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An experiment in Pleistocene seafaring

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Introduction

Recently the topic of Pleistocene navigation has been introduced in this journal (Bednarik, 1997a), by reporting evidence of numerous successful colonizations of various islands, particularly in the region of Indonesia and Australia, which clearly involved the use of watercraft. Nearly all of this indirect evidence relates to hominids who had Lower or Middle Palaeolithic rather than Upper Palaeolithic technology. This categorically contradicts various currently dominant models in world archaeology.

In particular, the notion that what is considered to be 'modern human behaviour' was endemic to a recent strain of hominids emerging in Africa perhaps 200–150 ka ago is left without any foundation. The first known instances of rock art, portable art, beads and pendants all predate that time, and the first use of pigment or sophisticated hunting weapons precedes it by several hundred millennia (Bednarik, 1997b). Methods of navigation, the principal subject of this journal, were probably in use a million years ago, and the successful long-term colonization of islands has been demonstrated by about 800 ka ago in Indonesia (Koenigswald & Ghosh, 1973; Sondaar *et al.*, 1994; Bednarik, 1995, 1997c; Morwood *et al.*, 1998). This ability presupposes the use of sophisticated communication, presumably uttered language (Noble & Davidson, 1996), and the cited evidence suggests that *Homo erectus* was using symbolism, at least in the form of language, by perhaps a million years ago. In the context of the contemporary paradigm of hominid evolution this is a revolutionary proposition. Therefore evidence of Pleistocene seafaring is of crucial importance to ideas about human history, and the origins of the cognitive and technological characteristics that make us human. Indeed, one might argue that this is by far the most important issue in nautical archaeology.

No form of 'direct' evidence at all of Pleistocene seafaring has been found, no physical remains of artefacts, no acceptable depictions of watercraft (Bednarik, 1997a). The physical evidence comprises the artefacts and living floors found on many islands, and the remains of some 200 Pleistocene humans found in Australia. Nevertheless, this is sufficient proof to show that human populations were not only present, but were presumably well enough established to provide an *archaeologically visible* presence on these islands. These finds generally relate to inland sites, because most of the former coastal occupation sites of the Pleistocene are now under the sea. This taphonomic factor is no doubt also responsible for the complete lack of direct nautical evidence from the Pleistocene. Even many of the coastal settlements of the early Holocene are now under water, for instance Mesolithic sites in north-western Europe (Andersen, 1985; Fischer, 1995).

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Conventional archaeology shows that people reached islands, and Australia, and it can even provide a view, albeit distorted, of their material culture—distorted by innumerable taphonomic factors. It cannot, however, show us how they might have managed to do this, or even when, with any precision. After all, even where credible dating evidence is available for such occupation, it provides only a *terminus ante quem* date. The type and size of the watercraft used, and the other equipment necessary to facilitate first landfall cannot even be contemplated, with any semblance of rigour, with the methods of traditional archaeology. Did these Ice Age sailors set out intentionally, or had they been swept out to sea against their will? How long would their journey have taken; how did they survive it?

Theoretical considerations

In order to understand the significance of Pleistocene seafaring to questions of human evolution, these questions need to be examined systematically. Replicative archaeology cannot give definitive answers to most questions likely to be asked here, but if carefully applied, it can provide a logical framework within which specific propositions can be tested for their probability. What renders this approach particularly reliable in the case of very early seafaring is that it relates to matters of survival, to pushing technology and know-how to a limit, and not to a phenomenon over which hominids might have exercised much cultural control. This places interpretational constraints on constructing theoretical scenarios that would limit some forms of errors systematically.

Secondly, on the reasonable assumption that the first crossing of a sea barrier occurred at a particular time because it was *then* that the necessary abilities had reached the level required to succeed, there is a second theoretical constraint. If we could determine what absolute minimum technology was necessary to achieve a particular effect (a sea crossing), we would in effect acquire a minimum description of the technology available to hominids at the time in question. Bearing in mind that knowledge of Pleistocene technologies, as derived from conventional archaeology, is often hopelessly skewed by massive and quasi-quantifiable taphonomic biases (Bednarik, 1994), this might well be a much more reliable way of assessing levels of development than statistical treatment of, say, 'hand axes'. For instance, if it is determined that it is entirely impossible to complete a particular journey without a certain component it can be assumed that such a component must have been available.

There is a third factor available to assess these matters. While knowledge of early technologies may be very limited, there are some indicators available, and these can be used to test the findings of replicative technology. So this procedure is susceptible to some level of falsification, even though it is based on experimentation. Moreover, any interpretations formulated by it can be tested by trying to find more cautious explanations for both the archaeological and the replicative data.

Two basic forms of archaeological replication are perceived, *product-targeted* and *result-targeted*. In the former, one seeks to replicate an archaeologically demonstrated physical result of a culture (an artefact) so as to establish what has to be done to arrive at a known product (in terms of form, microscopic surface markings, taphonomic effects). In the second type of replication, no physical manifestation is available, only the known result of some process or strategy (the settlement of an island). The scientific process is then to account for as many variables as possible, in terms of understanding their relationship to the whole, thus creating the data for multiple probability scenarios that can be tested against known limits, indications

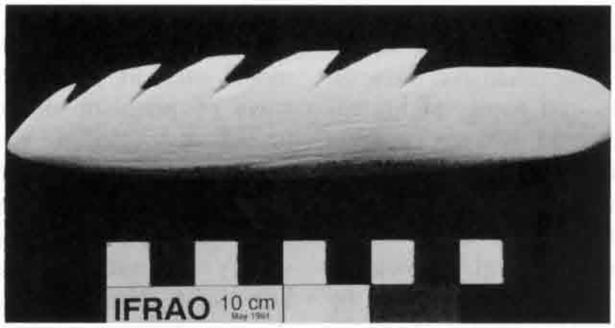

Figure 1. Bone harpoon replica, made with Middle Palaeolithic stone tool replicas, modelled on the harpoons from Katanda, Zaire. (Photo: author)

of technology and other quantifiable factors. Rigour becomes a function of the number of variables one can account for reliably, as does confidence in the models so developed. Depending on the complexity of the phenomenon under investigation, this procedure can involve the acquisition of massive amounts of data.

Such a case is the topic of Pleistocene seafaring. Until now, it has not been considered in any systematic fashion, and knowledge of the variables involved remains severely limited. Two expeditions are currently engaged in examining issues of Pleistocene navigation by means of replication, both through the construction and sailing of a series of vessels built and equipped with Palaeolithic stone tool replicas. As the Chief Scientific Adviser of both teams the author expects to travel on each experimental watercraft. The two principal objectives pursued by both expeditions are to determine the most minimal conditions under which the two principal water barriers in the region of Indonesia and northern Australia could have been traversed. These are Lombok Strait between Bali and Lombok, apparently crossed by *Homo erectus* prior to 800 ka BP, and the Timor Sea between Roti and Australia, apparently crossed by archaic *Homo sapiens* (perhaps similar to the Ngandong fossils) prior to 60 ka.

Replication work

The First Sailors Expedition and the *Nale Tasih* Expedition commenced planning in 1996. Their work involves both types of archaeological replication identified above. Product-targeted replication includes the manufacture of bone-tipped harpoons for use to capture food at sea. Such replicas are modelled on Middle Stone Age/Middle Palaeolithic archaeological finds of barbed bone harpoons (Narr, 1966; Brooks *et al.*, 1995; Yellen *et al.*, 1995), made at approximately the same time as the sea journey in question was undertaken (Fig. 1). Result-targeted replication involves all identifiable variables that might contribute to the success of an ocean crossing using a specific level of technology. It considers numerous processes that might have played a role in building and equipping very early watercraft, and comprises the examination of many other factors. Such factors include not only carrying capacities, vessel performance at sea under various conditions, or the performance of crews under conditions of stress and anxiety (standard psychological tests), but most especially information relating to how the many necessary materials were procured, such as cherts for stone tools, bamboo, binding and cordage materials, resins and waxes and foods. The means to procure, transport, prepare and preserve foods, the means to transport drinking water, to make fire and so forth all need to be considered. Only comprehensive data on the numerous skills and forms of knowledge required to succeed in a sea crossing can lead to plausible models, and in the case considered here, the required replicative work is most extensive.

The amount of practical knowledge about Pleistocene technology gained by this approach is vastly greater than the mere study of ancient specimens. To illustrate this point, the manufacture of a bone-tipped harpoon can be considered. The specimen in Figure 1 took the author four days to make with Middle Palaeolithic stone tool replicas, starting with the leg bone of a freshly butchered animal cut up and cleaned with stone implements. Several stone tools were involved in its making, as well as the making of the bamboo shaft, before the bone point was set into the shaft with plant resin and bound with split rattan vine (*Calamus* sp.) coated with beeswax. It is obvious that each stage in the process involves forms of knowledge and expertise, in procuration, processing and use. For instance, the plant resin needs to be heated carefully for this purpose, and the process requires great understanding of material properties, which also applies to the many processes involved in fitting out a seagoing raft. Resins were used in Middle Palaeolithic technologies, and have been found in Germany and Syria (Mania & Toepfer, 1973; Bosinski, 1985; Boeda *et al.*, 1996). In addition to exploring these forms of knowledge, such a project also offers feedback in the form of new archaeological insights. For instance, the bone harpoon replicas have all been studied under the microscope, and from this can be learned new ways of utilizing striation markings in the study of ancient bone tools. This approach (cf. Semenov, 1964) brings to life the study of archaeological specimens in ways not possible by other means.

The same applies not just to individual replicas modelled on archaeological specimens, such as stone implements, but to ways of problem-solving generally: how to replenish drinking water at sea; how to cook on board; how to carry live shellfish: and other everyday issues of technology. Through replication experiments the diversity of culturally acquired forms of knowledge required to succeed in crossing the sea become evident in a way that remains entirely inaccessible to conventional archaeology. To illustrate this point, one of the many experiments of the two expeditions is briefly described.

The *Nale Tasih 1* experiment

The *Nale Tasih 1* was a 23-m bamboo raft of about 15 tonnes (inclusive of superstructures and supplies), built between August 1997 and February 1998 near Oeseli, a remote fishing village on Roti, southeast of Timor. The raft comprised five parallel pontoons of circular section, made of 550 bamboo stalks (Fig. 2). It takes an average of 205 seconds to fell a stalk of average diameter, and 516 seconds to dress it, removing branches, leaves and the top (Fig. 3). Two experienced workers can prepare and assemble the bamboo required for a raft of this size and design in under two weeks, and if the bamboo occurred within a few hundred metres of the Pleistocene dockyard, eight adults could have comfortably assembled the material ready for curing in a fortnight. To acquire its maximal buoyancy, bamboo needs to cure for 4–6 months.

In lashing the bamboo together, several binding materials were used and tested, including *gemuti, pipa lontar* and *rattan*. Thirteen cross members held the pontoons together and supported the deck, of split bamboo, and the superstructures: two raised decks, three weatherproof huts made of woven palm leaves, two A-frame masts, and alternative stands for steering oars. Besides the oars and stands, only the

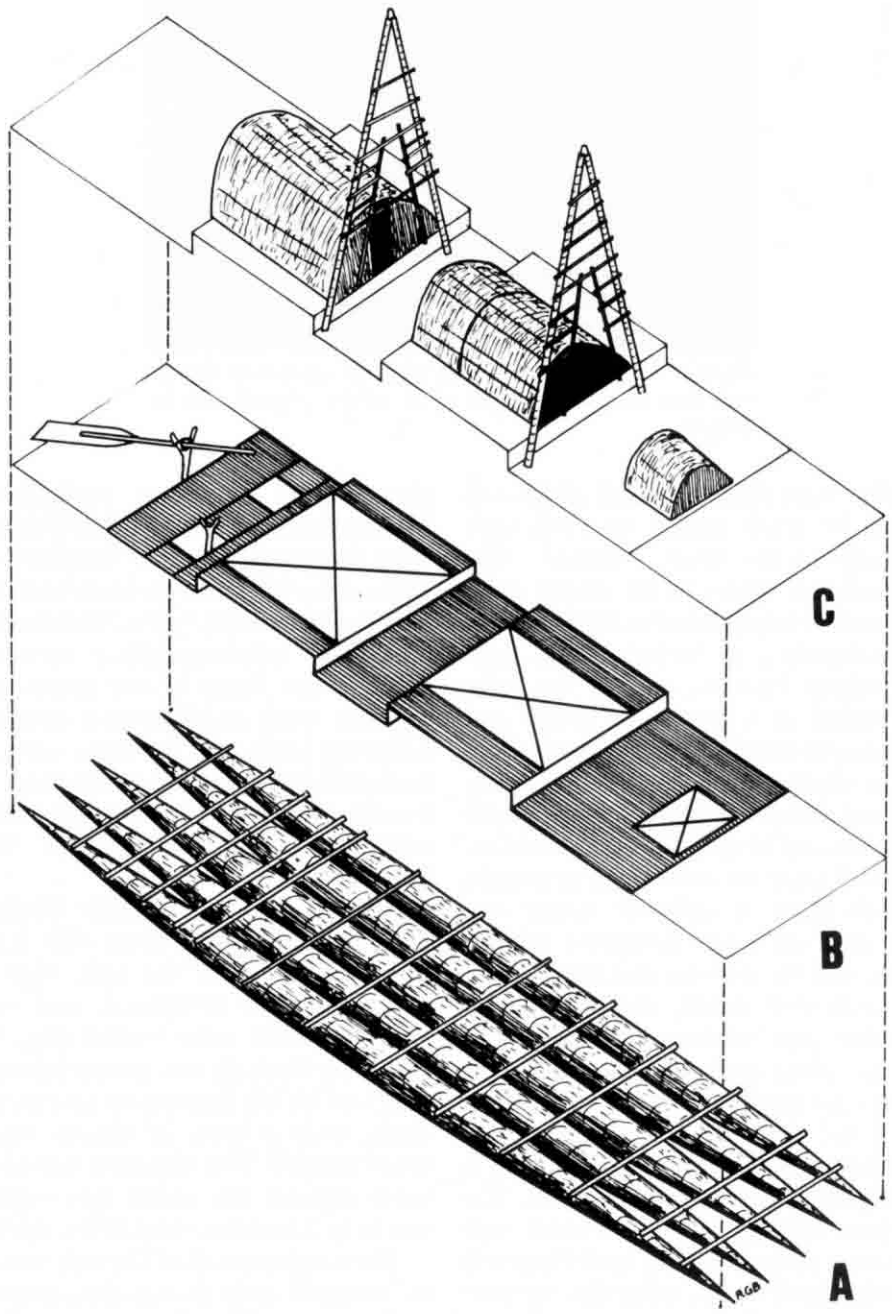

Figure 2. Exploded view of the *Nale Tasih 1* bamboo raft, 23 m long and 5 m wide, showing the arrangement of pontoons (A), decks (B) and superstructures (C). (Drawing: author)

Figure 3. Bamboo stalk felled with the chert tool shown, and then chopped through again on the ground. (Photo: author)

mast joints were made of wood, which was found to be much harder to work with stone implements than bamboo. The leaves and leaf spines of the lontar palm (*Borassus flabellifer*) found extensive use in raft construction, in baskets, mats, sun-hats, cooking buckets, and in the sails. Pork pickled in lontar sugar syrup and goat meat preserved in vinegar made from the same sugar were both stored in cylindrical containers of bamboo, capped with woven palm leaf covers dipped in beeswax. More palm syrup was contained in gourds, while 600 litres of drinking water was carried in three large mangrove trunks, hollowed out by termites and blocked off at the ends with wood, and sealed with paper bark and beeswax. Coconut shells served as eating and drinking cups. Live shellfish were carried alongside the raft in baskets, and the food provisions also included native millet, *kusambi* fruit and a large supply of half-ripe coconuts. The millet gruel and the preserved meat were cooked over an open fire, lit by drilling soft wood with hard wood, using dry coconut husks as tinder (Fig. 4).

However, it was expected that the principal sustenance would be provided by marine food acquired at sea. For this purpose, the *Nale Tasih 1* was equipped with eleven bone harpoons, replications of Middle Stone Age and Middle Palaeolithic bone harpoons, set into bamboo shafts. There were 170 stone tools on board, all of Middle Palaeolithic types, most made from dark-grey, microcrystalline sedimentary silica, a few from brown jasperite. The majority were multi-purpose cutting and chopping tools, and the most worn specimens will be subjected to microwear study. Finally, the vessel's anchor consisted of a naturally perforated block of Tertiary limestone.

After the launch of *Nale Tasih 1* on 14 February 1998, when 400 Rotinese lifted and carried the raft, the superstructures were completed, and supplies and equipment were loaded (Fig. 5). On 6 March, the raft was towed through the heads of Oeseli Lagoon to commence sea trials, with a crew of eleven, including three females. The objective was to determine whether the vessel was capable of reaching Australia, some 800 km away.

The displacement of the raft was found to be significantly greater than anticipated, and upon reaching the open sea, the deck was under about 15 cm of water. Sails and rigging performed very well, but could not compensate for the excessive weight of the largely submerged vessel. Steering was

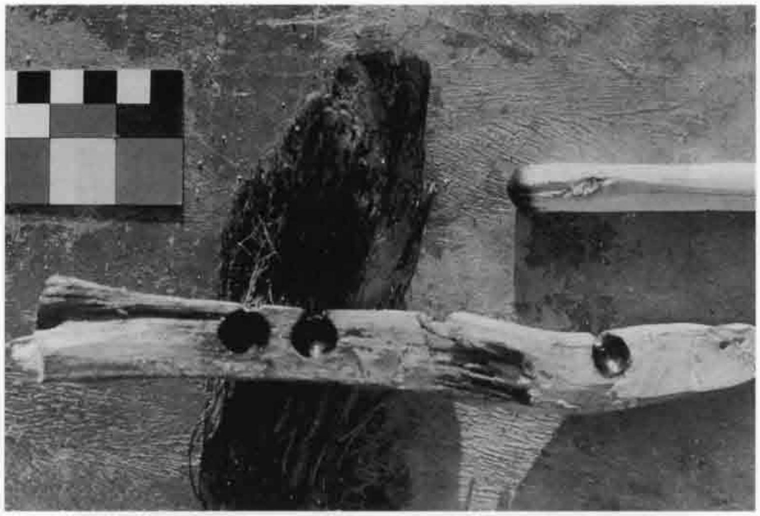

Figure 4. Fire-making equipment used on the *Nale Tasih 1*: hardwood drill (right), softwood base and coconut husk. (Photo: author)

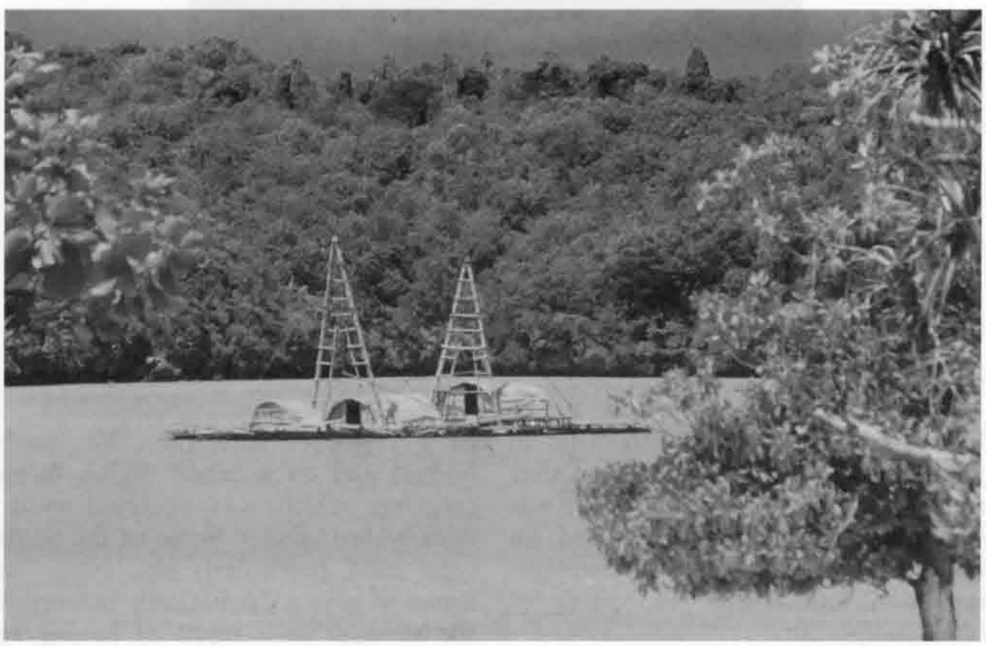

Figure 5. The *Nale Tasih 1* in Oeseli Lagoon shortly before sea trials. (Photo: author)

inadequate in that the oar was found to be too short to be effective. The raft showed excellent flexibility, as its overall construction allowed it to flex with every wave rolling under it. However, current, wave direction and wind direction were all unfavourable. El Niño had affected the north-west monsoon adversely, and the maximum speed achieved was 1·7 knots (Fig. 6). With an average speed in the

Figure 6. The *Nale Tasih 1* during sea trials in the Timor Sea. (Photo: author)

order of 0·5 knots it was unrealistic to expect the raft to reach Australia, and after completion of sea trials and tests, it was towed back to Oeseli and beached on 9 March, in order to conduct extensive examination and destructive testing of selected components.

Over the following week, the raft was completely stripped down to its basic components. A 30-cm section was removed by chainsaw from one of its pontoons (Fig. 7), to determine the performance of various bamboo species and the effects of water penetration. It was found that 93% of all air chambers had contained water, mostly as a result of infestation by bamboo borers, and to a lesser degree through cracking, which was observed even in thick-walled species. Some of the cordage types used, particularly *pipa lontar*, were found to have a dramatically reduced tensile strength as a result of having been soaked in sea water, while others had performed very well. It is clear that the raft had been overloaded and would have sunk further, had it travelled on.

Conclusions

Thus the thorough examination of the failed raft showed clearly that the *Nale*

Figure 7. Destructive sampling of bamboo pontoon of *Nale Tasih 1* with chainsaw. (Photo: author)

Tasih 1 would not have reached Australia. It also provided a great deal of valuable data for the design of *Nale Tasih 2*, and some of the expensive components of the first raft were salvaged for reuse. The most important result of the *Nale Tasih 1* experiment was, however, the realization that the technology of Middle Palaeolithic seafarers had been massively underestimated. The numerous replicative procedures involved in the construction of a bamboo raft permitted unparalleled insights into the technological competence of the early mariners. They include details about the acquisition, transport, processing, storage, curation and application of numerous types of materials, the need for a comprehensive understanding of their properties, and for an ability to predict their performance over time. These forms of information, without which it is impossible to undertake such a project, needed to be communicated to others in the group in question, particularly to the next generation. This involved competent use of an appropriately complex communication system. The same applies to the requisite ability to organize the considerable labour investment required to construct a raft, and of motivating the work group, not to mention the need to convince the crew to embark on this course of action in the first place, and to persist with it over a period of months. It is difficult to see how all this could have been possible without the effective use of speech, or in the absence of a well-established cultural and social system.

Broca's and Wernicke's areas, the anterior and posterior speech cortices, occur on endocasts of *Homo habilis* (Tobias, 1980, 1981, 1987; Falk, 1983). While this may perhaps not prove the use of language two million years ago, its use one million years ago is effectively demonstrated by the level of culture that led to marine colonization in Indonesian waters.

The *Nale Tasih 1* experiment has shown, even through its failure to succeed in crossing a sea barrier that was navigated by humans at least 60,000 years ago, that the knowledge and technological skills required to sail the open sea are significantly greater than most archaeologists are capable of imagining. The mariners on the *Nale Tasih 1* were highly motivated, they had at their disposal knowledge not available to the Palaeolithic seafarers, yet they failed where others succeeded eons ago. Their experiment also lays to rest the thought, entertained by some archaeologists, that the Pleistocene sea crossings may have been made unintentionally, by people swept out to sea.

The voyage from Timor or Roti to Australia was made by a marine people whose accumulated knowledge derived from a history of seafaring spanning at least 700,000, and quite probably a million, years. It was preceded by many other crossings of sea barriers, beginning with that of Lombok Strait, and thus of the Wallace Line, the most important biogeographical filter in the world (Bednarik, 1997b). In all these previous cases, the target land was well visible from the point of departure, and in all or most of them, humans had been preceded by elephants or Stegodontidae. We have no good reason to assume that the proboscideans were swept out accidentally; their outstanding long-distance swimming ability had led them to cross to new land, to which they swam in herd formation. In the cases of hominids, their ability to build seagoing vessels and their faculty of systematic planning were essential for marine colonization. The hominids some describe as having a '15-minute culture' because of their 'short attention span' (Gamble, 1994: 138), as unable to understand a sentence because 'the listener might forget the beginning of the sentence before it has been finished' (Gamble, 1994: 171), were in fact capable of planning and executing projects involving many months of concerted endeavour, and of communal collaboration in an effort with a totally abstract goal. None of this is realistically possible without language, established social structure, and a thorough, culturally-based understanding of material properties and natural phenomena that could not be matched by the experienced mariners on *Nale Tasih 1*. This conscious comprehension of natural phenomena probably included an understanding of indirect indicators for the existence of land, where the land itself remained out of sight: land-borne cloud formations or smoke columns; and the movement of birds and sea animals. The existence of Australia was almost certainly deduced from such signs observed at sea, probably while fishing, and the courageous decision to build a larger raft than usual, and to set out to find that land, was entirely deliberate. These Palaeolithic people of the 'short attention span' have been misjudged by minimalist interpretations and a slavish adherence to the 'Garden of Eden' model.

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