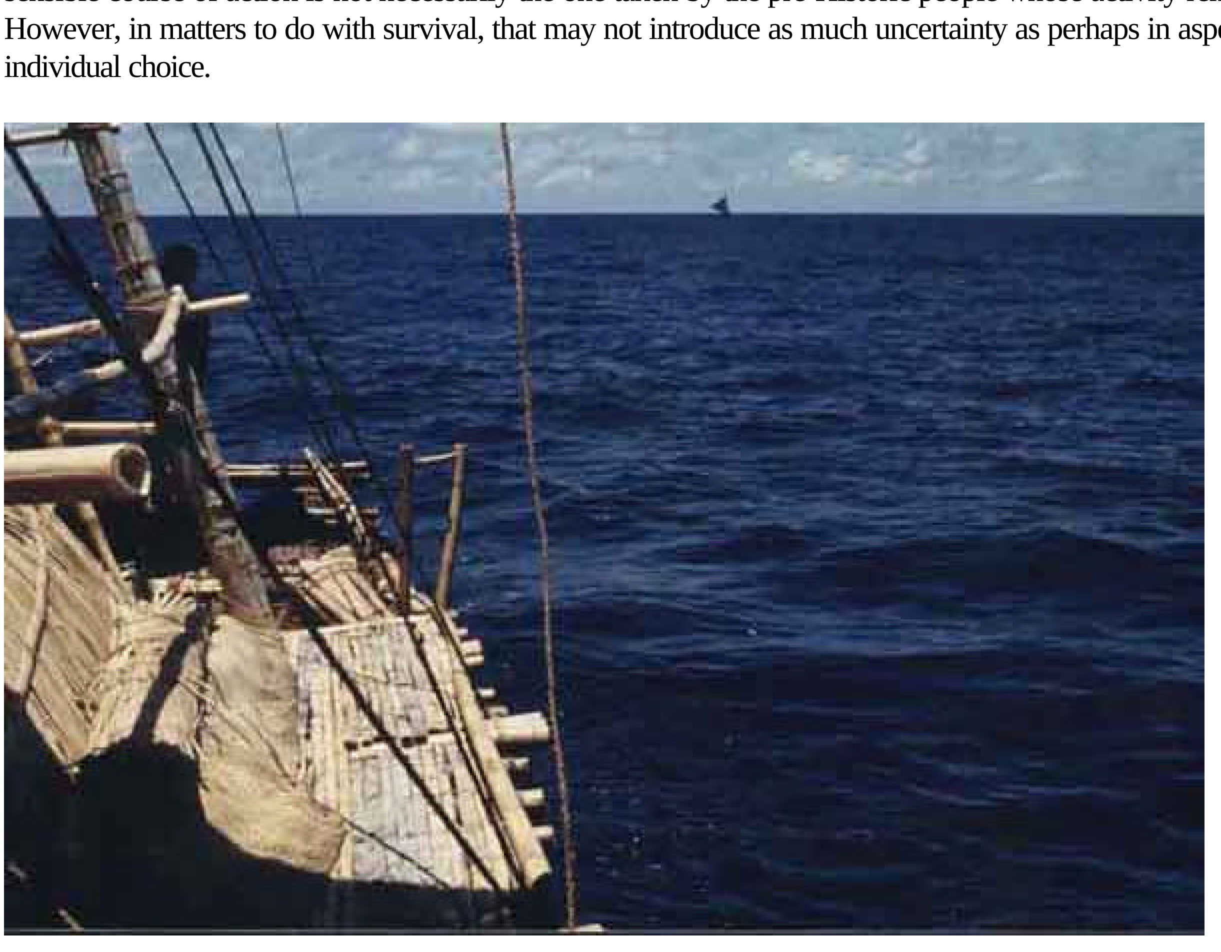

Fig. 3. The Nale Tasih 1 during sea trials on the Timor Sea, 8 March 1998.

A research program dealing with questions of Pleistocene navigation is currently under way, with the purpose of creating probability scenarios for the Pleistocene crossings of several sea barriers in eastern Asia and in the Mediterranean, among them Lombok Strait >800 000 years ago and the Timor Sea >60 000 years ago. A series of international expeditions, called the First Mariners Project, was commenced in 1996. It is engaged in result-targeted replication experiments, supplemented where possible by product-targeted replication (Bednarik 1997b, 1997c, 1997d, 1998a, 1999a, 1999b, 2001b). A number of rafts are built with the help of Palaeolithic stone tool replicas, equipped entirely with materials that would have been available to Pleistocene seafarers. The purpose of this work is to construct a scientifically based (i.e. testable) probability framework that can generate the most rational explanations of how very early maritime navigation may have been achieved.

The first Pleistocene-style raft built and sailed in modern times was the Nale Tasih 1 (Fig. 3), built between August 1997 and February 1998, and dismantled after sea trials without attempting a sea crossing. This vessel was 23 m long and weighed about 15 tonnes plus load, and it carried a crew of eleven. Constructed as a pontoon raft, it was launched at Oeseli Lagoon, southern Roti, on 14 February 1998. Only split vines (rattan, Calamus sp.) and palm fibres (gemuti) were used in lashing 550 bamboo stalks together. Three rain-proof shelters were constructed from lontar palm (Borassus sundicus) leaves, the vessel carried a fire box over which native millet was boiled in buckets made from palm leaves (haik). Fire was made by drilling softwood with hardwood, the raft carried 170 stone tools on board, modelled on Middle Paleolithic types. For experimental purposes the vessel was equipped with two sails of woven palm leaves, rigged on A-frame masts.
During sea trials in March 1998 the craft was found to be too heavy, and the El Niño effect made a successful crossing of the Timor Sea to reach Australia unlikely. Nale Tasih 1 was beached for destructive testing, and totally dismantled for inspection of all components. Materials and design were both critically analysed, and this work led to the design of Nale Tasih 2. This second bamboo raft was very significantly lighter and of an entirely different configuration, 18 m long, and weighed only 2.8 tonnes plus superstructures and payload. Built near Kupang, Timor, by eight men in three months, it performed superbly, carrying equipment, supplies and a crew of five effortlessly. Single masted and of very simple design, rigged and tied together by forest vines, this vessel crossed from Kupang harbour to the south coast of Melville Island near Darwin in 13 days, during December 1998. The shoreline at the presumed time of first landfall in Australia roughly 60 000 years ago is the margin of the continental shelf, which was crossed after only six days. A variety of conditions were encountered on the journey, ranging from calms to heavy tropical storms. The latter tested the vessel to its very limits, which helped greatly in determining breaking strains of materials and studying the design under stress conditions. Various design adjustments were made at sea, with some of the 65 stone tools carried on board, at times under perilous conditions (Bednarik and Kuckenburg 1999). Drinking water was carried in two hollow mangrove tree trunks, food consisted primarily of fish caught with harpoons of Middle Palaeolithic design, supplemented by native millet (pottok), palm sugar and fruit (Fig. 4). Upon arrival in Australia, the raft was in better state than when it had left Timor, due to design improvements made at sea, and both the vessel and its crew were in such condition that they were perfectly capable of repeating the journey. The raft had travelled almost 1000 km without any escort, without a radio, and with only one life jacket on board (the author is a non-swimmer). The Australian coast guard insisted that landing on the heavily crocodile-occupied coast, at night, was totally unacceptable under conditions of 5-m waves, so the crew was evacuated before the raft beached itself without significant damage, on 29 December 1998. It was recovered and brought to Darwin after the storms subsided.

Fig. 4. View of the deck of the Nale Tasih 2 approaching Australia, 28 December 1998.

The First Mariners Project launched its initial attempt to cross from Bali to Lombok on a primitive raft in early 1999, soon after the successful journey of Nale Tasih 2. In March, an 11.4 m long bamboo raft was constructed by six local boat builders on a beach at Padangbai, using only natural binding materials (split rattan, a vine, and gemuti, a palm fibre). Oars were fashioned with stone tools from a local softwood (bulalu), and the thwart timbers from a hardwood species (canari). The vessel was equipped with a sunroof of woven palm leaves supported by a frame, and capable of being manipulated at sea so as to catch any available westerly breeze. Two days after the Nale Tasih 3 was launched on 23 March, it was towed along the Balinese coast to Pula Giliselang, at the easternmost point of the island. From there we set out to reach the west coast of Lombok, a little over 35 km away, propelled by six oarsmen. The vessel made excellent progress east initially, peaking at 3.2 knots, but as it entered the deepwater channel, over 1300 m deep here, its northward drift in a strong current proved irresistible. Every effort was made to row against the current, but after about six hours it became evident that we would inevitably miss the north-western corner of Lombok. The attempt was abandoned under appalling weather conditions, about 15 km from the nearest Lombok coast.
At our base in Padangbai some of the materials of Nale Tasih 3 were salvaged for the next experiment. It was planned to construct a very similar vessel, a simple bamboo platform lacking any provision for steering or for a sail, thus reducing the design to the realistically simplest possible form. Six thwart timbers tied together horizontally arranged, tightly packed bamboo stalks, and the raft was propelled by twelve paddlers. The finished vessel weighted about 1080 kg, was 12.0 m long and took about 70 man days to construct. This work was commenced on 16 January 2000 and included the production of wooden paddles with Lower Palaeolithic stone tool types.
On 31 January 2000, the Nale Tasih 4 was towed from Padangbai to the prominent tiny rock islet Pula Gilibiaha, near Bugbug, south of Amlapura. Twelve carefully chosen paddlers boarded the raft just off-shore and commenced the marathon effort of paddling continuously all day. Initial progress was superb, with a consistent speed above 3 knots, peaking at 4.2 knots, and maintaining the planned eastern course well. However, once the depth exceeded 1000 m, the raft entered waters of choppy condition and waves of 1.5 m, with a distinct current. The current's strength increased and at times the vessel remained essentially stationary, despite enthusiastic efforts by the crew to overcome it. However, after continuous paddling for 12 hours, landfall occurred at the western coast of Pula Trewangan, a small island off Lombok. A distance of just under 51 km had been covered (Fig. 5).

Fig. 5. The Nale Tasih 4 approaches the west coast of Lombok, after successfully crossing Lombok Strait on 31 January 2000.

Shortly before this memorable event replicating the presumably very first sea crossing in human history I began preparing the next stage of the First Mariners Project, addressing the question of early Mediterranean seafaring. The first experimentation in Pleistocene marine technology in the region of Europe and Africa was undertaken in September and October 1999, on the Moroccan coast of the Strait of Gibraltar (Bednarik 2000b). A suitably sheltered beach near Ksar Seghir, east of Tangier, was the location chosen for this part of the project. It involved work with locally available materials such as animal hides, whole animal skins, softwood, cane, palm fibre and beeswax. Two prototype watercraft were assembled and sea-trialled. One was a pontoon raft made of cane (Fig. 6), the other was of inflated animal skins. All work was conducted entirely with stone tools made of Australian chert, copying specific Lower Palaeolithic types of the Maghreb region. The principal finding of the replication study in Morocco was that rafts of inflated animal skins have excellent buoyancy, but their construction involves skills that were probably not available to Lower Palaeolithic hominids. It is therefore assumed that navigation at that time was in all probability by simple rafts made of cane, which still occurs widely around the Mediterranean.

Fig. 6. Construction of a cane pontoon raft on the Moroccan coast of Gibraltar Strait, 7 October 1999.

The next two maritime experiments will examine how it would have been possible to cross from Elba to Corsica or Sardinia (joined at low sea level), and from Andikíthira to Crete, using purely the technology available in the late Lower Palaeolithic period. Elba was joined to the Italian mainland at lower sea levels, as Andikíthira was to the Greek mainland, via what is today the Island of Kíthira (Fig. 7). Preparations for the Greek experiment were begun in late 2001 and it is expected that the first attempt will take place in 2002. About 6000 stalks of kalamia (cane, phyllostachys sp.) were harvested on Kíthera by Albanian labourers in November 2001 and prepared to cure for six months. It is intended to bind them together with either a local bulrush, psathi, the fronds of the Washingtonia filifera palm, or split green cane as used in Morocco. Local light timbers will provide the frame in the fashion of thwart timbers. Perhaps there will be a deck mat made from split cane which can be raised as a kind of sail if a useful breeze appeared. Primarily the vessel will be propelled by ten paddlers using paddles carved with Lower Palaeolithic stone tool replicas as we made them before in Indonesia and Morocco. Construction is expected to commence in mid-May 2002 at Kapsali, a beach at the southern end of Kíthira. Once completed, the raft will be towed to a protected bay at the south-eastern end of Andikíthira, from where it will be attempted to reach Crete.

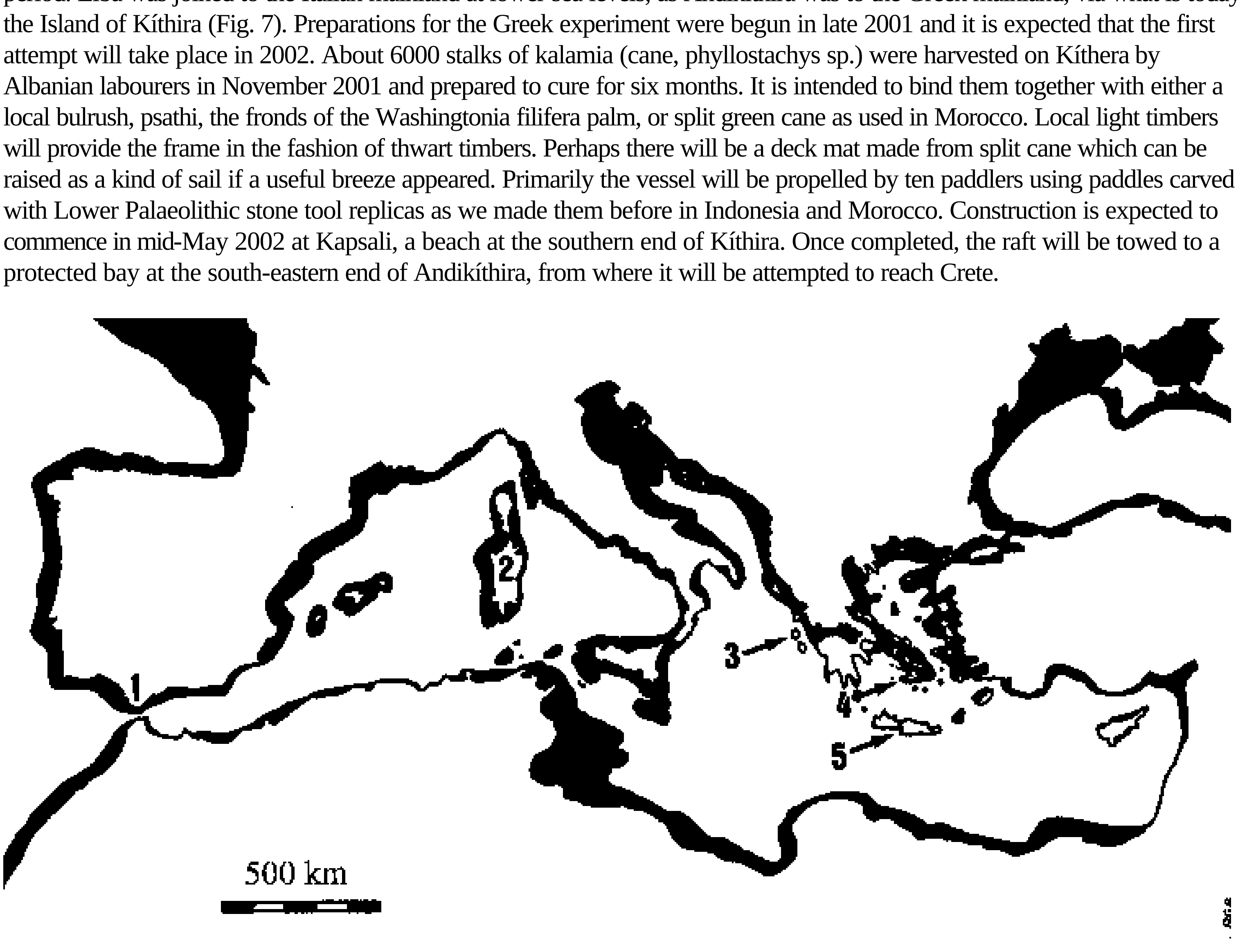

Fig. 7. Map of the Mediterranean, indicating the shore lines at low Pleistocene sea levels, and the locations of early sea crossings: 1 - Strait of Gibraltar, 2 - Sardinia, 3 -Kefallinia, 4 - Melos, 5 - Crete.

Discussion
It needs to be emphasised that I do not suggest that the raft on which the first landfalls we are replicating occurred resembled any of the versions we construct. The purpose of the project is to determine the minimum conditions necessary for each Pleistocene crossing, which essentially means that the circumstances of severity have to be progressively raised to the point when a successful crossing becomes clearly impossible. In a logical sense I am therefore not trying to cross sea barriers, I am trying to find out how they cannot be crossed-much in the same way that refutation operates. Therefore the raft experiments themselves are not actual replicas, which should be obvious, they are merely building stones within an overall project. However, artefacts and many technological aspects are replicative, or very closely so, and the end result should be a close definition of the conditions under which the initial crossings did occur.
Until 2004, when this work is expected to be complete, it would be premature to discuss its results in any detail. However, some fundamental issues can be clarified unreservedly. In particular, I would like to take issue with the notion that Pleistocene colonisations might have been accidental, that the seafarers had no intention of departing from their homeland. They may have been swept out to sea by swollen rivers or caught up in strong ocean currents. Not so long ago it was even suggested that humans had drifted to Australia on naturally accumulated vegetation matter, rather like rats. These kinds of scenarios imply a lack of understanding of the issues involved. Having sailed all 'Pleistocene' bamboo rafts of modern times, my most important finding is that the Middle Palaeolithic seafarers were technologically and cognitively far more advanced than archaeology has ever thought possible. Hundreds of cultural skills (sensu Handwerker 1989; Bednarik 1990) and forms of knowledge are essential to construct a raft of adequate design and size to carry the minimum number of colonisers required, and their essential supplies. Without such a vessel, no colonisation was possible, and I submit that such a craft was not built by mere accident. Even with the required labour effort and maritime expertise, the venture was audacious far beyond the comprehension of anyone who has not tried it.
What we need to ask is why scholars advocating the replacement model tend to find it necessary to explain away such incredible accomplishments, which parallels the efforts of others who deny pre-modern humans the ability to communicate, to use symbols, to hunt effectively, to construct shelters and so forth. To understand these biases in their context we need to examine them, and the ideologies responsible for them. At Laetoli, australopithecines walked fully erect and rather like modern humans 3.6 my ago (Leakey 1981), while 3 my ago, those at Makapansgat probably recognised the 'staring eyes' in a jasperite cobble and carried it a long distance into a cave (Bednarik 1998b). Are we to believe that hominids did not progress at all until the Late Pleistocene? We need to ask why some archaeologists find it so difficult to accept any evidence of gradual evolution, or of technological, cognitive or intellectual sophistication prior to the Aurignacian of France.
Perhaps archaeology, being a humanistic and anthropocentric, indeed sapiens-centric and sometimes Périgord-centric (Straus 1995) discipline that remains rooted in Western religious ontology, is uncomfortable with the biological concept that there is no qualitative difference between humans and other animals, in respect of any characteristic. Perhaps it seeks to assemble evidence favouring a distinctive separation of modern humans from archaic Homo sapiens. Perhaps being sapiens-centric involves the promotion of the achievements of one's own sub-species at the expense of another. Historically we have experienced the use of archaeology and anthropology to serve the political currents of Eurocentric scholarly traditions. It may not be so far-fetched to suggest that the last stand of this anthropocentric attitude is to deny major cultural achievements prior to the 'invention of culture' in, of course, Europe.
Seen in this perspective, the endeavours of some archaeologists to deny the people of the Lower and Middle Palaeolithic any level of cultural or cognitive sophistication may relate to the only recorded case in which one species appropriated the credit due to another species, in order to write its preferred version of history. I would argue that it is not the purpose of archaeology to justify our usurpation of achievements of our predecessors. Homo erectus was the greatest coloniser in the phylogenic history of the primates, and he was also the greatest achiever in a cultural sense. It may be unpalatable to those members of our species who tend to think we are in God's own image that Homo sapiens merely added some minor embellishments to the conceptual world his predecessor had already created.

Summary
The peopling process of islands began apparently with the crossing of the most important biogeographical barrier in the world, the Wallace Line, and with the first colonisations of islands in what is now Indonesia. The initial colonisation of Nusa Tenggara, previously known as the Lesser Sunda Islands, was accomplished by Homo erectus well before 800 000 years ago (Bednarik 1995c, 1997b). This is one of the most important discoveries related to hominid evolution, and yet it has attracted almost no interest in the forty years since the relevant evidence first became known (Bednarik 1997d).
Flores is separated from Bali by the islands Lombok and Sumbawa, both of which have never been connected to the mainland (Bednarik 1997b). Bali itself was joined to the Asian continent via Java and Sumatra at times of low sea levels, and these islands were presumably settled at such times. The entire island chain is the result of recent tectonic uplift of the late Pliocene and the Quaternary periods, caused by the subduction zone where the Australian Sahul plate glides under the Asian Sunda plate. Recent dating information from Java suggests that Homo erectus was present there about 1.81 million years ago (Swisher et al. 1994). We do not know when he first crossed to Lombok or to Sumbawa, but on present indications this is likely to have been up to a million years ago. To do so, and especially to do so with a colonising party of adequate size to establish a new population, he had to acquire seafaring capability. Consequently the Indonesian evidence demands that marine navigation was initially developed around a million years ago.
Although Java and Bali have had a full assortment of Asian faunas almost since they rose from the sea, the islands east of the Wallace Line are characterised by impoverished and endemic island faunas, with frequent dwarfism or giant forms (Wallace 1890; Sondaar 1987). The only large mammals that have ever crossed to these islands, other than Homo, were proboscideans, which occurred on many of the deep-water islands, both as elephants and as Stegodonts, and in both dwarf and full-size forms. Endemic island populations of elephants that are not exposed to carnivores have evolved into dwarf species in several parts of the world (Philippines, Indonesia, Sardinia, Sicily, Crete, Malta, Cyprus, Rhodes, Channel Islands near California).

Humans, however, are not assumed ever to have colonised islands by swimming. Not only did Homo erectus reach Flores, and thus presumably occupy Lombok and Sumbawa first, the author has found his stone tools also on Timor and Roti, two islands further south-east, and there are unconfirmed reports that such tools may also occur on Sulawesi (Van den Bergh 1997: 309). This implies that navigation was not a rare occurrence during the Pleistocene, but that seafaring technology was being developed in the archipelago for hundreds of thousands of years. Indeed, this technology eventually culminated in what must be considered to be the greatest technological achievement of humanity, the crossing of the open sea to a continent that, for most of the journey, remained invisible: the first landfall in Australia. In all cases of sea crossings before the peopling of Australia we assume that the opposite landmass was visible at any Pleistocene sea level. This was not the case for the final crossing to Australia perhaps 60 000 years ago. This demonstration of human courage and technological competence was accomplished by a people with a Middle Palaeolithic technology. This alone refutes the claims by 'African Eve' advocates that 'modern behaviour' appears only with the Upper Palaeolithic. It is generally agreed, even by the most extreme protagonists of the Eve scenario, that seafaring, especially when used to colonise new land, presupposes the existence of language, presumably in the form of speech (Noble and Davidson 1996). On that basis alone, language is at least a million years old. Language is a form of symbolism, and we have other evidence for symbolic expression which seems to begin around 800 000 years ago. Many archaeologists seem unaware that the use of pigment and beads, petroglyphs, engravings on portable items and skilled working of wood all begin in the Lower Palaeolithic, and not, as frequently claimed, in the Upper Palaeolithic (Bednarik 1992, 1995a, 1997d).

Seafaring was widely practised during the Pleistocene, especially in the region of Indonesia and Australia, but also elsewhere in the world. The effects of fluctuations of Pleistocene sea levels are a massive taphonomic factor preventing direct evidence of this technology from being recovered. In fact the earliest direct physical evidence of navigation is all from western Europe, and all of it dates from the early Holocene (Bednarik 1997c). It has been argued by archaeologists that Pleistocene sea crossings may have been accidental rather than planned. Such views are voiced by scholars who have neither examined the topic of early maritime technologies, nor have they attempted or considered replicative experiments.

The author has been engaged in replicative archaeology for about thirty years. Since we lack any physical remains of Pleistocene navigation equipment, any understanding of the period's maritime technology, however speculative, can only be acquired through replicative experiments. The available knowledge from other areas of technology of the periods in question, for instance in wood and bone working, serves as a reference source for such work (Bednarik 1997b). Some aspects of relevant material use can be precisely replicated on the basis of archaeological finds, as for instance bone harpoons. Others must be determined according to systematically derived probability estimates based on experimentation. In the case of Pleistocene seafaring, this involves a great deal of data gathering, and can lead to experimentation on a massive scale.

In 1996 began a series of expeditions to test hypotheses about how as many as twenty sea barriers were breached by Pleistocene seafarers. Literally hundreds of issues of technology need to be addressed, including the means of carrying freshwater, of fishing at sea, of locating sources of stone tool materials, and of course issues of maritime design (Bednarik 1997b, 1997c, 1997d, 1998a, 1999a, 1999b, 2000b). The understanding of Pleistocene technology to be acquired in this way by far exceeds the understanding accessible by traditional archaeological approaches. Replicative tools, for instance, can be subjected to microwear studies, and the practical application of tool replicas tells us more about their use than any amount of theorising ever could. The author of this paper is responsible for 'authenticity', and for the collection of all scientific data on all these expeditions. The first full-size experimental vessel was commenced in August 1997 and launched in southern Roti in early 1998. It was the Nale Tasih 1, which on 6 March sailed with a crew of eleven for sea trials. It was built as a Middle Palaeolithic, ocean-going bamboo raft, 23 m long and about 15 tonnes plus cargo. In December 1998 the Nale Tasih 2, a primitive bamboo raft, successfully crossed from the southern tip of Timor to Melville Island off Darwin under dramatic conditions, taking thirteen days (Fig. 8). The first attempt to cross Lombok Strait failed in March 1999, but in January 2000, a simple bamboo platform without sail or steering crossed from Bali to Lombok with a crew of twelve men. Since then I have built two rafts entirely with stone tools on the Moroccan coast in preparation for testing issues of Mediterranean Pleistocene seafaring. The next experiments are also taking place in the Mediterranean.

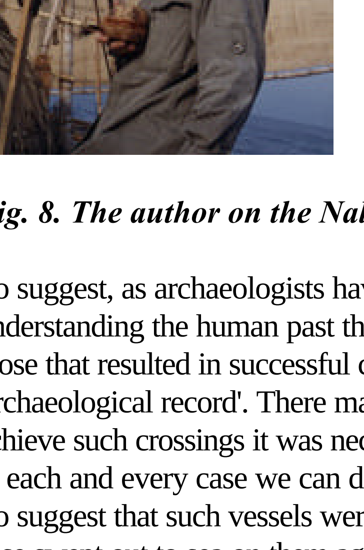

Fig. 8. The author on the Nale Tasih 2, 20 December 1998.

To suggest, as archaeologists have, that Pleistocene seafaring was accidental, or not pre-meditated, illustrates the lack of understanding the human past that is so widespread in archaeology. The only sea crossings we can possibly know about are those that resulted in successful colonisations capable of becoming visible on the very coarse and heavily distorted 'archaeological record'. There may have been several unsuccessful colonisation attempts for every successful instance. To achieve such crossings it was necessary to bring a group of sufficient numbers of males and females to found new populations, in each and every case we can document. This required adequate vessels to carry these people, their supplies and equipment. To suggest that such vessels were built without a quite deliberate plan, and that an adequate number of people was in each case swept out to sea on them against their will is not just illogical, it is symptomatic of a discipline that treats hominids as culturally, technologically and cognitively inferior, much in the same way Europeans in the past treated indigenous peoples wherever they found them. These kinds of arguments, which permeate so much of Pleistocene archaeology, indicate a lack of knowledge about the practical aspects of the human past. One is in no position to judge, or comment upon, the circumstances of the formation of what is quaintly called the 'archaeological record', without first having acquired the understanding that comes from practical experimentation with the materials in question, and under the circumstances in question, and without having a good understanding of metamorphological processes and biases (Bednarik 1995d). To illustrate with the example at hand: the author rejects any comment by an alleged expert of the human past about Pleistocene seafaring unless that person has tried seafaring under Palaeolithic conditions. No-one who has not done this can have any idea of the knowledge, competence, enterprise and courage such a feat actually involves.

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