THE ORIGINS OF PLEISTOCENE NAVIGATION IN THE MEDITERRANEAN: initial replicative experimentation

by

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Abstract: Techniques of investigating questions of Pleistocene seafaring developed in Indonesia and Australia are applied to questions of the beginnings of Mediterranean navigation. This paper describes first preparations for maritime experiments intended to examine the region's archaeologically demonstrated or suspected sea crossings of the Pleistocene. A series of initial replicative experiments has been conducted in Morocco, as part of a project intended to clarify the conditions under which the earliest navigation in the Mediterranean took place. This involved the use of various Lower Palaeolithic technologies that could be applied in the construction of seaworthy watercraft.

Key-words: Replication; seafaring; Pleistocene.

Resumo: Neste artigo aplicam-se a questões relativas aos começos da navegação no Mediterrâneo técnicas de investigação das travessias do mar durante o Pleistoceno desenvolvidas na Indonésia e Austrália. Descrevem-se os primeiros preparativos para experiências realizadas hoje no mar, experiências essas que se destinam a examinar possíveis travessias marítimas – demonstradas ou de que simplesmente se suspeita, de um ponto de vista arqueológico – durante o Pleistoceno. Fizeram-se uma série de experiências preliminares, em Marrocos, baseadas em réplicas. Tais experiências integram-se num projecto que pretende clarificar as condições em que se deram as mais antigas navegações no Mediterrâneo. Esse processo implicou a utilização de diversas tecnologias do Paleolítico inferior, as quais poderiam ter sido usadas na construção de dispositivos que possibilitassem a navegação marítima.

Palavras-chave: Réplicas; navegação marítima; Pleistoceno.

INTRODUCTION

The global evidence presently available for Pleistocene maritime navigation reveals a pattern of widespread island colonisation during the Late Pleistocene, and of much earlier sporadic seafaring feats in two world regions, south-eastern Asia and the Mediterranean

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(Bednarik, 1997, 1999a). So far, one continent and about twenty islands have been demonstrated to have been initially colonised in the Pleistocene (Bednarik, 1999a, 1999b). Sea barriers have acted as technological filters for hominids, in the sense that crossing them became 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 sea distance a breeding population was able to cross. If we possessed adequate information about the technological level humans required to cross specific barriers as breeding groups, the maximal technological capacity at specific points in time could be determined with much greater accuracy than by any other means available to us. The *First Mariners* project – some aspects of which will be related in this paper – seeks to establish the minimum technology required for all known Palaeolithic maritime colonisations through a series of experiments.

The principal importance of the hominid maritime navigation capability is not, however, that it enabled *Homo erectus* to settle a number of islands (Verhoeven, 1958; Maringer and Verhoeven, 1970; Sondaar *et al.*, 1994; Bednarik, 1995, 1997, 1999a, 2000; Bednarik *et al.*, 1999; Bednarik and Kuckenburg, 1999; Morwood *et al.*, 1999). What marks the human ascent more than any other development is 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 using the energies of wind, wave action, current and buoyancy was their breach of a sea barrier. Rather than the invention of the wheel, of agriculture, writing or flying machines, this was the most consequential single achievement in human history. The destiny of humanity was decided more than 850,000 years ago, when hominids made a conscious decision to entrust their very existence to a contraption they themselves had built, and to seek their future in an unknown land. It has led to the irreversible and ever-accelerating technological spiral that now transforms the biomass of our planet and has begun to affect other objects in space. The ongoing extinction catastrophe on Earth has developed alongside this technological ascent of our species, mushrooming at a rate massively outstripping our physical, cognitive and intellectual evolution.

Replicative archaeology experiments with numerous types of materials have been conducted in the course of the *First Mariners* project, in Morocco, Indonesia and Australia: stone implements, bone harpoons and other artefacts of the traditions in question have been replicated, and numerous organic materials of potential use in Pleistocene maritime navigation have been tested and used. Six prototype and full-scale primitive rafts have been constructed, two of them entirely with appropriate stone tool replicas, the remainder partly so. These vessels have been sea-trialled, and four actual crossings were attempted so far. The first, from Roti (Indonesia) to Australia failed, primarily due to material defects (Bednarik, 1998a, 1998b). The second, from Timor to Australia, succeeded in December 1998, when a bamboo raft covering almost 1000 km reached Australia under dramatic conditions (Bednarik, 1999b; Bednarik *et al.*, 1999; Bednarik and Kuckenburg, 1999). The third, repeating history's first crossing of Wallace's barrier between Bali and Lombok, failed due to strong and unpredictable currents in Lombok Strait. In January 2000, the attempt of this crossing succeeded with a very simple raft propelled by twelve paddlers (Bednarik, 2001). Next, a series of sea crossings on primitive rafts of various materials and designs will be attempted to Mediterranean islands reached by Pleistocene seafarers (Bednarik, 1999a).

The earliest archaeological evidence for seafaring in the Mediterranean is estimated to be about 300,000 years old, consisting of a series of stone implements excavated from three different occupation horizons at the site Sa Coa de sa Multa, near Perfugas, northern Sardinia (Martini, 1992; Bini *et al.*, 1993; Sondaar *et al.*, 1995). Discovered by Fabio Martini from Siena University, these tools resemble the Clactonian, a Lower Palaeolithic industry first identified in England. Sardinia, although joined to Corsica at times, was never connected to the Italian mainland for the entire duration of hominid history (Fig. 1). While their dating remains to be reliably secured, the Sardinian tools seem to predate the Middle Palaeolithic settlements of Crete and Kefallinía (Bednarik, 1999a).

Nevertheless, there are several forms of indirect evidence that much earlier hominids crossed the narrow seaway between north-west Africa and the Iberian Peninsula in Early Acheulian times (Freeman, 1975; Johnstone, 1980; Bednarik, 1999a). On present indications this could have been up to a million years ago, and it would indicate that the first humans to have reached Europe did not come by land from the east, but as mariners from the Maghreb. It is important to appreciate that, strictly speaking, there is no such thing as a Mediterranean archaeology of the Pleistocene available to us: the numerous eustatic oscillations have ensured that no evidence of coastal or near-coastal societies and economies could have survived – along the Mediterranean or any other sea. Hence all the information we have about Pleistocene culture and technology is massively distorted, coming as it does entirely from perhaps 'impoverished' inland economies and mobile hunting communities. We have virtually no information about marine economies of the period, when it should in fact be assumed that at least one half of all Pleistocene humans were essentially coastal dwellers.

The purpose of the present paper is not to pursue any of these questions, or to discuss the pros and cons of a Lower Pleistocene crossing near Gibraltar. For the time being the evidence in its favour remains circumstantial, and I emphasise that I do not seek to 'prove' anything, in any of my many First Mariners experiments. As a scientist I do not 'prove' hypotheses, I test refutable propositions by seeking to falsify them, and I have no patience with archaeologists who, not understanding the scientific process, falsely assume that my work is confirmation inspired. To make my position quite clear: at present I have no idea, or preference, whether Europe was initially colonised by land from the east, or by sea from the south-west. I will test both propositions without favouring either, and I will report my findings. I do not intend to discuss misconstructions of the purpose of this work inspired by an inclination to attack it. But we do need to appreciate that the Indonesian evidence from such islands as Flores and Timor demonstrates conclusively the presence of hominids during the Lower and Middle Pleistocene, on islands that were never connected to either the Asian (Sunda) or Australian (Sahul) plate (Wallace, 1890; Bednarik, 1997). If the hominids of Java had developed navigational skills a million years ago, as we must assume on the basis of the extensive dating evidence now available to us, it would be judicious to consider the possibility that they might have done so also in north Africa. Moreover, a crossing from Africa to Iberia would have been considerably shorter and less dangerous than crossings known to have occurred around that time elsewhere (Bednarik and Kuckenburg, 1999).

REPLICATIVE ARCHAEOLOGY

The first experimentation in Pleistocene marine technology at the Strait of Gibraltar, and indeed in the entire region of Africa and Europe, was undertaken in September and October 1999, as part of the First Mariners Project. It involved work with a number of locally available materials, including animal hides, whole animal skins, softwood, cane, palm fibre and bees wax. Two prototype watercraft were assembled, one a pontoon raft of cane, the other of inflated animal skins, and all of this work was conducted entirely with stone tools of black chert (flint-like sedimentary silica of Australian origin). All tools used in the experimental work were replicas of Lower Palaeolithic tool types, including 'handaxes', cleavers, hand adzes and cutting flakes of Acheulian and Clactonian forms. All tools used extensively were retained for subsequent micro-wear analysis (Fig. 2).

The purpose of this study was to establish a working base for a projected attempt to cross from the north African coast between Tangier and Ceuta to the Spanish coast, i.e. to traverse the Strait of Gibraltar, on several rafts of the most primitive designs possible, in 2002 or 2003. A suitably sheltered beach near Ksar Seghir, east of Tangier, was chosen as the assembly site. This part of the Moroccan coast is mostly steep, dominated by ridges of fine-grained sandstones, mudstone facies and occasional dyke formations. The maritime regime is determined by either easterly or westerly currents, which change fortnightly in accordance with the lunar phases. Prevailing wind directions are also either east or west. It is assumed that these conditions, particularly those of the currents, were much the same in the Pleistocene, as no significant change to the seabed or shore line contours has been caused by eustatic oscillations, and the impact of the moon would presumably have been similar in the past.

Experimentation undertaken in the course of this work included various potential technologies. Thirty stone tools had earlier been knapped at the massive chert deposits near Mt Gambier, South Australia, and had been modelled broadly on Lower Palaeolithic types of the Maghreb and south-western Europe. All had been made by direct hard impact, with minimal retouch, and they ranged in size from a 19-cm ovoid biface to small thin lamellar flakes. On the whole, working edge angles of >30° were preferred, including for cutting cane, and some of the hand adzes had angles of 70° to 80°, similar to woodworking tools I had observed ethnographically in north-western Australia in the 1960s. Spokeshaves and knives generally ranged from 20° to 45°.

Woodworking focused on the manufacture of a 1.6-m-long paddle of conifer wood, which took about one day. The rough adze finish was partly polished with a sandstone beach cobble to match the finish on the polished willow 'plank fragment' from the Acheulian of Gesher Benot Ya'aqov, Israel (Belitzky *et al.*, 1991). Such polish can be achieved without any great effort, therefore its technological significance may have been somewhat exaggerated.

Thin-edged chert flakes were used to cut dried goat hide into strips of about 10 mm width, to be used as thongs. Suitable stone tools were found to be highly effective but some dexterity is required to keep cuts straight and parallel. Complete goatskins were obtained by the following traditional method.

Immediately after an animal is killed, a small incision is made in one of its hind legs, just below the knee. The skin around the incision is carefully lifted away and the operator then blows air from his lungs into the opening between the skin and the carcass of the animal. With some effort the skin is literally inflated up off the still warm carcass, rather like a balloon. Once the whole skin is free, the extremities are removed at the joints and the head is cut off near the upper end of the neck. A line is cut from the initial incision to the other knee of the hind leg and the remaining carcass is then pulled through this opening in one complete piece. Therefore the skin now has two small opening where the forelegs were, one where the head was, and a larger opening across the rear. Before closing three of these, the skin has to be checked for any small holes elsewhere, but it is preferable to use only flawless skins. Any defects need to be sealed by applying a sealant, placing a small disc of cork or similarly light material on it, and tying the skin over it with a strong cord (e.g. sinew). In my experiments I used bees wax as the sealant which I found to be inadequate, bitumen or vegetable resins (such as we used in sealing cracked bamboo in Indonesia) would be more effective. The use of both of these substances has been recorded from the Middle Palaeolithic period (Bednarik and Kuckenburg, 1999), and sealants may be prepared by mixing them with animal fats or brain tissue.

Next, the opening at the back and those at the forelegs are sealed, and then the whole skin is turned inside-out, which means that it has to be passed through the neck opening. All the sealant applied thus ends up on the inside, which means that it will be pressed against the openings it is intended to seal once the skin has been inflated. A short piece of hollowed cane is inserted into the remaining opening and, holding the skin tightly around the tube it is inflated by lung power. When it reaches full capacity a string is placed around the neck skin, the blow tube is withdrawn quickly, and the inflated skin is pushed under water to check if any air bubbles escape. If so, the skin has to be deflated, inverted, and the leaking seal repaired, after which the rest of the procedure is repeated. Once the skin is air proof some sealant is applied to the inside of the skin at the upper neck and string is tightly wrapped over the outside of the skin containing the plug of sealant.

Such inflated animal skins were among the most buoyant of all flotation means available to Pleistocene navigators. Another possibility would have been the use of inflated bladders of large animals, especially proboscideans. To render such equipment functional it had to be harnessed into a suitable frame holding it in position. In facilitating this it was found useful to leave long ends on the cordage applied to seal the individual skins. In the experiments described here the skins were strapped to a frame of cane, which is easy to work with stone tools. To cut a 30-mm stem only takes a few seconds: held tightly against the stone flake (Fig. 2, centre specimen) positioned at right angle to it, using the thumb to grip the cane, it is scored by a combination of pressure and cutting action, and then rotated slowly with the second hand, with the stone tool cutting a groove around the cane's circumference. After five or six seconds the length of cane can be snapped in two effortlessly (for more details in cane working, see below).

One of the difficulties of constructing a raft of animal skins concerns the means of strapping the flotation units tightly into their intended positions so that they will retain them securely once the payload is applied, pushing the vessel under water. In practice, about six skins of goat-sized animals are needed per human passenger, therefore a raft intended to convey a number of potential colonisers involves the use of many skins that must be secured in such a way that they are held below the raft platform. The skins of large ungulates are still used in this way ethnographically in some regions (Bednarik and Kuckenburg, 1999: 166). A lightweight frame of cane can easily be constructed with bindings of split cane, sinews or leather thongs, which can support a platform of similar material.

A 'LOWER PALAEOLITHIC' PONTOON RAFT

Nevertheless, a much easier method is to construct a very simple pontoon-type raft of cane alone. The cane presently growing in abundance along the northernmost coast of Morocco occurs in dense stands on any reasonably well watered land available to it. Reaching a maximum height of some 6 m, at which it has a basal diameter of almost 35 mm, its physical properties are closely related to soil composition and water availability. The air chambers usually range in length from 7 cm to 25 cm, their length typically reducing from bottom to top. Where the stem curves, just above ground level, it is slightly elliptical in section, otherwise the section is perfectly circular. Except for the thickening at the joints that separate the air chambers, the wall thickness is slightly over one-tenth of the diameter. This means that the total air space amounts to a volume of 45-50% of the bulk volume of each stem. In short, the buoyancy of each fully cured stem allows it to carry a payload roughly equal to its own weight before it is fully submerged. In that respect it is therefore superior to almost any type of timber.

Harvesting of the cane with Lower Palaeolithic stone tools requires very little effort. Using an Acheulian-type biface ('handaxe') or a thick flake chopper, a stalk of 25-30 mm can be chopped off at its base with one or two well-directed blows. A bundle of about 40 cm diameter, of a weight that can easily be carried by one man, takes no more than 5 or 10 minutes to harvest and assemble. The leaves are not removed at this stage, they are easier to strip off after drying. As the green, freshly cut cane is much too heavy to float effectively it needs to cure for 5-6 months to achieve its maximum buoyancy. In contrast to the large bamboo species of South-East Asia, which may split if they are not carefully cured, this much smaller cane is simply dried in a vertical position, exposed to sun and rain. Also, whereas the Asian bamboos are highly susceptible to infestation by bamboo borers which renders them unsuitable for raft construction (Bednarik, 1998a) and must therefore be harvested during a specific brief phase of the lunar cycle, I have not observed a similar infestation in the Moroccan material. However, if the cane were left on the ground it would soon attract fungal infestation or other deterioration.

Concerning the availability of large gramineous species in north-western Africa during Palaeolithic times, it is relevant to note that such vegetation types were far more widespread during the Pleistocene, ranging not just along the coastal perimeters, but extending far inland. For instance the huge Fezzan lakes in the Muzuq Basin of western Libya, which occupied an area three times the size of modern Lake Victoria, were surrounded by dense cane belts, which in the late Acheulian were annually burnt in places by hominids for periods of many millennia (Ziegert, 1995: 11).

Once the stalks of cane are cured, the now dry and brittle leaves can easily be stripped off by hand and their thin tops be broken off, but this is not essential. Cane bundles of manageable size, preferably weighing 20-30 kg and in the order of 5 m long, are strapped together tightly, using split cane bindings. These, however, need to be made from green stalks as the cured material lacks the required flexibility.

The production of such split cane bindings involves considerable manual skill. The freshly felled stalk is stripped of its leaves, scored circumferentially with a flint flake along an air chamber near its thick end, which is then snapped off. The thin edge of a stone blade is then pressed very hard against the end of the cane, taking care that it is positioned precisely over the centre of the circular section. The end of the cane should then split in half, up to the next air chamber joint along the stalk. To extend the fracture through the joint, the two halves are levered apart with a slight twisting movement of the stone tool, which leads to the splitting of the next air chamber, up to the next joint, and so forth. However, there is a tendency for the split to veer off centre as one proceeds along the stem. This has to be countered as soon as it becomes apparent, by bending the half that is becoming larger then the other slightly more as the two are levered apart at the next joint. This arrests the deviation quite effectively in skilled hands, bringing the splitting plane back into the central axis. In the hands of the experienced operator these almost imperceptible corrections at each joint are executed with almost reflex-like skill.

Once the stalk is separated into two equal halves, each of them is split in precisely the same way, again starting from the thick end, again correcting for any deviation in the splitting plane. Finally, the resulting quartered strips are also halved, thus yielding a total of eight cane strips that are in the order of 12 mm wide and 3 mm thick at the thick end, and measure perhaps 5 mm by 2 mm at the other end. To improve their pliability they need to be run around a tree trunk. The operator firmly grasps the two ends of each strip and, with an energetic, sweeping to and fro movement, runs the inside of the strip over the surface of the tree trunk (i.e. the silica-rich outer epidermis must be on the outside of the curvature). A half-dozen such movements will not only render the strip more pliable and less prone to snap when bent, it will also smoothen the burrs on the inside of the cane where the joints between its air chambers used to be, and it will eliminate any defective lengths.

The resulting strip of green cane will be several metres long and while it does not match the tensile strength or pliancy of the clearly superior rattan of South-east Asia, it does provide adequate lashings for the construction of a simple pontoon-type raft. Each of the prepared bundles is lashed together at intervals of well under one metre, with a single cane strip. The use of fully formed knots is not possible with this material, because it breaks when it is bent sharply. However, the split cane is wrapped tightly around the bundle several times and the two ends are then secured with series of half hitches. (Even extant apes possess elementary skills at knotting, gorillas for instance make granny knots and reef knots in constructing their nests [Sanderson, 1937: 187], and we can assume considerably more advanced abilities for early hominids [Warner and Bednarik, 1995].) Half hitches were found to be quite adequate to construct a water craft able to withstand the rigours of sea trials.

In the experiments conducted at Ksar Seghir in 1999, four bundles of 30-35 cm diameter were selected from among those made and were assembled to form a pontoon raft. They were held together by five cross members, each consisting of three short pieces of thick cane. Each bundle was then lashed onto each of the thwart pieces, using again lengths of split cane (Fig. 3). Finally, the four bundles were tied together at each cross member to ensure that their bindings could not permit them to slip sideways and thus become detached.

This vessel, almost 5 m long and 1.4 m wide, had an estimated weight of 120 kg, consisting entirely of cane. It took two men a mere three hours to assemble from already cut and cured cane, after which it was launched by four men on a beach just west of Ksar Seghir, in calm water (Fig. 4). Its draft of only 14 cm did not increase substantially after placing one man on board, but a doubling of the payload pushed the top of the vessel almost down to water level. A second sea trial, two days later, demonstrated the craft's stability even under quite turbulent conditions, despite its relative narrowness. A coastal swell, choppy sea and several collisions with rocks had no adverse effect, and it was clear that a broadening to, say, 2 m would result in a craft capable of withstanding all but the most extreme maritime conditions.

CONCLUSIONS

The first experimental archaeology in Pleistocene maritime technology undertaken in the general region of Europe and Africa has followed on from the experience gained in Australia and South-east Asia. The site chosen is on the short stretch of the Moroccan coastline most likely to have been the point of departure of any Pleistocene crossing from Africa to Europe. While it is very probable that such crossings were made in the Late Pleistocene, their occurrence significantly earlier remains a subject of investigation and may never be conclusively demonstrated. Nevertheless, the archaeological evidence as it stands, particularly the absence of an early Acheulian in eastern and central Europe vis-a--vis the rich evidence from south-western Europe, especially Iberia, suggests that the Strait of Gibraltar may have been crossed by hominids very early. Other factors to be considered in this context are the great similarity in the technological and cultural trajectories of Lower Palaeolithic industries north and south of the western Mediterranean, the inclusion of disc beads in the Acheulian of both regions, and the evidence of lake navigation by Acheulians of the Fezzan (Werry and Kazenwadel, 1999).

The purpose of the present work was to review local maritime conditions and the availability of local materials that may conceivably have been of interest to Lower Palaeolithic people. In particular, two options of raft construction were examined, and two prototype pontoon rafts (Bednarik, 2000) were constructed with Lower Palaeolithic stone tool replicas, and were tested. One was made entirely from cane, the other relied on inflated animal skins for buoyancy. The experiments implied a considerably greater complexity of the latter option. For instance, while no knots of greater sophistication than half hitches are required for the construction of a basic but robust reed or cane pontoon raft, more effective knotting as well as structural planning are essential for the skin raft, primarily for securing the skins. The preparation of the skins demands significantly more complex procedures than the preparation of the cane bundles for the alternative raft type. Most particularly, rendering the skins airproof is a delicate, culturally (learnt) complex process that involves the application of evolved material processing skills. While it has to remain doubtful that these were available to Lower Palaeolithic people, *Homo erectus* of the Indonesian region clearly managed to cross the sea, almost certainly on bamboo rafts. Since the suspected first crossing from Africa to Europe would have occurred during roughly the same stage of hominid development, and since there is currently no indication of any earlier maritime navigation (Bednarik, 1997, 2000), it would be judicious to expect only the most rudimentary level of navigation technology. While the use of inflated animal skins as flotation devices has to be considered realistically possible for a later phase of the Palaeolithic period, it can probably be safely excluded for the Lower Palaeolithic.

It must also be remembered that in comparison to the bamboo or cane pontoon raft, which for all practical purposes is unsinkable if it does not disintegrate, a vessel relying on inflated membranes of any type is rather susceptible to fatal damage. Sharp rocks and other objects, including the ends of the frame components, not to mention a variety of marine creatures, can all puncture the skins or bladders. While a skin raft does offer the significant benefit of an extremely high ratio of vessel weight to carrying capacity (a raft capable of carrying several people can itself be carried by one man), its fragility and its technical complexity would both favour a much earlier development of the more robust bamboo-based rafts, most especially of the pontoon type (Bednarik, 2000).

Also to be noted in this context is the apparently complete lack of ethnographic evidence of a maritime use of skin pontoon rafts. While their use on lacustrine, estuarine or riverine waters is so widespread (Bednarik and Kuckenburg, 1999: 166), their maritime suitability may be limited to near-coastal waters. Bamboo rafts, although not observed ethnographically on the high seas, certainly were widely used in minor sea crossings in historical time. For instance they were regularly used up to the beginning of the 20th century to cross from Roti to Timor, a distance of around 10 km, i.e. similar to that to be crossed near Gibraltar.

This project has only been of a preliminary nature, but it nevertheless forms an important part of the overall First Mariners Project. It has suggested the feasibility of crossing the Strait of Gibraltar by purely Lower Palaeolithic means. Examination of archaeologically recovered stone tools of that period from Morocco has been commenced as part of this project, and comparative studies of Maghreb and Iberian industries are in progress. It is clear that the archaeological data from these two regions needs to be far more comprehensively studied, and that several other avenues need to be explored over the coming years. Nevertheless, the study of Mediterranean Pleistocene seafaring has at last commenced in earnest.

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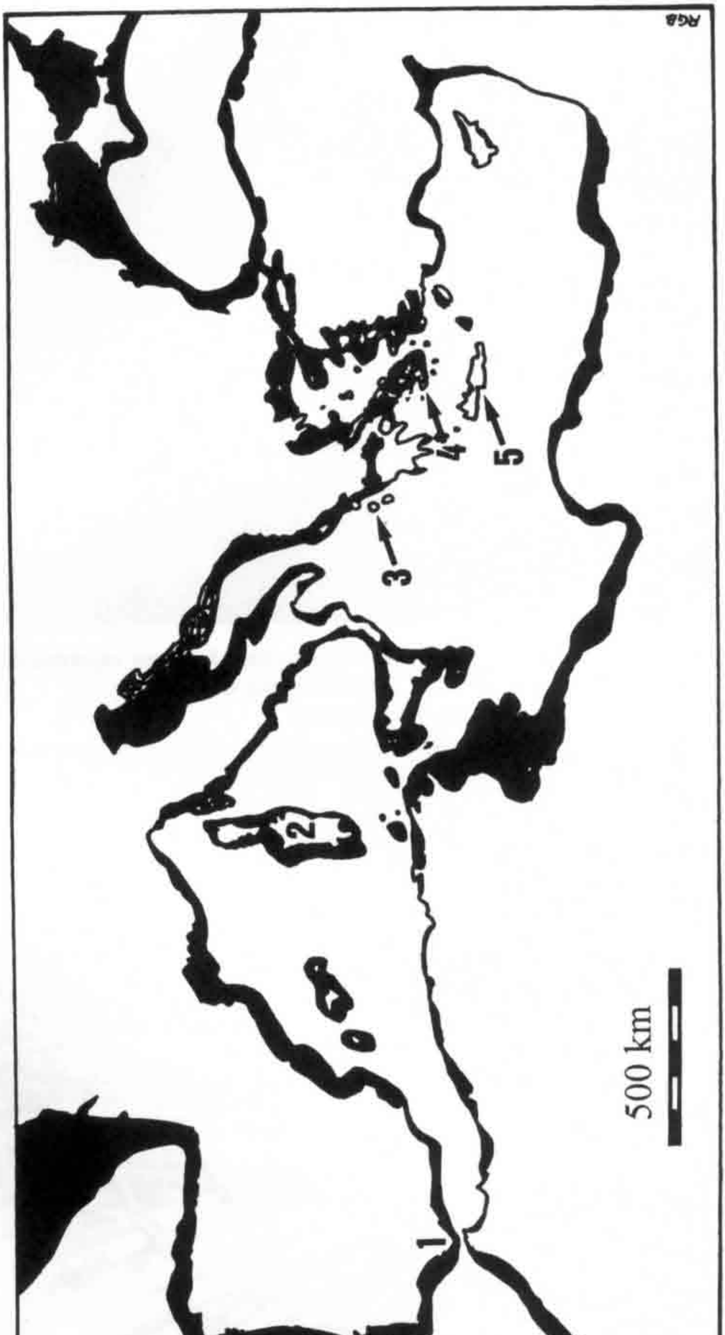

Fig. 1 – Mediterranean locations of Pleistocene sea crossings inferred from archaeological evidence: 1. Gibraltar, 2. Sardinia, 3. Kefallinía, 4. Melos, 5. Crete. The black areas, above -120m, were exposed during the Last Glacial Maximum.

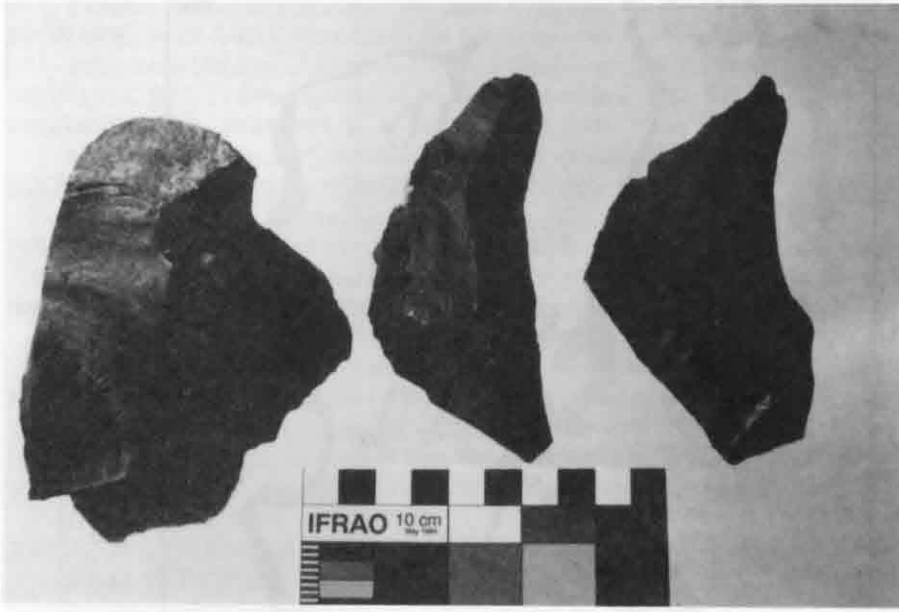

Fig. 2 – Three of the stone implement replicates used in the Moroccan experiments. The centre specimen was used to cut cane, the two others were used in woodworking.

Fig. 3 – The construction of a 5-m prototype pontoon raft made entirely of cane and with the exclusive use of stone implements.

Fig. 4 – The launch of a prototype pontoon raft near Ksar Seghir, Morocco, October 1999.