The Pleistocene Peopling of Greater Australia: A Re-examination

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Abstract: The problem concerning the initial Pleistocene peopling of Australasia is reviewed in light of recent findings that suggest this settlement may be earlier than the conventional view of 35,000 to 40,000 BP. Methods including anthropogenically interpreted paleoecological changes and the application of luminescence dating techniques clearly suggest people settled this continent earlier than the applicable limits of conventional radiocarbon analysis. Early luminescence ages at the Ngarrabullgan Cave (David *et al.* 1997), Malakunanja II (Roberts *et al.* 1994), Nauwalabila I (Roberts *et al.* 1994), and Jinmium (Fullagar *et al.* 1996) clearly indicate that the initial phase of Australian prehistory must be re-examined and radiocarbon ages may no longer be an applicable methodology utilized to obtain ages for the initial settlement of Australia.

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Introduction

The initial peopling of Australia has been one of the most intriguing problems faced by archaeologists, paleo-anthropologists, and prehistorians. It was not until the latter part of this century, with the advent of radiocarbon dating, that Western scholars had undeniable proof of the Pleistocene origin for Australia's aboriginal population. It is generally agreed that the first occupants of Australia had origins in the closest proximal landmass of Pleistocene Southeast Asia. Since these two areas have never been connected by land throughout the Quaternary period, colonization of Australia must have been accomplished with the aid of watercraft. The past generation of prehistoric research in Australasia has attempted to provide a temporal chronology for the initial occupants of Australia and its adjacent islands of Tasmania and New Guinea. Although much information has been recovered concerning the initial peopling of Greater Australia, there is still much scholarly debate concerning the timing of the first modern *Homo sapiens* on this island continent. This paper will review the issue of the first Australians, and the current archaeological, paleoenvironmental, and paleoanthropological evidence, along with the major interpretations of the material discussed. Attention will focus on the debate concerning the timing and the species involved with the initial hominid occupation in Australia along with the related debate concerning Pleistocene dating methods.

Pleistocene Geography of Southeast Asia and Greater Australia

The geography of southeast Asia and Australia has not remained constant through the ages (Lowe and Walker 1997). During much of the Upper Pleistocene, global water reserves were largely stored in continental glaciers in both the northern and southern hemispheres. This dramatic change in the earth's hydrologic regime caused global sea levels to fall 150 metres from their present state, exposing vast amounts of the Australian and South Pacific continental shelves (Birdsell 1977). Shallow sea-straits that now separate the present islands of Tasmania and New Guinea from mainland Australia were open plains, forming the vast Pleistocene continent of Greater Australia or Sahul. Exposed sea shelves became land bridges between South East Asia the present islands of Sumatra, Java, Bali, and Borneo, creating the continent of Sunda. At the same time, the islands of Wallacea, comprised largely of present Sulawesi and Timor, became probable "stepping stones" between the two Pleistocene continents (Fagan 1995). Most importantly, the landmasses of Sahul and Sunda never shared a landbridge, and the islands of Wallacea remained always separate from these two continents. During the lowest Pleistocene sea levels, about 30 kilometers of open water would have separated Wallacea from Sunda and at least 90 kilometers from Sahul. These relatively short distances are considered key factors in allowing the probable human colonization of Sahul during this period (Birdsell 1977).

Pleistocene Archaeology of Sunda

Since the earliest Australians likely had their origins in the landmass of Sunda, a discussion about its Pleistocene occupants is essential for understanding the eventual peopling of Sahul. Evidence of the earliest hominid population in southeastern Sunda comes from the 1.16 million year old BP *Homo erectus* find at Sangiran in Java (Jones 1989). Although some debate exists regarding the reported antiquity of this find (Fagan 1995), there is firm evidence for a *H. erectus* presence in the region by 780,000 BP (Jones 1989). Later discoveries representing a further evolved, more modern looking population referred to as *H. erectus soloensis* may have existed on Java from 200,000 BP up to 75,000-100,000 BP. Jones (1992) indicates that in Java, a single lineage of *erectus* populations inhabited the southeast shore of Sunda for nearly a million years. Evidence of these more modern looking *H. erectus* populations in Java 75,000-100,000 BP has potentially revolutionary implications for the multi-regional approach to modern human origins on a global scale, as well as for the species of hominid populations involved in the initial peopling of Australia.

Archaeological evidence in the islands or mainland southeast Asia is very scarce in spite of the long fossil hominid record (Jones 1992). There is no reliable evidence for archaeological material in association with any of the Java *H. erectus* fossil discoveries in Sunda (Jones 1989). The lack of cultural material from the *H. erectus* sites may be attributed to geomorphic conditions hindering site formation in the hominid bearing beds. It may also be likely that the Java *H. erectus* populations did not make use of stone tools, instead relying on split bamboo as the material used for cutting purposes (Jones 1989). This hypothesized ability of *H. erectus* to manufacture tools out of wood and plants may also suggest they had the technological capability to manufacture rafts or boats. The use of fire is one of the hallmark cultural innovations of *H. erectus*, and evidence of its use may exist in the archaeological and palaeoecological record in the form of charcoal or charred remains of food processing. The Sunda *H. erectus* populations likely left some record of their cultural activities and only further investigation can lead to their discovery.

The only archaeological evidence to suggest the activity of *H. erectus* on the islands of Wallacea, dating to 880,000 +/- 70,000 BP, has recently been discovered from the island of Flores in east Indonesia (Morwood *et al.* 1998). Along with the fission-tracked dated stone tool assemblage at this site, faunal material that is only native to continental Sunda was also recovered (Morwood *et al.* 1998). The island of Flores lies southeast of Wallace's biogeographic line and was never part of Pleistocene Sunda, therefore proving that the continental fauna at the site must have crossed water to get to Flores. The fact that these faunal and archaeological components were found in association suggests to the researchers that the animals must have joined a *H. erectus* population during their sea crossing made with the aid of watercraft (Morwood *et al.* 1998). This is the only archaeological evidence suggesting *H. erectus* in the islands of Wallacea or the rest of Sahul. If the age of the stone tool assemblage at Flores is accepted, it clearly shows that *H. erectus* must have achieved sea crossings and had the potential to settle the continent of Australia.

The Journey from Sunda to Sahul

Although it is generally agreed that human colonization of Greater Australia happened as a result of sea-crossings with watercraft from Sunda, the routes of travel and how this happened remain matters of conjecture. Birdsell (1977) has theorized two major Pleistocene routes from Sahul to Greater Australia. The first route hypothesizes a departure from the Sunda shelf for Sulawesi, passing through a series of islands to reach the northern tip of New Guinea or the exposed Sahul shelf between New Guinea and northeastern Australia. This route, which would entail about three major optional sub-routes, would have a minimum of eight water crossings, and in all cases one or more crossings exceeding 65 kilometers (based on estimates of a maximum eustatic sea level drop of 150 metres during the period around 53,000 BP) (Birdsell 1977). The more southerly passage would begin in Sunda, near the present day eastern shore of Java, passing through the island chain to Timor with two sub-routes arriving on the Sahul shelf of northern Australia. Birdsell (1977) believes that the southerly route would have been more attractive because its initial water crossings are considerably shorter than the northern route. Even with shorter island hops during the majority of the southerly voyage, the final water gap from Timor would have been at least 90 kilometers in distance. Computer simulations suggest that a drifting raft would take about seven days to reach the coast of Australia from Timor with the aid of strong monsoon winds (Fagan 1995).

The important factor of island intervisibility for water-crossings between Sunda, Wallacea, and Sahul is explored by Birdsell (1977), with the conclusion that at least one of the three northern sub-routes provides intervisibility along the entire chain of islands. The other two northern sub-routes had at least partial intervisibility along their chains, while the more southerly routes were completely blind inter-island voyages. Although these determinations are only hypothetical models of possible Pleistocene conditions, Lourandos (1997) believes that intervisibility between islands was an important factor concerning intentional colonization. Although some of the islands may not have been visible during the various possible water-crossing routes, the extant *H. erectus* must have had some idea that other land must have existed over the horizon by watching migratory birds.

There is considerable debate whether the earliest settlement of Greater Australia was accidental or deliberate. White and O'Connell (1982:46) believe that the long sea trips involved in the journey to Sahul "...[imply] that the settlement was both accidental and unlikely to have been much supplemented by later voyages." In contrast, Birdsell (1977:123) suggests that the colonization of Greater Australia was a result of a "...constant if somewhat straggling trickle of small groups of human beings over all or most of the routes." Birdsell also hypothesizes that due to the small size of watercraft that was likely used, the groups probably consisted of small biological family units. The fact that these groups of people had the technology to build watercraft that could survive the long treacherous journeys between islands, sometimes crossing over 90 kilometers in length, is likely evidence that they possessed sufficient knowledge of sea-faring skills and of navigation on the ocean to intentionally colonize Sahul. Irwin (1992:29) suggests that it is likely that, with many short inter-island crossings and gained experience, the number of intentional voyages increased and covered an expanding distance. These populations inhabited a coastal environment and likely had knowledge of nearby islands. It is only natural that they would assume that venturing out onto the seas would result in the discovery of another island. This worldview, largely a product of their environment, may have encouraged ocean exploration by coastal populations due to their familiarity with the marine cultural strategies. In order to explain the expansion of the original population, after the initial landfall in Sahul, Jones (1989) suggests that there were probably many successive arrivals thereafter, of several individuals of both genders, to maintain a viable breeding gene pool. Although the accidental settlement of Australia could have happened in a number of isolated, unrelated events, it is more probable that the continued colonization of Australia was an intentional act to expand their resource base or to satisfy human curiosity in exploring a new frontier.

The Initial Settlement of Sahul

There is much debate concerning the antiquity of the earliest archaeological evidence for human occupation in Sahul. Much of the debate has focused on the reliability of current dating methods, whether it be thermoluminescence (TL) or radiocarbon, and how these are used to accurately date archaeological material. On one side of the debate, conventional views have largely postulated an initial arrival into Australia about 35,000 - 40,000 BP, essentially because no older radiocarbon dates form archaeological materials have been recovered (Allen and Holdaway 1995). Recent work has criticized these conventional views, advocating that the reasoning behind these 40,000 BP dates may only reflect the limitations of conventional radiocarbon dating at these sites, and not their actual age of occupation (Roberts *et al.* 1994; Chapell *et al.* 1996). The other view of the initial occupation of Australia advocates human presence before 40,000 BP based on recent work using TL dating, and exploring the evidence of paleoenvironmental changes (Singh and Geissler 1985; Kershaw 1986). Given the known limitations of radiocarbon dating (Arnold 1995), ages obtained utilizing the radiocarbon method must be reviewed in light of new evidence based on thermoluminescence dating (Roberts *et al.* 1994; Hutt and Raukas 1995; Chapell *et al.* 1996).

Conventional Radiocarbon Dates Accepted for the Initial Occupation of Sahul

The earliest radiocarbon dates for the initial peopling of Australia have fallen into the time range of 35,000 to 40,000 years BP (Fagan 1995). These have long been interpreted as representing the first peopling of Australia and are found throughout the continent at the sites of Swan River (Pearce and Barbetti 1981), Devil's Lair, and Lake Mungo (Lourandos 1997). Presently, no radiocarbon ages older than 40,000 BP for archaeological material have been reported for Greater Australia (Allen and Holdaway 1995). The Swan River site, near the coast of southwestern Australia, provides cultural evidence for human occupation which Lourandos (1997) believes is the mainland's demonstrably oldest. Over 200 retouched and unretouched flakes were recovered, and four radiocarbon dates between 35,000 BP and 39,500 BP were obtained from associated material. These reported radiocarbon dates are believed by the site's excavators to be too recent because the ^{14}C counting rates were "...very close to the lower limit of detection of our best counter" (Pearce and Barbetti 1981:177). This site clearly portrays the limitations of conventional radiocarbon dating for Pleistocene material because of the insufficient amounts of measurable radiocarbon left in the samples.

The Devil's Lair, found in a limestone cave on the coast of southwestern Australia, is another archaeological site reporting dates within the period considered to represent the conventional view of the earliest peopling of Sahul. The upper layers display a clear record of human activity throughout the site's stratigraphic profile. The lowest stratified layer, although absent of stone tools, contains a layer of charcoal radiocarbon dated to 38,000 BP which is believed to be a cultural deposit (Jones 1992).

Sites discovered in the Willandra River system, and at Lake Mungo in southeastern Australia, provide evidence for early cultural activity in the form of archaeological material and intentionally buried human remains. Finds at Lake Mungo consist of stone tools, hearths containing charred animal bones, and stratified shell middens (Bowler *et al.* 1970). Stone tools excavated from the lowest levels of the lunette dune at Lake Mungo were found in association with a charcoal sample that gave a ^{14}C count indistinguishable from background causing Jones (1989) to believe that these archaeological finds may have an antiquity greater than 40,000-45,000 BP. Other shell middens found at nearby Lake Arumpo were ^{14}C dated to 37,000 BP, but the reliability of the ages obtained from freshwater shell material must be questioned because of the common reservoir effect of old carbon accumulation common in such specimens (Taylor 1987).

Earlier Ages Reported for the Peopling of Sahul

There are also two proposed lines of evidence that place the appearance of humans in Australia much earlier than the 35,000-40,000 BP age range; one is based on paleoecological data, and the other is based on thermoluminescence dating of contextual archaeological sediments. Both appear to suggest that the initial colonization of Sahul may date to around the Last Interglacial at 125,000 BP. The implications of these reports can be revolutionary in terms of conventional views on Australian prehistory as well as cultural chronology on a global level.

The first line of evidence, based on paleoecological research, is proposed by Kershaw (1986) and Singh and Geissler (1985). Through pollen studies of samples from the southeast Australian Lake George site, Singh and Geissler (1985) discovered a sudden vegetation change in sediments suggested to date to oxygen isotope sub-stage 5e. A decrease in fire-sensitive tree and fern species was accompanied by a definite increase in fire-adapted eucalyptus and open savanna grasses. They also discovered a concurrent, sudden increase in charcoal in the same deposits. This increase in charcoal in the Lake George record persists from the Last Interglacial throughout the Upper Pleistocene (including periods of relatively treeless full glacial conditions). Singh and Geissler (1985) could not explain such a change in vegetation history and fire-frequency on the basis of climatic changes, and consider them to be the result of fire use by humans beginning at 125,000 BP. It should be noted that the correlation between marine sediment sequences and terrestrial records does pose some problems (Lowe and Walker 1997), and the age of the Lake George sediments proposed by Singh and Geissler (1985) may prove not to be completely accurate. Wright (1986) carried out his own analyses of the Lake George cores and correlated the zone of change in question with an interstadial within a glacial period dated only to 60,000 BP.

Jones (1989) believes that Wright's analysis is more consistent with the archaeological record. However, the introduction of anthropogenic fire in Sahul could indeed have caused the changes observed in the Lake George core record. Thus Singh and Geissler's (1986) interpretation of the Lake George material, when associated with the recent archaeological findings discussed below, may well prove valid evidence of a colonization of Australia about 125,000 BP. However, more paleoecological studies of this nature are needed in order to prove their hypothesis.

The other potential supporting evidence for an occupation of Sahul around the Last Interglacial is found in the recent archaeological work conducted at the Jinmium rock-shelter site in northwestern Australia (Fullagar *et al.* 1996). The lowest stratigraphic unit (Unit 1) contained multi-platform quartzite cores, flakes, fragments, unifacially retouched flakes, as well as quartzite pounding stone cobbles with attached starch residue. Thermoluminescence dating of the fluvial sands found above the lowest artifacts in Unit 1, yielded a date of 116,000 +/- 12,000 years BP (Fullagar *et al.* 1996). Along with evidence of human activity very early in the Upper Pleistocene, Fullagar *et al.* (1996) also discovered evidence of artistic expression as early as 75,000 BP. Significant quantities of red ochre found in between upper and lower TL dated sediments (75,000 and 116,000 BP) are interpreted as possibly being used for cave wall drawings. An excavated weathered sandstone fragment with circular depressions similar to the engraved depressions on the rock-shelter wall are associated with TL dated sediments earlier than 58,000 BP. Fullagar *et al.* (1996) believe that this piece of sandstone was detached from the rock-engraving found on the shelter wall and could represent the earliest direct evidence of rock art found in Australia.

Fullagar and colleagues (1996) are confident that this date is evidence of human occupation in northwestern Australia by at least 116,000 BP. Possible problems of TL dates are examined, but they remain confident in the TL method as "[they] draw primarily on internal consistency of TL and the archaeological context to evaluate the age determinations" (Fullagar *et al.* 1996:771). Evidence is presented that rules out the possibilities of artifact movement downward through the deposits and possible insufficient re-setting of TL in the sands. The authors' reasons to support these early TL ages presented are: "the stratigraphic consistency of TL ages;...good correspondence of TL and ^{14}C dates in the younger parts of the deposit and archaeological integrity of the deposit, including trends in the density of the components" (Fullagar *et al.* 1996:771). Even with all the evidence presented for the early occupation at Jimnium, Fullagar *et al.* (1996:771) remain critical, stating "...the ages cannot yet be accepted unequivocally, neither can they be easily dismissed."

The work conducted at Jinmium rock-shelter provides the only artifactual evidence suggesting that early humans did occupy Greater Australia 116,000 years ago. If we accept the work of Fullagar and colleagues (1996), the existence of archaeological material dating to the Last Interglacial would support the suggestion by Singh and Geissler (1985) that anthropogenic fire was the cause of the ecological change discovered in the Lake George cores. These combined lines of evidence suggest it is possible that other sites exist in Australia that display similar paleoecological changes to those uncovered at the Lake George site. In turn, further evidence of such paleoecological changes might also be correlated with cultural material of this age.

Thermoluminescence dating has also been used at other sites in Australia and New Guinea and has suggested evidence of a pre-40,000 BP occupation for Sahul. Although these TL dates are nearly half the age of those obtained at Jimnium, they tend to support the evidence of a human presence in Sahul in the period which is clearly beyond the practical limit of radiocarbon dating. At the Malakunanja II site in the northern territory, Roberts *et al.* (1994) report a TL age determination of 45,000 +/- 9000 BP yielded from a sediment sample overlying a feature containing stone artifacts and hematite. Thermoluminescence dates for deposits associated with the lowest artifact recovered at the site gives an age determination of 61,000 +/- 13,000 BP. To check their results, Roberts *et al.* (1994) also investigated the Nauwalabila I site in northern Australia. The earliest artifacts were recovered from within a sand lens deposit measured to have an upper optical-stimulated luminescence (OSL) date of 53,400 +/- 5400 BP and a lower OSL date of 60,300 +/- 6700. The investigators report that post-depositional disturbances can be ruled out because of a layer of rubble in the stratigraphic profile that would prevent artifact movement into or out of the sand lens.

Roberts and colleagues (1994:5) are confident of the "...stratigraphic integrity and chronological coherence at the Malakunanja II and Nauwalabila I sites" and suggest that the combination of TL and OSL age determinations at these two sites represent clear evidence for human occupation in northern Australia between 53,000 and 60,000 years ago. Although the earliest TL dates at both sites could not be cross checked with radiocarbon ages, luminescence ages accorded well with ^{14}C dates obtained from associated charcoal samples at three points in the upper portion of the stratigraphy at Malakunanja II. Further support for these early occupation ages of Australia is given by Chappell *et al.* (1996:551) who adds that "...the luminescence method has been supported well beyond the age-range of the early Australian archaeological sites, with the same type of sample material, there is no good reason to doubt the TL or OSL dates reported by Roberts *et al.* (1994)." The evidence presented at these two sites implies that human occupation in Australia is at least 15,000 to 20,000 years earlier than the conventional view of colonization as determined through previous radiocarbon results.

Further evidence that the OSL method is a reliable dating technique for early Australian archaeological material is presented by David *et al.* (1997) in their work at the Ngarrabullgan Cave site in north Queensland. The lowest stratigraphic layer at this site was dated using both the OSL and radiocarbon methods. The OSL age for the sample is 34,700 +/- 2000 BP, which is about 2,200 years older than the average radiocarbon age for the stratum. David and colleagues believe, after proper calibration of the ^{14}C results, that these two dating techniques will produce broadly comparable ages for the period 35,000-40,000 BP. They also suggest that their results support the TL and OSL ages reported by Roberts *et al.* (1994).

The Dating Controversy for Early Australian Sites

Evidence adduced in support of the opposing views outlined above, relating to the age of the initial settlement of Australia, emphasizes the considerable controversy concerning the reliability of the radiocarbon method for dating archaeological layers deposited prior to 40,000 BP. The integrity of using radiocarbon dating for archaeological deposits of Pleistocene age has long been investigated (eg. Jones 1989; Roberts *et al.* 1994; Chappell *et al.* 1996). The problem is that very little isotopic material remains to measure the decay. Even with AMS, counts required are too long. Disintegration is an excessively slow process. Given the half-life of ^{14}C, even utilizing mass spectrometry, the practical limit for radiocarbon measurements is reached at 40,000 BP.

One of the assumptions made in using the radiocarbon method is that the sample was in a closed system, free of exchanges of carbon, from the time of formation to the time of measurement. However, during burial, carbon migration within the sediments might contaminate the archaeological material to be dated. Further, during recovery, modern carbon may come in contact and be mixed into the sample. If such contamination has taken place, the radiocarbon dates obtained for the sample will be incorrect. Although various laboratory methods are used to isolate the original carbon in a sample, it is difficult to test whether the process is perfect when the ^{14}C itself is the only tracer. The problem is that, when working with very old samples, there is such a scarce amount of the original carbon isotope left that measurement of the remaining isotope is difficult. In fact, a sample with an actual age of 50,000 years old, when contaminated with only 0.5% modern carbon, will produce an underestimated age of approximately 35,000-40,000 BP when radiocarbon tested (Allen 1994). Accordingly, the time range of 35,000-40,000 BP for the initial occupation of Australia, as obtained by means of radiocarbon dating, is referred to by Chappell *et al.* (1996) as an "event horizon." Roberts *et al.* (1994) suggest that reported radiocarbon ages of 35,000-40,000 BP are actually older and that contamination problems affect the early part of the ^{14}C chronology for the initial human settlement of Australia. Chappell *et al.* (1996:550) conclude that "...our ability to measure low levels of ^{14}C often surpasses our ability to remove contamination by sample pretreatment; at the very least, all ^{14}C dates near 40,000 BP require close scrutiny." The TL ages provided by Roberts *et al.* (1994) and Fullagar *et al.* (1996) suggest the use of radiocarbon dating no longer be trusted to represent the initial peopling of Australia.

Nonetheless, some workers still advocate that the 35,000-40,000 BP radiocarbon ages obtained for the initial settlement for Australia are valid. Allen and Holdaway (1995) report that this supposed "event horizon" for radiocarbon ages only exists for Australian archaeological samples and that there is sufficient evidence for radiocarbon ages older than 40,000 BP and up to 54,000 BP, from Australian geological contexts. They believe the reason for the absence of radiocarbon dates on archaeological material older than 40,000 BP (uncalibrated), is that humans did not occupy Australia before this period. Allen (1994) stresses that it is not reasonable to assume that all radiocarbon ages between 35,000-40,000 BP are the result of contamination, and that the only way to determine which ones are accurate is to re-excavate and re-date the sites in question. He also suggests that results might change once a proper calibration curve for radiocarbon dating becomes available (Allen 1994).

Discussion

In contrast with radiocarbon, thermoluminescence dating techniques have provided an alternative approach to obtaining ages for Australia's earliest archaeological sites. Luminescence is one of several techniques that go beyond the 40,000 BP limit of radiocarbon dating and has proven to be reliable in the upper stratigraphic sequences at some Pleistocene sites where comparison with ^{14}C age determinations were possible. Radiocarbon dating does not have a sufficient time depth to date the earliest sites. While there are other dating techniques that have been employed successfully beyond the radiocarbon range, TL and OSL seem adequate methods to determine ages for the first occupation of Australia. It would be very beneficial for Australian prehistory if the sites that were conventionally viewed as representing Australia's first people were now re-dated using the luminescence techniques where applicable instead of the radiocarbon method.

The long hominid fossil record from the islands of southeast Asia and Wallacea poses many questions regarding the antiquity and species of the first Australians. Fossil evidence from Java and archaeological material from Flores suggests that human populations occupied the shores of Sunda and Wallacea for the better part of a million years. The possibility of a *H. erectus* population, with the aid of watercraft, settling the shores of Sahul probably seems unlikely to most archaeologists. Even though no fossil *H. erectus* material has been recovered in Australia, I do not believe that this possibility should be ignored. The latest finds at the island of Flores seem to indicate that *H. erectus,* at 880,000 BP, did have the technology which permitted a water crossing with crafts, possibly even carrying animals (Morwood *et al.* 1998). If we accept that *H. erectus* had the cultural capability to manufacture watercraft, there is no reason why they could not have reached Australia. Australian archaeologists and palaeoanthropologists can no longer ignore this likelihood and the search for early settlement sites must be continued. Only the discovery of *H. erectus* skeletal remains in Sahul can prove that they were the original settlers of the continent.

The implications of the evidence from Jinmium rock-shelter are truly revolutionary for Australian and hominid prehistory because the TL dates obtained are almost double other TL ages and nearly triple the conventional radiocarbon dates for initial Australian colonization. The age of 116,000 +/- 12,000 BP at Jinmium (Fullagar *et al.* 1996) poses many questions regarding the species that occupied the site. Age estimates for the first modern *H. sapiens sapiens* in the world are between 100,000 and 200,000 BP (Wilson and Cann 1992; Thorne and Wolpoff 1992). Based on genetic evidence and the "Out-of Africa" theory (Wilson and Cann 1992), it is not unreasonable to assume the 116,000 +/- 12,000 BP, TL dates at Jinmium may represent modern humans of African origin living on the Australian continent. However, based on the fossil evidence, Thorne and Wolpoff (1992) suggest a regional continuity of hominid populations, from *H.erectus* to modern *H. sapiens sapiens,* in the Australasian region. The Java fossils of a modern looking, more evolved *H. erectus soloensis* population that lived 75,000-100,000 BP, may also be the ancestral population of the initial occupants of northern Australia. The archaeological material at Flores (Morwood *et al.* 1998) suggests that full *Homo erectus* populations did have the ability to cross water and potentially colonize Australia. If a *H. erectus* population could cross Wallace's line with watercraft at 880,000 BP then surely the more evolved *H. erectus soloensis* had the same cultural ability to cross open water. These discoveries from Java and Flores surely give new light suggesting a lineage of non-African, modern *Homo sapiens* that evolved locally either in Australia, Wallacea, or southeast Asia. The age of the archaeological material recovered at Jimnium indicates the possibility that the inhabitants may have been equally of a late *H. erectus* lineage, an archaic or transitional *Homo sapiens*, or a fully modern *H. sapiens sapiens* population. Current research has only yielded fully modern human skeletal remains from Australia. Although some variation in skeletal morphology is evident within the populations, it is impossible to ascertain the species or degree of modernity in the population of the initial settlers of Australia from current prehistoric osteological material. Thorne and Wolpoff (1992) argue for regional continuity in the Australasian region during the Pleistocene, and link the Australian populations back to *H. erectus* populations from Java. A potential discovery of Australian hominid material dating to similar ages of the artifacts recovered at Jinmium, and the paleoecological evidence reported by Singh and Geissler (1985), would help prove the ancestry of Australia's aboriginal population.

Summary and Conclusions

Providing an age for the initial peopling of Greater Australia is a highly debated topic in world prehistory. Prehistoric populations crossed over the Straits of Wallacea at some point during the Pleistocene but providing a definite chronological date of this event has been a very difficult task for archaeologists. Archaeometrical evidence provided by TL and OSL dating of the Malakunanja II, Nauwalabila I, and Jinmium rock-shelter sites appears to suggest that humans occupied Australia much earlier than the conventional date of 35,000-40,000 BP. Thermoluminescence ages from the Jinmium rockshelter site, along with possible anthropogenic paleoecological changes, could be interpreted to suggest that humans occupied Australia at least by 116,000 BP or even during the Last

Interglacial. Although the excavators of Jinmium suggest caution regarding such an early date obtained from the sediments, they believe that there is sufficient evidence that the TL age at this site may reflect the true antiquity of the associated artifacts (Fullagar *et al.* 1996). The existence of TL and OSL dates that are earlier than 40,000 BP, for at least three Australian archaeological sites, challenges the conventional view of Australian prehistory and confirms that radiocarbon ages between 35,000-40,000 BP should no longer be used as the sole line of evidence for the first settlement of the continent. The luminescence dates also confirm that radiocarbon dates in the range of 35,000-40,000 BP should be considered with a great degree of skepticism. The work at the Ngarrabullgan Cave (David *et al.* 1997), Malakunanja II (Roberts *et al.* 1994), Nauwalabila I (Roberts *et al.* 1994), and Jinmium (Fullagar *et al.* 1996) sites all provide evidence that the TL and OSL methods cover a dating range sufficient in time depth to determine reliable ages for Australia's first people. In addition, early occupation sites in Australia should be dated using a third technique such as Electron Spin Resonance (ESR) (Blackwell 1995) to confirm the ages obtained by luminescence methods and build a stronger chronological case for the early peopling of the continent. As Allen (1994:5) states, "...currently we are in the middle of a dating revolution." The revolution appears to be overthrowing the conventional views of Australian prehistory that were based on radiocarbon dating, with luminescence dating becoming a more applicable method to provide accurate ages for the early settlement of the continent.

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