

SAHUL IN REVIEW



Edited by M.A. Smith, M. Spriggs and B. Fankhauser

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SAHUL IN REVIEW

Pleistocene Archaeology in Australia, New Guinea and Island Melanesia

Edited by

M.A. Smith, M. Spriggs and B. Fankhauser



1993

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Map on the cover is reproduced with the permission of
Winifred Mumford and Rhys Jones and shows the distribution
of early sites in Sahul as of 1975

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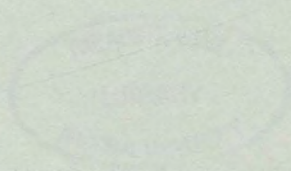
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Frontispiece

Sahul, showing the shape of the Pleistocene landmass at different times. The modern landmasses of New Guinea, Australia and Tasmania are shown within the shaded area. Sea level fell to -65 m for a brief period at ca. 35,000 BP. From approximately 26,000 to 11,000 BP sea level was between -65 m and -130 m. The maximum extent of the Pleistocene landmass was attained for a brief period at ca. 18,000 BP when sea level fell to -130 m. This exposed shallow continental shelves on the northwestern and southern margins of the continent but did not substantially alter the shape of the prehistoric landmass. Bathymetric data are from U.S. National Oceanographic and Atmospheric Administration computer tape records, held by the Cartography Unit, Research School of Pacific Studies, The Australian National University.

SAHUL IN REVIEW: AN INTRODUCTION

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Goethe spoke of 'an epoch of great cold' and the geologist, Louis Agassiz, coined the term *Eiszeit* or Ice-Age for what we now call the Pleistocene (see Goudie 1977:4-7). In terms of glaciation, the last Ice-Age (beginning about 115,000 years ago, see Martinson et al. 1987) was predominantly a northern hemisphere phenomenon. However, one of its major global effects was lowered sea levels. These exposed the continental shelves joining the Australian mainland to Tasmania and to New Guinea, creating the Pleistocene landmass now known to prehistorians as *Sahul* (Frontispiece; Ballard, this volume). Another of its effects was global cooling, most markedly about the last glacial maximum at 18,000 BP, which even in Australia produced hydrological circumstances and vegetation formations with no modern analogue. For the greater part of the late Pleistocene, Sahul also supported a much more diverse fauna, including the diprotodontids (*Diprotodon* and *Zygomaturus*), giant macropodids (*Sthenurus*, *Procoptodon*, *Protemnodon* and *Simosthenurus*) and at least one additional large flightless bird (*Genyornis*) (see Hope 1984).

It should be no surprise, therefore, that when Etheridge asked in 1890 'Has man a geological history in Australia?' he clearly had in mind that the decisive evidence of antiquity would lie in the Pleistocene, either in an association of human artefacts with the bones of extinct megafauna, or in contexts associated with glacial deposits or changing sea levels. However it was not until 1962, with the advent of radiocarbon dating and John Mulvaney's excavations at Kenniff Cave (Mulvaney 1962; Mulvaney and Joyce 1965) that human occupation of Australia during the Pleistocene was unequivocally demonstrated and the 'new vistas of prehistoric research, predicted since the nineteenth century...' (Horton 1991:155) opened up. Mulvaney's results were soon confirmed by a score of archaeological discoveries across the continent (e.g. Bowler et al. 1970; White 1967; White et al. 1970; Wright 1971).

Most readers will be familiar with the speed at which the earliest dates for occupation of the continent were pushed back, quadrupling between

1960 and 1980, from 8700 BP to 38,000 BP, and quickly reaching the limits of the radiocarbon dating technique (see successive reviews in Flood 1983; Hallam 1977; Jones 1968, 1973, 1979; Mulvaney 1961, 1964, 1969, 1975; White and O'Connell 1982). Now, with alternative dating techniques which can be deployed in the crucial time period between 150,000 and 35,000 years ago, there is evidence to suggest that initial colonisation took place about 50,000-60,000 years ago (Roberts et al. 1990; Plate 1), although some scholars argue that current evidence best indicates initial dispersal of humans at ca. 35,000 BP (J. Allen 1989; Bowdler, this volume) and others point to evidence suggesting a catastrophic human impact upon the Australian vegetation at the beginning of the last interglacial ca. 130,000 years ago (Kershaw et al. 1993; Singh and Geissler 1985).

What has been less obvious to the casual observer is the rapid rate at which new Pleistocene sites, in the lee of this frontier, have been discovered and are continuing to be discovered. The number of known archaeological sites dating to the late Pleistocene increased from 35 sites in 1979 to more than 165 today. There is now an impressive body of archaeological evidence dealing with the period before 10,000 BP (see Smith and Sharp, this volume for an overview) with best coverage in the period between 30,000 and 10,000 BP.

The major concerns of Pleistocene archaeology, up till now, have been those dealing with initial human colonisation of an empty continent, about the antiquity of this event, the evolutionary status of these colonists, the pattern and rate of colonisation, initial human impact upon a naive flora and fauna, and the evolution of stone tool technology. While these will no doubt continue to be of fundamental interest, it is also now clear that the most appropriate focus for these questions is prior to 30,000 BP.

What is beginning to emerge as an alternate focus for research, at least in the 30,000-10,000 BP time range where our data is strongest, is a concern with the nature of late Pleistocene societies and

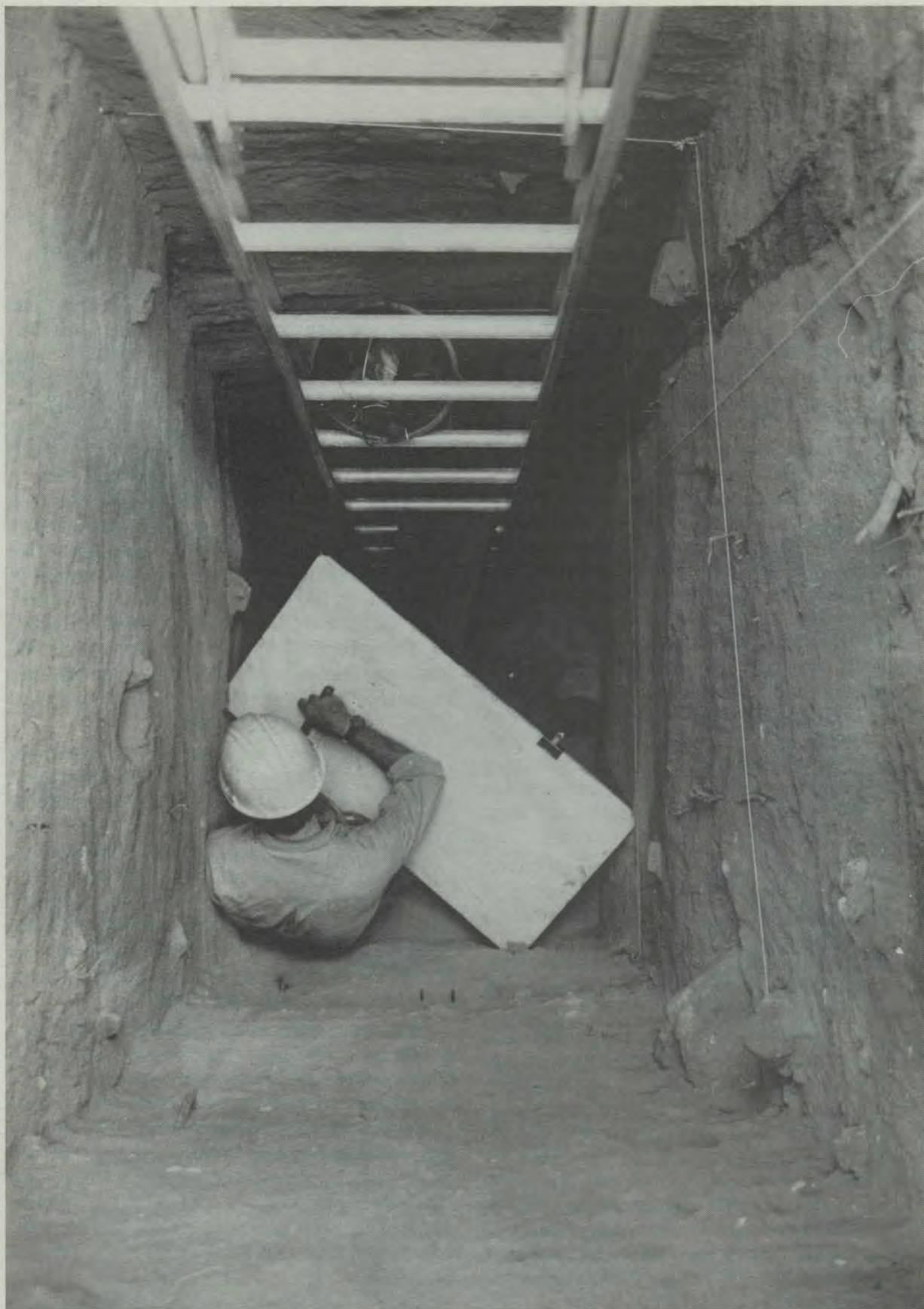


Plate 1 The 1989 excavations at Malakunanja II, western Arnhem Land, showing the great depth of the sand apron at this site. The lower string-line marks the level of the lowest artefacts, in sediments dated by TL to ca. 50,000 years ago. (Photo: Rhys Jones).

their variability. What are the vital statistics of Pleistocene societies? How many people did they incorporate? What were their geographic limits? How extensive were social networks, in various parts of the continent at various times? What sort of differences distinguish late Pleistocene societies from each other and from those societies familiar to us from the ethnohistoric period? The former are often depicted as a pale reflection of those of the late Holocene, with lower population densities, greater mobility, and unspecialised economies based on broad-spectrum foraging (cf. Lourandos 1987). But did they really lack effective exchange systems, elaborate ceremonial life or specialised extractive technologies? How well do these ideas now stand up? The papers in this volume were solicited to begin to explore some of these questions.

Most of the papers were originally presented at the annual conference of the Australian Archaeological Association, held in December 1991 at Lake Jindabyne (New South Wales). Mindful that 1992 was the 30th anniversary of Mulvaney's breakthrough, we thought it appropriate that the meeting should review the Pleistocene archaeology of Australia, New Guinea and Island Melanesia. The December 1991 meeting was also an opportunity for the Association to honour Jack Golson on the eve of his retirement from the Chair in Prehistory at The Australian National University. We dedicate this volume to him and to John Mulvaney. A few papers (Frankel, Johnston, McGowan et al.) were originally presented elsewhere and have been included because of their relevance to our theme. One paper (Rosenfeld) was specifically written for this volume. Papers given at the conference by Stern and Marshall and by David are to be published elsewhere (David 1993; Stern and Marshall, 1993). Crosby's conference paper is to form part of a monograph in the *Queensland Museum Memoirs*, entitled *The Axes and Adzes of Melanesia*.

In revising their papers for publication, authors were encouraged to take stock of the last three decades of research and, where appropriate, to provide bibliographic overviews of the literature. Smith and Sharp attempt to list all known Pleistocene sites in the region, Rosenfeld reviews data on Pleistocene rock art and Pardoe that dealing with human skeletal remains. Golson wraps up the volume with an historical overview of the development of research in the region. An appendix by Smith and Sharp provides an indexed bibliography of Pleistocene archaeological sites.

Several of the papers focus on the sorts of problems likely to be encountered in attempting any fully-fledged reconstruction of Pleistocene societies. Ballard in his paper on the use of the term

Sahul outlines how our name for the Pleistocene landmass both reflects and reinforces certain assumptions about the prehistory of the region. Frankel, Horton, and McNiven et al. are concerned with questions of scale and resolution of data and the effects of these factors on explanations of linkage and causality (cf. Bailey 1981). Papers by Smith and Sharp and by Davidson, Sutton and Gale discuss some of the problems in determining the history of use of individual sites. What is now very evident in the data-set is that there are distinctive regional archaeological signatures (see Smith and Sharp, this volume). For instance, occupation of sites in southwestern Tasmania ceases after about 12,000 BP, the Bassian Plain is abandoned at ca. 7000 BP (Jones 1987), sites in southeastern Cape York Peninsula are used most intensively from 13,000 BP, sites near small lakes and rivers on the central Murray cluster in age between 13,000 and 12,000 BP and so on. If, following the historian, Fernand Braudel, we were to dissect history into different planes (see Braudel 1966:20-1), these are events of the *longue durée*, of history on the geographical scale recording the demise or transformation of individual Pleistocene worlds and landscapes. Between these and records of individual events, such as that represented by the chance finding of a 32,000 year old shell bead necklace (see Morse, this volume) or of a post-hole or an oven (Smith et al. 1990), there is a great dearth of evidence on the scale of social history, that which documents the operation of corporate groups or institutions at the level required for a processual analyses of archaeological data. It seems to us that this is one of the major challenges to be faced in investigating the structure and operation of Pleistocene societies, or for that matter those in much of the Holocene. Such investigations will also require the close coordination of field investigations with modelling at various temporal and spatial scales (cf. McNiven et al., this volume), if we are to achieve more than a coarse-grained historical geography.

Several authors in this volume question whether the Pleistocene should be treated as a discrete period for study (Frankel; Freslov; Pardoe). This is a question that has also troubled geologists (see for example Bowen 1978), who point out that the boundary between the Pleistocene and the Holocene is no different in character to the boundaries between preceding glacials and interglacials. However, it was never our intention here to claim any special status for the Pleistocene, or to imply that societies across the length and breadth of Sahul were in some sense structurally more similar to each other than to those at other times. We aimed simply to focus discussion on a time-period which

is comparatively data-rich, and which lies between the major phase of initial colonisation of Sahul and the *lacunae* of the early Holocene (about which we appear to have much less data than for some periods of the Pleistocene). While it is an arbitrary boundary in terms of both human adaptations and technology, the beginning of the post-glacial period in Sahul is in fact marked by changes in land-use and demography, as many of the papers in this volume show. At risk of resurrecting the Mesolithic we draw attention to the fact that major changes in land-use (Brown; Gosden; Hope; McNiven et al.; Morwood; and Smith and Sharp), in the use of graphic systems for marking place (Rosenfeld) and in the use of cemeteries and development of corporate descent groups (Pardoe 1988) mark the terminal Pleistocene at ca. 13,000-10,000 BP.

Detailed models of Pleistocene land-use, logistics, or demographic arrangements have been attempted elsewhere by H. Allen (1989), Cosgrove et al. (1990), Horton (1986) and Smith (1988, 1989). Despite our invitation, few of the authors in this volume (except O'Connor et al.; Hope) took the plunge and attempted detailed reconstructions, although many dipped their toe in. McNiven et al., Freslov, Pocock and Brown present glimpses of societies, in southwestern Tasmania and on the Bassian plain, that are strongly geographically circumscribed. For instance, on the Bassian Plain the distribution of distinctive artefacts made on fossil shell suggests a cultural division into western and eastern provinces (see Brown, this volume), presumably reflecting the presence of Pleistocene Lake Bass and associated salt marshes in the central part of the plain (Blom 1988). In contrast, Morse draws a picture of a community on the arid north-western coast of the continent which had exchange networks of some form or another extending for 300-800 km. Similarly, earlier work in eastern Kimberley by Cleverley and Dortch (1975) documented the presence of Australites from southern Australia in the Pleistocene levels at Miriwun rock-shelter. In their spatial extent these Pleistocene societies broadly resemble ethnohistoric groups in these regions. In Island Melanesia the picture is also of extensive inter-island travel in the Pleistocene (Gosden; Fredericksen et al., this volume) with the widespread exchange of obsidian from at least ca. 20,000 BP.

The Pleistocene in Europe has often seemed 'a very remote period indeed; even beyond that of the present world' (in the words of John Frere [1800] cited in Daniel 1975:27). In Australia, however, it is the continuities that appeal. The more we learn of Pleistocene groups the stronger the sense that their technology (including seaworthy watercraft, use of fire and forest clearance, ground-edge imple-

ments, grinding stones and small-flake technology), and their artistic and social sensibilities (as reflected in the use of red ochre crayons, personal ornaments, concern for the dead) were like those of ethnographic groups. O'Connor et al. put up a case for much higher population densities in northern Australia before the last glacial maximum than have previously been allowed. All of these are strong temptation to think of Pleistocene societies as direct analogues of those societies familiar from the ethnography, particularly in the Australian context. One of the pitfalls of Pleistocene archaeology, of which the authors here are well aware, is of using ethnography to provide a template for the reconstruction of prehistoric societies that are so far removed in time. In this volume, Johnston discusses whether it is realistic to consider the Pleistocene use of lacustrine resources in the Willandra as a transliterated coastal economy. Dunnett looks at what might have been a very different use of coastal resources in Tasmania during the Pleistocene. Horton (1986, this volume) points out that the megafauna are one obvious factor preventing a direct historical analogy. The availability of giant marsupials has ramifications for the scale and demographic structure of prehistoric groups (see Horton 1986 for further details), suggesting that this is a case where we need to give primacy to the archaeological record rather than ethnographic models. In this respect, that record has been disappointing, showing only meagre evidence for a temporal overlap of humans and the megafauna, and saying little about the nature of their interaction (Furby et al.; Mountain, this volume).

Several of the classic concerns of Pleistocene archaeology also get a mention in this volume. Various aspects of colonisation are discussed in several papers. Bowdler puts a case for a synchronous colonisation of southeast Asia and Sahul. Papers by Fredericksen et al., Gosden, and Spriggs stress that the evidence from Island Melanesia shows that maritime capabilities went well beyond the ability to survive accidental drift voyaging. The Pleistocene occupation of New Ireland (Allen et al. 1988), the Solomon Islands (Wickler and Spriggs 1988) and of Manus (Fredericksen et al., this volume) demonstrate an ability to successfully settle islands which were depauperate in both fauna and flora, and to cross substantial water barriers to do so. Of particular importance is the settlement of Manus, which involved blind crossings (there is evidence it happened more than once) out of site of land for a minimum distance of 60-90 km (see Irwin 1991:12). This is the longest attested open ocean crossing in the Pleistocene world. Gosden stresses that the colonisation of these regions, and possibly of Sahul proper, may have been a deliber-

ate rather than opportunistic process, that it was purposeful rather than a result of accidental drift voyaging. In passing we might also note that Davidson (1991) has suggested that the manufacture of boats for the colonisation of Australia is the earliest evidence to indicate the presence of language, itself the hallmark of modern humans (see also Davidson and Noble 1992).

Another issue that is canvassed in this volume is that of the impact of humans upon local environments. In northern Australia, Morwood outlines tentative evidence for a massive destabilisation of sand sheets at a time when a substantial intensification of settlement took place. Haberle outlines evidence for successive forest clearance events in the New Guinea Highlands. On the same theme, Spriggs discusses the deliberate introduction of new plant and animal species into the depauperate island environments of Melanesia and the scale of subsequent manipulation of these habitats.

In the thirty years since the Kenniff Cave excavations, fieldwork has shown that Sahul and its outliers possess one of the great bodies of Pleistocene archaeological evidence in the world. The pace of discovery has, however, been so rapid that few of us have fully appreciated how extensive and diverse that record has now become. With the publication of this collection of papers we hope that the primary archaeological literature will become more accessible and that scholars will be encouraged to explore the nature of late Pleistocene societies and their variability.

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THEY'VE DRAWN A VIEW OF THE NEW GEOLOGY

SCALE, RESOLUTION AND EXPLANATION

HERE BE DRAGONS: A VIEW OF AUSTRALIAN ARCHAEOLOGY

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A conference is a time for catching up with old friends and enemies and for making new friends and enemies. A conference is also a time for extrasppection, of comparing your site with other sites, your results with other results, your ideas with other ideas. It can also be an occasion for introspection: a time to ask yourself the question 'why am I doing this?' Once upon a time this question was just a touchstone, something that we checked nervously from time to time to make sure that we were still keeping the faith and not digging up 'mere things' when our 'proper aim is to dig up people' (and doesn't that have a curiously archaic sound now). It stopped being purely a matter of introspection in recent years when Aboriginal people began to ask why we were digging up their land, and bureaucrats wanted to know why we should be funded to do so.

In these economic rationalist times it is no longer enough to say that the practice of archaeology is worthwhile because it involves the acquisition of knowledge, or (as Grahame Clark said in 1957) that prehistory led people to 'feel themselves members of a world society' and that it served 'its highest social purpose in helping to promote human solidarity'. Well, there would be some chuckles over those reasons for studying prehistory in the Department of Finance, and you would have been hard put to stop Dawkins (when Minister for Education) closing down a university just because it had excellence in a discipline with wishy-washy aims like that.

As a consequence, prehistorians, and people in related historical disciplines such as history, palaeontology and geomorphology, may find themselves attempting to justify their work by claiming that a study of the past has relevance for the future. This is the 'those who do not learn from history are doomed to repeat it' gambit. By and large such claims are false. Academics who study the past are in the business of analysing trends through time and have an occupational hazard of seeing those changes as having been inevitable, and, what is worse, projecting them into the future as predictions. They share both the business and the hazard

with gamblers and science fiction writers. In the case of gamblers, the fallacy of believing that a horse with number nine saddlecloth is due to win, or that the little white ball is overdue to land in slot twenty-five, quickly becomes obvious, though this rarely affects the strength of the belief. Archaeologists have learnt from science fiction writers, more and more of whose predictions are shown to be false as we approach the end of the century, to make **undated** predictions.

A positive example of this kind of thing is the 'we buggered them up just at the wrong time' approach – if we Europeans had not arrived in Australia for another few years there would have been indigenous farming, cities, ocean-going boats, pottery, metallurgy and so on already here when we arrived. All of this is a useful antidote to the negative view that Aboriginal society was in **decline** before Europeans arrived, but the 'predictions' are outside of time, in parallel universes, and are therefore incapable of disproof. Anyone who believes in their reality is probably an ex-stockmarket adviser to Alan Bond.

Negative 'predictions' have been prevalent in Australia virtually since the first European sighting of this continent. Aborigines were descendants of one of the lost tribes of Israel, or came from Africa or Melanesia. Wherever they had come from, it was said, they had degenerated. Aboriginal culture had been going downhill so fast that it really was lucky that Europeans arrived when they did, so they could 'soothe the dying pillow'. Perhaps the funniest version of this nonsense, if you were not a Tasmanian Aborigine, was the infamous Cobern (1982) article in *The Bulletin* in which it was claimed among other things that the eating habits of Tasmanian Aborigines were causing their extinction. Perhaps she meant their habit of eating lead. Australian plants and animals were also well on their way to extinction, according to those Coberns of the environment, the foresters. It is in fact a pity that Arthur Phillip arrived when he did – just a few years down the track there would have been no problem in colonising Australia because it would

have been a bare brown land. A land devoid of plants, animals and people, waiting for the 'hands of industry' to begin tilling the soil and (because a 'wise providence' had removed the megafauna to make way for them) the cattle to arrive.

We would be mistaken if we believed that the problem with this nonsense is that it is the result of good science perverted by bad people. While claims of an aborted future golden age are useful in neutralising the ratbag visions of degeneracy and doom, they are no more firmly based, and may, in apparently legitimising the process of prediction, also legitimise the Patricia Coberns of this world.

A particularly insidious example of this dichotomy is the contribution of prehistory to the environmental debate. A common approach is to say 'let's study past Aboriginal management of the environment in order to plan our own management practices'. The 1990s version of this seems to be 'if Aborigines made a mess of the environment in the past then (a) it's OK for us to do so and/or (b) it is too fundamental a problem for us to correct'.

It is possible that Aborigines caused 'the extinction of the megafauna', removed forests and created grasslands, started erosion, and altered plant and animal distribution patterns. **Whether or not** any of that is true, it should have no bearing on our behaviour now. The two arguments used (and they are contradictory) are that either Aborigines knew what they were doing better than us, so we should imitate them, or Aborigines didn't know what they were doing and stuffed things up, so nothing that goes wrong now is our fault.

This may seem a far cry from the suggestion that Aborigines manipulated the environment massively but benignly, a suggestion that was a useful corrective to the view of Aborigines as 'parasites' who didn't work the land and therefore had no right to keep it. A view of the Australian environment, however, as one which is not only susceptible to major changes, but which has been subjected to them for 40,000 years, slams the door in the face of those who have been gradually getting across the message that this is a fragile continent, and opens it to those who wish to make massive changes for their own benefit. It could in fact be suggested that, given the radical, European-induced changes in the Australian environment in the last 200 years, a useful procedure would be to examine environmental management practices of Aborigines with a view to **avoiding** using the same regimes. Similarly I would suggest that even if it could be shown that some present day environmental problem is the result of a process set going 10,000 years ago this doesn't mean that we should throw up our hands in

despair. We should make even stronger efforts to deal with the problem.

A factor which makes prehistory susceptible to this kind of misuse of its data is that other occupational hazard of archaeologists – a lack of a sense of time. One reason for this lack may be that in excavating we are dealing not only with time made flesh and consequently trivialised, but with time compressed. If a slip of a trowel can remove a few hundred years of deposit, it is hard to comprehend the slowness of the process that laid down those sediments. Another factor is the terminology we have begun using for time – as in the title of this conference – '10 kyr', '30 kyr'. We have become blase about time, and using this terminology both symbolises and reinforces this attitude. In the old days they had a much greater, and more concrete, appreciation of what time meant. Howitt (1898) said

In considering all the facts before me bearing upon the question of the origins of the Tasmanians and the Australians, I have been much impressed by the immense periods of time which seem to be essential as one of the elements of any solution to the problem.

In the roll of that phrase 'immense periods of time' we can hear the waves slowly lapping at the edges of the Bassian Plain, and watch as grains of sand trickle slowly from sand dunes.

MacPherson (1884) observed

the common ash-heap which had been formed in a country locality connected with a European dwelling. It was about the size of one of the smaller oven-mounds to be seen in the Meredith district. It had been formed in about ten years by a family of about ten persons.

In this example of MacPherson's Scottish down-to-earth character we can hear the clink of spade on hearth, hear the scrap bucket emptied, day after day, month after month, year after year. Pulleine (1928) said

when we consider that Tasmania is nearly as large as Ireland, we get some inkling as to the length of occupation necessary to accumulate such abundance of stone remains.

While Pulleine was never quite clear which Celtic country Tasmania most resembled, he still gives us a picture here of endless shorelines with middens, and rolling hills covered in stone flakes. Pulleine also said 'a thousand years is a long time' which has a ring to it quite different to that of '1 kyr is a long time'. 'One kyr' it should be remembered is about 50 generations, an unimaginable sequence of births, lives and deaths. Once it was customary to equate dates in Australian prehistory to events of European and Middle Eastern history – perhaps it would be a useful mental discipline to again remember that when the sediments at a depth of, say,

5 cm were being laid down, the pyramids were being built.

There are two aspects of time that are important in archaeology. First, the greater the length of time, the greater the chance of improbable things happening – time is the ultimate improbability drive. The Elliott Smiths and von Danikens are just extreme examples of the misunderstanding of the creative effect of time. Really **knowing** in our bones that a thousand years is a long time, may make us less likely to impute significance to things which are the results of chance and coincidence. Second, and conversely in a way, time needs to be included as a dimension in analysing 'events' in prehistory. It may seem obvious, but it is easy to lose sight of the fact that an 'event' which takes '1 kyr' to unfold is vastly different in nature (that is cause and effect, social and cultural factors, physical and geographic aspects) to one which takes one year. Maybe there should be a ban on putting a name to any process that takes longer than, say, ten years. Or a change in terminology in which we could make it clear whether we were talking about process or metaprocess, event or metaevent. Such a change might make it more obvious that, for example, forestry commissions cannot duplicate the effects of a thousand years in ten.

Another way of ensuring that archaeological data is not used in inappropriate ways is for us as prehistorians, who best understand the nature and limitations of archaeological data, to remain engaged in synthesising data, and developing explanatory models. There seems to have developed a feeling in the last few years that model making is a less worthy activity than gathering data. Archaeology, like all sciences, goes through cycles of discovery and synthesis. A period of synthesis ends with the feeling that nothing more remains to be said on a topic (or, to quote Richard Wright in about 1982, 'any journal editor who sees a title which includes the words "Tasmania" and "Fish" should reach for a gun'). One can imagine a number of other combinations of words which might stimulate a similar reaction).

A new major period of model building begins when there is a feeling that there are too many pieces of information which do not fit existing models, either because they are contradictory or because they allow for a new way of looking at some aspect of prehistory. There was such a period around the turn of the century, another one in the 1950s and early 1960s and another one in the late 1970s early 1980s. The time does not yet seem ripe for a new frenzied period of model building but there are indications that another one may be approaching. If, for example, the 50,000 years plus date from Arnhem Land holds up, or if analysis of

blood residues produces the goods, or if the Liverpool Plains time sequence is confirmed, present understanding could dissolve very quickly. There needs however to be constant examination of existing models to see how they are holding up and to refine them where necessary.

One person who has seen no need to refine an existing model is that Doctor of Christian Education, Alan Roberts, still searching for the ark – an 'arkologist' as a reporter cleverly put it – 'no formal training in archaeology' (and you can perhaps imagine a deprecating smile) but just a 'dirt digger' (*The Canberra Times* 18 October 1991). This last 'dirt digger' was put in quotation marks as if it was a technical term, and probably it was intended to be one. The implication, clearly, was that here was someone who, without all the limiting superstructure of academic trappings, simply took up a spade to see what was there.

Now this picture is, of course, such a total reversal of the truth as to be laughable. It may be that my world view is completely wrong and this guy has found the ark, and will soon be reporting a gangplank with hoofmarks in pairs, a wardrobe with remains of a white robe, and a dove skeleton with traces of olive phytoliths on the beak, but I don't think so.

This man is digging for a metaphor and we can sit back and laugh at him. But while there is no doubt that someone who expects to find 'the ark' is a figure of fun, we should be aware that most archaeology is in fact a search for metaphor. If we are investigating 'colonisation' just what is it that we expect to find – remains of the first raft (or boat), remains of the first meal on Australian soil, a set of fossilised footprints leading up a beach? If we are investigating 'extinction' are we trying to find the bones of the last *Diprotodon* ever to die? If we are investigating 'intensification' are we looking for the first eel trap? And what about cause and effect, just how do we excavate in order to demonstrate a link between two separate events or objects?

Archaeologists are not 'dirt diggers', digging holes without any preconceived notions about what may lie beneath the surface. Intellectual baggage which we bring with us to a dig, perhaps in a suitcase, is important because it helps to shape and order our perceptions of what is being found. If every object excavated, from sand grain to an arm of the Venus de Milo, was accorded equal value then no sense could be made of the archaeology of a site. Our preconceived notions result in us ranking objects and relationships in order of importance (or significance), and this allows analysis to proceed because only the top ranks are considered.

However there is always the danger with intellectual filters that they may prevent you appreciating the significance of something which does not fit your expectations. I suspect the danger does not lie in the excavation or analysis, where things which do not fit stick out like sore thumbs, but in the interpretation. We should be wary of simply explaining away the odd late *Diprotodon* tooth, or early backed blade, or 'anomalous' date. Although 99 out of 100 of such finds will simply be errors in technique or quirks of taphonomy, number 100 may require a shift in paradigm. If reports are always 'cleaned up' by explaining away all the untidy bits, it may prove impossible ever to shift from orthodoxy.

The search for the earliest evidence of human occupation of Australia, and the search for human interactions with megafauna were for many years entangled because proving the former required proof of the latter. Both quests have continued for almost two centuries and continue today. Debate rages about the interpretations of TL dates (see e.g. Hiscock 1990; Roberts et al. 1990), and people are once again digging at Cuddie Springs. The answers to these quests are such glittering prizes that traditionally high levels of proof have been required (or demanded). This may get out of hand, and it has certainly seemed at times that for some archaeologists and some sites there are some critics for whom no level of probability is going to be satisfactory. Since both taphonomy and human behaviour involve matters of chance, to require absolute proof of something is to ensure that no case can ever be made.

Last century the concept that depth of burial was related to age was thrown out the window because of the observed alternation in droughts and floods and consequent radical changes in landscape in Australia. Recent criticism of Pleistocene sites also throws into question a fundamental principle of archaeology – association in space equates with association in time. In effect, the result of the criticisms is that we must consider artefactual material and non-artefactual material separately in all excavations. The implication is that no site report can contain a stratigraphic diagram in which all of the contents of the site are figured together. Instead, all classes of finds would need individual diagrams, and a cause and effect link would need to be demonstrated between all the objects appearing in a particular chunk of space, before any meaning could be assigned to that association. Association is deemed coincidental (accidental) unless proved deliberate. At its worst, this kind of criticism can become arid scholasticism. Exchanges of letters and notes in journals can resemble in their intensity, nitpicking and time wasting,

a series of appeals to ever higher courts – a Bleak House of claim and counter claim. The trouble is that there is no contemporary higher court, no archaeological ombudsman, and therefore no possible resolution. It might be worthwhile extending the legal analogy, and instead of sites being assumed guilty until proven innocent, assume that all sites are innocent. If the results are correct, this will become apparent as other sites provide comparable data, if not then they will remain as anomalies, gradually forgotten except as curious abnormalities in the history books. The judgement of posterity is the only real higher court we have. Such an approach would save both diggers and critics so much time that twice as much productive archaeology could be done.

There is a positive side to the exhaustive examinations and criticisms however. At Lime Springs (see Gorecki et al. 1984) I made the comment that if the sample of bones we had excavated had not included *Diprotodon*, no questions would have been raised about the association. One could argue that this proposition should be turned on its head. We should never just assume association, even of the smallest quartz fragment and dingiest kangaroo tooth or fragmentary mussel shell. The science of taphonomy, originally used on megafaunal sites in Australia, has come to be much more widely applied to analyse the ways in which objects can reach the same place on the earth's surface without human intervention. Doubts about human-megafauna associations and early dates for humans have, I believe, had considerable spin-off in improving techniques of excavation and analysis in Australia.

The lack of certainty about human-megafauna association has also positively affected the writing of prehistory. In Europe a satisfactory demonstration of the association between humans and megafauna marked in effect the beginning of archaeology (and, one would have thought, the end of searches for the ark). With ancient rock art also available in Europe to provide an eyewitness account, there became established in the minds of archaeologists (and of the general public) an image of a past age unimaginably different to the present. There was no question of seeing continuities between present and past, of giving the ancient humans of Europe the behaviour, appearance, voices and motives of modern Europeans. The early establishment of a definite human-megafaunal association then had no ill effects in European archaeology and indeed had positive effects. While it is true that ethnographic analogies for the European Palaeolithic have been sought from all parts of the world, the distant nature of the sources has ensured that they have been seen as analogies and

not continuities. In Europe it has always been clear that there is no prehistory without archaeology.

The constant danger in Australian prehistory since its beginnings, was to see continuities between present and past. Indeed Aborigines had of course been used as analogues for European Palaeolithic man. This is a problem, not of the past projected forward, but of the present projected back. Stories of the Dreaming should have given us pause, for they are a clear statement that the 'past is a foreign country'. But it is all too easy, too seductive, to see the figures in the landscapes of 10,000 or 30,000 years ago hunting the same way, dressed the same way and living the same way as the people in whichever is our preferred ethnographic analogy. The only thing putting the brakes on this process to some extent has been the lack of data on the relationship between humans and megafauna. If we had known with certainty either that there had never been any interaction, or that there had been but it had ended at, say, 30,000 BP then we would have been free to fill some or all of Australia's prehistory with the ethnographic present. The uncertainty about facts and dates has acted like the Australian Democrats before their self-destruction: it has 'kept the bastards honest', making us work to use archaeology rather than ethnography to write prehistory. Had the megafauna not existed then it would have been necessary to invent it.

The search for the Holy Grail was probably a quest designed to keep knights busy and stop them bickering. It also had good side effects as the intrepid knights fought and defeated evil, helped the poor, rescued damsels, slew dragons and so on. It was never intended that the Grail be found – the whole point being to travel hopefully rather than to arrive. The search for human-megafaunal association, that holy grail of Australian prehistory, has had similar qualities and benefits. It would, I think, be a great pity if new techniques such as those of Tom Loy (see e.g. Loy 1990) result in the finding of the 'smoking gun' (or dripping hand axe) and an end to the quest.

Perhaps 'travelling hopefully' is a good metaphor for archaeology in general. One of the values of wilderness, even if one never visits it, lies in knowing that it is there. The world, it could be said, is a poorer place, now that there are no mountains unclimbed, deserts uncrossed and jungles unmapped – no places left in fact on which to write 'here be dragons'.

It is similarly important to have mysteries remaining beneath our feet – important for archaeologists, for whom the major driving force has always been the thought that the next shelter or sand dune

or swamp will reveal all the answers. A country of which it was known that every site had been sampled would be one that attracted few archaeological students. More seriously, perhaps, although the significance of a site is normally assessed by comparing its properties with those of known sites, another important aspect is how the site relates to the **unknown** universe. A site excavated in an extensively investigated area will also be dug and analysed differently, thought of and cared about differently, and will have a different impact to one in an archaeological *terra nova*. All the aura of intellectual and emotional baggage we bring to a site has a surprisingly great effect on how we interpret that site. More generally, the fact that Australian archaeology as a whole has been conducted in a continent where the area investigated is only a fraction of the total, and what is known is greatly outweighed by what is not, has greatly influenced the form and style of our archaeology.

It is also important for the general public to know that neither past nor present in Australia is under control. Since Europeans arrived they have attempted to tame, clear, fence, remove, introduce and control the land. As we face the Greenhouse Effect it is useful to know that the land has been both wetter and drier, and sea levels higher and lower, in the past. Perhaps a certainty that we knew **everything** there was to know about the past, that these were the limits of possible misfortune and that the country (and Aboriginal people) had survived before, could result in a dangerous complacency. The last thing we need as we face the next century is a feeling that things are under control, that people know what they are doing, because they have learned from the past.

It is important however that people learn about the past, and realise that every piece of soil potentially contains archaeological remains. In Britain people are aware that the land is suffused with the past, because every spadeful of earth dug in a garden can contain archaeological relics. In Australia it is unfortunate that stone artefacts are not easy for the non-archaeologist to recognise, and people can remain unaware of how thoroughly, and for how long this land was owned by Aboriginal people. If archaeologists concentrate only on the sites which have been excavated, the relatively small number of these, still mainly concentrated in the southeast, leaves Australia looking like an archaeological *terra nullius*. As far as public perceptions of the history of Aboriginal people are concerned, what has not been excavated should be far more significant than what has been.

Finally, it is important for Aboriginal people to know that prehistory is an **addition** to the Dreaming, not a replacement for it. The response of

Aboriginal people to discussions of their origins and time of arrival in Australia, where they are dignified with a response, could be summed up as 'what a load of rubbish, we've been here forever.' Points of contact between prehistory and the Dreaming have tended to be attempts to rationalise stories of the movement of people, land bridges, volcanoes, giant animals and the like, as actual folk memories of prehistoric social and environmental change. Such attempts are well-meaning efforts to integrate two different approaches to the past, and in doing so to validate the Aboriginal approach. These efforts however use science as the benchmark of truth, and the Dreaming story as the version which has to shape-up or ship-out. The discipline being tested automatically has an inferior status to the one doing the testing. Unless we are prepared to accept Aboriginal people saying things like 'no, that pollen analysis must be wrong, there was rain-forest here once', we should stop these misguided attempts at the integration of two traditions, and just recognise that the Dreaming is everywhere that archaeology is not. Since archaeology will never cover more than a very tiny fraction of the continent, this leaves a very large area on which to write, not 'here be dragons' but 'here be Dreamings'.

Archaeology in Australia is as much about context as content. Perhaps we should be nervous when we ask ourselves 'why am I doing this'; perhaps the aims of archaeology in Australia would be better served by not excavating, than by exca-

vating, and some 'unknown regions should be preserved as hunting-grounds for the poetic imagination'.

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STIMULATING MINDS TO FANTASY? A CRITICAL ETYMOLOGY FOR SAHUL

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Sahul is now well established amongst archaeologists as the name for the Pleistocene landmass incorporating Australia, New Guinea, Aru and Tasmania. A brief survey of the literature shows how the meaning of Sahul has gradually been extended over time. A genealogy for the name and the idea of Sahul is offered in an attempt to demonstrate how this most basic feature of archaeological cartography has both reflected and come to fuel certain assumptions about the prehistory of the region.

AN ETYMOLOGY FOR SAHUL

'It is rather a singular circumstance', declared G.W. Earl in 1845, 'that the kangaroo, an animal which was long supposed to be peculiar to Australia, is found both on the Arru Islands and on the southern part of New Guinea' (Earle 1845:362). Drawing on contemporary naval maps, Earl sought to account for this distribution by proposing a distinction between the 'Great Asiatic Bank ... [which] extends into the Archipelago from the south-eastern extreme of Asia to a distance of nearly 1000 miles, in fact to within 50 miles of Celebes', and the 'Great Australian Bank', linking the continent of Australia to the connected islands of Van Diemens' Land (Tasmania), New Guinea and Arru (Aru) (1845:359-61). His original map, the first attempt to illustrate what archaeologists now describe as the continent of Sahul, is reproduced as Figure 1.

Though Earl made no use of it, the term 'Sahull' or 'Sahoel' had already appeared on 17th century Dutch maps, applied to a much smaller feature, a submerged sandbank lying off the northwest coast of Australia. De Bry's 1598 map, *Descriptio Hydrographica* (Clancy and Richardson 1988), which was compiled from Portuguese sources, shows a major submarine feature south of Timor identified by the term *baixas*. This presumably derives from the Portuguese word *baixio* for shoal, and suggests that the Portuguese were already familiar with the seas to the south of Timor. The original source of the term Sahul is not certain, but was possibly the

name given by Malay-speaking crews or pilots on Dutch vessels, familiar with the waters, to a well-known feature of their fishing-grounds (Fairbridge 1948:193). In a note on his 1803 map, Matthew Flinders writes of the 'Great Sahul Shoal' that 'The Malays of Macassar formerly came to fish upon it for Trepang' (Flinders 1803). No obvious gloss for Sahul can be found in Malay dictionaries and it may be Macassan in derivation. Table 1 lists a selection of references to the Sahul Bank on maps from the 16th to the 19th centuries.

The 1633 Janssonius map is amongst the first to identify the 'Sahull' bank by its current name (Fig. 2). After the discovery in 1611 by Hendrick Brouwer of the southerly route to the Dutch East Indies via the west coast of Australia, Dutch mariners would have become rapidly familiar with at least the western margins of the Sahul bank (Fairbridge 1948:198). The bank subsequently made appearances on globes and world maps, such as the 1714 del'Isle map, and briefly surfaced as an island on the 1690 Coronelli map (Table 1). Both the size and depth of the bank fluctuated on maps until the initiation of detailed bathymetric surveys of eastern Indonesia by the Belgian Siboga Expedition in 1899 and 1900 (Weber and de Beaufort 1902). Although the Sahul bank was not covered during these surveys, the published results of the Siboga expedition laid the basis for the first submarine maps of the Timor, Arafura and Banda Seas, and it was in a summary of the expedition that Molen-graaff and Weber (1919) renamed Earl's Great Asiatic and Great Australian banks the Sunda and Sahul Shelves, respectively.

In a series of articles, the geologist and historian Rhodes Fairbridge (1948, 1953, 1966) attempted to rein in what he described as the 'loose application' by other geologists of the term 'Sahul Shelf' to the entire submarine platform lying off northwestern Australia (e.g. van Bemmelen 1949:721). Instead, he advocated the restriction of the Sahul Shelf to the area lying immediately opposite the island of Timor, retaining the earlier term, 'Arafura Shelf'

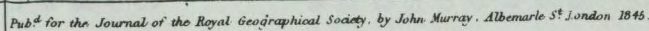


Figure 1
The Great Australian and Great Asiatic Banks (reproduced from Earl [1845]).

Date	Cartographer	Identification
1598	de Bry	Major submarine banks south of Timor (Clancy and Richardson 1988).
1633	Janssonius	'Sahull' bank (Clancy and Richardson 1988:78-9).
1666	Goos	Un-named bank south of Timor (Goos 1666).
1681	Jacobsz	Un-named bank south of Timor (Jacobsz 1681).
1690	Coronelli	Sahul island (Clancy and Richardson 1988:96-7).
1709	Loots	Un-named bank south of Timor (Loots 1709).
1714	De l'Isle	Un-named bank south of Timor (Clancy and Richardson 1988:110-11).
1803	Flinders	Great Sahul Shoal (Flinders 1803; Clancy and Richardson 1988:166-7).
1815	Anon	Banc de Sabul [sic] (Anon. 1815).
1827	v.d.Maelen	Grand Bas-fond de Sahul; apparently derived from Flinders' map (van der Maelen 1827).
1840	Daussy	Banc de Sahul (Daussy 1840).

Table 1 References to the Sahul Bank on Maps of the 16th, 17th, 18th and 19th centuries.

(following Krummel 1897), for the area between northern Australia and western New Guinea. These, then, have been the terms current amongst geologists during the most recent phase of submarine mapping (Balke and Burt 1976; Caye 1968; Nicol 1970; Veevers and van Andel 1967), and minor features such as the Sahul Rise and the Sahul Valley are all found within the more limited area identified by Fairbridge as the Sahul Shelf (Fig. 3).

NAMING A PREHISTORIC CONTINENT

If the initial extension of Sahul from its original limited application can be traced within the geological literature, how has Sahul come to identify the entire continent? It appears that only archaeologists have made this last move. As early as 1923, Edgeworth David had singled out 'the trench between Timor and the Sahul bank' (Horton 1991:133) as one of the critical barriers to the original colonisation of Australia. Early archaeological writing (Birdsell 1953:203; Mulvaney 1969:58) referred to the Sahul Shelf in its broader submarine sense (that is, including the Arafura Shelf), but never to a continent of Sahul.

Where it was named, the continental mass formed during glacial maximums was identified as 'Australasia' (e.g. Jones 1968). But the discovery of Pleistocene sites in both Australia and New Guinea during the 1960s extended the scope of earlier discussions of continental colonisation and, following Jennings' (1971) landmark paper on sea level change, Jones introduced the term 'Greater Australia' (1973, 1975) in a conscious attempt to instill an image of the physical unity of Pleistocene Australia and New Guinea.

Rhys Jones can perhaps also take the credit for establishing Sahul in the archaeological vocabulary in selecting the phrase 'Sunda and Sahul: Hunters in the tropics' for the title of a session of the 13th Pacific Science Congress at Vancouver in 1975 (Jones pers. comm. 1992). In his introduction to

the 1977 volume that carried the papers from the Vancouver conference (Allen et al. 1977), Jones referred to his choice of title 'as an expression of intellectual debt to the great biogeographers and biohistorians of the past, as a device to stimulate minds to fantasy' (1977:2).

In this, as in his writing more generally, Jones was attempting to introduce biogeographic models to Australian archaeology. Sahul served neatly to distinguish between 'land-bridge' or continental islands, such as Aru and the islands of the Bass and Torres Straits, and the 'oceanic' islands of the Bismarck Archipelago (Diamond 1977). In the proc-

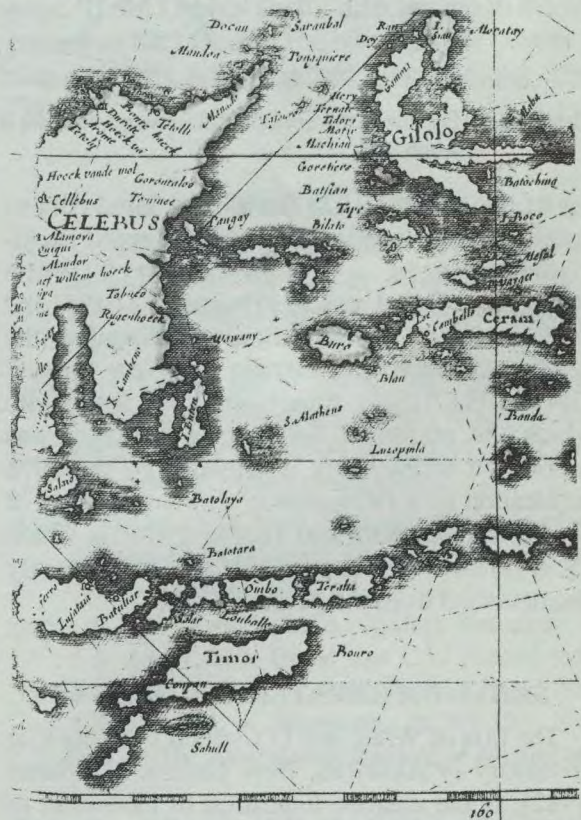


Figure 2 The Sahull bank. A Detail from the 1633 Janssonius Map (reproduced from Clancy and Richardson [1988], with the permission of the Shakespeare Head Press).

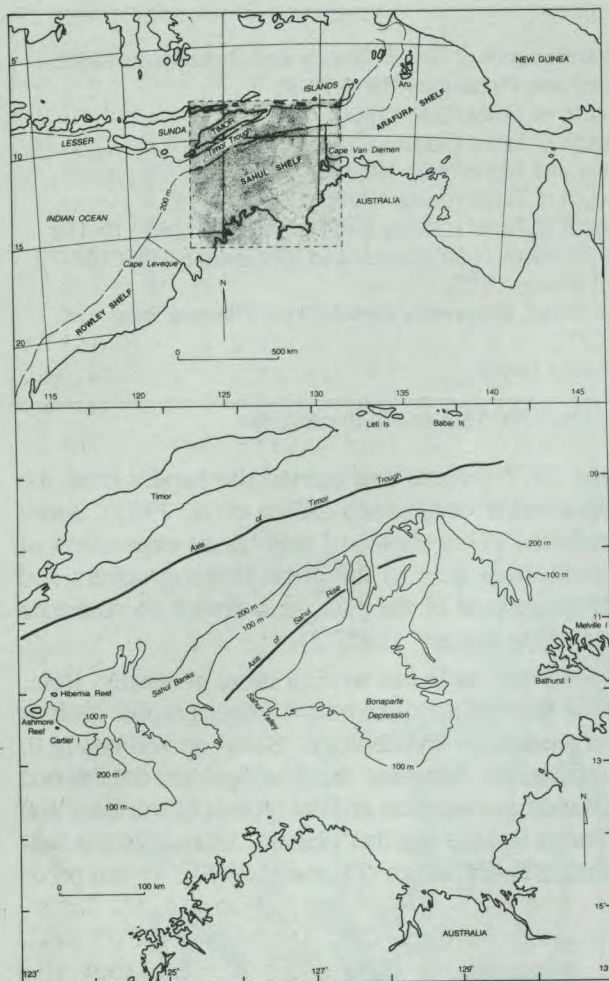


Figure 3 Details of the continental Shelf off northwest Australia.

ess of revising the 1975 Sunda and Sahul conference papers for publication, a further set of neologisms emerged: a 'Sahul industry' (White 1977:25), a 'Sahul region' (Thorne 1977:195) and the first comprehensive definition of Sahul as 'the landmass embracing Australia and New Guinea' (Thorne 1977:187). A measure of the speed with which the notion of Sahul as a continent was adopted in archaeology is provided by the 1976 publication of a 1974 conference on the origin of the Australians (Kirk and Thorne 1976), in which Sahul refers solely to the Shelf, and is frequently distinguished from the Arafura Shelf.

SAHUL OR GREATER AUSTRALIA?

The title of White and O'Connell's textbook, *A Prehistory of Australia, New Guinea and Sahul* (1982), is the clearest indication of the extent to which Sahul has achieved the status of common currency in archaeological discourse. The cover illustration itself shows the now familiar silhouette achieved by tracing the 200 m isobath. The expla-

nation provided for their adoption of the term is illuminating. White and O'Connell begin by noting that the continental shelf that encompasses Australia, New Guinea and Tasmania 'has no single name' (1982:6). Two alternatives present themselves in the literature: 'Greater Australia', and the biogeographic term 'Sahul-land'. While the second refers to an 'area of biotic similarity', the first has the advantage for archaeologists of incorporating the Shelves submerged during interglacials.

Greater Australia is still the term preferred by many writers (e.g. Jones 1979, 1989; Lourandos 1987; Thorne and Raymond 1989: map on page 41), some even drawing the distinction between Greater Australia as the continent, and Sahul as the exposed Shelf (Dortch and Muir 1980; Irwin 1991; Jones 1986). But as White and O'Connell note, Greater Australia tends 'to subsume the whole into one part, Australia, which although the largest, is, and has been, climatically and biotically distinct from its northern quarter, now New Guinea' (1982:6). Climatic and biotic considerations apart, the implicit image of New Guinea as 'a northerly extension of the Australian landmass' (Thorne 1981:1752) is open to the charge of cartographic imperialism; a problem that becomes more apparent in an Australian context when comparable alternatives, such as 'Greater New Guinea' or 'Irian Besar', are aired. To the extent that names serve to structure thought and enquiry, 'Greater Australia' has the effect of privileging a particularly Australian perspective with its corresponding theoretical heritage (see Filewood 1984 for a similar argument about Australian fauna). These may turn out to be equally as valid and useful for the Pleistocene prehistories of New Guinea and Aru, but that needs to be proven rather than assumed.

THE IDEA OF SAHUL

Yet if, despite its rather tortuous history of usage, Sahul appears preferable to Greater Australia as a term for the prehistoric continent, it is not without its own problems. Sahul has proven useful for archaeologists in establishing the idea of land-bridges, of the possibility of links between Pleistocene New Guinea, mainland Australia and Tasmania. Part of that value has derived from the lack of precise definition of the idea of Sahul. But the issues in regional archaeology have changed dramatically over the last 15 years and we need to question whether that value still holds and how widely we now want to apply the term. Is there anything to be gained, for example, in talking of the 'European occupation of Sahul' (Sutton 1991)? Two key assumptions that have underwritten our use of Sahul look increasingly questionable.

The first of these is the notion of a correspondence between continental and cultural entities. A broad cultural and historical unity that matches the physical unity of the glacial continent is implied. Thus White and O'Connell (1982:3) suggest that 'for about the first 40,000 years, the people of Sahul have a common history'. As Thomas (1981:167) has shown, much of the literature on Tasmania's physical and cultural isolation works from the same position: continents allow for more complex, continental-sized social systems than do islands. Yet, despite the claims made for parallels in waisted blade technology or hand stencils, it is perhaps fair to suggest that any significant cultural continuity between New Guinea and Australia during the Pleistocene still remains to be demonstrated.

The second related assumption is that land-bridges have been critical determinants of continuities and discontinuities in Pleistocene culture history. The privilege that the idea of Sahul accords to land links is an ironic emphasis given the presumed maritime competence and immediate island origin of the Pleistocene colonists (Irwin 1991). Where such an emphasis may be valid is for Bass Strait, and this in turn suggests that the idea of Sahul has been developed largely from a Tasmanian perspective. However, in light of the new evidence from Island Melanesia for Pleistocene colonisations of New Ireland (Allen et al. 1989), Manus (Fredericksen et al. this volume), and the Solomon Islands (Wickler and Spriggs 1988) it is now 'likely that humans were reaching the southern end of the Solomons chain at the same time they were attaining the southern margin of the Australian continent' (Wickler and Spriggs 1988:706). The identification of New Ireland as a Sahulian or Greater Australian 'outlier' (Allen et al. 1989) suggests the extent to which the idea of Sahul is now being stretched.

CONCLUSION

The idea of Sahul, an old term recast within a new context to provoke fresh ideas, has evidently played an important role in Australian archaeology. Interestingly, biogeographers have recently proposed a new but somewhat parallel, geographical term, Meganesia, that fills their perceived need to express the unity of the animal species found within 'the area exposed as a single geographical unit during the Pleistocene glaciations' (Filewood 1984:1124). 'Oddly enough,' Filewood continues, 'although the reality of the Tasmanian-Australia-New Guinea island is quite certain, no one has published a name for it.' This re-invention of the wheel aside, there may now be scope for a series of names for over-lapping geographical constructs in

archaeological thought; separate terms that each stress the significance of the wide range of different issues being addressed within Pleistocene archaeology. This is not the place to propose these terms but, as an example, the existence in climatic theory of an Indonesia-Carolines 'maritime continent' that incorporates New Guinea but not Australia (Ramage 1968) raises the possibility of a geographical unit constructed around wind currents that might better serve our understanding of Pleistocene Island Melanesia. Jones' inspired 'invention' of Sahul for archaeology demonstrates the contingent, problem-specific nature of the definition of prehistoric landscapes, and represents a strong case for continued debate on the role that cartography plays in the archaeological imagination.

ACKNOWLEDGEMENTS

Though Les Groube's fulminations on the subject of 'Greater Australia' were an unwitting inspiration, a chance query from Jack Golson about the origins of the term Sahul led me to write this paper, initially in the form of a poster for the 1991 Australian Archaeological Association conference. Rhys Jones generously responded to my enquiries and drew my attention to the Edgeworth David reference. Colin Groves kindly directed me to the literature on Meganesia. The advice of the editors is also gratefully acknowledged. Ian Faulkner drew Figure 3.

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PLEISTOCENE CHRONOLOGICAL STRUCTURES AND EXPLANATIONS: A CHALLENGE

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It is worthwhile starting this discussion of chronological problems in Australian prehistory with a brief note on the broader social context of time and tradition, for time has different meanings for different people in different contexts (Leone 1978), and these views are affected by, and in turn may affect, archaeological research. Over the last decade the date of 40,000 years ago has become internalised into the Australian consciousness as the date of first human occupation of the continent. An extension of this is the common claim that Aboriginal people represent 'the oldest continuous culture' in the world.

This image of great antiquity is often used to emphasise Aboriginal claims for land rights. Recent claims for occupation at 60,000 years ago have been welcomed by some Aboriginal people, who see it as further legitimisation of tradition and claims for land rights (*Land Rights News* July 1990, Vol. 2.19:11). But, as Wright has pointed out, 'land-rights are a matter of justice not of elapsed time' (1986:244).

This measure of time is, of course, founded directly on archaeological data. It is now well entrenched, and any claims for greater antiquity are enthusiastically, if uncritically, picked-up, despite the increasingly clearly articulated problems of dating techniques and the inadequacy of current information.

Parallel claims for continuity as well as antiquity suggest that cultural legitimacy is also enhanced by longevity. This can be more dangerous as the assumption of long-term continuity essentially denies the value and validity of archaeological research. While genetic and cultural continuities may be traced, they need to be discussed and assessed, demonstrated rather than asserted. The analysis of cultural, economic or technological change needs to be separated from any judgements, positive or negative, on the respective value of conservatism or innovation.

In some of the recent debates concerning disposal of ancient human remains, archaeologists have argued that different policies should be

adopted for those of different ages. It is often asserted that recent remains should be handed over to Aboriginal communities, but that Pleistocene remains have greater research significance, requiring preservation. An associated argument is that remains so old cannot have any personal (as opposed to scientific) significance for living people, and that there is (to borrow Wright's phraseology) a regression of association on time. This alienation from older skeletal remains certainly applies to most Western peoples. Many Aboriginal people, whether stimulated by a different view of the relationship between past and present or motivated by current political considerations, see things differently and make no distinction between recent and Pleistocene material.

Within archaeology itself, time is treated in different ways. Some prefer fine detail; others paint with a broader brush. Some believe that older is better, others are less fixated on early dates. But all understanding comes back to fundamental questions in archaeology. How does one date material? Does significance vary with antiquity? What is continuity? What is change? How do we measure time and identify significant variations? Can we differentiate and explain forms of and rates of change? The aim of this paper is to expose some of these fundamental issues in the context of Australian prehistory.

VARIABILITY IN TIME AND SPACE

We use time to establish synchronicity or sequence, but are plagued by an inability to determine appropriate scales in either case, or to link particular scales of observation to types of explanation (Bailey 1981, 1983). There are parallel issues in spatial scales. Just as we may contrast short-term and long-term processes, we must also recognise local or site specific as opposed to regional or continental systems.

In Australia it will be many years before we have more than a thin spread of excavated sites, scattered widely in both time and space. Site-specific, or

very localised research may allow a tighter focus and one approach to explanation. But for much of Australian prehistory the poverty of the archaeological record forces (or encourages) the larger continental-scale as well as longer temporal scale of analysis. Are local factors simply noise within broader systems or if site-specific explanations are possible, does this discount the possibility of seeing meaningful trends at a broader scale? Can we use individual sites as exemplars, regarding their individual histories of occupation and use as representative of regional or continental patterns?

There are three main strands to Australian prehistoric research: environmental, biological and cultural. Developments in each may be significant at different scales. The measurement and significance of variation in human biology is, at present, very confused. Australian physical anthropologists differ radically not only on the time-scales and explanations of change, but on the fundamental structure of the data (Pardoe this volume). Quaternary geomorphologists, however, can measure processes of different types with different tempo (slow erosion, medium coastal change, fast or catastrophic volcanic activity). In most prehistoric archaeology such distinct time-dependent causality cannot be assumed.

The archaeological record involves the measurement of a range of material and attributes making up an interconnected series of different dimensions of meaning. These differ disproportionately. In order to understand the significance of temporal differences, we need to consider the comparative variability expected of, for example, technological, functional and stylistic attributes of artefacts. Our scales of observation and techniques of measurement, coupled with the intrinsic variability of these different facets, accentuate some elements and overlook others: those with a high profile attract more attention and become pivotal points around which further discussion is built (see Frankel 1988).

UNIFORMITY, TREND AND DISCONFORMITY

Much archaeological discussion is concerned with identifying and explaining variation. Comparatively little attention is paid to explaining uniformity – the opposite pole on the axis of similarity or difference. In considering temporal change, we must consider both the scale and rate of variation. At the simplest level this allows us to separate temporal uniformity, trend and disconformity.

Uniformity: no differences observable between analytical units.

Trend: differences between analytical units appear cumulative, tending in the same direction.

Disconformity: an unexpected relatively sudden or strophic change.

The identification of each of these is, in large part, a question of the scale of resolution or observation used to identify patterns. In Figure 1 the scale of time along the horizontal axis may be decades, centuries, millennia or longer. The vertical axis represents varied scores on any assemblage or material. Two fluctuating scores through an equivalent time range are shown: these continually vary in both amplitude and wave-length (that is, degree and tempo of change). At finer scales the two lines differ (one increases while the other decreases; one fluctuates more, and more rapidly than the other). At a finer scale some variations appear as trends, which at a medium scale appear as disconformities, while at a still larger scale a different (common) trend emerges. Observation or measurement at the crudest scale – the entire time-span – collapses all this variation into one average form of behaviour.

Which of these oscillations are significant and which are minor fluctuations or noise within a system (cf. Frankel 1988)? Although individual items or specific contexts may represent specific episodes, we can seldom, if ever, analyse assemblages or sites at the fine scale (decade, generation or century) and are forced to move to coarser-grained analysis, suppressing or avoiding lesser variation. In a sense this runs parallel to some concepts developed by Braudel and the French *Annales* historians, concerned with levels of temporal analysis and linkages between events and series or structures of longer duration. The archaeological scale of observation is, however, so different from that of history that an archaeologically visible 'event' might well be coeval with (or even longer than) the historically perceived 'longue durée'.

Temporal uniformity is sometimes explained as conservatism (implying a long-term continuity of a specific cultural tradition) and sometimes as the

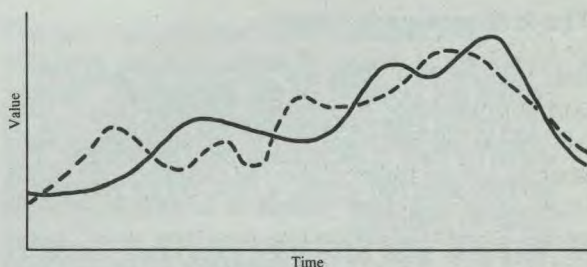


Figure 1 Variations through time are not constant, but fluctuate in both degree and rate. Coarser-scales of observation will identify some patterns, finer-scales will show others.

reflection of a particularly efficient adaptation to an unchanging environmental context. The latter does not suggest any other cultural continuity, but carries implications of appropriate, normative and most efficient behaviour.

Adaptation is also invoked to explain contemporary changes in behaviour or technology and the environment. But there has been little consideration of how or what adaptation is or how it operates at different scales of time. Nor, indeed, much questioning of the value of the concept.

This leads to a more fundamental question. Is there any basis for assuming that any of the uniformities or trends which we identify are related or cumulative over long periods of time? Is there any meaning in observed trends or can they only be explained as the product of individual acts (Mithen 1989)? If this were so, then there would only be meaning at the finest level of resolution, and trends would be only accidentally cumulative. A contrary view would be to see trends as the product of a positive feedback in a system, with each specific change enhancing further change of the same sort.

STRUCTURAL AND METHODOLOGICAL CONSTRAINTS

This discussion brings us back to archaeological basics. Before further issues of chronological practice can be addressed, it is important to clarify technical and procedural issues. Whatever the scales of resolution we aspire to, our analyses are structured by:

1. the formation and survival of sites, the nature of the archaeological record, and the current state of research; and
2. technical aspects of dating methods.

Some Australian examples of these problems using later material have been dealt with elsewhere (Bird and Frankel 1991a, 1991b; Frankel 1988, 1991b). Only selected aspects of particular relevance will be noted here.

The archaeological record

- a. Typological dating of artefacts is not available (either not possible or not attempted). Neither excavated assemblages nor surface sites can be dated by their contents, but only by context. For surface sites this gives, at best, only a very rough guide to antiquity.
- b. Very few sites have been excavated, dated, or published. These are not necessarily representative.

- c. Only caves or shelters have the potential for showing continuity or discontinuity of use, and then only when there is a good series of dates.
- d. Most excavated sites are inadequately dated, with too few samples to allow internal corroboration or analysis of changing site use.
- e. Sediment within sites tends to be uniform or undifferentiated, with little stratigraphic structure that can be directly related to time.
- f. The finest-scale stratigraphy still normally includes discard from numerous events in basic excavation units. In analysis these are combined into even longer-term units (see Frankel 1988).

Archaeometric dating

- a. While AMS dating is still generally unavailable, 40,000 years remains an upper limit for C¹⁴ dating (Bowman 1990:37).
- b. Unless a large series of C¹⁴ dates are available, there is an effective minimum level of precision for individual C¹⁴ determinations of ± 100 years.
- c. C¹⁴ determinations are relative not absolute. Older dates are increasingly, or unpredictably younger than the true age (Bard et al. 1990). Older dates compact time, enhancing synchronisms and reducing differences.
- d. Thermoluminescence dates are absolute, not relative.
- e. Systematic error-levels of TL dates are very great (20% of sample age is not uncommon). Problems associated with the rate of sediment accumulation may also lead to higher error-levels than with many C¹⁴ dates.
- f. Cation-ratio dates must be treated with extreme caution (Bednarik 1990) and are perhaps best seen as relative rather than absolute ages, other than in the grossest terms.

THE PLEISTOCENE ENVIRONMENTAL TIME-SCALE

The Pleistocene

Both the conference for which this paper was originally prepared, and that from which this volume derives, conform to a current convention in Australian archaeology where research is structured around the general temporal reference point of the Pleistocene/Holocene boundary. This simple dichotomy is based on implicit concepts of a continental scale of analysis. It stems from a long tradition of broad-scale approaches to prehistoric research and explanation coupled with a tendency to universalise and simplify complex systems.

In the original European context the identification of different faunal assemblages representative

of the two epochs was crucial to the demonstration of the great antiquity of human occupation. To this initial identification, typological and later economic and behavioural models were added. The Pleistocene was equated with the Palaeolithic, the early Holocene with the spread of people into areas released from glacial ice and the development of what would now be termed the Mesolithic or Epi-Palaeolithic. From a Eurocentric view the Holocene is identified with new and unique forms of socio-cultural evolution.

The association of Pleistocene fauna and human remains was not possible in Australia. A range of now extinct megafauna were first identified over a century ago, but even today their association with cultural material is, at best, dubious. Earlier archaeologists in Australia did, however, use associations of lithic industries and coastal geomorphology to argue for a deep prehistory, clearly linked to a global Pleistocene succession (for example Tindale 1937, 1947).

With the advent of independent, archaeometric dating for both environmental and archaeological evidence, the need for such faunal or geological chronological markers has become irrelevant. Nevertheless use is still made of these terms. Why is this so? Several justifications may be put forward.

1. The terminology has a historical place in archaeological discourse and provides a link to longer sequences of Pleistocene events abroad, connecting Australian prehistory to the rest of the world.
2. There is a real difference, separating the early periods of Greater Australia or Sahul from those of three separate land masses after the flooding of the Bass and Torres Straits; the environment was distinct and different; human behaviour was distinctly different.
3. It is simply a shorthand convenience to refer to earlier periods, and has no further significance.
4. It separates out an archaeology of long time-scales from that of shorter time-scales.

I am unconvinced by any of these arguments. There is no longer any need to refer to a common geological time-scale to associate events globally. We cannot assume that either environments or behaviours were distinct; there was certainly extreme variation within the period, and plateaus of uniformity as long as any in the Holocene. In no sense can one regard occupation 40,000 years ago in the tropics, 30,000 years ago in southern Tasmania, 20,000 years ago in the arid zone, and 10,000 years ago along the Murray as part of any unity separate from later periods. There is no correlation of the Holocene and new socio-economic systems. Even though researchers will claim otherwise, the termi-

nology still carries connotations of broad-scale continental unity, hiding variation rather than exposing it, for both earlier and later periods. The fourth aspect is the most important, and leads on to the consideration of the measurement and meaning of different archaeological scales. If Pleistocene archaeology is the archaeology of the long time-scale, then it is appropriate to consider what this means and how long-term uniformity or variation can be explained.

Finer environmental divisions

On the basis of radiometric dating the Holocene is often subdivided into Early, Middle and Late; this is less easily done with the Pleistocene, as geological usage prohibits the equivalent terminology within the known time-span of human settlement in Australia.

Other environmental referents are however in use: glacial maximum; arid phase; period of low sea level and so on. While introducing a somewhat finer scale of time (several thousand years) these subdivisions of the Pleistocene emphasise particular episodes and carry the two important implications of a connection between gross environmental structure and archaeological material and a continental scale of explanation.

BROAD-SCALE CHRONOLOGY AND SETTLEMENT HISTORY

General models of Pleistocene settlement and colonisation have been constructed at a broad chronological scale. Several procedural and technical issues in dating emerge from a consideration of recent research on this topic by Allen (1989), Bowdler and O'Connor (1991), O'Connor (1990), Roberts et al. (1990) and Veth (1989). While most of the problems dealt with here are methodological, these need to be considered before questions of explanation can be adequately addressed.

Archaeological issues

Present evidence and representative sites

Seldom, if ever, do we have Pleistocene sites with closely parallel histories of occupation or use. How representative of general systems is any one site? This problem is compounded by the general paucity of present evidence: with few sites excavated, fewer analysed and published, and a strong bias toward rockshelters.

Veth (1989) has discussed colonisation and changing settlement pattern across two-thirds of Australia and over 30,000 years. He uses radiocar-

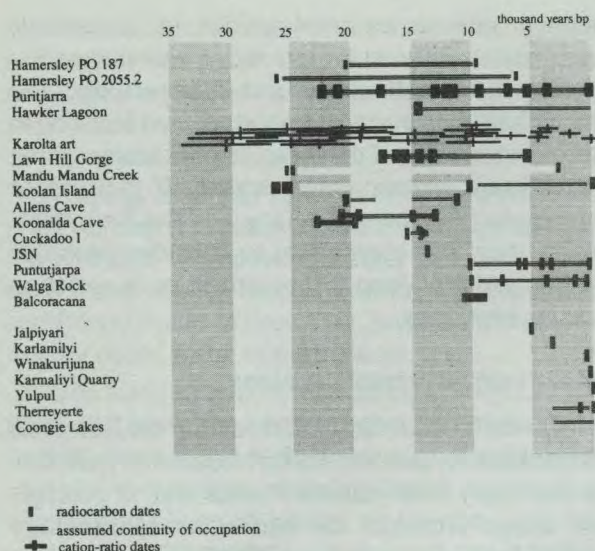


Figure 2 Diagrammatic representation of material used by Veth in his analysis of arid zone occupation. The graphic presentation of data and inferred continuities and discontinuities reveals inadequacies in both. (Data from Veth 1989 supplemented by dates from Bordes et al. 1983; Gould 1977; Hiscock 1984; Nobbs and Dorn 1988; Smith 1989; Wright 1971.)

bon dates from less than two dozen sites, excavated as part of different research strategies and not selected as a representative sample. Few have been extensively excavated or published in any detail (data summarised in Fig. 2). Is this sufficiently large a body of data for building broad continental-scale models?

The continuity of use of Lawn Hill Gorge and Koonalda Cave is seen as atypical, and hence not a contradiction of Veth's general model. What criteria can we use for arguing that the other sites are typical – that is, their sequences reflect broad patterning or processes (cf. Bird and Frankel 1991a, 1991b)?

Similar arguments from single sites are common in Australian prehistory: a syndrome of the current state of research. A slightly different aspect is seen where Roberts et al. suggest that the earliest artefacts at Malakuninja II represent the first arrival of people in the continent (1990:156). While one site may be enough to provide an early date, can it be taken to show the earliest date, or be representative of behaviour at any time? However, as Allen has argued (1989; cf. Stanley Price 1977), identification of early settlement can only be based on secure data, so that present absence of evidence constitutes evidence of absence.

Continuity and discontinuity of site occupation

Significant stratigraphic disconformities have seldom been defined in the field (Smith and Sharp, this volume). Continuity or discontinuity of occupation, or changes in the rate of sediment deposition can only be defined by subsequent archaeometric dating or the analysis of the distribution of excavated material.

Of Veth's refuge area sites only Punitjarra has a reasonable series of radiocarbon dates. It may be possible to argue that gaps between radiocarbon dates of 5000 years at this site are simply artefacts of sample selection, while changing quantities of discard represent a small break in occupation of 500 years or so (Smith 1989:98). But can continuity of use be argued when there are only two dates for a site, 10,000 or 20,000 years apart (as in the Hamersley Range sites)? The quantity of material in most sites could represent occasional irregular visits to a site over very long periods of time.

The observation of continuous occupation at long time-scales is obviously a crude generalisation. Continuity here does not even demonstrate that sites were part of some regular use of a region. They may have only been visited at extremely long intervals – perhaps not even every generation. With coarse-grained analysis of sites or regions, gaps in site use of hundreds or even thousands of years are not visible. These may well represent significant changes in settlement pattern and other activities. Only finer-scale analysis of individual sites can avoid glossing over such variations and the assumption of broad uniformity and continuity of settlement pattern.

A variant of this problem in establishing continuity, or arguing for discontinuity is seen in the recent work of O'Connor at Widingarri Shelters 1 and 2 (Bowdler and O'Connor 1991; O'Connor 1990). This involves a highly dubious cross-dating of two adjacent shelters. The postulated 11,000 year abandonment of the two sites (from 18,500 to 7500 BP) is simply created by an ingenious piece of sleight-of-hand, and the swapping of dates from one site to the other. Although it is possible that similar sediments in two separate sites may indicate parallel sequences of accumulation, this needs to be demonstrated by an adequate array of C^{14} dates from both, and cannot simply be assumed. Any broader-scale models of local, regional or continental population densities based on such inadequate bases must be regarded with great suspicion.

Technical issues in dating

Limits of C^{14} dating

In his recent assessment of other early dates, Allen rejected indirect evidence, including that of

poorly-dated sediments (e.g. Cranebrook Terrace) and argued that the earliest secure radiocarbon dates in Australia are of the order of 40,000 BP (Allen 1989) (cf. Fig. 3). Is this a factor of the limits of normal C^{14} dating (Bowman 1990:37; Roberts et al. 1990)?

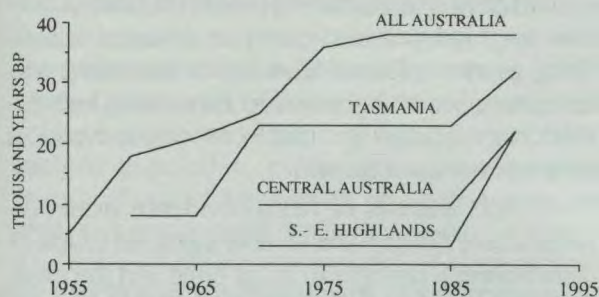


Figure 3 The changing information base in Australian prehistory is exemplified by the oldest radiocarbon dates from different parts of the continent known at different times (after Frankel 1991a: Fig 1.1).

Selective use of dates

Veth (1989) accepts the Karolita cation-ratio dates in principle, but explains away two which fall in the 18,000 to 15,000 year period as having such wide error levels that they need not come from that time. Statistically this may be so, and the absolute values of cation-ratio determinations are also a matter of uncertainty. But is it legitimate to exclude only those that fail to fit a general model?

Precision of archaeometric dating

While the standard-error for C^{14} dates is minimal compared with the age of samples, this is not so for TL dates. The date of $52,000 \pm 11,000$ years for artefact-bearing sediments at Malakuninja II may equally well demonstrate an age for the artefacts as young as 41,000 and as old as 63,000 years ago. Even the conservative suggestion of 50,000 cannot be justified statistically.

Can we really use such coarse-grained dates either for specific dates of occupancy or as a basis for sequences?

Chronological currencies

Apart from the TL dates on volcanic ash from the Huon Terraces (Groube et al. 1986), the oldest well-accepted dates of about 40,000 BP are radiocarbon determinations. It is possible that a TL date of 50,000 may be no older than a radiocarbon age of 40,000. In other words, the Malakuninja dates do not demonstrate a greater antiquity of occupation, but give an absolute value to it.

As older C^{14} dates contract time in earlier periods, sites seem closer together, and developments

look more rapid than they really are. This may materially affect our image of a rapid colonisation of the continent, or speedy response to environmental fluctuations.

Rate, behaviour and explanation

We may accept that people first arrived in Australia about 40,000 radiocarbon years ago, were near Perth and in western New South Wales 38,000 years ago and in southern Tasmania by 35,000 years ago. How should we describe and explain this? Two statements suffice to highlight the way in which perceptions, attitudes and explanations may be blended.

1. If we accept the latter possibility, that the current dates do approximate the time when humans first reached Australia, we must accept not only a rapid colonisation of the entire continent but one by very adaptive humans, who, in only a few thousand years, managed to occupy environments as diverse as the tropical lowlands, the arid zone and the periglacial uplands of southern Tasmania. (Allen 1989:152).
2. The current dates show that slowly but surely, over the course of thousands upon thousands of years, there was a gradual expansion, as the later descendants of early colonists crept into distant regions, eventually coming to terms with a range of diverse environments.

UNIFORMITY, TREND AND DISCONFORMITY IN LITHIC TECHNOLOGY

Pleistocene industries have been seen to show all three basic temporal structures: underlying uniformity, long-term trends and specific innovative disconformities. This is in part a reflection of the scale of analysis (spatial and chronological) but is also a product of the emphasis or significance given to individual elements or types. Description of broader assemblage structure may imply continuity. The introduction of a single new type, technology or raw material at any one site may always appear sudden, but slightly varied sequences at sets of sites give an image of slower regional adoption or innovation. The high archaeological visibility of some innovations may exaggerate their importance when seen against a constant background.

The comparative variability of different dimensions of stone tools is also important. Some dimensions (for example technology) may change little. Others, such as function, may follow the rhythms of environmental change, while yet other (stylistic) attributes may vary more, and more unpredictably, through both time and space. It is also possible to

suggest that, as most tools were used for maintenance rather than extractive activities, they were relatively conservative, and so demonstrate less variability than the (unknown) items that they were used to produce.

While the unity of the Australian Small Tool Tradition has been undermined (Kamminga 1978:358, 1982:102; Lampert 1981) the earlier Core Tool and Scraper Tradition is still generally seen as an entity, representing a long continuity over the whole continent throughout the Pleistocene. For Lampert at least (1981:154-5) the similarity of tools within Australia and south-east Asia represented a common tradition of steep-edged tools lasting at least tens of thousands of years, varying minimally in space. Flenniken and White (1985) go further, and argue that all Australian industries represent a single 'ingeniously simple and flexible' reduction sequence. Temporal and spatial variations only exist as variations on an underlying theme of opportunistic stone-working.

Superimposed on these views of lithic uniformity are suggestions of a long-term cumulative trend as tools became progressively smaller (Lampert 1981:160-3; Lorblanchet and Jones 1979:484). Lorblanchet and Jones see

in Australia as a whole the continuous and slow technological progression toward more efficient tools, already recognised in Europe and in Asia, which is deeply woven into human efforts towards a greater mastery of the natural environment (Lorblanchet and Jones 1979:484, translation by C.F.M. Bird).

That is, uniformity represents a common and conservative tradition, while the trend shows a growth in ability and efficiency – a combination, perhaps, of biological and technological adaptation.

A similar duality of explanation – conservatism and environmental adaptation – may also be identified in the long-term uniformity seen by Gould in lithic resource use and typology in Holocene central Australia (1977:171).

At the other end of the scale of similarity is the short-term disconformity. On the basis of limited evidence, Jones argued that the appearance of thumbnail scrapers at Kutikina was an archaeologically 'instantaneous' event about 17,000 BP (1988:36). He suggests that so rapid a change signals the arrival of a new ethnic group. Although uncertain as to date, and confused as to rate, Cosgrove et al. (1990:71, Table 2) seem to support a rapid introduction of this tool type into the central south Tasmania, but refrain from any specific explanation for this or other regional or temporal variation within Pleistocene industries. They too regard the introduction of this specific tool-type as important, but avoid discussing why this is a sig-

nificant variation, and not a minor innovation in a context of long-term uniformity.

STRATIGRAPHY AND FAUNAL ANALYSIS OVER 20,000 YEARS

Different dimensions of faunal exploitation may also vary independently, and at different scales. Some aspects reflect availability of resources, others techniques of exploitation. Processing and discard may change for different reasons and at different rates and times.

In their analysis of faunal evidence from Nunamiira cave Cosgrove et al. note a general synchronism between changes in burnt bone and the onset of colder conditions 24,000 to 21,000 years ago (1990:68). They present data on bone taphonomy in two figures (1990: Figs 4 and 5). These show a time-series with 22 stratigraphic (analytical) units, which are treated differently in the two figures. Figure 4 gives information on proportion and structure, and so carries no implications as to the time-span of each stratigraphic unit, unless rate-of-change is being discussed. Figure 5, by presenting raw numbers, implies that the units are equivalent. In both cases there is the common and unavoidable assumption that behaviour **within** each of the (millennium-long) units is constant or, at least, that a conflated average or normative measure is meaningful.

The changing percentages of burnt bone in Figure 4 show an early plateau of uniformity, followed by a later trend of increasingly lower proportions. By contrast, Figure 5 suggests fluctuations in intensity of occupation and a slightly earlier disconformity (or more rapid change) in the quantity of burnt bone.

These two different images of change are products of the method of analysis and presentation. The apparent disconformity seen in Figure 5 may well be exaggerated, but if it is substantiated by additional radiometric dating it will require a different explanation from that of the longer-term trend seen in Figure 4. The shape of this trend is dependent upon the time-span of the stratigraphic or analytical units. As presented here they are all regarded as equal. While beginning at the start of the colder phase, this apparent trend cannot be simply causally related to environmental fluctuations, as it continues through the coldest period and into later warmer conditions. While species exploitation may be uniform over 20,000 years, there are behavioural disconformities and trends visible at different scales of time.

DISCUSSION

From this selective, and deliberately provocative critique it is clear that the current database, chronological frameworks and explanatory mechanisms employed by archaeologists are only adequate at a very general level. Gross synchronisms are treated as if they were more specific; individual sites as if they are representative; and general environmental correlates as if they were causally related. Discussions of colonisation and change are perforce crude and general. Where a finer-scale of analysis is possible, explanations are still inadequate. Rates of innovation or development are often an unrecognised product of method of analysis. There is little attempt to show, let alone exploit, the way in which different parts of the archaeological record vary in different ways, to different degrees and at different times. There is, instead, a general tendency to look for, perhaps even force, synchronisms leading to simplistic models.

Methodological issues in handling stratigraphic sequences, or shorter-term regional histories have been discussed elsewhere (Bird and Frankel 1991a, 1991b; Frankel 1988, 1991a). Such analyses show that individual sites have complex and varied histories. The developments at any one site may be explained in terms of resource availability or other local factors and it is still not possible to argue that any one site is representative of a region or larger-scale trend. That is obviously one task for the future, where detailed site-histories can be compared, parallel trends identified, and site specific factors separated from others. The other task is to consider closely the multidimensional structure of the archaeological record and to determine how significance and meaning can be ascribed to it, if not derived from it.

Following his overview of the rich Pleistocene archaeological data of Europe, Gamble declined to address questions of causality or explanation for social change (1986:382). Even the finer-scale information of later periods in Australia seldom, if ever, approaches the quality of that data-set. Although we should not therefore refrain from explanation until far more data, with closer synchronisms, cultural and environmental, are available, we should still beware of building broad models upon inadequate bases.

The issue here may really be one of changing perspectives, giving priority to discussion of local and regional sequences. In essence this is a question of whether the key issues in Australian archaeology are those of establishing a continental history, or of investigating the nature of hunter-gatherer society and its variability. In doing so we will need some measure of the significance of archaeologi-

cally observed differences in time and space, so that we can assess whether or not these reflect substantial changes in hunter-gatherer behaviour. Are we really dealing, as is commonly assumed, with 'a changing people in a changing land' or essentially with unchanging people (Bird et al. nd)?

FINAL PROVOCATIONS

In conclusion, some provocative comments may be made:

1. More attention should be given to the way in which research strategies skew the primary data base, and why particular elements are selected as significant.
2. Broad environmental divisions are not an appropriate measure of time at which to divide Australian prehistory. They presuppose, rather than demonstrate relationships.
3. Just because we are dealing with older periods, does not mean that broad time-frames are appropriate. These gloss over significant variation in both time and space and avoid significant finer-scale changes and fluctuations.
4. Earlier periods (the Pleistocene) should not be treated separately, but all Australian prehistory be seen as a continuum, with similar behaviour, temporal and spatial variability and explanations.
5. Different elements may vary at different rates: we may need to separate technological, functional, stylistic and economic variables and monitor them separately.
6. Australian prehistory may need to differentiate between long-term, continental narrative and description, and short-term regional explanation.

However, in addressing these and other questions, our ambitions are, as always, tempered by reality, as the nature of archaeology 'provokes the desire but takes away the performance'.

It is also a question of the scales of research itself. Short-term, or broad-scale research projects can only lead to large-scale narrative. Longer-term, more specific projects will provide localised, site- or region-specific studies in the first instance, but these can later form the basis for identifying common behavioural patterns. Perhaps we should work outward to the broad picture from accumulated data and concepts developed in detailed local sequences, accepting a slower pace for substantial contributions.

NOTE

This paper is a minimally revised version of one presented at a small conference on the Pleistocene

on the Periphery, held at Tidal River, Victoria in August 1990. It was intended to provoke discussion, and so raises more questions than it answers. Several key points were summarised in a poster presented at the Australian Archaeological Association Conference in 1991.

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PALEOCEANICITY IN AUSTRALIA, NEW GUINEA AND THE MELANESIA CIRCUMCARUM AND ITS IMPLICATIONS FOR THE ANTHROPOLOGICAL RECORD

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The discovery of the Pleistocene in Australia and New Guinea has been a landmark event in the history of the continent. It has opened up a new world of possibilities for the study of the human past. The discovery of the Pleistocene in Australia and New Guinea has been a landmark event in the history of the continent. It has opened up a new world of possibilities for the study of the human past.

BROAD SCALE PATTERNS

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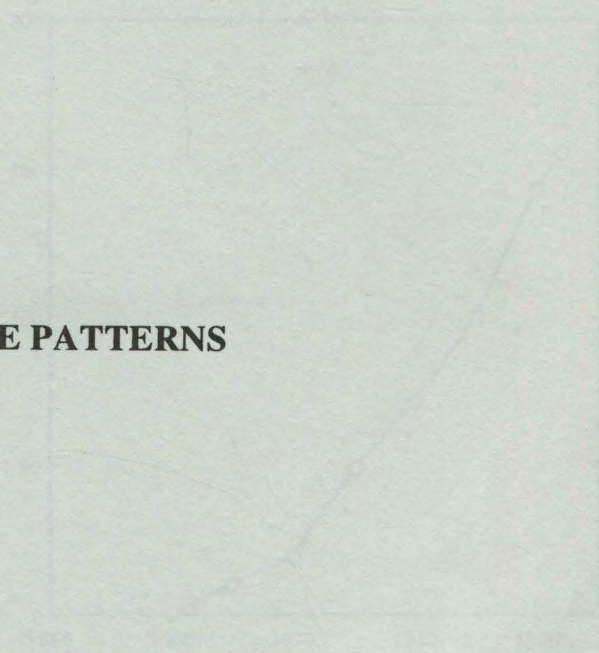


Figure 1. A line graph showing a sharp increase in data over time, likely representing the discovery of the Pleistocene in Australia and New Guinea.

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THE ANTHROPOLOGICAL RECORD

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BROAD SCALE PATTERN

PLEISTOCENE SITES IN AUSTRALIA, NEW GUINEA AND ISLAND MELANESIA: GEOGRAPHIC AND TEMPORAL STRUCTURE OF THE ARCHAEOLOGICAL RECORD

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The discovery of late Pleistocene sites in the Sahul region has proceeded at an accelerating pace since 1962 (Fig. 1). In 1968, when Jones first reviewed the Pleistocene evidence, he was able to list 10 sites (1968:188-90). Five years later his list had grown to 24 sites (1973:Table 1) and by 1979 included 36 late Pleistocene sites (1979:Fig. 1). The 1980s added a large number of new sites, often in regions where a late Pleistocene phase of occupation was previously unknown such as in Island Melanesia (Allen et al. 1988), southwestern Tasmania (Kiernan et al. 1983), central Australia (Smith 1987), the northwestern coast of the continent (Morse 1988; O'Connor 1989) and the Australian Alps (Flood et al. 1987). The last decade has also seen an upsurge in contract and salvage archaeology leading to the discovery of new sites in comparatively well-investigated regions, in particular in southwestern Western Australia and eastern New South Wales. New techniques for the dating of art surfaces have also given Pleistocene dates, albeit often controversial, for a small number of rock art sites across the continent (e.g. Dorn et al. 1988; Dragovich 1986; Loy et al. 1990; McDonald et al. 1990; Watchman 1987).

With the rapid growth of this dataset, it has already become difficult for any one person to fully list the relevant archaeological sites, let alone command an overview of the archaeology of this period. Nor, to echo Jones (1973:278), does the pace of discovery show signs yet of abating. Thirty years after the excavations at Kenniff Cave firmly established a Pleistocene antiquity for human settlement in Australia (Mulvaney 1962, 1964), it is an opportune time to take stock of the evidence.

In this paper we review the extent and quality of the archaeological record for the late Pleistocene. In the first part we list the sites and examine the quality of this dataset, looking in particular at the extent of investigation of sites, the extent to which basic site data have been reported, levels of analy-

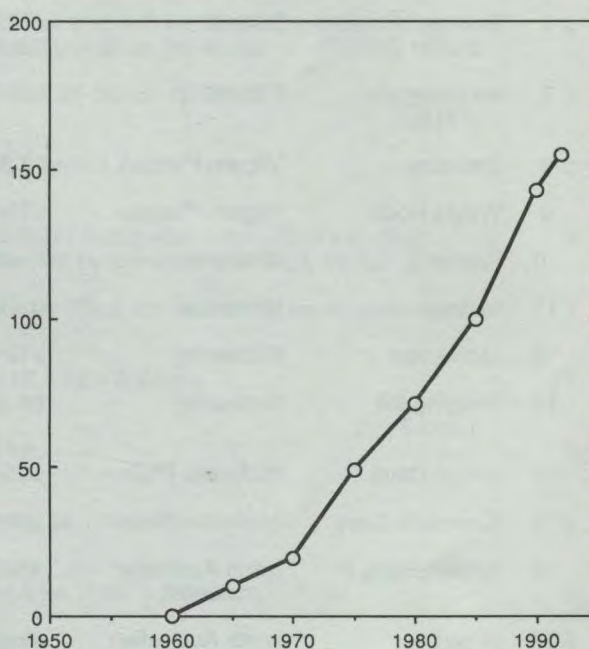


Figure 1 Rate of discovery of late Pleistocene sites in the Sahul region. Data are the number of known sites, plotted at intervals of five years.

sis, and the basis for site chronology. Our approach to looking at these issues follows loosely that employed by Bird and Frankel (1991) in their review of Holocene sites in southeastern Australia. In the second part we plot the distribution of Pleistocene sites at a variety of spatial and temporal scales.

THE ARCHAEOLOGICAL RECORD

Late Pleistocene sites

There are now at least 154 late Pleistocene sites known from the Sahul region. These are listed in Table 1, together with an outline of the chronology of occupation at each site and an indication of the number of dates that this is based upon. A bibliog-

	Site	Region	Occupation Sequence	#Dates
	Rockshelters or Caves			
1	Devils Lair	west Australian coast	redeposited archaeological material 32.5-27.7 ka; occupation of cave and entrance 27.7-6.5 ka.	18
2	Mammoth Cave	west Australian coast	burnt and cut megafauna bone in >37 ka deposit.	2
3	Mandu Mandu Creek	west Australian coast	// ca. 32-20 ka. // 5.5-0 ka.	9
4	Pilgonoman Creek	west Australian coast	// ca. 31.8-10.2 ka. // 0.5-0 ka.	6
5	Yardie Well	west Australian coast	// 10.5-<5.5 ka.	3
6	Newman Rock-shelter (P2055)	Pilbara	>26.3-0 ka. but possible disconformity between ? and 6.3 ka.	3
7	Newman site (P0187)	Pilbara	>20.7-0 ka.	4
8	Cheetup	Yilgarn Plateau	13.3-10.6 ka. // ? late Holocene unit.	4
9	Walga Rock	Yilgarn Plateau	>10-7 ka. // 3.8-0 ka.	5
10	Koolan 2	Kimberley	// >27.3-24.6 ka. // 10.9-0 ka.	8
11	Miriwun	Kimberley	// >18-12 ka. // 1.7-0 ka.	4
12	Monsmont	Kimberley	>12-0 ka.	5
13	Widgingarri 1 and 2	Kimberley	ca. 27.6-18.5 ka. // ca. 7.5-0 ka.	10
14	Allens Cave	Nullarbor Plain	>20-17 ka; 15-0 ka.	5
15	Koonalda Cave	Nullarbor Plain	22-15 ka.	13
16	Anbangbang II	north Australian plateaux	artefacts in basal (?Pleistocene) gravel // 5.8-0 ka.	8
17	Jimeri 1	north Australian plateaux	single hearth at 10.8 ka; 3.8-0 ka.	4
18	Malakunanja II	north Australian plateaux	ca. 55-4 ka // 0.5-0 ka.	18
19	Malangangerr	north Australian plateaux	25-18 ka // 6-0 ka.	10
20	Nauwalabila 1	north Australian plateaux	>50-0 ka.	13
21	Nawamoyrn	north Australian plateaux	>21.5 ka // 7.1-0 ka.	2
22	Ngarradj Warde Djokkeng	north Australian plateaux	>8.7-4 ka // 0.5-0 ka.	9
23	Puntutjarpa	central Australian ranges	// 10.2-0 ka.	10
24	Puritjarra	central Australian ranges	>27-0 ka.	35
25	Colless Creek 1	Carpentaria fall	basal unit inferred >30 ka on geomorphic evidence // 17.3-0 ka.	6
26	Louie Creek	Carpentaria fall	18.6-0 ka.	?
27	Cuckadoo 1	Lake Eyre Basin	// 15.3 ka // 12.4-12 ka // 6-3 ka // 1.8-0 ka.	14

Site	Region	Occupation Sequence	#Dates
Rockshelters or Caves (continued)			
28 Seton Cave	Flinders Ranges and South Australian Gulfs	16.1 ka; 10.9-? ka.	2
29 Early Man	eastern Cape York Peninsula	> 13-0 ka.	12
30 Fern Cave	eastern Cape York Peninsula	>26-17.2; >1.1-0 ka. Base of occupation is 29 ka by extrapolation.	5
31 Magnificent Gallery	eastern Cape York Peninsula	>10.3-0 ka. First occupation by extrapolation at ca. 13 ka.	3
32 Mushroom Rock	eastern Cape York Peninsula	>6.8-0 ka. basal occupation undated but Pleistocene age inferred from depth.	2
33 Nurrabullgin	eastern Cape York Peninsula	>37.2-30 ka // >5.4-0 ka. First occupation by extrapolation at ca. 38-40 ka.	4
34 Sandy Creek 1 and 2	eastern Cape York Peninsula	// 32 ka; ca.25-20 ka; 13-0 ka.	?
35 Walkunder Arch Cave	eastern Cape York Peninsula	19.5-13.5 ka // 3.7-0 ka.	10
36 Yam Camp	eastern Cape York Peninsula	// intermittent occupation from >17-0 ka. First occupation by extrapolation at ca. 25 ka.	?
37 Mickey Springs 34	north Queensland highlands	// >9.9-0 ka. First occupation by extrapolation at ca.13 ka.	?
38 Kenniff Cave	central Queensland highlands	// 18.8-10.3 ka // 5.4-0 ka.	21
39 Native Well 1 and 2	central Queensland highlands	// 13-0 ka.	8
40 Bridgewater Caves South	Murray-Darling Basin	ca. 12-8.4 ka. // 0.5-0 ka.	6
41 Kings Table	Blue Mountains	22.2-14.5 ka. // ca. 1.2-0 ka.	5
42 Loggers Shelter	Blue Mountains	11.1-0 ka.	4
43 Lyre Bird Dell	Blue Mountains	// 12.6 ka. // 0.5 ka.	2
44 Noola	Blue Mountains	12.6-8.1 ka; ca. 7-0 ka.	4
45 Shaws Creek KII	Blue Mountains	>13-0 ka.	8
46 Walls Cave	Blue Mountains	ca. 12-0 ka.	2
47 Birrigai	Australian Alps and south-eastern uplands	21-0 ka.	12
48 Burrill Lake	Australian Alps and south-eastern uplands	// 20.8-0 ka.	7
49 Cloggs Cave	Australian Alps and south-eastern uplands	17.7-8.7 ka. in cave; 1.1-0 ka. in outer rockshelter.	6
50 ACH/84/1	Tasmania	ca. 16-12.5 ka.	3
51 Artefact Creek Waterfall	Tasmania	?-14 ka.	1
52 Beginners Luck Cave	Tasmania	artefacts in secondary context in cave breccia at 21 ka.	5

	Site	Region	Occupation Sequence	#Dates
	Rockshelters or Caves (continued)			
53	Bone Cave	Tasmania	// 29-13.7 ka.	11
54	Cave Bay Cave	Tasmania	22.8-18.6 ka; hearth at 15.4 ka; 7.2-4 ka; 3-0 ka.	14
55	Cliff Cave (King Island)	Tasmania	burial of partly disarticulated human skeleton at ca. 14.3 ka.	3
56	Condominium Cliffs 2	Tasmania	// 17.5-13.8 ka.	2
57	Deena Reena	Tasmania	19.2-13.4 ka.	2
58	F82-6	Tasmania	?-13.9 ka.	1
59	Kutikina Cave	Tasmania	19.8-14.8 ka.	4
60	Macintosh 90/1	Tasmania	17-15 ka.	12
61	Maneena Langatick Tattana Emita	Tasmania	10.3 ka.	4
62	Mannalargenna Cave	Tasmania	>20.6-8 ka.	11
63	Nanwoon Cave	Tasmania	inferred terminal Pleistocene date on geomorphic grounds, ESR date on bone provides minimum age of 7.2 ka.	1
64	Nelson River 1*	Tasmania	bone accumulation, dated by ESR at ca. 19 ka; initially thought to be anthropogenic.	1
65	Nunamira	Tasmania	30.8-11.6 ka.	11
66	ORS7	Tasmania	30.8-2.5 ka.	7
67	Warragarra	Tasmania	// 10.6-9.8 ka. // 3.4-0 ka.	3
68	Warreen	Tasmania	// 35-18.3 ka.	>10
69	Lachitu	northern coast and ranges of New Guinea	// 35.4 ka. // 13.9-12.3 ka. // 9-5.6 ka. // 2-0.3 ka.	8
70	Batari Cave	New Guinea Highlands	16.9 ka. (but association with cultural material equivocal); 8.2-0 ka.	4
71	Kafiavana	New Guinea Highlands	ca. 11-0 ka.	6
72	Kiowa	New Guinea Highlands	10.4-0 ka.	6
73	Nombe	New Guinea Highlands	26.2-0 ka.	5
74	Yuku	New Guinea Highlands	>9.8-0 ka.	7
75	Balof 2	Bismarck Archipelago	14.2-<3.1 ka.	5
76	Buang Merabak	Bismarck Archipelago	32 ka; 11-0 ka.	3
77	Matenbek	Bismarck Archipelago	ca. 20-18.6 ka; 8.1-6.2 ka; 1.8-0 ka.	7
78	Matenkupkum	Bismarck Archipelago	ca. 33-21.3 // 14.3-10.9 ka.	13

Site	Region	Occupation Sequence	#Dates
Rockshelters or Caves (continued)			
79 Misisil Cave	Bismarck Archipelago	5 flakes in level dated to 11.4 ka; 3.4-0 ka.	3
80 Pamwak	Bismarck Archipelago	>12.5-0 ka.	20
81 Panakiwuk	Bismarck Archipelago	15.2-8 ka; 1.6-0.5 ka.	14
82 Kilu	Solomon Islands	// ca. 28.3-20.1 ka. // 9.4-4.9 ka. // ca. 2.5-0 ka.	10
Alluvial Terraces			
83 Helena River site	west Australian coast	29.4 ka; 3.8 ka.	2
84 Upper Swan	west Australian coast	38 ka.	4
85 Greenough River site	Yilgarn Plateau	<i>Zygomaturus</i> mandible and stone artefact in >37 ka. unit. Age inferred from pedogenesis.	0
86 Kalgan Hall	Yilgarn Plateau	18.9-0 ka.	9
87 OKA-2 (Toolapinna soakage)	Lake Eyre Basin	late Pleistocene age of human cranial fragment inferred from similar flourine content to that of local megafauna.	0
88 Talgai	New England/ Morton uplands	human cranium found in alluvial soil, dated by associated soil carbonates at ca. 14 ka.	10
89 Cranebrook Terrace	Blue Mountains	artefacts in river gravels at ca. 47-43 ka.	20
90 Fal Brook site (SGCD 16)	Blue Mountains	artefacts and hearths in late Pleistocene palaeosol. Core at 34.6 ka; hearth at >20 ka.	3
91 Keilor (Dry Creek)	Australian Alps and southeastern uplands	dated hearths at 38.8 ka, 26 ka and 18 ka; human cranium at 15 ka; artefacts in D clay at >30 ka. inferred from degree of pedogenesis.	33
92 Keilor (Green Gully)	Australian Alps and southeastern uplands	artefacts throughout Keilor Terrace at 18-12 ka; intrusive burial at 6.5 ka.	16
93 Spring Creek	Australian Alps and southeastern uplands	bone deposit at 19.8 ka. Only trace of human association is putative cut marks on a single <i>Diprotodon</i> incisor.	1
94 Flying Fox site	Tasmania	two phases of occupation at: 17.1 ka. and ? ka.	1
95 Wanlek	PNG intermontane trough	15.1-12 ka; 5.5-2.8 ka; followed by recent cultivation.	11
96 NFX	New Guinea Highlands	post remains at 18.1 ka; otherwise ? 13.2-11.5 ka.	4
Lunettes			
97 Dempsey's Lagoon	Flinders Ranges and South Australian Gulfs	late Pleistocene age inferred from dune stratigraphy.	0
98 Kangaroo Lake	Murray-Darling Basin	ca. 17 ka; 13.6-11.5 ka.	6
99 Kow Swamp	Murray-Darling Basin	primary burials at >13-9.3 ka; artefacts in Cohuna silt at 13-10 ka and in Kow sand at >8-3 ka.	20

Site	Region	Occupation Sequence	#Dates
Lunettes (continued)			
100 Lake Arumpo (outer lunette)	Murray-Darling Basin	shell middens 38.5-33.1 ka; hearths 34.8ka; 26.6 ka; 1.4-0 ka.	15
101 Lake Benanee	Murray-Darling Basin	shell midden at 13.2 ka.	1
102 Lake Garnpung	Murray-Darling Basin	ca. 32-25 ka; 18.6-11.7 ka; 2.4-0 ka.	17
103 Lake Leaghur lunette	Murray-Darling Basin	inferred late Pleistocene age for burials based on regional chronology and lunette stratigraphy.	0
104 Lake Menindee	Murray-Darling Basin	hearth at 26.3 ka; other archaeological material deflating from late Pleistocene palaeosol; shell scatters at 6.9-6.6 ka. and modern.	7
105 Lake Mulurulu	Murray-Darling Basin	shell middens 15.6-15.1 ka.	7
106 Lake Mungo lunette	Murray-Darling Basin	ca. 32-15 ka.	66
107 Lake Nitchie	Murray-Darling Basin	shell midden 23.4 ka; cremation 15.3 ka; burial 6.8 ka.	3
108 Lake Tandou	Murray-Darling Basin	ca. 36-35 ka; ca. 27-22 ka; ca. 16-15 ka.	24
109 Lake Victoria	Murray-Darling Basin	ca. 18.2-15 ka; 6.4 ka; 2-0 ka.	18
110 Lake Bolac	Australian Alps and southeastern uplands	? 12.5 ka	2
111 Lake Woods*	Lander-Barkly plains	late Pleistocene lunette; artefacts eroding from dune now shown to be mid-late Holocene in age.	1
Coastal Dunes			
112 Arumvale	west Australian coast	18.4-9.2 ka. but with unresolved problems regarding stratigraphic mixing.	3
113 Ellen Brook site	west Australian coast	late Pleistocene/early Holocene age inferred from presence of bryozoan chert. Artefacts eroding from >37 ka. horizon within dune but excavator queries association.	2
114 Minim Cove	west Australian coast	artefacts in sand sheet at >9.9 ka.	1
115 Quininup Brook	west Australian coast	18.5-10.6 ka.	3
116 Wallen Wallen Creek	New England/ Morton uplands	>20.5-0 ka.	14
117 Kurnell Peninsula site	Blue Mountains	12.2 ka.	1
118 Cataragui Monument site	Tasmania	10.2 ka; <4.3 ka.	6
Wetlands and Swamps			
119 Cuddie Springs	Murray-Darling Basin	30.3-<19.3 ka.	4

Site	Region	Occupation Sequence	#Dates
Wetlands and Swamps (continued)			
120 Kow Swamp (Cohuna site)	Murray-Darling Basin	human cranium; inferred date of ca. 13-9 ka.	0
121 Wyrie Swamp	Murray-Darling Basin	10.2-9 ka. (wooden artefacts in peat at 10.2-9 ka; stone artefacts in underlying clay at 26.3-8.6 ka.)	25
122 Lime Springs	Blue Mountains	>19.3-ca. 6 ka.	1
123 Trinkey	Blue Mountains	26-6 ka.	2
124 Lancefield Swamp	Australian Alps and south- eastern uplands	artefacts beneath bone bed at 26 ka.	10
Other Open Sites			
125 Silver Dollar site	west Australian coast	25.2-18.7 ka; 7-6.6 ka.	6
126 CC139 (lower Coopers Creek)	Lake Eyre Basin	single hearth at 11.8 ka.	1
127 CC77 (lower Coopers Creek)	Lake Eyre Basin	single hearth at 11.8 ka.	1
128 JSN	Lake Eyre Basin	discrete hearths at 14.4 ka; 13.8 ka; 10.5 ka; 2.7 ka.	5
129 Lake Yantara	Lake Eyre Basin	hearths at 26.2 and 1.3 ka	2
130 Hawker Swamp	Flinders Ranges and South Australian Gulfs	ca. 14.8 ka. // 5.1-0 ka.	6
131 Chibnalwood Lakes	Murray-Darling Basin	artefacts in beach gravels at >14.6 ka.	2
132 Coobool Creek	Murray-Darling Basin	skeletal remains of 126 individuals; CC65 dated by U/TH to 14.3 ka.	1
133 JH/1 Midden	Murray-Darling Basin	16.1 ka; 13.3 ka.	2
134 Lake Leaghur	Murray-Darling Basin	27.2 ka; 24 ka; 16.7-15.7 ka; 3.3-0 ka.	9
135 Lake Mungo	Murray-Darling Basin	inferred late Pleistocene age for carbonate encrusted human bone; 2.2-0 ka.	4
136 Nacurrie	Murray-Darling Basin	several carbonate encrusted skeletons; N1 dated at 11.5 ka.	1
137 Redcliffs Midden	Murray-Darling Basin	12.1-1.1 ka.	3
138 Roonka	Murray-Darling Basin	Four hearths at 18 ka.; other evidence of occupation including burials ca. 8.5-0 ka.	3
139 Snaggy Bend	Murray-Darling Basin	shell midden and burial at 10 ka; Holocene middens and burials 6.9-? ka.	2
140 Talyawalka Creek	Murray-Darling Basin	17.5-11 ka; 9.4-6 ka.	?
141 Tandou Creek	Murray-Darling Basin	13.6-12.4 ka.	6
142 Tuckers Creek	Murray-Darling Basin	12.6-? ka.	1

Site	Region	Occupation Sequence	#Dates
Other Open Sites (continued)			
143 WLC-1 (Wilcannia)	Murray-Darling Basin	shell midden at 15.1 ka.	1
144 Bass Point	Blue Mountains	ca. 17.5-0 ka.	29
145 Murramarang Point	Australian Alps and south- eastern uplands	// artefacts within sand sheet at 12.6 ka. // 5.5-? ka.	2
146 Old Beach site	Tasmania	artefacts in sand apron of terminal Pleistocene age.	3
147 Fortification Point	northern coast and ranges of New Guinea	ca. 40 ka.	35
148 Kosipe	New Guinea Highlands	26.5-??2 ka. (pollen profile shows burning and forest clearance at ca. 30 ka.)	6
Dated Art Surfaces			
149 Gum Tree Valley (Dampier)	Pilbara	marine shell in fissure in engraved panel provides minimum age of 18.5 ka. for the rock art.	1
150 Laurie Creek	north Australian plateaux	20.3 ka on organics on rock surface but uncertain association with nearby paintings	1
151 Eight Mile Creek (Sturts Meadows)	Lake Eyre Basin	minimum age of 10.4 ka. for engraved panel.	3
152 Karolita 1	Flinders Ranges and South Australian Gulfs	31.7-1.4 ka. using CR technique to date engraved rock surfaces.	24
153 Gnatalia Creek 1	Australian Alps and south- eastern uplands	AMS dates of 29.8 and 6.1 ka. on same painted motif.	2
154 Ballawinne Cave	Tasmania	inferred date of ca. 14 ka. for red ochre hand stencils.	0
155 Judds Cavern	Tasmania	hand stencils dated at 10.7 and 9.2 ka., possibly a single episode of stencilling at ca. 11 ka.	2
156 Keyhole Cavern	Tasmania	inferred terminal Pleistocene age for hand stencils overlain by calcite skin.	0
Addendum			
- Millys Cave	Pilbara	ca. 19-? ka.	?
- Hearth Cave	eastern Cape York Peninsula	>21-0 ka.	3
- Mitchell River Cave	eastern Cape York Peninsula	>15.9-0 ka.	3
- Crazy Man Shelter	Blue Mountains	// 17.1-0 ka.	>2
- Bobs Cave	Australian Alps and south- eastern uplands	// 10.9-? ka.	1
- Douglas Cave	Australian Alps and south- eastern uplands	>12.9-ca. 9 ka.	3
- Beeton Shelter	Tasmania	// ?-ca. 9 ka.	1

Site	Region	Occupation Sequence	#Dates
Addendum (continued)			
- Seraba rockshelter	northern coast and ranges of New Guinea	ca. 14-<6 ka.	>2
- Kuk Swamp	New Guinea Highlands	manuports and possible hearth at ca. 30 ka; agricultural ditch systems at ca. 9 ka; 6-5.5 ka; 4-2.5 ka. and 2-1.2 ka.	>10

Table 1 Late Pleistocene archaeological sites in the Sahul region. Sites are ranked by depositional context and physiographic region and then listed in alphabetical order. Numbers in the left hand column key the table into Figure 6 and to sites discussed in the text. For bibliographic references and alternative site names see Smith and Sharp (Appendix, this volume). An asterisk next to the site name indicates that subsequent investigations have not confirmed evidence of Pleistocene occupation. Physiographic region follows usage in Jennings and Mabbutt (1977) with some modification of regional names for the sake of clarity. For sequence of occupation, // indicates a stratigraphic unconformity where basal occupation deposits rest on bedrock or where there are other breaks in the stratigraphic record. The right hand column gives the total number of C¹⁴, TL, ESR, AAR, CR or U/TH dates available for each site. An addendum lists sites added subsequently to the table. These are not included in the various analyses nor plotted on Figure 6.

raphy for each site is presented in Smith and Sharp (Appendix, this volume).

Our total is a minimum figure as we have counted adjacent rockshelters as single sites (Table 1:13, 34, 39). We have also had to treat whole complexes of sites on anabranch channels of the Darling River (Table 1:140-1) and on lunettes associated with the fossil lake systems of the lower Willandra (Table 1:100, 102-3, 105-6), Darling (Table 1:98, 104, 107-8) and central Murray (Table 1:101, 109) as single entities. These are made up of small shell middens (Johnston, this volume) or scatters of fish bone, fish otoliths or stone artefacts, hearths, burials and cremations (Webb 1989). Such sites are so numerous that they are rarely discussed individually in the archaeological literature and only a small proportion have been directly dated (e.g. Balme and Hope 1990). In the analysis below we treat each lunette as if it were a single archaeological site (Table 1:98-110). However, we have made a distinction between sites on the lunettes and those found in other parts of the lake systems (Table 1:131, 134-5) as these represent different depositional contexts.

Criteria for listing sites

Table 1 includes all archaeological sites with occupation, or other evidence of use, dating to at least 10,000 BP. In most cases the Pleistocene component is directly dated by either radiocarbon (C¹⁴) or, less frequently, by thermoluminescence (TL). In others it is by extrapolation from radiocarbon dates higher in the same stratigraphic profile (Table 1:32, 37, 114). In some cases a late Pleistocene age has been attributed on the basis of geomorphic evidence or stratigraphic association

(Table 1:16, 63, 85, 97, 103, 120, 135, 146, 154, 156).

We have not listed sites whose claim to Pleistocene antiquity rests solely upon painting style or stone artefact typology. For example, we have not attempted to include the hundreds of western Arnhem Land sites with dynamic-style paintings. This painting style is probably early Holocene or terminal Pleistocene in age (Chaloupka 1985) but a late Pleistocene antiquity has yet to be demonstrated for individual sites (Rosenfeld, this volume). Another group of sites loosely attributed to the late Pleistocene are those with Kartan implements on Kangaroo Island. On typological grounds, a probable Pleistocene age for Kartan implements has been claimed (e.g. Lampert 1981) but some Kartan sites are now known to be early Holocene in age (Draper 1987).

Nor does Table 1 include sites with indirect evidence of human presence, such as palynological or geomorphic sites where changes in fire regime, vegetation disturbance or slope instability are suggestive of human impact on the local environment (see Haberle, this volume; Mountain, this volume). Sites with large accumulations of the bones of megafauna are only included if there is some direct evidence of human presence, such as cut marks on bone, burnt bone or the presence of stone artefacts (Table 1:93, 119, 122-4).

Problems of identification, association or dating

Although we have not sought to make judgments about the soundness of attributing a Pleistocene age to each of the sites listed in Table 1, some preliminary comments are in order here.

Firstly, subsequent investigations at two sites, Nelson River Cave 1 (Pocock, this volume) and Lake Woods (Smith 1986), have failed to substantiate earlier claims of possible late Pleistocene occupation. These two sites are excluded from further analysis below and are only listed in Table 1 in order to clarify their status.

Secondly, the reader should be aware that there are several sites where the human origin of the Pleistocene remains is not firmly established (OKA-2, Roonka, Lake Yantara) or where association with human activity can be questioned (Mammoth Cave, Spring Creek, Laurie Creek). From the OKA-2 site there is only a small fragment of skull, thought to be of human origin, but whose identification is not certain (Lampert et al. 1988). In the case of Roonka, Paton (1983) has questioned whether the thin charcoal features exposed on the surface of layer 4 are hearths. Similarly, at Lake Yantara the identification of the dated feature as a hearth is open to question because its internal structure was not investigated at the time of discovery (Dury and Langford-Smith 1970) and subsequent investigations by Barbetti (1973) established that it had not been baked. At Mammoth Cave (Archer et al. 1980) the only indication of human activity is in the pattern of bone breakage, cut marks on a tibia of *Sthenurus* sp. and the presence of a small amount of burnt bone. Similarly, at Spring Creek the only evidence that humans were associated with an extensive Pleistocene bone deposit is a *Diprotodon* incisor with cut marks (Vanderwal and Fullagar 1989). At Laurie Creek, organic material, believed to be a component in pigments used in adjacent rock paintings, was radiocarbon dated using accelerator mass spectrometry (AMS) but the authors caution that the results are preliminary as the chemistry and taphonomy of the material dated is not fully understood (Loy et al. 1990).

Thirdly, there are four sites, Batari, Cranebrook Terrace, Ellen Brook and Gnatalia 1, where the archaeological remains are not unequivocally Pleistocene in age. In the case of Batari, White (1972:16) argues that charcoal which gave the Pleistocene date may have been derived from natural sediments underlying the occupation deposit. At Cranebrook Terrace (Nanson et al. 1987) neither of the two definite artefacts were found in situ in Pleistocene river gravels. At Ellen Brook, stone artefacts of bryozoan chert, were found to be eroding out of a >37,000 BP horizon within a dune, but Bindon and Dortch (1982) raise the possibility that the dated charcoal was redeposited older material. However, in southwestern Western Australia the presence of bryozoan chert in an assemblage generally indicates an early Holocene or late Pleistocene age. At Gnatalia Creek 1 (McDonald et al.

1990) two samples of charcoal-based pigment from a single motif were dated using AMS and gave results differing by more than 23,000 years. The authors suggest that a mid Holocene age is the more likely.

Finally, there is a large group of sites which, though late Pleistocene in age, lack precise dating for this time period (Table 1:16, 63, 85, 90, 97, 103, 114, 132, 135, 136, 149, 151-2, 154-6). For example, most dated art surfaces can only be assigned a minimum age.

Types of sites

Depositional context

One of the strengths of the current sample is that a wide variety of site types and depositional contexts are represented (Fig. 2). For the purposes of our analysis we have divided Pleistocene sites into seven major categories: rockshelters/caves (53%) (Plate 1), alluvial terraces (9%), lunettes (9%), coastal dunes (4%), wetlands (4%), dated rock art surfaces (5%) and other open sites (16%). The latter includes sites in sandsheets, palaeosols, source-bordering dunes or continental linear dunes, as well as dated hearths on deflation surfaces. The seven categories represent different depositional contexts and are potentially different in functional terms. They may also be expected to differ in terms of site survival and visibility and are treated separately below.

Figure 2 shows that rockshelters do not dominate the record to the extent that we might have expected. This is less true of some of the constituent regions, such as Island Melanesia and northern Australia, where rockshelters or caves are the only Pleistocene site type so far represented.

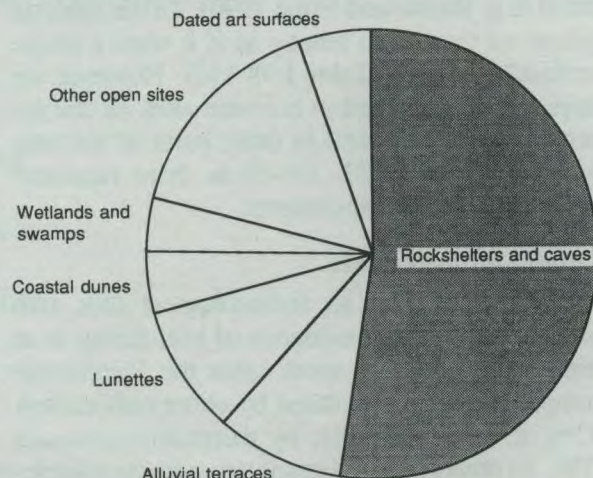


Figure 2 Site type. Pie diagram to show the proportion of sites in each depositional category. Data are expressed as percentage of the total number of Pleistocene sites.

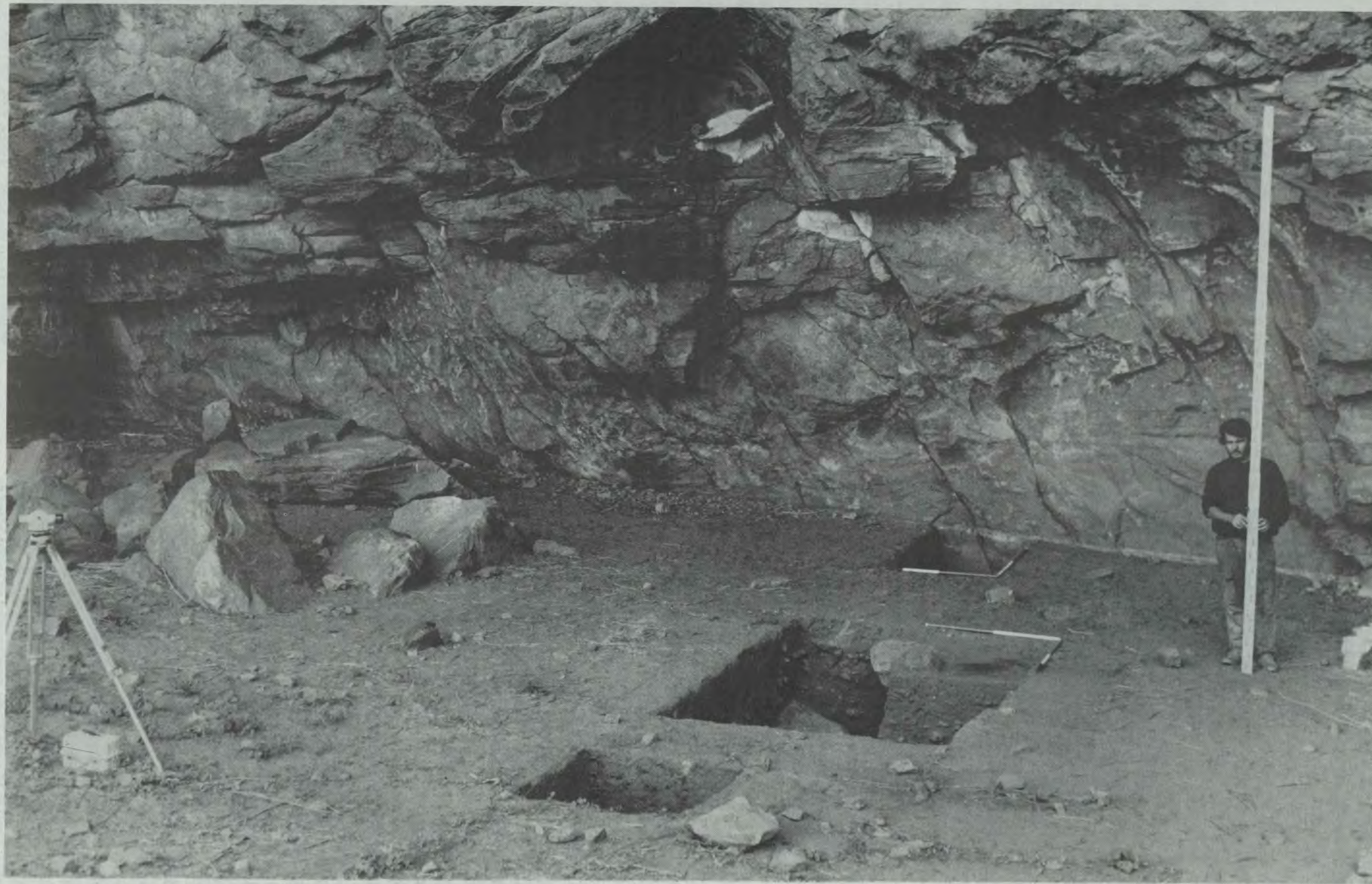


Plate 1 Excavations in the northern part of Puritjarra rockshelter, Central Australia, May 1988. (Photograph: M.A. Smith).

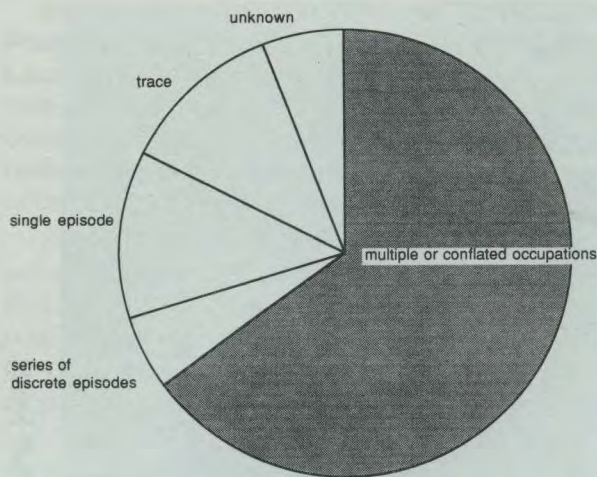


Figure 3 Occupation type. Pie diagram to show the proportion of sites having the different types of occupation. See text for discussion. Data are expressed as percentage of the total number of Pleistocene sites.

Nature of occupation

Allied to differences in depositional context there are differences in type of occupation (Fig. 3). The majority of sites have been repeatedly occupied during the late Pleistocene and often into the Holocene, although the latter period is not dealt with here. These sites characteristically have dense accumulations of occupation debris and attendant problems of isolating individual episodes of occupation. Most rockshelters and many of the open sites (e.g. Table 1:86, 92, 95-6, 115-9, 125, 137, 148) fall into this category.

In other sites, stratigraphically discrete episodes of occupation can be identified. This is mainly a feature of lunettes, where circumstances often allowed rapid burial and preservation of small, discrete, single-episode sites (Johnston, this volume; Hope, this volume). This pattern is also present in some rockshelters and caves where there is a rapid accumulation of sediment, as in Seton Cave (Lampert 1981), Cave Bay Cave (Bowdler 1984) and Allens Cave (Rhys Jones pers. comm.). At a further group of sites there is only evidence of a single-episode of Pleistocene occupation. This category includes isolated hearths (Table 1:126-9) and middens (Table 1:143) as well as some rockshelters (Table 1:17, 55).

About 12% of sites have only a trace of Pleistocene occupation, often limited to a few stone artefacts in a palaeosol (Table 1:16, 85, 90), sandsheet (Table 1:114, 117-8, 145-6), swamp sediments (Table 1:124) or river gravels (Table 1:89) or in secondary contexts in re-worked deposits such as in cave breccia (Table 1:52). Whereas about 24% of open sites fall into this category, the figure is only 5% for

rockshelters and caves, indicating the latter disproportionately provide the most useful part of the archaeological record.

QUALITY OF THE ARCHAEOLOGICAL RECORD

Although overall site numbers, the diversity of site types/depositional contexts and the presence of sites with closely parallel histories of occupation (see below) all suggest that the quality of the late Pleistocene archaeological record for Sahul is better than expected, there are still some obvious deficiencies. The most important of these concerns site chronology.

Chronology

Figure 4 shows the number of dates per site (see also Table 1). Although radiocarbon is the only dating method used at most of the sites (130 sites) we have also included in these counts any direct date produced by other methods (TL, CR, electron-spin resonance (ESR), amino acid racemisation (AAR).

Three radiocarbon dates is the bare minimum required to establish a chronology for most types of sites. Yet 11% of Pleistocene sites have only one date, while 40% of the sites have three or fewer dates. A critical assessment of the radiocarbon chronology is currently available for only 55% of sites and the average number of dates per site has declined since 1971. All of this suggests that, once a high order of antiquity became commonplace,

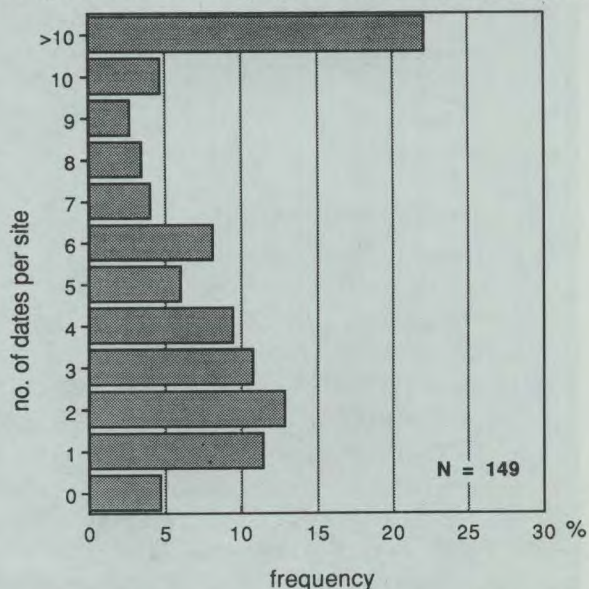


Figure 4 Number of dates per site, expressed as percentage frequency of Pleistocene sites. Data are the total number of dates for each site and include dates by different techniques (C^{14} , TL, ESR, AAR, CR, U/TH).

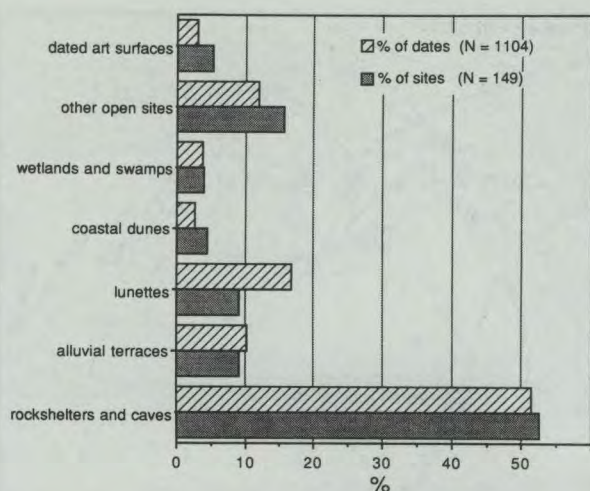


Figure 5 Bar graph to show the proportion of dates allocated to each site type. Data are expressed as (a) percentage frequency of each site type, using a sample of 149 sites and (b) percentage frequency of dates for each site type, using a sample of 1104 dates (all techniques).

there has been a tendency to uncritically accept radiocarbon dates that fall within the last 30,000 years. Whatever the reason, it is clear that the chronological basis for looking at broad-scale patterns in site distribution is still rather inadequate. Most sites have too few dates to allow internal cross-checks or the establishment of fine-grained chronologies for occupation and site use.

On the positive side, 26% of sites do have 10 or more dates and firmly established chronologies (Table 1). Furthermore, dating effort is allocated fairly across the different site types (Fig. 5). Lunettes receive slightly more dates than their numbers would suggest but this is a reflection of the need to individually date the discrete, single episode sites that are common on lunettes.

Site reports and levels of analysis

Another area of concern is in the extent to which basic site data are reported. In 1971, Mulvaney (1971:244-5) pointed out that fewer than half of archaeological excavations then carried out had been published in detail. To find out if the situation had improved we compared available site data against a checklist of the sort of information essential in any site report (site plan, detailed stratigraphic description or section drawing, an outline of site chronology, some discussion of recovery methods). Together with some information about small finds, this represents very much the minimal requirement for an adequate site report. For this analysis we have included information culled from all available sources for an individual site, not simply information available in a single report.

Of the 154 sites in this dataset, 113 (73%) fail at present to meet even these standards of reporting and 15 sites fail to meet any of the criteria. There also appears to have been a decline in reporting since the 1960s. Whereas 50% of sites excavated between 1961 and 1970 (using latest year of field investigation) meet these criteria, only 25% of sites between 1971 and 1980 and 29% of sites between 1981 and 1990 do so.

What is also evident in the data is a dichotomy between sites that are well-dated, well-reported and which have detailed analyses of stone artefacts, faunal remains and sediments and sites which have few dates, only minimal details of stratigraphy and site contents and which are reported in a perfunctory fashion. This suggests that after initial interest only a small proportion of sites receive further attention. In other words, few sites get through the 'quick and dirty' phase of investigation. Rockshelters, with concentrated assemblages of artefacts and faunal remains and with continuous sedimentary records, are fully reported twice as often as open sites and the material from rockshelters is generally subjected to more detailed analysis.

SPATIAL AND TEMPORAL PATTERNS

Despite the problems listed above we are beginning to reach the stage where the number of Pleistocene sites is sufficient to look at spatial and temporal patterns in human occupation at a variety of scales. Certainly, a more detailed examination of site distribution and site numbers can now be attempted than was possible when Jones (1973, 1979), Bowdler (1977, 1981), Horton (1981) and Beaton (1985) reviewed archaeological evidence about the timing of colonisation in the different parts of Sahul or concerning the pattern of population growth.

Gross spatial distribution of sites

Figure 6 shows the distribution of late Pleistocene sites as they are known today. It includes all the sites listed in Table 1 except Nelson River Cave 1 and Lake Woods. The major feature of the map is the widespread distribution of sites, despite obvious clustering in those areas where particularly favourable geomorphic circumstances for the preservation of Pleistocene sites have been identified and where field investigations have accordingly been most intensive.

Two features of the distribution are worth special comment. The first is the presence of sites on or near the Pleistocene coast, wherever the continental shelf is steep enough to allow their preservation, and on the major islands lying off the

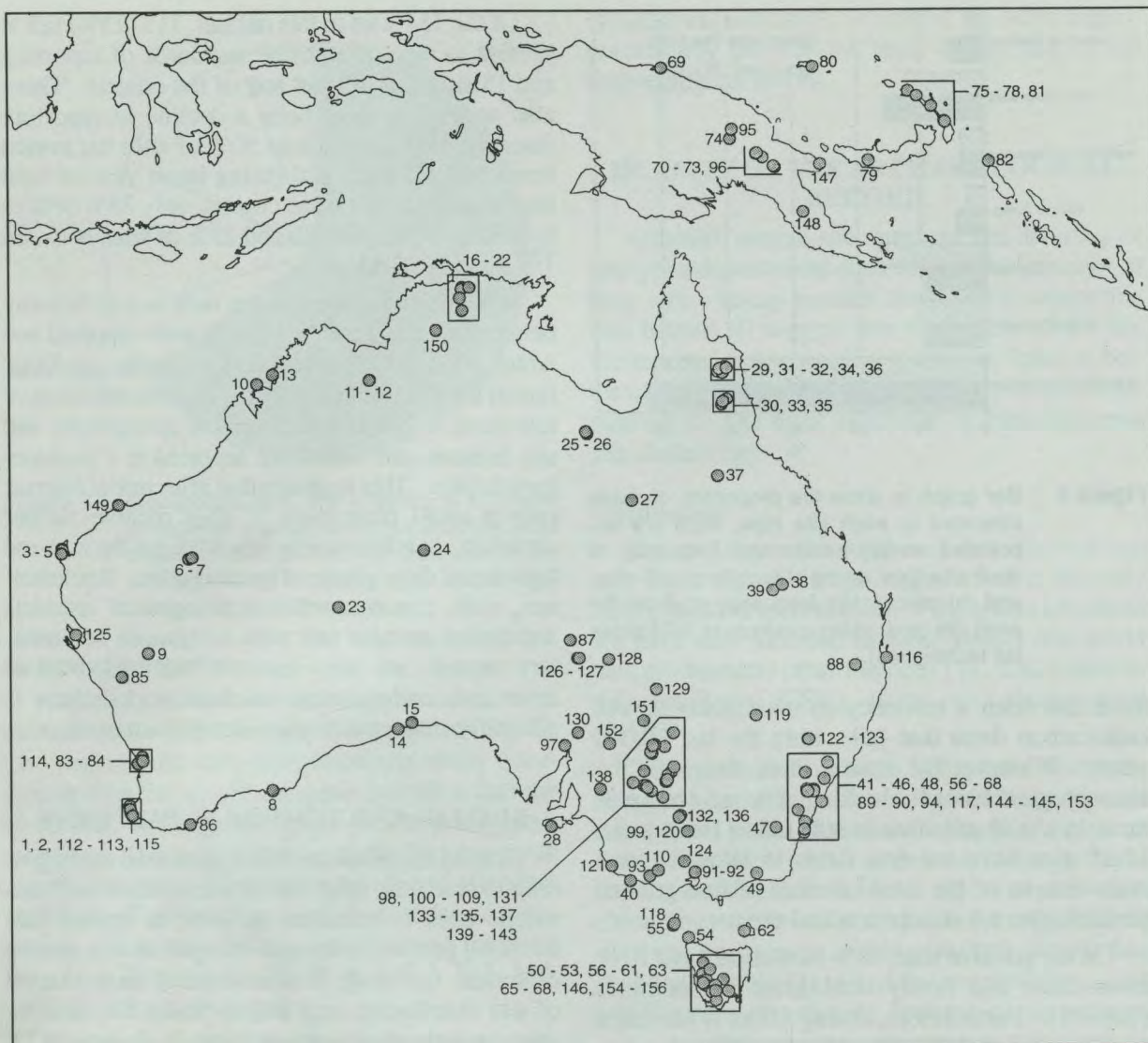


Figure 6 Distribution of late Pleistocene sites in the Sahul region. Lake Woods and Nelson River Cave 1 are omitted. The numbers key the figure to sites listed in Table 1. For an indication of the extent of the Pleistocene landmass at various time periods see the Frontispiece, this volume.

northeastern coast of Sahul. The second is the widespread distribution of sites across the interior of the continent, including both arid and montane environments.

These aspects of the distribution persist when Figure 6, which is a composite of many time periods, is broken down into finer chronological slices (see below).

The major blanks in the distribution are those where there has been little field investigation (e.g. western New Guinea) or where there are obvious problems with site visibility due to relatively young landscapes (e.g. parts of Papua and western Cape York Peninsula). Away from the southeastern sector of the arid zone, the interior of the continent faces similar problems with rapid deposition of aeolian sand in some areas. It also lacks the shell middens, heat-retainer hearths and clay dunes

which contribute so much to the visibility of Pleistocene sites in the southeastern sector of the arid/semiarid zone (cf. Hope et al. 1983).

Temporal distribution of sites

5000 year intervals

Figure 6 can be broken down into a series of site distribution maps at 5000 year intervals (Figs 7a, 7b, 7c, 7d, 7e). To do this we have excluded:

1. sites where the Pleistocene occupation cannot yet be assigned to a particular time period.
2. dated art surfaces. Dates for these are usually expressed as minimum ages. There are also doubts about whether some techniques such as cation-ratio (CR) dating give even broadly comparable results to other dating methods.

From 10,000 to 25,000 BP (Figs 7a, 7b, 7c) there is little change in the distribution of sites,

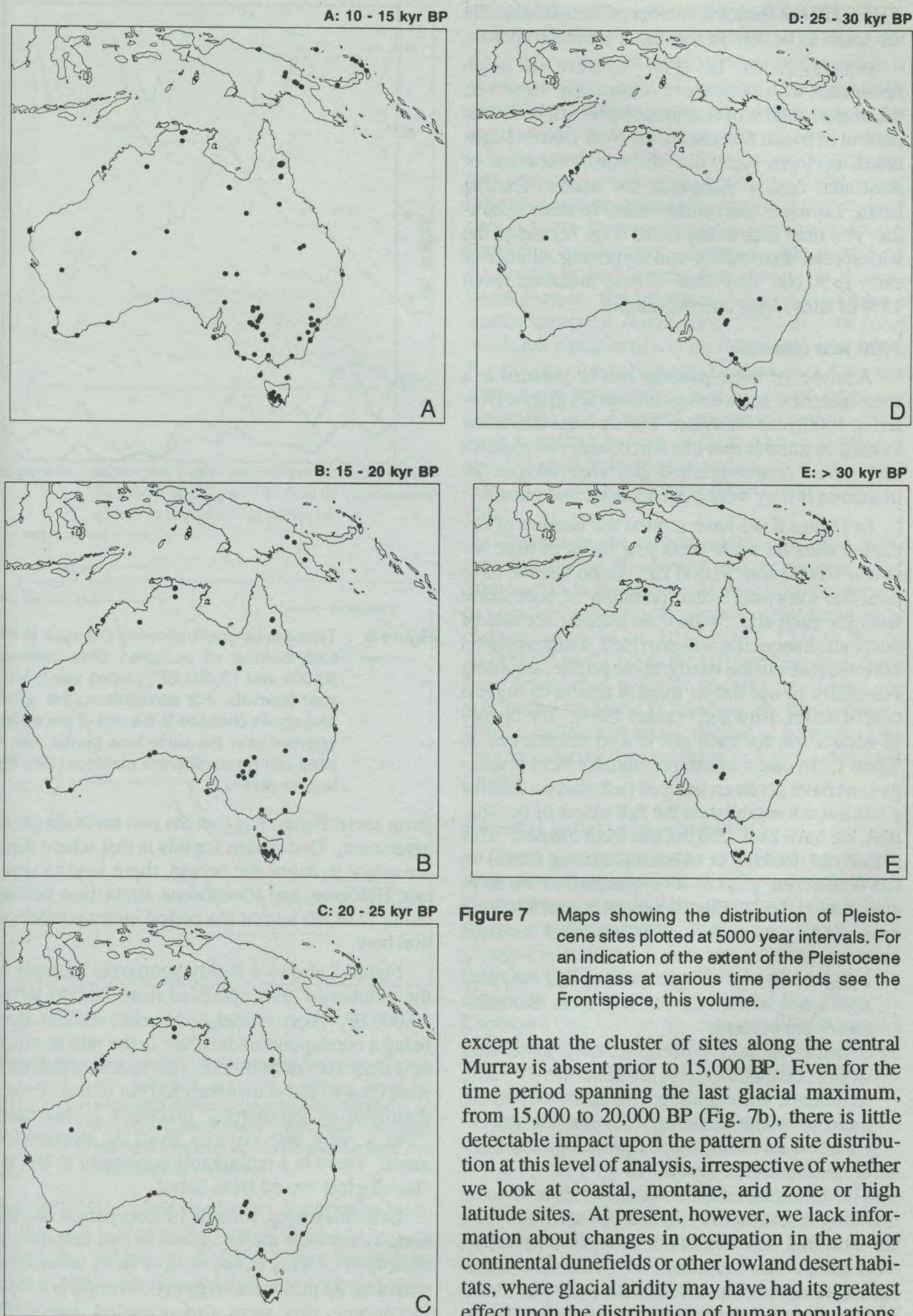


Figure 7 Maps showing the distribution of Pleistocene sites plotted at 5000 year intervals. For an indication of the extent of the Pleistocene landmass at various time periods see the Frontispiece, this volume.

except that the cluster of sites along the central Murray is absent prior to 15,000 BP. Even for the time period spanning the last glacial maximum, from 15,000 to 20,000 BP (Fig. 7b), there is little detectable impact upon the pattern of site distribution at this level of analysis, irrespective of whether we look at coastal, montane, arid zone or high latitude sites. At present, however, we lack information about changes in occupation in the major continental dunefields or other lowland desert habitats, where glacial aridity may have had its greatest effect upon the distribution of human populations. The number of sites in the New Guinea Highlands and the Blue Mountains increases slightly after

20,000 BP but the total number of sites involved is too small to be certain that these are real trends.

Prior to 25,000 BP (Fig. 7d) there are much fewer sites with evidence of occupation. However, the overall pattern of distribution persists, with sites present in Island Melanesia, the New Guinea Highlands, northern Australia, the northwest coast of Australia, central Australia, the Murray-Darling basin, Tasmania and southwestern Western Australia. The final map in the series (Fig. 7e) shows the widespread distribution and surprising number of early (>30,000 BP) sites. These make up about 15% of sites in the current sample.

1000 year intervals

Analysis of these patterns can be pursued at a finer temporal scale using time-series graphs plotted at 1000 year intervals. The obvious limitation to keep in mind is that this sort of analysis requires that rather coarse-grained site chronologies be treated as if they were both accurate and precise.

In Figure 8 we have plotted the number of occupied sites for each 1000 year block of time between 10,000 and 30,000 BP. To do this we have used the excavator's interpretation of occupation span for each site. Where no explicit account of occupation sequence was provided, we interpolated between dates in the stratigraphic profile, assuming continuity of use unless there is reason to suggest otherwise (cf. Bird and Frankel 1991). The history of occupation for each site is also summarised in Table 1. In cases where preliminary field investigations have given an isolated radiocarbon date for a site but not established the full extent of occupation, we have excluded the site from the plot. This is to avoid masking or over-emphasising details on the time-series graphs. For comparison we have also plotted the number of new sites established in each 1000 year period. Two different methods were used to calculate this:

1. using basal age of occupation, and counting sites again where major stratigraphic unconformities are evident;
2. counting as newly occupied only those sites where occupation layers are underlain by sterile sediments, and counting sites again only where there are major demonstrable breaks in site occupation as shown by the presence of archaeologically-sterile layers.

The first method assumes that sediment accumulation is intrinsically linked to occupation of a site and that a stratigraphic unconformity represents a hiatus in occupation. The second makes no such assumption but requires an unbroken stratigraphic record in the crucial part of a site to determine whether the lowest occupation horizon represents initial human use of a site. The surprising

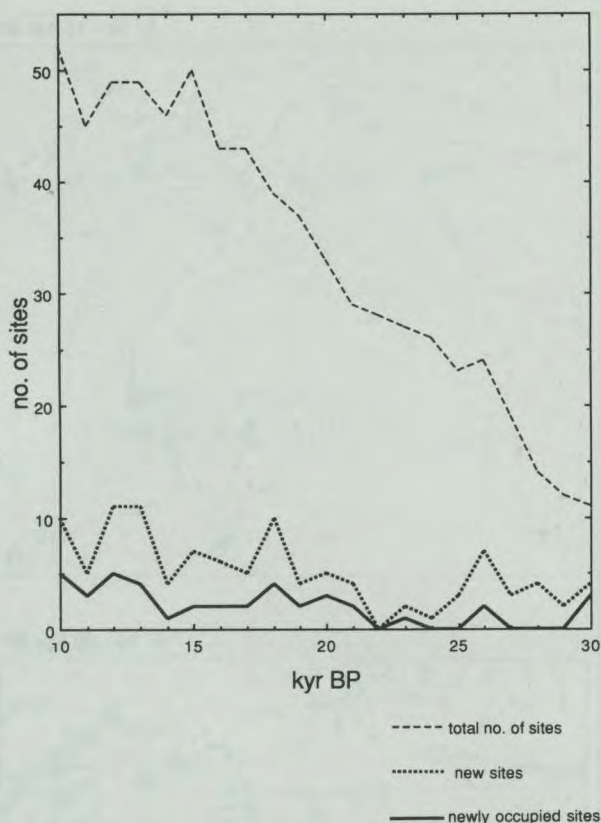


Figure 8 Time-series graph showing changes in the total number of occupied sites between 30,000 and 10,000 BP, plotted using 1000 year intervals. For comparison, the graph also shows changes in the rate of site establishment over the same time period, calculated using two different methods. See the text for details.

thing about Figure 8 is that the two methods are in agreement. One reason for this is that where there are major stratigraphic breaks, these tend to separate Holocene and Pleistocene strata (see below) rather than fall within the period under consideration here.

Figure 8 shows a steady geometric increase in the number of sites occupied from 30,000 BP to 10,000 BP. There is a net gain in sites without there being a corresponding increase in the rate at which new sites were established. This indicates that sites were created faster than they fell out of use or were destroyed by geomorphic processes. This illustrates a point also obvious from the distribution maps. There is a remarkable continuity in the archaeological record from Sahul.

Extremely long records of occupation are the norm rather than the exception in this dataset. At least 24% of sites in our sample have occupation spanning 20 millennia or more. Over 60% of late Pleistocene sites were also occupied during the Holocene. This continuity reflects the comparative stability of large parts of the Sahul landscape which

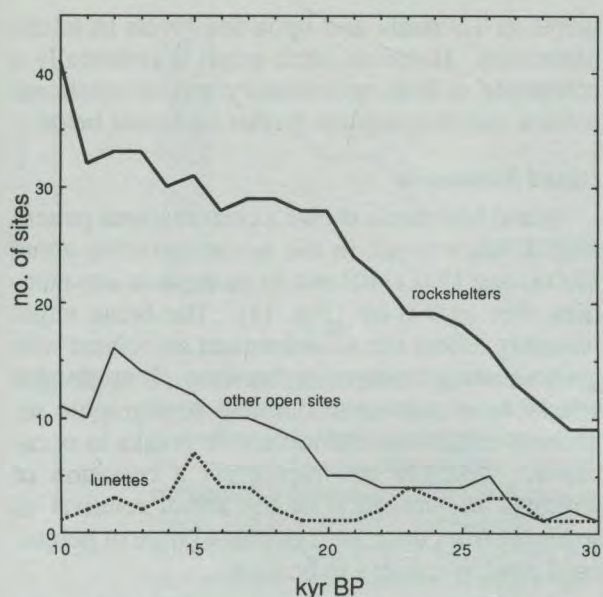


Figure 9 Changes in the number of occupied sites between 30,000 and 10,000 BP, comparing different depositional contexts.

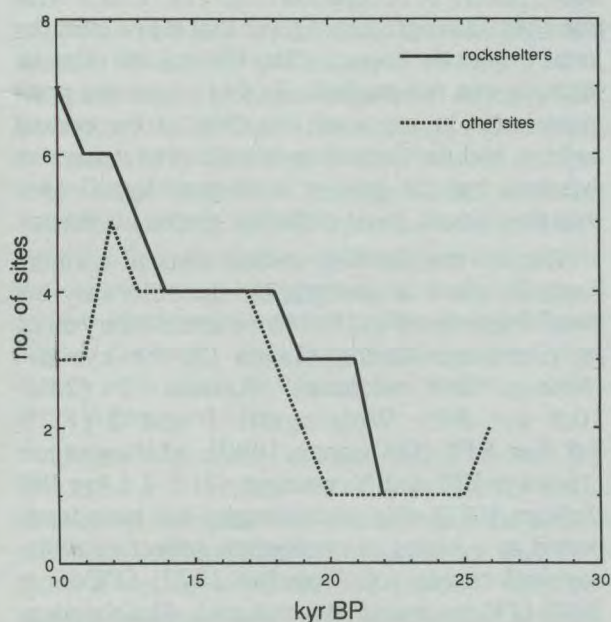


Figure 10 The number of occupied sites in southeastern Australia, showing a similar trend for sites with different depositional contexts. In this figure, southeastern Australia combines the Blue Mountains, the Australian Alps and southeastern uplands.

has not been scoured by glaciers or torrential meltwaters, nor buried under tens of metres of aeolian loess, nor subject to major tectonic movements with attendant erosion and mass movement of sediments.

It also reflects pragmatic field strategies, with a systematic bias towards excavating sites with vis-

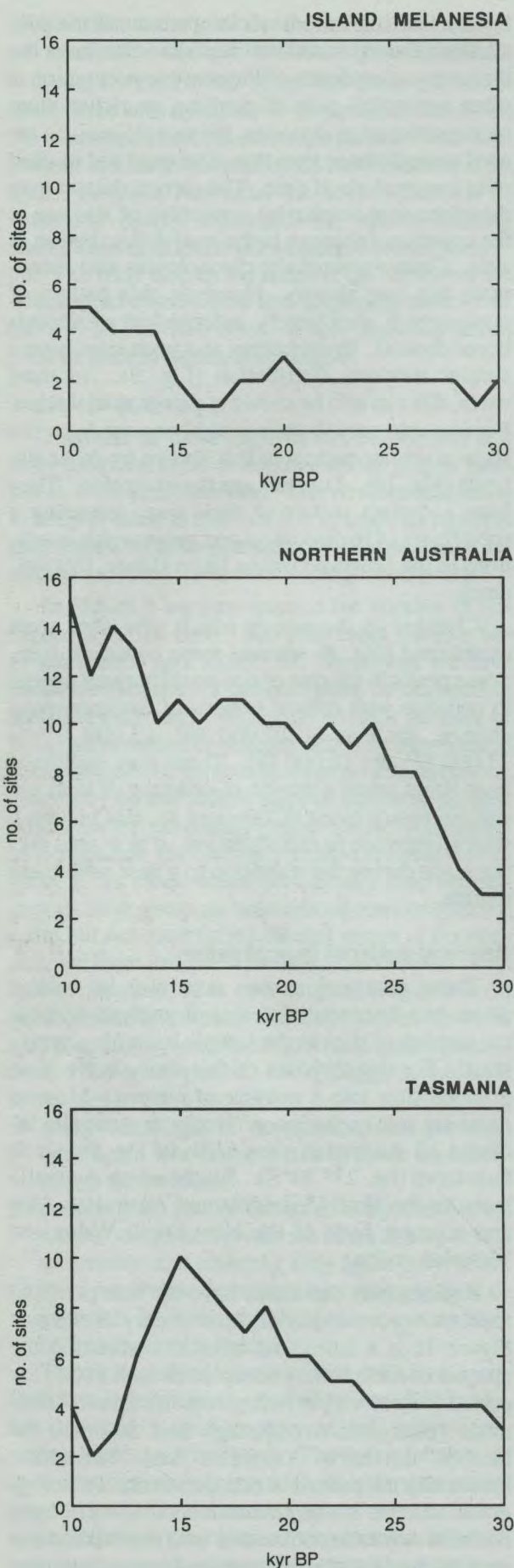
ible surface indications of occupation and the possibility of deep stratified deposits. Because the discovery of evidence of Pleistocene occupation is often a windfall gain of working on richer more recent occupation deposits, the sample may be biased towards those sites that were used and re-used over long periods of time. The current dataset may therefore over-emphasise continuity of site use at the expense of changes in the spatial distribution of sites. Coarse-grained site chronologies also accentuate this (see above). However, this pattern of continuity is also largely independent of depositional context. Rockshelters and open sites have a similar temporal distribution (Fig. 9). In most cases, this can also be shown at a finer spatial scale. For example, rockshelters in southeastern Australia show a similar pattern to that shown by other site types (Fig. 10). Lunettes are the exception. They have a distinct pattern of their own, reflecting a specific set of hydrological and geomorphic conditions in the Murray-Darling basin (Hope, this volume).

Changes in the rate at which new sites were established (Fig. 8) warrant some comment here. Some peaks in the rate of site establishment appear to coincide with critical periods of environmental change, such as at 10,000 BP, 12,000 BP to 13,000 BP and 18,000 BP. These may well have been times when a drastic re-ordering of land use was necessary (see O'Connor et al., this volume), with an increase in establishment of new sites taking place during the transition to a new settlement regime.

Regional patterns in occupation

These distributions can now also be broken down into finer spatial scales of analysis without the number of sites in the sample becoming overly small. For the purposes of this analysis we have grouped sites into a number of regions. Most of these are self-explanatory. Northern Australia includes all Australian sites north of the Tropic of Capricorn (lat. 23° 30'S). Southeastern Australia includes the Blue Mountains and Australian Alps and adjacent parts of the New South Wales and Victorian coasts.

Rockshelters and caves have the best potential for showing continuity or discontinuity of site use. Figure 11 is a latitudinal transect comparing the number of rockshelters occupied in each 1000 year period in three very different regions: Island Melanesia (Bismarck Archipelago and Solomon Islands), northern Australia and Tasmania. Essentially the pattern of occupation shown in Figure 11 reflects stable environmental conditions in northern Australia contrasting with the marked impact of the last glacial maximum upon environ-



ments in Tasmania and upon sea levels in Island Melanesia. However, each graph is potentially a composite of both sedimentary and occupational records and this requires further comment below.

Island Melanesia

Island Melanesia shows a clear regional pattern with a major break in the record between about 19,000 and 15,000 BP and an increase in site numbers after 14,000 BP (Fig. 11). The break might plausibly reflect site abandonment associated with glacio-eustatic changes at this time. It might also simply be a case of incomplete stratigraphic sequences rather than demonstrable breaks in occupation. Whether this represents a cessation of sediment accumulation or the actual removal of sediment from these sites during a phase of heightened erosion remains to be seen.

Another factor suggesting caution is the relatively small number of sites in this sample.

Northern Australia

In contrast, northern Australia has a relatively stable pattern of occupation (Fig. 11). This is what one would have predicted given that at low altitudes in the tropics the impact of late Pleistocene climatic changes was not marked. In this region the post-glacial rise in sea level, flooding of the coastal valleys, and the formation of extensive mangrove swamps, had far greater ecological significance than the climatic shifts of the last glacial maximum.

Despite this stability several sites in northern Australia show a stratigraphic unconformity between Pleistocene and Holocene sedimentary units. At five sites: Mandu Mandu (20-5.5 kyr BP) (Morse, this volume), Koolan 2 (24.6-10.9 kyr BP), Widgingarri 1 and 2 (18.5-7.5 kyr BP) (O'Connor 1990), Malangangerr (18-6 kyr BP) and Nawamoy (21.5-7.1 kyr BP) (Schrire 1982), this unconformity has been interpreted as a hiatus in occupation reflecting wider regional trends (cf. Bowdler 1977; O'Connor 1990; O'Connor et al., this volume). Site abandonment is either put down to glacio-eustatic changes in the position of adjacent coastlines or to the effects of enhanced full glacial aridity.

The distribution in Figure 11 shows that these sites are not representative of the broader pattern. Most sites in northern Australia have occupation across this period. This has been clearly demonstrated in western Arnhem Land where sites with

Figure 11 Time-series graphs showing contrasting patterns of change in the number of occupied rockshelters in three different regions. These are chosen to provide a latitudinal transect across the Sahul region. See text for discussion.

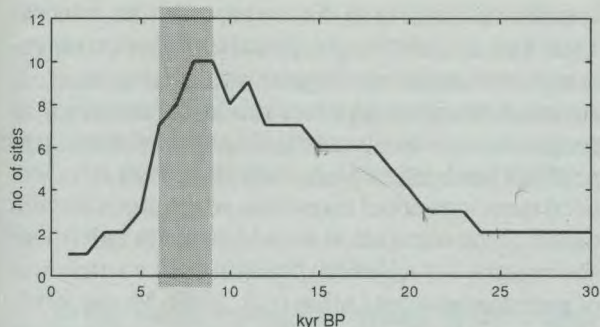


Figure 12 Time-series graph showing the temporal distribution of stratigraphic unconformities in northern Australian rockshelters. Data are number of rockshelters with incomplete stratigraphic records in each 1000 year interval. The shaded zone, between 9000 and 6000 BP, marks a time of widespread erosion of rockshelter deposits. The right-hand tail to the curve suggests that this phase of erosion affected the underlying Pleistocene strata to varying degrees and varying depths in individual sites. Deposits had begun to accumulate again in most sites after 5000 BP.

unbroken sedimentary records, such as Ngarradj Warde Djokeng (Allen and Barton 1989), Malakunanja II (Kamminga and Allen 1973; Roberts et al. 1990) and Nauwalabila I (Jones and Johnson 1985), fail to show any hiatus in occupation. In the Northwest Cape area, Morse (1988, this volume) reports mid Holocene shell middens, showing that occupation of the region also continued throughout at least part of the period spanned by the stratigraphic unconformity in the Mandu Mandu deposits. This should serve to remind us that in most cases an unconformity merely represents unrecorded time.

If the time frame is extended to include the Holocene it is evident that the terminal Pleistocene/early Holocene was a time when the rate of sediment accumulation in rockshelters was very much lower or when existing deposits were destroyed by erosion. Figure 12 shows that stratigraphic unconformities most frequently occur between 9000 and 6000 BP. Deposit had begun to accumulate again in most sites by 5000 BP. The strongly asymmetrical shape of the curve in Figure 12 also suggests that there is considerable variation between sites in the extent to which underlying Pleistocene strata were affected by this phase of erosion. Of course, most erosional processes that are likely to operate in rockshelters would remove fine sediments and leave a lag of coarser material, including stone artefacts, on the surface. However, the low numbers of artefacts in many of these sites, the sandy unconsolidated nature of the deposits and overall low rates of sedi-

ment accumulation suggest that any subsequent occupation would tend to obscure such features. There is also some doubt whether excavators have specifically looked for erosional surfaces, or whether the relatively coarse methods of excavation often employed are adequate to detect them.

Figure 11 shows an increase in the number of occupied rockshelters in northern Australia after 13,000 BP. The number of sites involved is not great but on Cape York Peninsula the change coincides with an increase in the intensity of occupation at existing sites (Morwood, this volume). In the gorge systems of the Lawn Hill area it coincides with a marked decline in the intensity of site use (Hiscock 1989). The underlying reason for both changes is likely to be the end of the glacial-age climate and re-establishment of the northern Australian monsoon (Singh and Luly 1991).

Tasmania and southeastern Australia

The effects of the full glacial climate are very evident in the pattern of site use in Tasmania (Fig. 11). The number of occupied sites peaked between 25,000 and 15,000 BP. The post-glacial decline in site numbers is marked and would be even more so if the sample were restricted to sites in southwestern Tasmania.

There is an undisturbed formation of flowstone, calcite or moonmilk on the surface of many of the deposits. Together with the paucity of ethnohistoric occupation of the southwest, this suggests that there is a genuine abandonment of many of these sites at 14,000-12,000 BP, rather than simply a cessation of sediment accumulation or a flushing out of later occupation during the warmer wetter conditions of the early Holocene. For some sites, such as Kutikina Cave, there is also a clear link between sediment accumulation and human occupation (Kiernan 1981).

There is also a strong contrast between the pattern of occupation in Tasmania and that in neighbouring southeastern Australia (Fig. 13). Whilst there is some occupation between 25,000 and 15,000 BP in southeastern Australia, numbers of occupied sites clearly increase in the post-glacial period from about 13,000 BP. Many of the shelters in southeastern Australia have basal occupation deposits resting on bedrock and it is not clear whether earlier sediments may simply have been flushed out. However, some confidence that the pattern reflects real changes in site use is provided by examining other types of sites. These show essentially the same pattern of occupation as the shelters (Fig. 10).

In Tasmania the cold, dry conditions of the full glacial climate opened up opportunities for occupa-

tion of the region (McNiven et al., this volume). In southeastern Australia it was the warmer, wetter conditions of the terminal Pleistocene/early Holocene that favoured occupation. It is this contrast that underlines the unique nature of the glacial period in southwestern Tasmania.

Some implications

Jones (1973) suggested that by at least 20,000 years ago, people had occupied all the major ecological zones of the continent. In contrast Bowdler (1977, 1981) and Horton (1981) proposed that there may have been major differences in the chronology of occupation in various parts of the continent. Further archaeological discoveries have already overtaken these hypotheses. The distribution maps presented in Figure 7 simply reinforce the view that they are no longer tenable. The distribution of sites at 30,000-25,000 BP is little different to that at 15,000-10,000 BP, vindicating the interpretation put forward nearly twenty years ago by Jones. By 30,000 BP, people had occupied the length and

breadth of Sahul and its major offshore islands. This does not rule out the possibility that colonisation of the major ecological zones took place at different times but much of the initial dispersal of people across the diverse landscapes of Sahul appears to have taken place before 30,000 BP. Related questions about economic adaptations and the nature of the occupation are addressed in individual site reports, but appear to confirm both an early use of marine resources (Allen et al. 1989; Morse 1988; O'Connor 1990) and an early economic adjustment to the interior of the continent (Bowdler 1990:62; Smith 1989).

If one accepts a date of ca. 35,000 BP for initial human colonisation of Sahul as proposed by Allen (1989), the distribution maps presented here (Fig. 7) lend support to the idea that people dispersed rapidly to occupy all parts of the continent within a few thousand years of first landfall (cf. Birdsell 1957). However, if one accepts the earlier date of 50,000-60,000 years ago for initial settlement proposed by Roberts et al. (1990), all we can say about the process of colonisation from these data is that it was essentially complete sometime before 30,000 BP.

Figure 8 is interesting to examine in light of the contrasting modes of population growth suggested for prehistoric Australia. Beaton (1985) described two alternative population growth models. The first was originally put forward by Birdsell (1957) and shows a population which grows rapidly to maximum size within a few thousand years of first landfall. The second shows a long period of little or no population growth followed by exponential population growth in the mid-late Holocene. Figure 8 clearly conforms to neither of these growth models. It shows a geometric increase in site numbers, increasing at a roughly constant rate of two sites per millennium. Furthermore, the rate of growth shown is identical to that reported for the number of occupied rockshelters in various parts of southeastern Australia during the Holocene (Bird and Frankel 1991:Fig. 5; Hughes and Lampert 1982:Fig. 7) throwing some doubt on whether rates of increase during the Holocene were significantly different to those in the Pleistocene. One explanation is that time-series graphs such as these, for both Holocene and Pleistocene datasets, reflect mainly the lower probability that older evidence of occupation will be preserved. If this is the case, the true shape of the curve in Figure 8 would be flatter and might fit the plateau region on either of the growth curves shown in Beaton (1985:Fig. 1). On the other hand, it is worth remembering that the large proportion of rockshelters/caves in this sample reduces the extent to which declining site visibility has an effect here. It is also worth noting that the

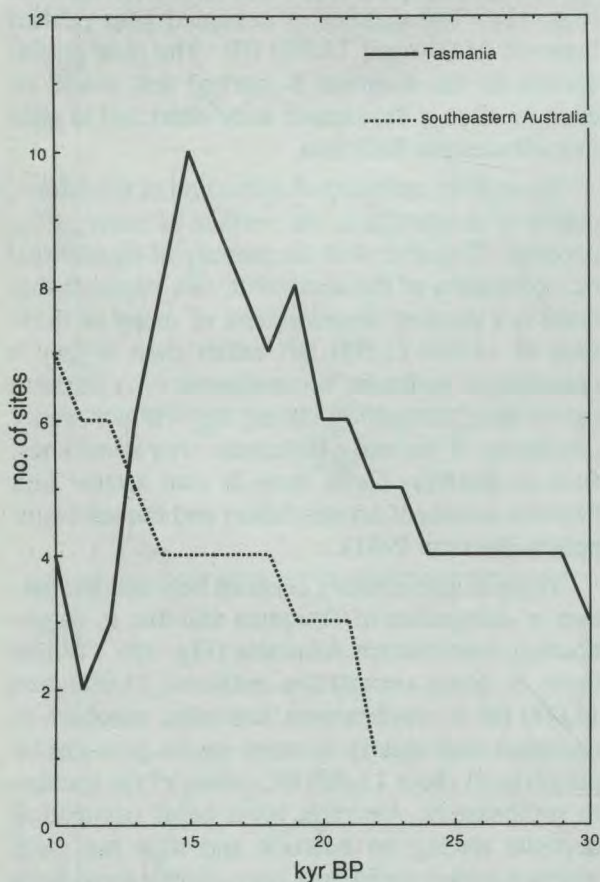


Figure 13 Time-series graph showing a strong contrast in the pattern of occupation in adjacent regions (Tasmania and southeastern Australia). Data are number of occupied rockshelters in each 1000 year interval. In this figure, southeastern Australia combines the Blue Mountains, the Australian Alps and southeastern uplands.

form of this growth curve is largely independent of geomorphic context (see Fig. 9). If Figure 8 faithfully depicts changes in the number of occupied sites, then it suggests a steady growth of population throughout the late Pleistocene rather than either of the growth models discussed by Beaton (1985).

CONCLUSION

In the Sahul region, the quality of the archaeological record for the late Pleistocene is now at least as good as that for the Holocene period. There are now a large number of sites, a diversity of site types and depositional contexts and in each region, despite a disclaimer by Frankel (this volume), there are sites with closely parallel histories of occupation. However, chronology remains an area of concern. Most sites do not have sufficient dates to accurately resolve patterns of occupation to within 1000 years, while coarser-grained chronologies gloss over significant spatial and temporal variation in occupation, at least at the regional level. Despite these problems, current data allow a more detailed look at the spatial and temporal distribution of sites than was possible ten to 15 years ago when several key models of colonisation were proposed (e.g. Bowdler 1977; Horton 1981). The distribution maps presented above show widespread settlement of the Sahul region by 30,000 BP with all major environments occupied in some fashion by this time. Changes that might be attributable to the impact of the last glacial maximum are only evident at a regional level. Time-series graphs, plotted using 1000 year intervals, indicate a steady growth in site numbers between 30,000 and 10,000 BP, a pattern that is largely independent of depositional context. In contrast with the models of population growth that have been proposed for Sahul (Beaton 1985; Birdsell 1957), the evidence presented here suggests a steady growth of population throughout the late Pleistocene.

ACKNOWLEDGEMENTS

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SUNDA AND SAHUL: A 30 KYR BP CULTURE AREA?

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Almost as soon as Europeans arrived in Australia, they began to speculate about the origins of those they had usurped, the Aboriginal people of Australia. Aboriginal people themselves were not concerned with this question, as their cosmology entertained a different notion of Aboriginal origins. Land and people were brought into being in the mythic realm of the Dreamtime. Scientists however demand another kind of explanation. Geologists tell us that Australia has been separated from the rest of the world by deep water barriers since the late Cretaceous, some 70 million years ago. It was during this period that the early mammalian life forms evolved. In Africa, Europe, Asia and the Americas, placental mammals, including apes and monkeys, are the dominant forms. Only in Australia, the fifth continent, were marsupials dominant during the Tertiary and Quaternary. Thus, if we accept the theory of evolution, we must accept that the human species could not have evolved in Australia.

Huxley's line coincides with the Sunda Shelf and identifies the eastern limit of the Oriental region. Lydekker's line, which coincides with the Sahul shelf identifies the western limit of the Australian region. Between them are the islands sometimes called Wallacea, which are not clearly identifiable as either Oriental or Australian, but against which we are also cautioned as seeing representing either a unified region or as a properly transitional zone (Simpson 1977:118-9).

From an Australian point of view, Lydekker's line is of particular significance. To its east we find, prior to the European colonisation of 200 years ago, no placental mammals except rats, bats, a dog, and *Homo sapiens*. The rats may have migrated from Asia, but are almost all of endemic species, and some are of endemic genera and even endemic subfamilies (Simpson 1977:115). The bats appear to be Gondwanic (Darryl Kitchener pers. comm.). The dog (the Australian dingo, *Canis familiaris*) has only been in Australia since about 4000 years ago, on present evidence, and need not concern us here (Bowdler and O'Connor 1991). Thus we are

left with a significant lone Pleistocene intruder, *Homo sapiens*. One of the Australian archaeologist's main concerns therefore is a biogeographical one: to document the time of arrival, and place of origin, of the first human colonists.

EARLY AUSTRALIA

The Australian archaeological record provides evidence for a human presence well before the end of the Pleistocene (Table 1, Fig. 1). Establishing a firm 'earliest date' is naturally very difficult, but the issue is not as vexed as it is for the American continent (e.g. Lynch 1990). Until recently, all the earliest dated archaeological evidence for the presence of humans in Australia fell within the period 40,000 to 30,000 BP. Recent evidence using the thermoluminescence technique for dating suggests a somewhat older date of 50,000 to 60,000, but this requires further confirmation and replication (Bowdler 1990a, 1991; Hiscock 1990; Roberts et al. 1990a, 1990b, 1990c).

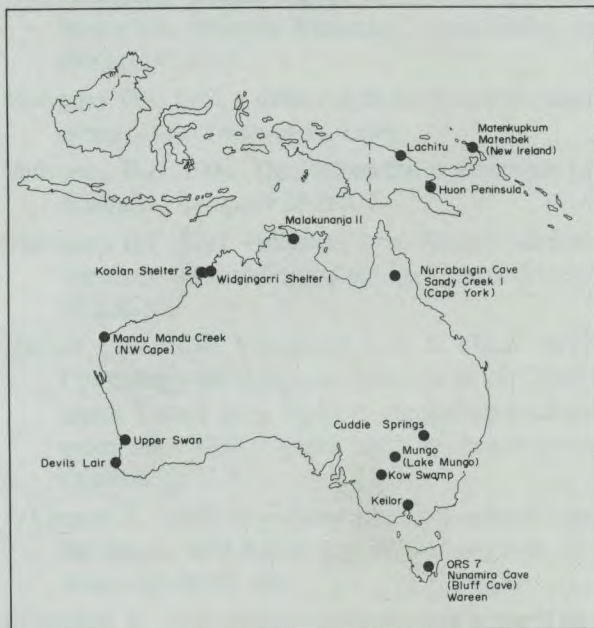


Figure 1 Australasia: Archaeological sites discussed in text.

Site	State	yr BP	reference
Malakunanja II	NT	50,000	Roberts et al. 1990a
Huon Peninsula	PNG	40,000	Groube et al. 1986
Upper Swan	WA	38,000	Pearce and Barbetti 1981
Nurrabulgin Cave	Qld	37,170	David 1991
Mungo midden (L. Mungo)	NSW	36,000	Bowler et al. 1970; Bowler 1976
Lachitu (RIQ)	PNG	35,360	Gorecki et al. 1991
Warreen	Tas	35,000	McNiven et al., this volume
Mandu Mandu Creek	WA	34,200	Morse, this volume
Matenkupkum	PNG	33,300	Allen et al. 1989
Buang Merabak	PNG	31,990	Allen 1991
Sandy Creek 1	Qld	31,900	Morwood and Trezise 1989
Keilor (hearth)	Vic	31,000	Pearce and Barbetti 1981
ORS 7	Tas	30,840	Cosgrove et al. 1990
Nunamira Cave (Bluff Cave)	Tas	30,420	Cosgrove et al. 1990
Cuddie Springs	NSW	30,280	Furby et al., this volume

Table 1 Early archaeological sites in Australasia.

Using the more conventional radiocarbon technique, a range of sites in Australasia has been dated to between 40,000 and 30,000 BP (Table 1; Allen 1989; Bowdler 1992). With respect to a chronological interpretation of the data, there are three possibilities. One is to take them absolutely at face value, and to suggest that Australia was first occupied 50,000 to 60,000 years ago (Malakunanja II evidence), with a gradual increase of supporting evidence available to fill in the time gap before it starts to become more replicative, which may be related to a gradually increasing and adapting population.

Another possibility is to argue that the data, scanty as they are, represent but a small portion of evidence which has survived the vagaries of time, and which represents a far greater body of evidence now lost. It may be further argued that there was an archaeologically 'invisible' phase, of which our earliest dates represent only an endpoint (Allen 1989).

Like Allen (1989), I do not subscribe to the 'invisible' phase argument, and I do not believe that we can currently defend a human occupation of Australasia before c.50,000 BP. Firstly, such an argument is hardly testable, if it is taken literally. There have however been data of a non-archaeological nature adduced towards such a position. It has been argued that changes in the vegetational regime evident in deep pollen cores and dated to c.120,000 to 75,000 years ago may have been due to the arrival of humans in Australia (Singh et al. 1981). This is, however, based, at best, on two cases, and it has been suggested that the dating for one of these should be revised downwards to at least 60,000 BP (Wright 1986). There is no supporting **archaeological** evidence.

There is also some evidence which might be said to support positively an absence of humans in Aus-

tralia earlier than c.50,000 BP. Bowler (1976) has argued two cases, as follows. At the Willandra Lakes the lowest stratigraphical unit, the Golgol, underlies the Mungo unit which is the one containing archaeological evidence. Like the Mungo unit, it relates to a period when the lake contained fresh water and would thus have been conducive to human occupation. It dates to about the time of the last interglacial (120,000 years ago), and is not known to contain any evidence of human occupation whatsoever. Sand dunes of similar age on the eastern Australian coast are also devoid of evidence of human occupation.

Furthermore, none of the excavated Australian cave or rockshelter sites contain deep archaeological deposits which **underlie** dates of the order of 30,000 to 40,000 BP, as is the case in Europe, Africa and the Middle East.

The third possibility is to treat the data with caution to the point of scepticism, and only accept those dates which clearly derive from materials clearly associated with unquestionable cultural materials. This is the course followed by Allen (1989). We would thus eliminate from consideration, at least for the time being, Malakunanja II, the Huon site in New Guinea, and Upper Swan (Allen 1989; Bowdler 1992). The 36,000 BP shell midden site at Lake Mungo might be accepted, on the grounds that what is dated is itself humanly gathered material (freshwater shells), although that material might be regarded as a less than ideal dating material. The dating of marine shells, on the other hand, is now generally regarded as reasonably accurate for Australia, although a reservoir correction factor of -450 years should be applied (Bowman 1985).

After such a culling exercise, we have several sites dated between 37,000 and 30,000 BP (Table 1). The distribution of these dates, contrasted with the distribution of the original sample, and

taking into account their wide geographical spread may be interpreted as showing a somewhat more rapid colonising and settling process.

The most common cultural materials from these early Australasian sites are stone artefacts. There are some bone and shell artefacts, most notably the shell beads from Mandu Mandu Creek (at c.32,000 BP: [Morse, this volume]), and bone beads and points from Devil's Lair at c.19,000 BP (Dortch 1984). Stone artefacts however are found at all currently known Australasian sites of this age range, although in varying degrees of abundance, and very few complete assemblages have been published in detail. A further difficulty arises from the fact that early Australian industries have been characterised on the basis of unstratified surface collections, which I believe distorts the picture presented by stratified assemblages, by conflating separate elements and possibly producing a sorting effect. I have reviewed this evidence elsewhere (Bowdler 1990b), and will only summarise my views here.

Despite what appears to be a wide range of variation, a general similarity can be perceived in the assemblages considered. Much of the variation can be attributed to differences in local raw material availability, from which the artefacts are generally produced. Overall, the impression is of a rather amorphous set of industries, but with some commonly recurring types. Despite earlier ideas, these tend to be small rather than large: small steep edge scrapers, thumbnail scrapers and bipolar pieces. Pebble choppers and the like are rare rather than common. The Huon assemblage (which comprises a large unstratified component) includes large waisted types, which have not been found elsewhere in a similar aged context, and indeed are known from very few places overall (Groube 1986). Another larger element is the edge ground hatchet or axe. These are now known from several sites in northern Australia in contexts dated in excess of 20,000 BP (Morwood and Trezise 1989; O'Connor 1990:344). In general, I have argued that these earliest industries may represent a sort of travelling survival kit, that their frequently amorphous nature reflects not a lack of sophisticated knowledge, so much as a flexible and opportunistic repertoire which becomes more defined as its owners become more attuned to local conditions and necessities.

Turning to biological evidence, there is now a quantity of Pleistocene to early Holocene human material from Australasia, almost entirely from the Australian continent, and indeed mostly from the southeast (Table 2; Pardoe, this volume). There appears to be an overall agreement that all this

material represents *Homo sapiens sapiens*, after which agreement stops.

The oldest preserved human Australians are from Lake Mungo. One is the cremation burial of a female, known as Mungo I, and dated to between 24,500 and 26,500 BP by a series of dates, including one on the bone itself (Thorne 1976:96; Jones 1989:761). The other firmly dated example is Mungo III, the extended inhumation burial of a male, which is dated to between 28,000 and 32,000 BP on the basis of radiocarbon samples from sediment and other material in close association with the burial (Bowler and Thorne 1976:136-8). Several other human remains are known from the Willandra Lakes complex, but few have been dated or described. One specimen, WLH [Willandra Lakes Hominid] 50, has attracted considerable attention. It was found as an unstratified specimen, and consists of a heavily mineralised calvarium. An attempt has been made to date this fossil by electron spin resonance, with a resulting suggested date of 29,000±5000 BP (Caddie et al. 1987:175).

One of the largest human fossil assemblages comes from the Kow Swamp burial site on the Murray River. Over 40 individuals were buried here between 9300 and 14,000 BP (Thorne 1976:96). Other large collections of skeletal material are known from the Murray valley, such as the Roonka, Wentworth and Coobool Creek collections. The first two sites have been dated to within the last 7000 and 6000 years respectively. The Coobool Creek collection, comprising 126 individuals, was made in the 1950s, and no information has survived as to stratigraphic or even locational details. One specimen has produced a uranium thorium date of 14,300±1000 BP (Brown 1987, 1989). Other human remains consist of individual burials or finds, often not well-dated (Table 2).

The morphology of these fossils has been characterised as falling into two distinct groupings, one robust, and the other gracile (Thorne 1977). As mentioned earlier, no-one argues that any of these are other than *Homo sapiens sapiens*. The robust group is said by Thorne (1977) to be generally

'Gracile'	years BP	'Robust'	years BP
Mungo I-III	32-25,000	Kow Swamp	14-9000
King Island	14,300	WLH50	?29,000
Keilor	?12,000	Lake Nitchie	?15-7000
		Cohuna	?14-9000
		Talgai	?12,000
		Coobool Creek	?12,000
		Mossiel	?11-5000
		Cossack	?<6000

Table 2 Human fossil sites in Australia.

outside the range of robustness for modern Aboriginal populations, and the gracile group is said to be generally outside the range for gracility of modern Aboriginal populations. The interpretations of these differences and what they signify are equally polarised, and tend to be connected with the current worldwide debate on the emergence of modern humans, in terms of regional continuity versus replacement.

Thorne (e.g. 1976:100) has followed the original argument of Weidenreich in seeing specific features of the Javanese *Homo erectus* fossils, particularly the later Solo or Ngandong group, perpetuated in Australoid populations. Macintosh before him was responsible for the apparently deathless phrase that 'the mark of ancient Java is on all of them' (1965:59). Subsequently however, and with considerably more fossil and archaeological evidence available, Macintosh and Larnach (1976:118) expressly rejected Weidenreich's argument that 'Solo man formed an ancestral stage in the evolution towards Australians'.

Thorne however has consistently followed Weidenreich, and has, with other scholars such as Wolpoff and Wu, put forward the Australian fossil evidence as one of the main pillars of support for the regional continuity model of emerging modern humans (Thorne 1976, 1977, 1981, 1984, 1989; Thorne and Wilson 1977; Thorne and Wolpoff 1981; Wolpoff et al. 1984; Wolpoff 1989). This model sees different lineages in different parts of the world for the emergence of regionally differentiated populations of *Homo sapiens sapiens* from regionally distinctive populations of *Homo erectus*. Thus, in China, a lineage is perceived leading from Lantian, Hexian and Zhoukoudian *H. erectus*, through intermediate forms Mapa, Changyang, Liujiang, Xujiayao and Zhoukoudian Upper Cave which demonstrate Mongoloid features and become increasingly sapient. In Africa and Europe different lineages obtain, and also in Java-Australia.

The opposing point of view, the replacement model, derives largely from genetic studies. Cann et al. (1987) and Stoneking and Cann (1989) argue that *Homo sapiens sapiens* originated in Africa between 100,000 and 300,000 years ago. This view is also supported by some Australian geneticists, whose work demonstrates the divergence of the ancestral lines of Aborigines, black Africans and east Asians taking place between 100,000 and 200,000 years ago (Kirk 1987). One implication of this is the extinction of *Homo erectus* populations outside Africa; this argument sees no relationship between Javanese *Homo erectus* and regional *H. sapiens* populations.

The retention of specifically Javanese *H. erectus* characteristics by later Australoid populations is essential to the regional continuity argument in our region. Modern Javanese, indeed southeast Asian populations generally, do not of course demonstrate these characteristics, being essentially Mongoloid. It is in the recent indigenous populations of Australia and parts of Melanesia that Weidenreich, and Macintosh in 1965, saw Javanese *H. erectus* characteristics. Macintosh and Larnach in 1976 no longer held that view; and Thorne does not perceive those characteristics so much in the recent populations, as in the fossil record, and specifically in the robust group of Australian fossils described above. The lineage for Indonesia-Australasia is believed to run from the early Sangiran *Homo erectus* group through the later Solo-Ngandong *H. erectus* group to the robust Australian *H. sapiens sapiens* group.

The most immediate problem with this argument is the non-robust group, particularly the Mungo I and III and Keilor fossils. Thorne and his colleagues would derive this group from China, and see them as essentially an intrusive Mongoloid element. They argue that Australia was colonised by two different groups.

Australian populations reflect a dual ancestry that involves the two distinct morphological clades that have existed in east Asia since the earliest hominid habitation ... the end result in Australia is a series of populations in which the effects of the Indonesian ancestry (the Sangiran-to-Solo line) predominate (Wolpoff et al. 1984:446).

There are further problems arising from this view. Most obvious is the chronology of the fossil populations. The oldest fossils are in fact the gracile Mungo I and II specimens. With the exception of WLH 50, which needs more precise dating, all the robust group said to display Solo characteristics are terminal Pleistocene or Holocene in age. While there is no clear chronology for the Solo group, with estimates ranging from 700,000 to 60,000 BP, even taking the most recent end of that range leaves a gap. The archaeological record also provides no support for this argument. There is, as we have seen, little firm evidence for an occupation of Australasia before 40,000 BP, and the archaeological evidence does not suggest any cultural differentiation of colonising populations.

Other interpretations of the Australasian biological evidence have been put forward. Perhaps the main contender with Thorne's views is the research of Brown (1981, 1987, 1989). Brown (1987) analysed the extensive Coobool Creek collection (see above), and re-analysed many of the other Australian fossil specimens, including those from Kow Swamp and Mungo I and III. One of his

more controversial arguments is that the robust individuals, including some from Kow Swamp, demonstrate artificial cranial deformation, and that this accounts for at least some of the perceived variation (Brown 1981). His overall conclusion is that his analysis 'provides little support for the presence of two biologically distinct populations' during the late Pleistocene '...therefore the construction of elaborate schemes of multiple occupations would ... seem inappropriate' (Brown 1987:62).

Pardoe (1988) similarly suggests that differentiation of Murray Valley populations in the terminal Pleistocene-early Holocene results from in situ development. He bases his observations on a non-metric analysis of skeletal material plus a consideration of cultural factors evident in the archaeological record. The details are rather too complex to explicate here, but if we accept his model of formalised exclusive social relationships on the Murray River, he argues that

the dichotomy between Pleistocene and Holocene southeastern populations disappears ... Kow Swamp is not an archaic relict Pleistocene population, but the forerunner of a modern, socially complex, dynamic system (Pardoe 1988:14).

With respect to the wider issue of whether Australoid fossils and/or recent populations display Solo characteristics, there are also contrary opinions, for example, those of Rightmire (1988:256) and Webb (1989:73-4). I do not wish to debate the matter on biological grounds. It is my impression that, among biological researchers, the regional continuity argument has the upper hand, at least with respect to Java-Australia. I do wish however to point out that it is in conflict with the cultural evidence as shown in the archaeological record, not just in Australasia, but in the wider Southeast Asian context.

EARLY SOUTHEAST ASIA

The earliest evidence for hominids in Asia is the *Homo erectus* fossils, known since the nineteenth century, and considered to date from perhaps 1.7 million years or less, perhaps 500,000 BP (see e.g. Pope 1988). A later group, the Solo or Ngandong fossil hominids, are variously described as early *H. sapiens* or evolved *H. erectus*, with dates estimated at anything between 700,000 and 60,000 BP (Bartstra and Basoeki 1989; Bellwood 1985:43, 50-2). None of these skeletal remains has any cultural context or associations whatsoever: no stone artefacts, no hearths, no evidence of subsistence, economic or any other activity.

Some widely distributed surface assemblages of 'poorly differentiated pebble and flake industries',

including the industry designated 'Pacitanian', have been attributed to *H. erectus*, but no proof of such an association exists (Bellwood 1985:56-67). Bartstra and Basoeki (1989) also suggest that some small 'inconspicuous' flake and core artefacts from the Solo high terrace are attributable to *Homo erectus soloensis*, but the association is hardly firm, and the artefacts themselves await further description.

It would appear that there is no cultural evidence anywhere in southeast Asia (not including south China) which is older than 40,000 BP. The only possible exception is a small collection of artefacts from northern Thailand. They are said to derive from fluvial gravel deposits which stratigraphically underlie a basalt dated by potassium argon to between 800,000 and 600,000 BP years. The actual artefacts do not however appear to have been stratified beneath the basalt, and it is not clear that the excavations carried out actually penetrated undisturbed basalt (Pope 1985; Pope et al. 1986, 1987; see also Anderson 1987:184; Jones 1989:750).

All firmly dated archaeological sites in southeast Asia are contemporary with or younger than those in Australia. There are various problems associated with the southeast Asian archaeological record, including early twentieth century work which falls somewhat below modern standards and lack of publication of results. Nevertheless, there is now beginning to be a solid body of modern archaeological research, and coherent patterns are becoming apparent.

Relevant sites (Fig. 2) are Lang Rongrien in peninsular Thailand, with human occupation dated to c.37,000 BP (Anderson 1987); the Niah cave, Sarawak, with its oldest occupation dated to between 35,000 and 40,000 years BP (Zuraina 1982);



Figure 2 Southeast Asia: Archaeological sites discussed in text.

Leang Burung 2 in southern Sulawesi, dated to c.31,000 BP (Glover 1981); the Tabon cave on Palawan Island, c.26,000 BP (Fox 1970) and Kota Tampan, in Perak, peninsular Malaysia, where recent research demonstrates the existence of a workshop site firmly dated to c.31,000 years ago (Zuraina 1990; Zuraina and Tjia 1988). One might also include Tingkayu in Sabah, Island Malaysia, indirectly dated to 28,000 BP (Bellwood and Koon 1988:48-9); Pilanduk Cave, also apparently dated to c.28,000 BP (Fox 1978) and four cave and rock-shelter sites in northern Vietnam dated to 23,100 BP, 19,000 BP, 18,400 BP and 18,000 BP (Hoàng Xuân Chinh 1991; Ha Va Tan 1980). These dates conform very closely to those from Australasia.

With the possible exception of the three artefacts from northern Thailand, all dated southeast Asian archaeological manifestations, in the sense of cultural evidence, are restricted to the last 40,000 years: that is, to within the same time range as the human occupation of Australia. If it were not for the *Homo erectus* fossil material, we could argue on archaeological grounds alone that southeast Asia was unoccupied by humans until 40,000 years ago. Bellwood (1985:67) comments that it could be argued that no human crossed Huxley's line before 40,000 BP. I would argue that there is no evidence that *Homo sapiens* was present in southeast Asia before 40,000 BP (see also Bowdler 1990b, 1990c; Hutterer 1985).

A CULTURE AREA?

Plotting the earliest dated cultural sites for both Greater Southeast Asia and Greater Australia on a map, as in Figure 3, shows something that looks very uniform in time and space. With respect to cultural content, I have summarised the rather limited evidence elsewhere (Bowdler 1990b), and there certainly appears to be resemblances between the stone artefacts at the different sites from both regions. It seems possible to suggest that these assemblages can be construed as being part of a common tradition, with local variation due to different environments, site usage and raw-material availability. In the light of earlier opinion, it is interesting to note the general low frequency of pebble tools and other large core tools, with the exception of the Huon Terrace waisted tools. There are some types which occur in several sites, in both the Sunda and Sahul provinces, namely small steep edge scrapers and thumbnail scrapers. Otherwise, these industries could be characterised as somewhat amorphous, comprising ad hoc flake tools.

This sort of characterisation does however reflect an ultimately Eurocentric perception. An in-

dustry without a suite of recognisable (to the archaeologist) formal types is seen as amorphous, ad hoc and so on. Australian archaeologists have tended to turn away from typological studies and address questions of technology. But what, after all, does it tell us? Is it really ultimately all that interesting just to know how things were made? Perhaps we have abandoned too readily the pursuit of culture history through the study of cultural evidence. It may be possible to wring from these unprepossessing industries this sort of information, by deploying our new understanding of technological processes, allied with modern statistical techniques, to such an end. In other words, it may be possible to demonstrate that early southeast Asian and early Australian assemblages do in fact reflect a common cultural origin.

REPLACEMENT?

There is no doubt that the first hominid occupant of southeast Asia was *Homo erectus*. This *H. erectus* had certain primitive morphological features, but also appears to have been, compared with the populations in Africa, Europe and China, virtually without culture. It is my contention that this population evolved to some extent, as shown in the Ngandong fossils, but sometime perhaps in the Middle Pleistocene or even early Upper Pleistocene became extinct.

The first human occupation of southeast Asia took place about 50,000 years ago, by *Homo sapiens sapiens*. This fully modern human was probably coastally adapted and equipped with highly

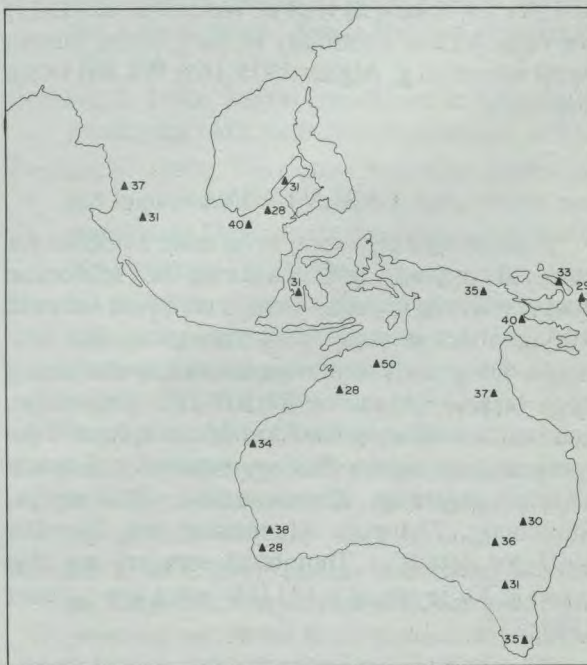


Figure 3 Australia and southeast Asia: Old sea levels.

functional watercraft. At a time of lowered sea level, water crossings of up to 65 km appear to have been negotiated across Wallacea into Australia and to oceanic islands of Melanesia. This was also a time of major dispersion of mammals into southeast Asia (Darryl Kitchener, Western Australian Museum, pers. comm.). Whatever the reason, whether due to climatic change, and whether there is indeed any connection between human and beast, the major human dispersal took place at about the same time. The animals, however, were stopped by the larger water barriers. The humans, on the other hand, seem to have found them to be no barrier at all. Thus we may see mainland southeast Asia, Wallacea, Melanesia and Australia colonised virtually simultaneously by modern human beings some 40,000 to 50,000 years ago.

This of course raises the question of whence they came. Even if we accept the genetic evidence which indicates an ultimate African origin, this need not mean an instant exodus from the heartland within the last 50,000 years. A recent summary of those findings suggests the time scale is somewhere between 50,000 and 500,000 years ago, and, furthermore, does not rule out interbreeding between 'resident non-Africans' and the 'dispersing African population' (Stoneking and Cann 1989). I would, on the basis of the archaeological evidence, argue against the regional continuity model as it is applied to Java and Australia. This does not however rule out another aspect of regional continuity, namely one which derives Asian populations, including Australian ones, from an ultimate Chinese *H. erectus* origin. This at least leaves half the now conventional Australian dihybrid model intact. Chinese, and other scholars, as well as Wolpoff et al. (1984) see considerable continuity in the Chinese human fossil record (e.g. Aigner 1978:165; Wu and Dong 1985:88).

EARLY CHINA

There would also seem to be more evidence for **cultural** continuity in China during the Pleistocene than elsewhere in Asia. Pebble choppers occur in low numbers at many sites throughout this time range. Dingcun is somewhat unusual in containing large bifaces (Aigner 1981:207-17). Otherwise, continuities occur in the form of amorphous flake scrapers, and bipolar flaking, especially of quartz (Xiaochangliang, Zhoukoudian, Shilongtou, Shuicheng, Zhaoacun, Xiaonanhai; see Bowdler 1992 for details). Thumbnail scrapers are also noted at Xujiayao, at c.131,000 years ago (Aigner 1981:233).

Of particular interest is the generalised resemblance between Chinese Pleistocene industries and

those from the early sites in southeast Asia and Australia. All industries in this part of the world have a long history of being problematical in terms of Eurocentric models. If however we distance ourselves from those kinds of expectations, we see not so much an amorphous collection of bits and pieces, as a surprisingly consistent set of assemblages spanning an extremely long period from c.1 my ago to the end of the Pleistocene. This is of course a subjective impression, and it is hoped, as suggested above, that future detailed metrical and statistical comparative studies may contribute to a better understanding of cultural relationships.

CONTINUITY AND REPLACEMENT?

On the basis of the **cultural** evidence there seems to be a *prima facie* case for an hypothesis which derives southeast Asian and Australasian populations of the upper Pleistocene from China, in an archaeologically simultaneous colonisation which swept across several water barriers. This might fit one view of the human fossil evidence (and was to some extent anticipated by Macintosh and Larnach 1976:124), but it is clearly in conflict with the other, based primarily on **biological** considerations, which derives Australasian populations at least from Javanese *Homo erectus* populations. As an archaeologist, I prefer to follow the interpretation which best fits the cultural evidence.

Various objections have been raised to this interpretation. The idea of a culture-free hominid in Java seems to be particularly difficult to accept, possibly because it challenges some of the accepted definitions of what makes a hominid. It also appears to be arguing for some form of devolution. This does not seem to me to be necessarily the case. It might for instance have been more adaptive for hominids in the forested environments of Java to have discarded the use of tools, if that facility had been brought from Africa. Puech's (1983) tooth-wear study suggests that Javanese hominids were 'mainly vegetarian and specialised in foods of little nutritive value' (admittedly the latter observation does not sound very adaptive), a type of diet which 'does not call for a sophisticated technology'. It is thus only in the face of changing environments that the lack of tools might have become non-adaptive.

It seems likely, given our current knowledge of the dating of the Javanese fossils, that this population had become extinct before the advent of *Homo sapiens sapiens*. This of course supposes a rather different scenario to any of those proposed for northern Europe, for instance, where the replacement model must cope with some form of temporal overlap between archaic and modern forms.

If, however, we do need to invoke some form of overlap for the southeast Asian-Australasian region, an argument of replacement based on competitive success seems to have a firmer basis here than elsewhere. It is generally agreed that, in Africa, the possession of patterned stone artefacts is one of the most significant attributes of the emerging human lineage (e.g. Lewin 1984:50). The lack of this attribute must also therefore have some significance. Despite Pope's (1988:62) observation that 'it seems unlikely that "invading" populations of *Homo sapiens* would possess technologies or adaptive strategies superior to those of resident populations', surely the possession of stone tools must be seen to constitute such an advantage. Furthermore, if such populations are derived from southern China, they need not be at an environmental disadvantage.

There are further possibilities. One is the standard explanation of the lack of stratified cultural evidence in southeast Asia older than c.40,000 BP: it has not been found yet. Although scholars have been searching for it now for one hundred years, that is of course still a possibility. The other argument is that early southeast Asian hominids possessed a culture which is archaeologically invisible, based on the use of plant and other perishable materials. It is not clear how one might test this argument. We can however consider its implications, and it can be used to reconcile the conflicting archaeological and biological sets of evidence, at least to some extent. Thus, it can be suggested that early resident populations in southeast Asia received cultural baggage from the north, with or without genetic exchanges, which brought them into archaeological visibility. This does not seem likely for Australasia however, unless we wish to argue for earlier maritime voyagings by archaeologically invisible populations.

It seems to me that, in our current state of knowledge, the most parsimonious explanation of the evidence is the one that explains both the biological and archaeological record. This appears to show regional continuity in China and replacement in southeast Asia-Australasia. This may not be acceptable to scholars who see Javanese *Homo erectus* characteristics clearly perpetuated in Australasian populations; there do however appear to be other biological points of view. With respect to the archaeological evidence, on the other hand, only the replacement model makes sense for southeast Asia-Australasia: that this part of the world was colonised c.40,000 years ago by *Homo sapiens* populations from China, and that a culture area was established between 40,000 and 30,000 years ago which spanned Sunda and Sahul, until separate developments led in due course to the

emergence of distinctive and characteristic Australian and Asian societies.

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A REVIEW OF THE EVIDENCE FOR THE EMERGENCE OF ROCK ART IN AUSTRALIA

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Dating rock art and related rock markings is notoriously difficult and the issue of the antiquity of rock art in Australia has become a very contentious subject. Furthermore, with the exception of Forge (1991), authors have not distinguished between rock art and other rock markings such as finger flutings, handstencils, abraded grooves and battered rock ridges. They are all subsumed under the rubric rock art and analyses and discussions encompass them without differentiation. For discussions of chronology this is justified insofar as the dating methods available for rock art and other markings are the same; indeed handstencils and abraded grooves frequently occur on the same rock surfaces as structured art and are often clearly contemporaneous. For the purpose of this paper, therefore, it will be easier to evaluate the dating evidence for both art and other markings according to the dating methods employed, and to follow this with a discussion of the significance of the chronological evidence that this reveals.

Chronological information has accumulated somewhat opportunistically and by diverse means: by directly dating components of the pigment or patina, by inference from geomorphological and/or archaeological association and by the identification of depictions of extinct fauna. A Pleistocene age has been claimed for several sites, for some as much as 30,000 years BP.

The idea of some considerable antiquity for Australian rock art was first mooted by Basedow (1907) for engravings in the Flinders Ranges on the basis of a deep patina and his identification of the tracks of extinct fauna. Mountford and Edwards (1962) discuss a number of further identifications of extinct (or locally extinct) fauna among the engravings at Panaramittee in the Olary district. These include their identifications of *Crocodylus porosus* and *Genyornis*, which led them to speculate on a Pleistocene antiquity for the engravings.

The first substantive rationale for a considerable antiquity of rock art in Australia was Edwards' important paper (1971) in which he defined a con-

sistent tradition of engraved rock art throughout the arid zones of Australia, always intensely patinated and frequently associated with artefacts of a 'core and scraper tradition'. This idea was further developed by Maynard (1979) who, on the basis of its relationship to dated deposits at Ingalladdi, argued for an antiquity of at least 7000 years for this tradition, and perhaps 10,000 years on the grounds that similar engravings occur in Tasmania (Tasmanian engravings are now considered recent Holocene, see Brown 1991). Maynard added, however, that not all figures or sites may be as old (Maynard 1979:95).

RADIOCARBON DATING

Secure dating evidence for rock art remains elusive, and only a few rock art or other rock marking sites can be dated to the Pleistocene by radiocarbon dating of associated material.

Early Man rock shelter, North Queensland

The first derived from Trezise's discovery of deeply weathered engravings covered by archaeological deposit at a site which he named Early Man on his intuition of great antiquity for its execution. Subsequent excavation and radiocarbon dating of deposits immediately covering the engravings confirmed his expectations, with an age of ca. 13,000 BP (Rosenfeld 1981a:11-13). This age estimate derives from three radiocarbon determinations on charcoal, each collected through 5 cm spits of deposit close to the engraved shelter wall. The stratigraphic relationship between deposit and engravings are clear, but charcoal samples were small and two provided dates with fairly high standard deviations: ANU 1441: 13,200±170; ANU 1566: 12,600±2800. A very small sample of charcoal from deposit immediately over the rock surface was also dated, although its adequacy was, at the time, questioned by the radiocarbon laboratory: ANU 1567: 15,450±1500. Deposit below this was sterile. Thus a cautious use of the radiocarbon dates

indicates that the lower part of the engraved frieze (Plate 1) was initiated approximately 13,000 BP, toward the close of the Pleistocene.

The bearing that this date has on the age of arid zone engravings has been disputed depending on one's views of the stylistic relationship of the Early Man engravings to those in the arid zone (e.g. Franklin 1991:121-2; Rosenfeld 1981b:88-9).

Sturts Meadows, western New South Wales

Independent evidence for a similar antiquity for arid zone engravings has now been obtained at Eight Mile Creek, Sturts Meadows in western New South Wales. The dating of these engravings depends on evaluation of the complex relationship between a calcrete formation dated by AMS radiocarbon and a desert varnish patina that covers most engravings (Dragovich 1986). Dragovich obtained two dates for thin samples of compact carbonate from the inner layer of a carbonate concretion overlying varnish: Beta-13803: $10,250 \pm 170$ BP and Beta-13804: $10,410 \pm 170$ BP. A thin discontinuous layer of varnish, not visible to the naked eye, also occurs over the calcrete, the outer layer of which has been dated to less than 7000 years old. Dragovich argued that since a high proportion of engravings have relatively thick varnish, this is more likely to belong to the earlier episode of varnish formation which antedates the calcrete. Clearly, varnish formation may have continued during the period of calcrete formation, and to a limited extent it also postdates the period of calcrete formation. The age determinations obtained from this study demonstrated that some, and probably most, engravings at Sturts Meadows are older than 10,000 BP. Engravings with no, or very little, varnish are probably younger and the site appears to have been in use over a considerable period of time. Clegg (1987) has argued independently for a long period of use on the basis of stylistic variation in certain motif categories.

For both Early Man and Sturts Meadows, the dates obtained relate to specific sets of engravings within a more extensive site which in each case is likely to have been in use for a considerable time. It is not possible to assess how these age estimates relate to the entire span of the sites' usage. The dates, however, clearly demonstrate the use of structured systems of graphic symbols to mark a locality during the terminal Pleistocene.

Other sites

At the site of Mickey Springs 34 in the Flinders region of north Queensland deposits covering and just below engravings have been dated to the beginning of the Holocene (Morwood 1992 pers. comm.)

and preliminary results for the age of a roof fall at Puritjarra in the Cleland Hills, Northern Territory, indicate that patinated engravings of circles also probably date to the early Holocene (M.A. Smith pers. comm.).

Lorblanchet (1988:286) quotes a date of $18,510 \pm 260$ BP (LY3609) for shells associated with petroglyphs at Gum Tree Valley on the Burrup peninsula. Until the full publication of the site and its chronology are available it is difficult to evaluate the significance of this date. Lorblanchet (pers. comm.) states that 'Large pieces of a *Syrinx aruanus* stuck in a crag between two engraved boulders of the top of Gum Tree Valley provided this date', and that it was unexpected. Elsewhere (Lorblanchet 1983) he had argued for an age immediately predating present sea level for the engravings on the top of the Gum Tree Valley site, on the grounds that, in contrast to those on lower boulders, they do not include marine subjects, and that their orientation is not focussed on the midden.

With the advent of AMS radiocarbon determinations, several attempts have been made to isolate carbon-containing components from rock art pigments for dating. Results to date suggest the method is promising, but still poses some procedural problems. Dates have been obtained for organic carbon thought to be blood haemoglobin (Loy et al. 1990) at Judd's Cavern in southwestern Tasmania, RIDDLE-1268: $10,730 \pm 810$ BP, RIDDLE-1269: 9240 ± 820 BP, and from Laurie Creek in the Northern Territory, RIDDLE-1270: $20,320 \pm 3100$ BP. The Tasmanian sample dates ochre hand-stencils and the Laurie Creek sample an ochreous encrustation, the anthropogenic origin of which has not been fully established (Rhys Jones pers. comm.). AMS dating has also been applied to samples of black pigment from dry pigment art in Gnitalia Creek, Waterfall Cave and in Native Animals rock shelters, all located in eastern New South Wales. The Native Animals sample yielded insufficient carbon, bringing into question the nature of the black pigment used. At Gnitalia Creek two very disparate age estimates were obtained on two samples from the same figure, AA-5850: 6085 ± 60 BP and AA-5851: $29,795 \pm 420$ BP (McDonald et al. 1990). The source of errors in this latter case are thought to derive from older carbon contaminants within the silica skin on the rock surface. Further sampling and research are in progress, but in view of the style of the art and the nature of the rock surface it is not expected that a Pleistocene age will be confirmed at this site (Kelvin Officer pers. comm.).



Plate 1 Frieze of Pleistocene rock engravings at Early Man rockshelter (cf. Rosenfeld et al. 1981:Fig. 22c). (Photo: M. Lorblanchet).

Finger markings in limestone caves

A Pleistocene antiquity has been suggested for the finger markings drawn through the soft weathered or calcite-covered surface of the rock in limestone caves along the southern margin of the continent. At Koonalda cave, South Australia, these markings extend along the wall of a long passage and are in part covered by a rock fall, thus indicating some antiquity. Charcoal on the cave floor found close to the finger flutings has been dated to $19,900 \pm 2000$ (V-92) (Wright 1971). As Wright states: 'Although the markings cannot be stratigraphically related to it there is a presumption of contemporaneity' (Wright 1971:28). This is based on the concurrence of this date with the period ca. 15,000-22,000 BP when the cave was mined for its flint nodules and that there is no evidence for either earlier or more recent use of the cave.

At Malangine cave in South Australia, Bednarik was able to identify a sequence of rock marking episodes interleaved between the layers of calcite formation (Bednarik 1984). Radiocarbon dates for the third most recent phase of finger fluting yielded an age of 5550 ± 55 BP (no laboratory number quoted). In a more recent paper Bednarik (1990b:66) considers that the age of earlier markings may 'extend well into the Pleistocene', but this requires confirmation. In his earlier paper (1984:75) he had suggested that excavation might yield dating evidence for fragments of marked calcite skin fallen from the roof. Frankel (1986), however, found that the deposits in this cave were too disturbed for archaeological investigations.

Excavations by Frankel in the nearby Koongine cave which also has finger flutings has revealed two short distinct episodes of cave-use: the first for about a millenium from ca. 10,000 BP (based on four radiocarbon dates Beta-14859: 8270 ± 400 ; Beta-15996: 9240 ± 100 ; Beta-14861: 9710 ± 180 ; Beta-14862: 9590 ± 140) and a short period in the last millenium Beta-14858: 700 ± 70 (Frankel 1986:81). Bednarik (1989) questions the necessary association of finger flutings with other indicators of cave-use, and develops a complex argument about the cave's geomorphological history which enables him to suggest that the finger flutings must predate a considerable rock fall, and be earlier than the deposits dated to nearly 10,000 BP by Frankel. Frankel (1990) has countered this by affirming that his stratigraphic observations do not support Bednarik's interpretation of the site's history. Although the relationship between occupation and finger flutings remains unresolved, a separate third episode of cave-use solely to mark its walls is, on present evidence, the less likely scenario.

At Prung-kart cave, also in South Australia, samples of a very porous calcite skin with finger flutings have yielded recent Holocene radiocarbon dates (Bednarik and Rosenfeld in prep.).

DATING VARNISH AND OTHER SKINS ASSOCIATED WITH ROCK ART

AMS dating of oxalate crusts

Rock art researchers have long hoped that techniques for the dating of patina over engravings will resolve their dating problems for a large body of rock art. The advent of a wide range of microanalytical techniques and of small sample dating have yielded preliminary results, but research in this area is still largely experimental (Watchman 1992b). Watchman has demonstrated the possibility of obtaining radiocarbon dates from the carbon in oxalate skins that form on a range of substrates in Australia (Watchman 1991). He obtained radiocarbon dates for oxalates at several sites in the Kakadu National Park which range from modern to two dates of 8200 ± 460 (ANU 4270) and 8880 ± 590 (ANU 4271) on a multilayered crust from Ngarradj Warde Djokeng (Watchman 1987). These ages are means for the entire thickness of a multilayered crust. The relationship of rock art pigment to the layers within the crust was not established. A further problem in interpreting the significance of these dates is uncertainty as to the origin and geochemical history of the carbon. Despite his discussion of these uncertainties Watchman considers that he has established a minimum age of 8800 BP for some of the paintings covered by oxalate skin (Watchman 1987:40). Elsewhere (1991:29) he argues that the formation of oxalate skins in rock shelters in the tropical north was probably initiated by the burning of a denser vegetation that accompanied the climatic amelioration from cool, dry to warm, humid conditions in the late Pleistocene to early Holocene period.

Cation-ratio dating of desert varnish

The method of cation-ratio dating has been developed to date the patina known as varnish or desert varnish that forms over rocks in relatively arid environments and has received much attention here and in the United States of America (see especially Krinsley et al. 1990). In Australia the method has been tested on engravings in the Olary district of South Australia (Nobbs and Dorn 1988). The 24 age estimates obtained range evenly from 1400 ± 180 BP to $31,700 \pm 3700$ BP for engravings that cannot be distinguished on grounds of technology, style or the appearance of the patina.

Cation-ratio dating depends on measuring the gradual leaching of mobile cations from the patina. The original chemical composition of the varnish varies with environmental factors, particularly the nature of windblown dust and it can be very variable within a site (e.g. at Sturts Meadows [Dragovich 1984:56]). The leaching rate depends largely on the humidity regime. The method therefore requires calibration of fixed points for any particular field situation, and these are carried out by AMS radiocarbon dating of the varnish. Given the minute amounts of carbon present in the varnish, AMS is not considered appropriate for more than calibration dating of a very few fixed points. Cation-ratio dating also requires assumptions of environmental stability, or alternately the calibration of a number of samples, chronologically controlled in relation to the environmental history of the area. The Olary study assumed environmental stability over the period in question.

An age of around 30,000 BP for the Olary engravings, and by apparent stylistic similarity for the arid zone engraving tradition as a whole, has had some acceptance in the general literature on Australian prehistory and rock art (e.g. Bahn 1991; Lorblanchet 1988). However, these results raise problems of apparent symbolic stability in otherwise changing cultural contexts over some 30,000 years. The cation-ratio dating method for varnishes has been severely criticised, mainly on methodological and procedural grounds (Bednarik 1990a; Clarke 1989; Dragovich 1987; Reneau and Harrington 1988; Watchman 1989) and recent attempts to replicate the Olary determinations demonstrate that the method does not yield consistent results (Watchman 1992b).

DATING BY SUBJECT MATTER

A totally different approach to dating, that of evaluating the chronological significance of the content of the art, has been used by a number of authors (Mountford and Edwards 1962; Murray and Chaloupka 1984; Trezise 1992), but with very limited success. The method depends on two important assumptions which can only rarely be satisfied in the context of Australian rock art: firstly that the iconography of the imagery can be identified with a high level of certainty and, secondly, that the regional chronological status of the subject matter is clearly defined.

Western Arnhem Land rock paintings

The most thorough study of this kind is that of Chaloupka for the paintings of western Arnhem Land (Chaloupka 1984). Chaloupka's work may be analysed in two stages. In the first instance he

followed, with minor modification, the broad stylistic sequence first outlined by Mountford (1956) and more closely defined by Brandl (1973). He identified an early Dynamic style, separated by a period of varied intermediate styles from the recent X-ray styles. He contrasted the wetlands and estuarine faunal assemblages of the X-ray styles with the terrestrial and freshwater nature of fauna in the earlier Dynamic style. On this basis he postulated that the Dynamic style predates the establishment of present environmental conditions, and probably predates the establishment of present sea level in the mid-Holocene, about 6500 years ago. This model is generally accepted (e.g. Lewis 1988), particularly in view of the different geographical focus of the two styles: the recent styles are widespread in shelters bordering the present lowlands on the edge and outliers of the escarpment, while the Dynamic paintings are more abundant on the higher ground.

Chaloupka also proceeded to refine the stylistic sequences within the broad schema, and to use superimposition to construct a relative chronology. He obtained a very long series of styles within the earlier and intermediate periods. He also distinguished a recent Wetlands period and an earlier Estuarine period within the X-ray styles which he estimates to begin ca. 9000 years ago (Chaloupka 1984:16). In order then to fit in the series of intermediate stylistic periods between the Dynamic style and the first, Estuarine, phase of the X-ray style, he needs to postulate a clearly Pleistocene age for the Dynamic style. There are methodological problems with Chaloupka's identification of stylistic assemblages, upon which this is not the place to elaborate, except to note that other researchers working on the same material have established very different stylistic assemblages and sequences (Haskovec 1992; Lewis 1988; Taçon 1987).

Finally, Chaloupka with Murray (Murray and Chaloupka 1984) have identified some of the animal images of the earlier style as those of extinct fauna, notably *Zaglossus*, *Sthenurus*, *Thylacoleo* and perhaps *Palorchestes*. These enable them to claim a fully Pleistocene age for the older paintings in western Arnhem Land. Elsewhere Chaloupka (1984:24) is less cautious about the identification of *Palorchestes*, and furthermore argues for an age of at least 25,000 years ago for the paintings on the grounds that suitable environments for *Zaglossus* were prevalent in the region before the massive erosional phase of this period.

The identification of extinct animal depictions has been questioned in a detailed examination of the paintings by Lewis (1986), who produces a different reading of the ochre paint on the rocks. Lewis has also discussed some of the methodologi-

cal procedures for the identification of animal imagery in a non-western art style (Lewis 1977) and points in particular to the need for very precise observation of anatomical detail, and its testing against comparable features in a wide range of indigenous animals. He further points to the difficulties in precisely reconstructing the soft tissues of fauna known only from very fragmentary skeletal parts, notably *Palorchestes*, and finally the difficulty of establishing the periods of local extinctions.

Laura rock art

A further methodological problem, not so acute with the high levels of visual realism in the early art of western Arnhem Land, is that of stylistic reading. Images are by definition conventionalisations of form that intend to allude to other realities. Style is the cultural language that enables the translation of shapes created in pigment into other concepts. The meaning of style is not often cross-culturally evident, and reading on the basis of intuitive recognition of form is analogous to doing a Rorschach test on a blot of ink. Only insofar as the 'other' style conforms to the observer's own will such readings coincide cross-culturally. The problem of image recognition becomes acute in the generalised formal conventions of much Aboriginal rock art, including that of the Laura region. Here Trezise (1992) has claimed a Pleistocene antiquity for paintings on the basis of his identification of *Diprotodon*. An analysis of the stylistic conventions that operate in Laura animal imagery (Rosenfeld 1982) indicate that the *Diprotodon* image conforms closely to conventions developed for the depiction of the introduced animal horse at other sites in this region.

Other localities

The possibility of identifying extinct fauna in Aboriginal rock art, initiated by Basedow (1907) at the beginning of the century, has clearly inspired researchers from time to time. To date, however, none, other than some depictions of *Thylacine* (Lewis 1977) and of *Sarcophilus* (Calaby and Lewis 1977), have stood up to closer analysis. McDonald's very thorough discussion of macropod track images at Sturts Meadows examines the problems of identification in detail. Although she has isolated macropod track images that cannot be related to the pes morphology of contemporary animals, she remains cautious in her suggestion that they may possibly be those of extinct species (McDonald 1983).

DISCUSSION

To summarise this brief survey of Pleistocene rock art in Australia, the earliest solid evidence for structured visual systems on rock date to the terminal Pleistocene/early Holocene: viz engravings in Cape York Peninsula, engravings in semi-arid New South Wales and probably similar engravings in Central Australia. On the basis of their general subject matter it is highly probable that the earliest paintings in western Arnhem Land have a similar antiquity. Finally an analogous argument for some of the engravings on the Burrup Peninsula also points to a terminal Pleistocene/early Holocene antiquity, though the radiocarbon age of apparently associated material may yet indicate greater antiquity here. In Tasmania only handstencils have been recorded from this period.

The only rock markings that may predate this period are the finger flutings and grooves associated with flint mining at Koonalda, although their dating is not as secure as one might wish. A similar argument applied to the situation at Koongine cave would date the finger flutings at that site to the beginning of the Holocene.

Rock markings and rock art: Gestural and referential systems

Bednarik, who has concentrated on the study of wall markings in caves, identifies six categories which may be grouped under finger flutings, sub-parallel grooves made with a tool, and circular and other engraved motifs (Bednarik 1990b). He argues that these show a sequential development (Bednarik 1988:37) and, for the finger flutings in particular, that their intrinsic interest lies in their evidence for an 'emerging human consciousness' (Bednarik 1986:38). Elsewhere (1988:37), however, he also clearly intimates that finger markings continue after the introduction of circles and other structured motifs.

The idea that there is a correlation between graphic simplicity, such as in finger flutings, simple grooves, and cognitive simplicity in visual systems is demonstrably false, and is rooted in outmoded evolutionary theories of art and cognition. Breuil (1952) first mooted the idea that finger markings in Palaeolithic art are the antecedents of structured graphic symbols, but the continuation of finger flutings well after the demonstrable occurrence of structured motifs both in Europe and in Australia brings this into question (see Bednarik [1986] for discussion of the chronologies of such markings worldwide).

More pertinently here, it is questionable whether finger flutings are qualitatively the same cultural phenomenon as other rock art (Rosenfeld,

in press). Formal analyses of finger markings reveal no organised regularities other than those that derive from the mechanics of their formation (e.g. Bednarik 1986:35-6). They may more usefully be conceived of as the visual manifestation of a gesture rather than as a system of referential symbols. As such their use in marking place may be considered to reflect a system of meanings distinct from referential symbols. From this perspective, finger markings are more closely allied to hand (or other body part) stencils the form of which, as argued by Forge (1991:40), is not mediated through any symbolic system because they are mechanically executed. Forge's argument for the individualising character of handstencils is forcefully illustrated in a case recently observed in the Watarrka National Park, Northern Territory, where on a panel with a large number of handstencils a pair of two identical stencils have been carefully scratched over, thus denying the visual statement of one person's claim to a relationship to that locale.

Stencils and finger flutings (and probably also simple grooves, battered rock ridges and related markings) may thus be understood as marks that manifest a person's relationship to place in the gesture of their execution. Both gestural and referential graphic systems of marks are visual manifestations that carry meaning. However the personalised mark mechanically executed in hand-stencil or finger fluting stresses the individual relationship of person to marked place, while the use of stylistic graphic units marks a corporately encoded relationship to place. There are no a priori reasons why gestural systems, such as handstencils or finger flutings should not operate in parallel with a referential graphic system. Finger flutings need not be perceived as archaic precursors of the seemingly more evolved graphic images.

CONCLUSION

From this evaluation of chronological data for rock art and rock markings in Australia, an age greater than the terminal Pleistocene cannot at present be upheld for any referential rock art. Only the gestural finger flutings and few grooves of Koonalda cave can be assigned to an earlier period with some degree of confidence.

Earlier evidence for symbolic action during the Pleistocene is found in burials and cremation, in personal adornment as in the *Conus* shell beads from Mandu Mandu rockshelter (Morse 1993) and the bone beads from Devil's Lair, Western Australia (Dortch 1979) and in the use of ochre for unknown purposes at Nauwalabila and at Malakunanja II in western Arnhem Land (e.g. Roberts et al. 1990). To date, however, evidence for the use of a referential

system of symbols to mark the landscape according to a corporate system of meanings appears to have its origins during the period of rapidly changing environmental conditions of the terminal Pleistocene.

This pattern for early symbolic behaviour is based on so few dated sites, that any conclusions are clearly very tentative. The possibility of an earlier age for engravings on the Burrup peninsula is tantalising. However, the integration of features of the landscape into a corporate symbolic system is entirely consistent with a model of tightened social and territorial organisation at the close of the Pleistocene. Corporate territorial expression through the indelible marking of place with a stylistic graphic system may have been a powerful means of asserting corporate rights and relationships. Earlier individualised symbolic expression may reflect less constrained social systems within which individual and interpersonal relations provided the principal means of social action among more circumscribed populations.

POSTSCRIPT

Since going to press, further information on the antiquity of rock art in Australia has come to light. Lorblanchet's date on shell at the Gum Tree Valley has been published (Lorblanchet 1992:41-2). He argues that its presence at the site, some 130 km from the Pleistocene sea, can only be explained by human action. The association between shell, stone artefacts and engravings remains inferential, but Lorblanchet stresses the central location of the shell among patinated engravings.

Dorn and Nobbs (1992) have published AMS dates of 30,000-35,000 BP for organic matter in varnish from the Olary petroglyphs. The use of AMS overcomes the problems of the cation-ratio method. Dorn and Nobbs argue that by selecting only layered varnish samples they overcome Watchman's (1992a) critique that the inherent instability of varnishes makes them unsuitable for dating. They do not, however, address the issue of the origin of organic dust in the varnish. While these AMS results are of interest, archaeologists will need to await the resolution of specialists' evaluation of the use of varnish for dating purposes.

Radiocarbon dates on oxalate skins from a rock shelter in the Laura area, North Queensland yielded a basal date of ca.26,000 BP (Watchman 1992c). Morphological traits of the skin suggest that it may be identical in formation with oxalate skin covering traces of hematite on an adjacent section of rock wall. Since hematite has not been identified as a component of the regional sandstone, its presence

on rock is likely to be anthropogenic. This suggests that rock art or rock marking may well date to the upper Pleistocene in this region.

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THE PLEISTOCENE IS STILL WITH US: ANALYTICAL CONSTRAINTS AND POSSIBILITIES FOR THE STUDY OF ANCIENT HUMAN REMAINS IN ARCHAEOLOGY

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There are methodological and analytical consequences of creating an intellectual disjunction between the Pleistocene and the Holocene, of dissociating the Pleistocene from the processes and events that link it to the recent past. Isolating the Pleistocene has affected our ways of thinking about the Australian past, as well as our methodologies, data collection and analysis. Some archaeologists have regrettably applied this Pleistocene-Holocene disjunction to current social issues. This has led them to deny contemporary Aborigines a socially and scientifically valid continuity with their remote past.

Following a brief overview of the extent of Pleistocene human remains I will offer three perspectives on the Pleistocene. First, we will see how the relatively few Pleistocene remains may be integrated into a much larger database by looking at *regional variation without respect to time*. Second, *indirect observation*, an analytical method which takes account of temporal process, is described. This may be used to learn about earlier time periods from the wealth of Holocene data. Third, I will look at *cultural information from bones and burials* to assess continuity and change through time.

WHAT ARE THE PLEISTOCENE REMAINS IN AUSTRALIA?

Until recently there were the remains of about 3000 individuals from all time periods, mostly crania, some fragmentary, in museums and other institutions around Australia. Over half of these came from the Murray-Darling Basin. Most were undated, but there can be no doubt that the majority were from the last few thousand years. I base this on personal examination of most of those 3000 remains for biological analysis (Pardoe 1984) and on the nature of preservation in the archaeological record in my fieldwork area. Outside the Murray-Darling Basin, collections very likely span only the last thousand years, although there are exceptions.

Over half of these remains have been returned to Aboriginal communities and have been reburied. Most of the Pleistocene remains have suffered the same fate.

Of these 3000 individuals, there are approximately 120 that we tag as being older than 9000 BP, of which 15 are securely dated (Table 1). A Pleistocene perspective on burial and skeletal biology is slanted almost exclusively to the Murray-Darling Basin. While we look forward to more information on data from other parts of Australia, particularly the northwest, there are a number of reasons why we are less likely to find ancient remains preserved elsewhere. These reasons include soil acidity, land-form stability, population numbers and density in the past and burial practices.

Many of these individual skeletons were discovered in the context of an archaeological paradigm seeking to produce evidence of great antiquity, rather than to provide a secure date for morphological variation. Thus, many of the 15 are no more than small fragments of bone, a shard of frontal bone, a few splinters of thigh bone, a couple of enamel chips from teeth shattered by exposure to the sun. The information we have gained from these is very little more than a radiocarbon date and maybe a single measurement, followed by an assertion that this individual is truly robust (or gracile).

Willandra Lakes (including Lake Mungo)

To date, over 130 individual burials have been noted or collected from the Willandra Lakes. There are six individuals that have been radiocarbon dated (Bowler et al. 1970, 1972; Webb 1989). Clark (1985) has estimated that 10 of the burials definitely predate 15,000 BP, while 44 are more than 10,000 years old and 11 to 23 are less than 10,000 years old.

In Figures 1 and 2, radiocarbon dates for occupation of the Willandra (as measured by dates on charcoal and shell) are compared to minimum estimated ages of skeletons (Clark 1985, 1987). Clark based most age estimates on stratigraphic position-

Locality	No. of Individuals	Sex	Date	± SD	Material dated	Lab #	Reference
Willandra/Lachlan							
Cliefden caves	1	male	7520	220	apatite	ANU-4763a	Pardoe and Webb 1986
			6250	430	collagen	ANU-4763b	Pardoe and Webb 1986
Taronga Dr., Cowra	1	male	103.3% modern	1.80%	apatite	ANU-6611A	Pardoe 1988, 1990
			99.8% modern	0.80%	collagen	ANU-6611B	Pardoe 1988, 1990
Mossgiel	1	male	6010	125	bone carbonate		Macintosh 1967
Mungo 1	1	female	24710	+1270;-1100	acid insoluble	ANU-618B	Bowler et al. 1972
			16940	635	insolubles	NZA-231	Webb 1989:7
			25120	1380	humic acid	NZA-230	Webb 1989:7
			24745	2400	humic acid	NZA-246	Webb 1989:7
Mungo WL 9	1	female	15780	430	insolubles	NZA-160	Webb 1989:7
Garnpung WL 23	1	female	11690	580	insolubles	NZA-165	Webb 1989:7
Garnpung WL 24	1	female	11910	335	insolubles	NZA-163	Webb 1989:7
Garnpung WL 44	1	female	18635	532	insolubles	NZA-159	Webb 1989:7
Garnpung WL 122	1	female	11100	370	insolubles	NZA-194	Webb 1989:7
Garnpung WL 122			16535	535	humic acids	NZA-164	Webb 1989:7
Darling							
Talgai	1		14,000-16,000				Macintosh and Larnach 1976
Boggabilla	3		100% Modern	2.00%	apatite	ANU-7670A	Pardoe 1990
Boggabilla			190	70	collagen	ANU-7670B	Pardoe 1990
Lake Tandou	1	male	15210	160	shell	SUA-1805	Freedman and Lofgren 1983
Menindee	1		2150	170	apatite	ANU-7504	Pardoe
Cawndilla Beach	1		107.20% Modern	2.70%	apatite	ANU-7671A	Pardoe
Lake Nitchie south	1		15300				Macintosh and Larnach 1976
Nitchie	1		6600				Macintosh 1971
Upper Murray							
Kow Swamp 1	1	male	10070	250	apatite	ANU-403b	Thorne 1975:64
Kow Swamp 9	1	male	9300	220	apatite	ANU-619b	Thorne 1975:64
Kow Swamp 14	1	male	8700	220	apatite	ANU-1038	Thorne 1975:64
Mitiamo	1		5540	200	organic	Gak-705	Gill 1967
Barham K2/1			5400	90			Daley 1986
Barham E4/1			4670	110			Daley 1986
Nacurrie	1	male	11440	160	bone		Peter Brown, pers comm
Coobool Creek	1	male	14300	1000	U/Th	LLO-416	Brown 1989:170
Glenesk, Swanhill	1		4800	140	carbonate	ANU-5310	
Central Murray							
Euston	1		3390	190	carbonate	ANU-5309	
Euston	1		1590	260	carbonate	ANU-5311	
Mallee Cliffs	3	male	6610	190	apatite	ANU-5787a	Pardoe 1988
			2430	260	collagen	ANU-5787b	Pardoe 1988
Keera Stn #2			5900				Blackwood and Simpson 1973:105
Keera Stn #29			5840				Blackwood and Simpson 1973:105
Keera Stn #28			5350				Blackwood and Simpson 1973:105
Keera Stn #11		female	4400				Blackwood and Simpson 1973:105
Keera Stn #10			4170				Blackwood and Simpson 1973:105
Keera Stn #69		female	750				Blackwood and Simpson 1973:105
Lake Wallawalla	40		7800	80	shell	ANU-7502	Pardoe
Lindsay Island	65		4110	120	shell	ANU-7500	Pardoe 1989
Katarapko Island	1		1070	200	bone	ANU-6894	Dowling 1990

Katarapko Island	1	1560	200	bone	ANU-6895	Dowling 1990
Katarapko Island	1	4700	140	bone	ANU-6896	Dowling 1990
Katarapko Island	1	350	200	bone	ANU-6899	Dowling 1990
Katarapko Island	1	590	220	bone	ANU-6901	Dowling 1990
Lower Murray	142					
Roonka #48		3930	120		ANU-407	Pretty 1977:322
Roonka #89		6910				Pretty 1977:297
NSW coast						
Ettalong Beach	2	1820	80	bone	Beta 35481	Donlon 1990
Barling's Beach	1	770	90	apatite	ANU-7501A	Pardoe 1991
		910	70	collagen	ANU-7501B	Pardoe 1991
S Victoria						
Keilor	1	12000	100	collagen	NZ-1327	Macintosh and Larnach 1976
		7360	105		R1742	AIAS Newsletter 2(6):23
Green Gully	1	6460	190		NZ-676	Mulvaney 1975
Colongulac	1	3600	60		R4824	Gill 1980
Maroona	2	1190	90	collagen	Gak 1059	AIAS Newsletter 2(6):22
Tasmania						
King Island	1	14270	640	charcoal	ANU-7039	Sim and Thorne 1990
Coningham	1	840	95	charcoal	SUA-626	Wallace and Stockton 1979
Mt Cameron West	1	4260	360	charcoal	ANU-1136	Wallace and Doran 1976
WA						
Cossack	1	less than 6500				Freedman and Lofgren 1979
Cheetup	1?	12845	310	charred wood	GX-6604	Freedman and Lofgren 1983

Table 1 Provisional listing of dated skeletal remains in Australia.

ing and preservational nature of the remains. I have used minimum estimates for these remains, following Clark, because in almost all cases it is the skeleton rather than the top of the grave that is seen on the present day eroded surface. The grave may well be tens of thousands of years younger than the apparent age of the skeleton on today's surface, since the skeleton lies at the bottom of the grave and depth of the grave is almost never known.

The graphs show some of the discrepancies in frequency between skeletal and occupation chronologies. Given that density of burial generally follows density of occupation (Pardoe 1985, 1991b), why are there such differences? It is possible that there are systematic errors in ages, including the above noted difference between the skeleton and the top of the grave. Some explanation comes from the geomorphic history, where the lake system died about 16,000 years ago and the land remained remarkably stable until the expansion of the pastoral industry and subsequent erosion. Dense occupation characterised times of abundant water, while Holocene occupation was relatively less. Other factors could include bias by investigators in a search for certain stratigraphic information or differential preservation of archaeological remains. Some features have more than one date.

From Figure 2, where the values are smoothed using a running average over three intervals, it appears that the distribution of skeletal remains reflects very accurately the nature of the archaeological record, perhaps modified by particular preservational phenomena. On the other hand, radiocarbon dates may be showing bias toward the older, rather than giving an even view of the archaeology of the Willandra. In any case, it is readily apparent that people did not stop living in the region when the lakes died.

Analysis of Willandra skeletal remains has generally been restricted to data from Mungo I and III. Most archaeologists view research on these ancient remains as addressing questions of migration (see Brown 1987; Habgood 1986, 1989, 1991; Pardoe 1991b; Thorne and Wilson 1977; Wolpoff et al. 1984; see Sharp and Smith 1991 for a more detailed bibliography for the Willandra Lakes). Migration is not, however, the only question that we might ask of these remains.

In addition, these remains have contributed to changing ideologies, both Aboriginal and archaeological, in Australian culture; to an un-

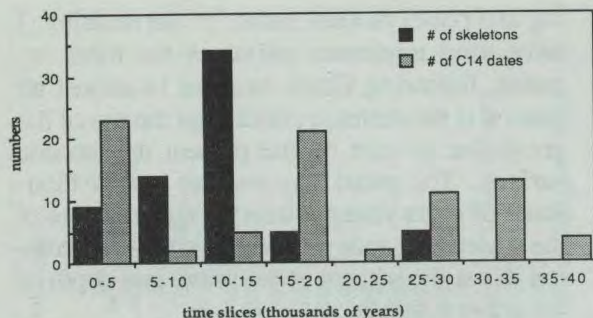


Figure 1 Willandra Lakes radiocarbon dates and minimum skeletal dates. Note the large number of skeletal remains from 10,000 to 15,000 years ago, in rough agreement with the death of the Willandra system. There are, however, many remains and occupation features from later than this period. Data are from Clark (1985, 1987).

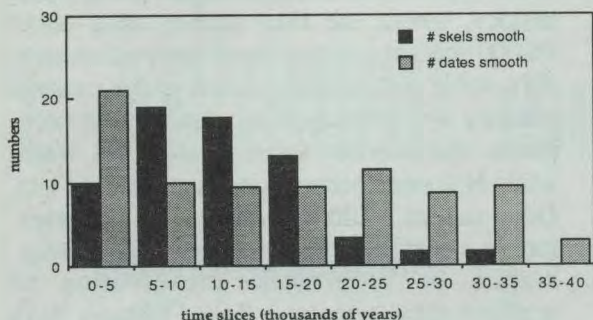


Figure 2 Willandra Lakes radiocarbon dates and minimum skeletal dates. The data are as for Fig. 1, but have been smoothed with a running average.

derstanding of Aboriginal cultural variation in terms of burial practice, personal vignettes of Pleistocene life; and biological information. The recent detailed compilation and analysis by Webb (1989) provides some idea of the numbers of remains, their preservation and the limited amount of information available. Despite the fragmentary nature of the bones, the Willandra assemblage remains an important sample of human skeletons spanning at least 25,000 years.

Kow Swamp

Kow Swamp is one of the best known sites in Australia (Thorne 1971, 1975; Thorne and Macumber 1972) with over 40 individuals excavated, mainly from one constricted area near the inlet, Taylor's Creek. Of these 40, most are too fragmentary for any analysis, leaving only 12 (one female) with measurements reported (Thorne 1975) and each measure having a sample size of 3 or 4.

The Kow Swamp cemetery has associated dates that bracket it between roughly 13,000 and

9000 BP, although some burials are later Holocene. All the remains have been returned to the local Aboriginal community and have presumably been reburied.

Coobool Creek

The Coobool Creek collection of 33 individual crania, 24 male and 9 female, has been intensively studied by Peter Brown (1981, 1982, 1987, 1989). These are part of a much larger series of remains dug by George Murray Black in 1949 and 1950 (Pardoe 1988a, 1988b). The presumptive Pleistocene remains were mostly dug in 1950 by G.M. Black, while those recovered in 1949 probably dated to within the last few thousand years.

Brown has argued that the Coobool remains which he documented are something like 9000 to 13,000 years old. This is based on morphology and preservation, and is corroborated by a uranium-thorium date of $14,300 \pm 1000$ BP (LLO-416). Conventional radiocarbon dating is not possible because the bones were preserved in gelatin and contaminated with modern collagen (Brown 1989:170).

If all the crania in this series are indeed of roughly the same age, then it is the best preserved single sample of Pleistocene remains in the country and provides detailed contrast with the later Holocene remains at the same site. As I have suggested elsewhere (Pardoe 1988a) these probably came from a cemetery, and therefore the genetic relationships of these individuals may be much closer than for other groupings. I will discuss the cultural significance of Pleistocene cemeteries below. All the younger remains and presumably the older ones as well have been reburied.

Nacurrie

This individual, a complete skeleton found by George Murray Black near Swanhill, has been dated at just over 11,000 years old (Brown nd). The Nacurrie skeleton is regionally similar in morphology to others at Kow Swamp and Coobool Creek. Furthermore this man shared with them a head shape altered by binding. He was 'relatively massively built' (Brown nd) and had suffered a number of depression fractures to the skull, as well as three other fractures. The skeleton has now been reburied.

Keilor

The cranium and partial femur found at Keilor in southern Victoria in 1940 has been dated to 12,000 BP and represents one of the few Pleistocene skeletons from outside the Murray-Darling basin. It is one of the few well preserved crania

used in the debate on multiple versus single founding populations. This debate propelled much of the scientific analysis of the 1970s and 1980s.

Brown (1989:6) gives a good background to the discovery and preliminary descriptions of the Keilor cranium. Osteometric data are readily available and appear in most analyses of the 'dihybrid question'. The cranium is in the Museum of Victoria.

King Island

A skeleton from King Island, off the northwest coast of Tasmania, has recently been excavated (Sim and Thorne 1990). The remains are associated with a date of $14,270 \pm 640$ BP (ANU 7039), however this date is on grave fill and could be twice as old as the actual burial, as was the case with Nitchie. The analysis was restricted to on-site observation and measurement, followed by reburial, in keeping with Aboriginal wishes. Reconstruction was limited, but the preliminary report gives osteometric data. One of the interesting points about this skeleton is that it is geographically and temporally very close to Keilor.

Talgai

Talgai was the first 'old' Aboriginal cranium, found near Warwick, Queensland, in 1886. It was assumed to be Pleistocene by virtue of the limestone encrustation and probable stratigraphic position. The poor preservation is typical of carbonate rich clays, but more importantly the Pleistocene date of $11,650 \pm 100$ BP (Oakley et al. 1975) was not demonstrably for a presumed grave surface, but rather for the level of the skull itself. The bones were not dated. Since burial was involved, and the body would have been placed down to this level, the skeleton could be significantly younger. There is very little osteometric data apart from the teeth.

Tandou

Lake Tandou is one of the Menindee lakes in western New South Wales and exhibits a large, heavily eroded lunette with relatively large Pleistocene surfaces revealed (Balme 1991; Balme and Hope 1990; Hope et al. 1983). This individual was recovered in 1967 and the description published in 1983 (Freedman and Lofgren 1983). The skeleton was assigned an age of $15,210 \pm 160$ BP (SUA 1805) on stratigraphic grounds. As with many stratigraphic dates, it is unclear how deeply the remains might have been buried. In lakeside lunettes, burial of as little as 50 cm can mean a difference of many thousands of years.

In summary, the Pleistocene sample is represented by a fairly large number of skeletons, sorted

into two or three population samples and some individuals. Geographic distribution of these remains is heavily biased toward the upper Murray River, although many Pleistocene remains have been recorded on the Darling River. Temporal distribution is heavily biased toward the Pleistocene-Holocene boundary. Many of these skeletons just sneak in, and I might suggest that some have been pushed. The availability of biological data is variable, but notably scant for Willandra, Kow Swamp and Talgai.

ANALYSIS: THE INDIVIDUAL VERSUS THE POPULATION

Although there are relatively many Pleistocene remains, there is actually far less data with which to work than most non-specialists realise. Research has been restricted to comparisons of a small number of individuals and has tended to follow a palaeontological model which focuses on the individual rather than the population (Pardoe 1991b). In this section I outline one path for resolving this analytical transition, drawing on the concept of regional variation and methods of population biology.

Palaeontological perspectives almost never deal with polymorphism: the 'many shapes' of living things that are phenetic and genetic variation (see Reyment 1991:213). Populations, by their nature, are distinct entities. Although populations are made up of individuals, their descriptive characteristics are different in kind from those of individuals. Populations embody variation, the raw material of population biology.

Palaeontology, especially the human sort, has relied on a historical approach that effectively creates lineages and sometimes clans out of individual skeletal remains. The 'first family' in Africa is closely paralleled in Australia by the 'Robust' and 'Gracile' lineages. To explain variation and through that the migration history of Australia, the palaeontological approach has set up a genealogy of lineages represented by ancestor heroes: Ngandong, Solo, Mungo I, Kow Swamp, Wadjak, WL50.

We individuate the Pleistocene pantheon, rather than integrate. This focus on the Pleistocene has not allowed for regional variation, but instead has forced the individual or palaeontological perspective, setting up lineages and focussing on legendary feats performed by the ancestor-heroes, such as colonising the continent and creating modern day people. Figure 3 is an example of the sort of genealogical approach to human evolution which characterises the palaeontological perspective.

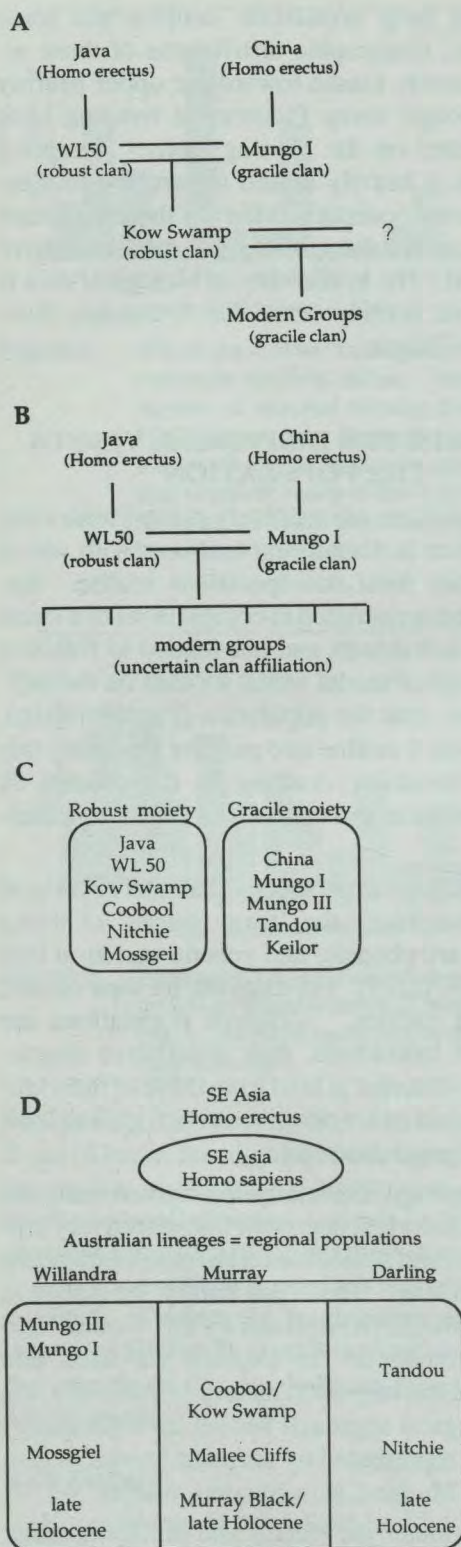


Figure 3 The history of human evolution in (and into) Australia has been reconstructed in many ways, reflecting many underlying assumptions and paradigms. Discredited views have been based generally on individuals rather than populations; and on genealogical rather than regional perspectives. Change through time and space must both be acknowledged and controlled for. (A) represents a genealogical reconstruction of individual remains to account for colonisation and change through time. Homogenisation of different groups is used to explain later Holocene size decrease. In (B) a palaeontological reconstruction is followed by later diversification. Rather than attempt genealogical links, remains are sometimes separated into moieties that incorporate most, if not all ancestor heroes (C). Historical reconstruction need not use the kinship system of lineages, clans and moieties when population biology supplies valid concepts of regional populations with relationships predicated by gene flow and change through time analysed by classical evolutionary theory (D).

differences between individuals, can be accounted for by regional variation? Freedman (1964) provided a benchmark for the examination of regional, patterned variation. He ended his article on cranial variation of coastal groups with the following:

The importance of analysing and comparing physical anthropological data from small, geographically – or ecologically – meaningful areas of Australia is stressed.

Pleistocene remains need to be seen in such a context. I applied this regional focus to an analysis of several individuals from the Murray-Darling basin ranging from roughly 6000 to 15,000 (?) years ago (Pardoe 1988c). One of the results of that analysis, based on principal components analysis of cranial measurements, is what I call a *biological map* or *biomap* of the region. In Figure 4 this biomap is superimposed on a geographic map of the river systems.

Even though separated by many thousands of years, there are regional similarities and differences that crosscut changes through time. In my view, there are regional groupings based on river systems, and all individuals within each region share a distinct genetic heritage and pattern that has been in operation perhaps since people first swam in those rivers. Mungo and Mossgeil fall within a distinct Willandra group, Coobool and Kow Swamp are identifiably upper Murray people, Nitchie and Tandou are Darling people. There are undeniable changes through time, but just as importantly, there are systematic regional similarities that persist for hundreds of generations (see Thorne and

Can we get around this analytical tension between individual and population approaches? I would say the answer is yes, but we must change the questions. It is not productive to reduce the Pleistocene to a question of migration history. As a start it might be worthwhile investigating the regional nature of Pleistocene variation (Pardoe 1988c): How much morphological variation, or

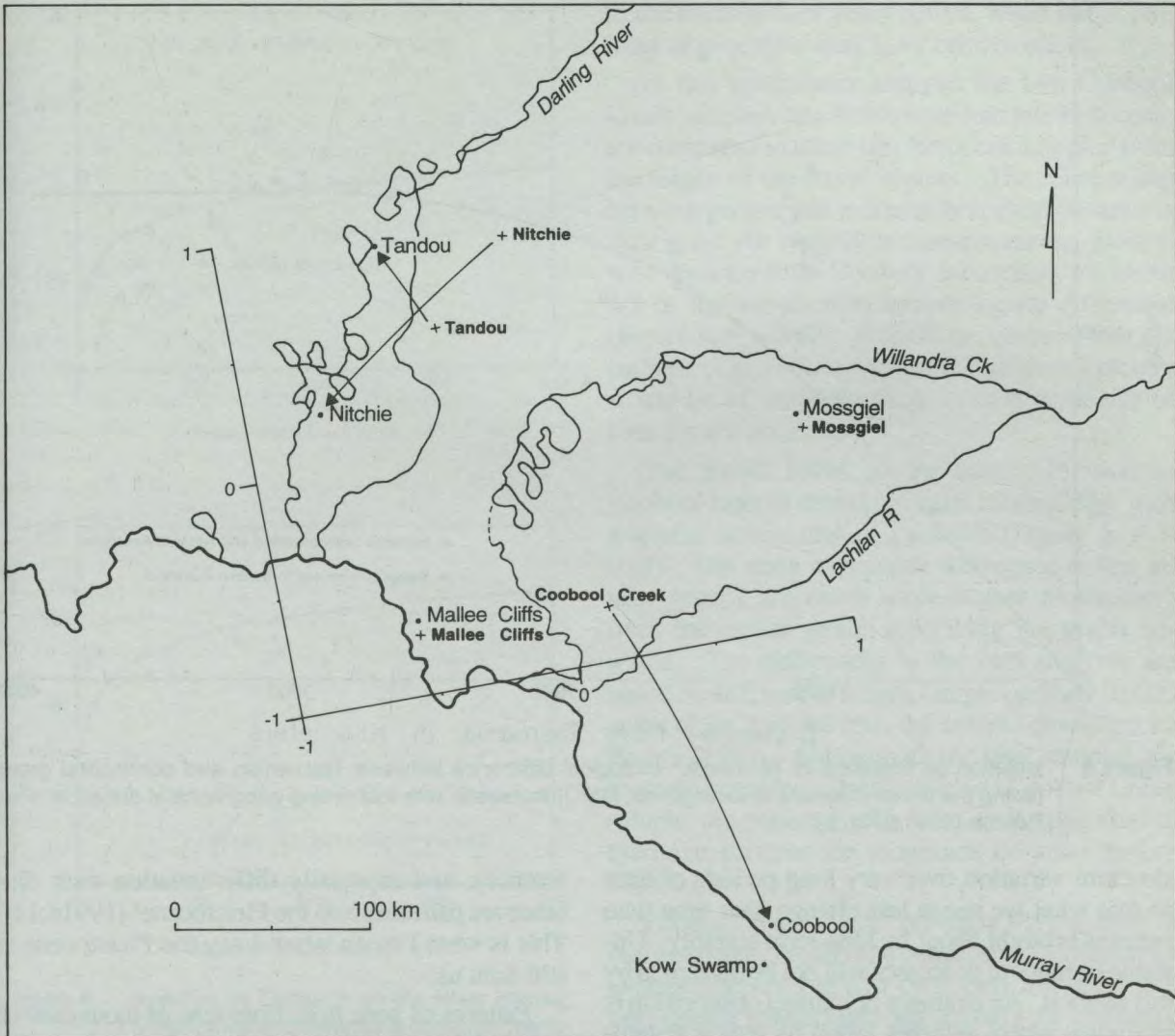


Figure 4 'Biomap' of regional diversity based on individuals (including sample statistics from Pleistocene Coobool), and specifically ignoring chronology. Just as a geographical map is constructed from the distance between places, a biological map is based on biological distances between individuals or samples. In this example, there is a high degree of correlation between biology (+) and geography (•). Scales were correlated with the distance from Mallee Cliffs to Mossgiel. After Pardoe (1988c).

Wolpoff 1981 for a discussion of regional continuity on the continental level). In effect, I am not asking how many groups came to Australia and who their children were. Instead I am asking questions about the nature of gene flow that do not differentiate Pleistocene and Holocene, but which set the scene for diversification and human evolution within the continent.

ANALYSIS: DIRECT AND INDIRECT OBSERVATION

The second issue I will raise concerns how we can look back into the past, using the relatively abundant information from the later Holocene. This issue also relates to a quest for the processes of evolution rather than strictly historical investigation.

Our genetic heritage is preserved in our bones, in our genes and in the pattern and distribution of biological variation. That variation is predicated on processes and historical events. Gene flow or marriage patterns, selection and genetic drift represent processes; migration and biological extinction represent events. With the tools of population genetics we can see past patterns of behaviour. This approach does not entail extrapolation back in time, but brings to view a remnant of ancient variation, modified and overlain by processes and historical events. Bones have a clear and direct link with the past: they remember it.

I have termed this method of investigating the more distant past *indirect observation*, as opposed to the direct observation of Pleistocene remains. Indirect observation could be said to be more concerned with the processual, with processes which

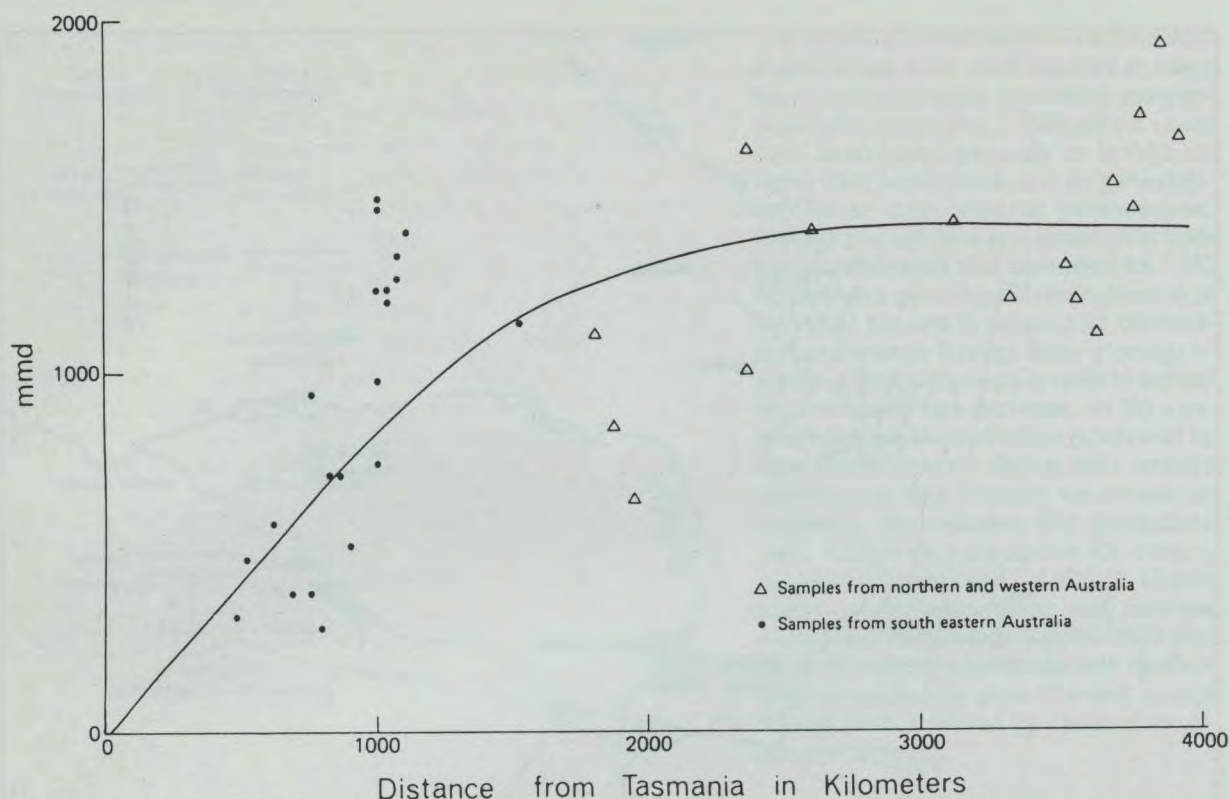


Figure 5 Isolation by Distance in Tasmania. Biological difference between Tasmanian and continental groups (using the mean measure of divergence, MMD) increases with increasing geographical distance. From Pardoe (1991a:Fig. 6).

structure variation over very long periods of time so that what we see is less change over time than patterns brought about by long term stability. Unstable or random processes will not be discerned by this method. An example of indirect observation is in studies where samples group by region regardless of age, such as Figure 4. I will give two further examples of indirect observation, to show that the Pleistocene is still with us.

1. One Tasmania, one history

The physical separation of Tasmania from the Australian mainland stopped gene flow between the two. Any stable biological patterns created by inter-marriage must date from at least 8000 years ago.

There is a consistent relationship between morphological and geographic distance that accords well with Isolation by Distance theory, as demonstrated in Figure 5 (Pardoe 1991a). In effect, although Tasmanian morphology drifted from that of mainland neighbours over the last 8000 years, that drifting or differentiation would have been random. The Isolation by Distance model that accounts for 50% of variation of morphology in respect to geographic distance owes nothing to the last 8000 years of Tasmanian history.

This is what I meant when, in reference to Tasmania, I said 'the patterns of relationships, dif-

ferences, and especially differentiation over distance are patterns from the Pleistocene' (1991a:11). This is what I mean when I say the Pleistocene is still with us.

Patterns of gene flow from tens of thousands of years ago are not guessed at on the basis of modern and late Holocene patterns, but rather are seen as underlying currents, amenable to investigation by indirect observation.

2. Two Coobool Creeks, one history

The geographical conditions of Tasmanian history provided a perfect opportunity to look at evolutionary systems in historical as well as processual perspective. The previous analysis centred on Tasmania as a controlled investigation of method and evolution. In the second application of indirect observation of the Pleistocene, I will present a preliminary analysis of the River Murray.

It should be obvious that occupation of the River Murray system goes back as far as anywhere in the country. For a number of reasons the evidence of this is almost completely lacking, so while there are very many remains and other features from the 13,000 to 9000 BP period, there is virtually nothing earlier.

When I proposed a model of Murray basin history based on gene flow, social organisation, popu-

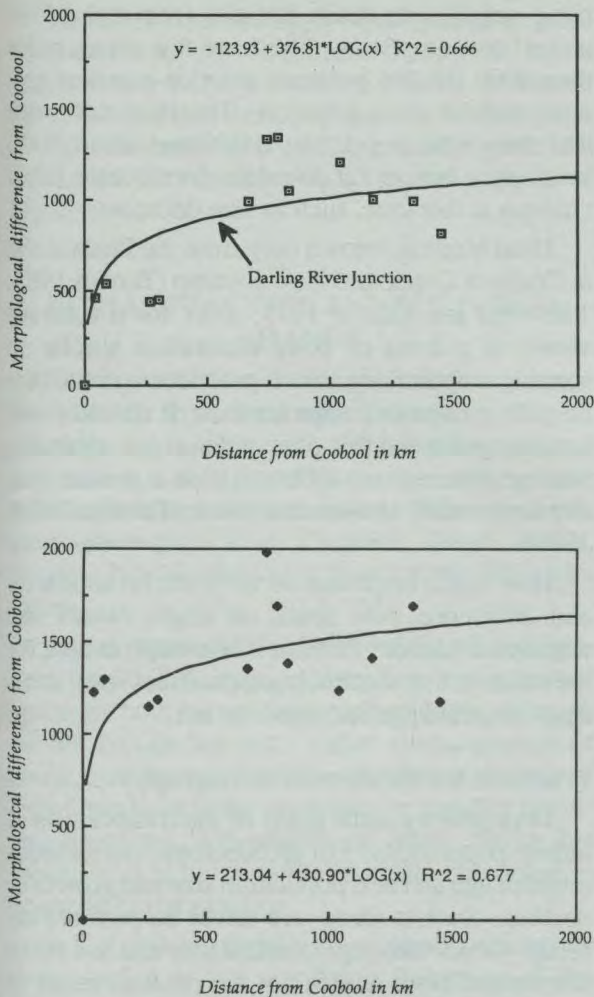


Figure 6 Isolation by Distance on the River Murray. Morphological difference is based on measurement of cranial non-metric traits (see Pardoe 1984, 1991a for description and method). Geographical distance is based on river kilometers from Coobool. Both the recent (top) and older (bottom) samples from Coobool show a significant Isolation by Distance relationship with recent population samples from the length of the river (r^2 , the amount of variation explained by regression on distance = 0.67 and 0.68 respectively). Note however that the more recent groups are much more different from the earlier Coobool sample. Change through time can be incorporated and estimated in a model-bound way.

lation density and resources (Pardoe 1988a, 1990), I was less concerned with the origins of that system than with the mechanisms of its operation. On the evidence, it appeared that social and genetic organisation had evolved along a different trajectory from other regions, but only the slimmest of data supported an origin in terminal Pleistocene times.

A biological model of isolation by distance can assist in looking beyond the terminal Pleistocene,

to the thousands of years before, when stable patterns of gene flow may have been in effect.

In this preliminary analysis the two Coobool Creek samples, late Pleistocene and late Holocene, are compared to other late Holocene samples from the length of the River Murray. The relationship between geographic and morphological distance is very good for roughly contemporaneous groups, with distance from Coobool accounting for about 2/3 of the variation in morphological difference (Figure 6, $r^2 = 0.67$). It could be assumed that the patterns of gene flow responsible for such a picture would be of some standing, even if estimates of time are not possible.

The model based on the earlier, Pleistocene Coobool sample shows a similar relationship, with a similar accounting of variation (Figure 6, $r^2 = 0.68$). The main expectable difference is that all later groups are much more distant biologically from the earlier group, displacing the graph upwards. The differences in the two analyses are based on differences from a sample perhaps 10,000 years older than the rest, the sample described by Brown (1989). Although all the later samples are more different from the Pleistocene Coobool Creek sample, the pattern is still there, indicating similar marriage patterns for thousands of years before 13,000 BP.

Population sizes were probably very similar in these two very broad time bands, since Isolation by Distance depends in part on population size. The very similar results highlight not only the similarity of the two Coobool Creek groups, Pleistocene and Holocene; ancestor and descendant, they also highlight the similar conditions that affect evolutionary processes such as gene flow and its social equivalent, marriage patterns.

CULTURE FROM BONES AND BURIALS

The third perspective that I will discuss is a cultural one that looks across the Pleistocene-Holocene divide. By looking at the broader context we can increase our ability to generalise from limited Pleistocene data. In reality, if we cannot compare and contrast with later times, we can say nothing of the Pleistocene.

Detailed analysis of skeletal remains can produce a picture of growth and development, trials and tribulations, single events, repeated activities, demography, economy and ecology. I will run through some examples of the sorts of analyses and interpretations that have come from studying bones and burials, partly to show the rich archaeological understanding that has come from these remains,

partly to put the limited Pleistocene data in wider context and to shed light on continuity and change.

What was life like in the Pleistocene? Was it different from later times?

Slim, but interesting evidence for continuity of technology might be seen in the degenerative changes in the elbow of Mungo III (a man buried on Mungo lunette). The osteoarthritis and destruction of the elbow joint is suggestive of the use of spear and woomera (Webb 1989:52), although Webb has pointed out that infection and the severity of joint destruction probably precludes mechanical use as the prime cause. Much later in time, at about 2000 years ago, a man buried at Menindee shows a pattern of musculature, asymmetrical bone growth and arthritic change to joints that is clearly indicative of sustained spear use.

Teeth record mechanical use through grooves and atypical abrasion of tooth surfaces. No teeth of Pleistocene-aged individuals, to my knowledge, show the grooves that in later individuals are quite clearly the product of string manufacture, or in the upper Murray, the pattern of dental wear that may be related to cumbungi chewing (Dan Witter pers. comm.). Yet there is faunal evidence for the use of nets in the Pleistocene (Balme 1983, 1991). It would be interesting to know if there is sexual division of labour in this task, how it might give clues to group structure and what its regional and temporal patterning is like.

Sexual division of labour is a topic that allows very little hard evidence in archaeology. Analysis of skeletal remains provides the only unequivocal data so far known in archaeology. The occurrence of auditory exostosis, also known as diver's or surfer's ear, is an anomalous growth of bone in the ear canal that is a response to immersion in cold water. Differences in diving and swimming occur both regionally and between the sexes (Pardoe *nd,a*). From Table 2 it is clear that along the length of the River Murray where aquatic resources have great importance, men do most of the under water work. Not only that, but they've been doing most of the work for 10,000 years! Sadly, the same does not necessarily hold for the rest of the country.

Tooth avulsion also shows variation by sex (Campbell 1981). The first recorded date for this practice occurs around 7000 BP at Lake Nitchie on the Great Darling Anabranch (Campbell and Prokopenec 1984; Macintosh 1971). It is variable by region, sex and date. Avulsion in men tends to decrease from south to north in the eastern part of the continent, while women show the opposite trend. Each areal grouping exhibits variable percentages of people with avulsion, partly from sam-

pling variation no doubt, but also from real differences between groups. There are few crania older than 9000 BP that preserve anterior maxillae and none of these show avulsion. That does not mean that this cultural practice originated about 7000 years ago, but so far the data corroborate other changes at this time, such as size decrease.

Head binding, known only from the Pleistocene at Coobool Creek and Kow Swamp (Brown 1987, 1989; but see Thorne 1975, 1989 for a contrary view), is a form of body decoration similar to scarring and piercing. Such practices serve to distinguish groups from one another. It should come as no surprise that this phenomenon occurs on the Murray, where group differentiation is greater than anywhere else in the continent (Pardoe 1984, 1990).

How much emphasis do we place on similarity and difference, how much on single events and negative evidence? Perhaps it is enough to note for the moment that some cultural practices start, some stop, some change and some do not.

Prospects for Pleistocene demography

Demography is the study of the composition of human populations. For archaeology, this includes ratios of age and sex, population size and growth or decline. Such a study will never be possible directly. Observable age distributions and sex ratios determined from burials are the obvious result of cultural bias (Pardoe 1985, 1988b). These are culturally interesting, particularly where sex ratios show regional patterning, but preclude demographic analysis.

Population size estimation is constrained by sampling considerations and time span and has been done directly only in exceptional cases in other parts of the world. This sort of estimation is not possible currently, and given the nature of the archaeological record in Australia, we should not expect direct size estimation from demographic means in the future.

Sample	Male %	Fem %	p	n m	f
Coobool (Pleistocene)	36.4	14.3	.60	11	7
Coobool (Holocene)	35.7	0.0	.02	14	12
Lake Victoria	75.6	17.1	.00	41	35
Coorong	28.9	5.8	.00	45	52
River Murray (total)	42.5	10.8	.00	332	344
NSW coast	6.5	8.0	.82	31	25
Tasmania	7.5	20.2	.10	40	40

Table 2 Percent occurrence of Auditory Exostosis by sex. P is the associated probability that the difference in proportions between the sexes is due to chance alone. n is sample size.

There are indirect ways of estimating population size via population genetics (Pardoe 1991a). It may well be possible to estimate population size not only for later Holocene populations, but for those in the Pleistocene as well, especially given the results of the Isolation by Distance analysis of Figure 6.

BURIAL PRACTICE AND CULTURAL CHANGE

Burial practice is another cultural phenomenon that benefits from the longer term view. But we should be explicit here about the dearth of cultural information. Very few Pleistocene remains have been archaeologically excavated. There is no cultural information from Coobool, Talgai, Keilor, Tandou, Nitchie South, or most of the Willandra series.

Burial practices have been consistent and variable for 30,000 years. Cremation and extended burial are both known from earliest times, although bundle burials are not. Other characteristics of burial, such as use of ochre and relative scarcity of grave goods, indicate continuity or stability in culture over tens of thousands of years. Given this variation, it is not possible to create chronologies based on burial practice.

Burial follows density of occupation along the rivers and it is not surprising that most of the Pleistocene remains come from lacustrine and riverine locations.

One exceptional change in burial location is the rise of cemeteries (Pardoe 1988a). Cemeteries occur over the length of the River Murray, in Arnhem Land, at least one instance on the east coast and in some areas of the Darling headwaters. No Pleistocene cemeteries are known outside the upper Murray. Those of Kow Swamp and Coobool Creek are very late, presumably starting about 13,000 years ago. I have seen no cemeteries on the lower Darling, and those of the Darling headwaters probably span the last thousand years at best.

To account for burial practice which included cemetery use, I set out a model of social and territorial organisation for the River Murray based on the concept of inclusion and exclusion (Pardoe 1988a, 1990, nd,b; cf. Myers 1986). In this model, resource rich regions tend to exclusivity, with large groups, smaller territories, vigorous boundary maintenance, corporate group organisation and unilineal descent. In contrast, regions of poor or unpredictable resources tend to inclusivity, with social and territorial networks extending over large areas and easing access across boundaries. The main archaeological feature of exclusive social and

territorial organisation is the cemetery, a symbol validating corporate territorial ownership. On present evidence, these cemeteries have their earliest expression on the upper Murray at the Pleistocene-Holocene boundary, say 9000 to 13,000 BP. The phenomenon of cemetery use may have started much earlier, but so far no older sediments have yielded an example.

One important point to stress here is that we should avoid generalisations about the Pleistocene River Murray suggesting inclusive social organisation pre-13,000 BP and exclusion post-13,000 BP, based on burial and specifically cemetery behaviour, although with the added use of population genetic information it may be possible to address this issue. What can be done, however, is make some generalisations about social and territorial organisation in a comparative, regional sense. Peoples of the Willandra and Darling may never have used cemeteries. In the model I outlined this might be attributed to economic and environmental reasons, where resources are scattered and unpredictable rather than being dense and stable. In contrast, people on the Murray may have started using cemeteries when they arrived there.

In other words, social organisation of the peoples on the Willandra and Darling Rivers was very likely based on inclusive behaviour from the Pleistocene through to modern times. In contrast, peoples on the Murray were either organised toward exclusive behaviour for their whole history, a view I currently favour, or they transformed their social organisation about 13,000 BP. This has clear-cut biological implications for diversity and regional differences in morphology (see Pardoe 1988a, 1990), as well as implications for a socially based explanation of stone tool technology and diversity. The Pleistocene-Holocene boundary is not necessarily a social boundary. It is certainly not on the Darling and Willandra systems.

Environmental change cannot have been so important that it affected basic social or territorial organisation of groups living along the Willandra or Darling. On the Murray, since at least terminal Pleistocene times, the persistence of cemetery behaviour, coupled with known patterns of biological variation, indicates that environmental change was socially and demographically insignificant. In all three regions the Pleistocene is not homogeneous, but emerges as a time of regional cultural variation, as much as it is characterised by richly patterned biological variation.

In conclusion, this paper is an examination of concerns that a focus on the Pleistocene can bias our data collection, analytical methods and research directions; in short, archaeological theory

and practice. In a review of the Pleistocene human remains, it becomes apparent that while there are over 120 individuals from this time, there are relatively few which contribute to current research questions. Analytical methods have influenced our understanding of human evolution in Australia; including whether individuals or populations are the unit of analysis and whether attention should be given to a regional perspective in addition to temporal considerations. Investigation of the Pleistocene has been assumed to be possible only with Pleistocene remains. I have shown that indirect observation, approaching the distant past from later patterns, is an important research tool as well as conceptually linking biology and culture across time. Detailed information from burials and bones forms a large part of our knowledge of Pleistocene cultures. A short review of some of that data persuades me that we have not pursued this vigorously enough. Finally, I have used burial practices and skeletal biology to suggest that not only can we address social and territorial organisation of the Pleistocene, but that environmental change may not be an overriding consideration in archaeological reconstruction.

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CHANGING INTERPRETATIONS OF POSTGLACIAL HUMAN SUBSISTENCE AND DEMOGRAPHY IN SAHUL

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A regional perspective on late Pleistocene Europe has now enabled workers such as Jochim (1987) and Soffer (1987) to characterise dramatic changes in demography during the last glacial maximum. They describe the depopulation of north and central Europe with major trends such as the lack of occupational evidence in Britain and Belgium between 25,000 and 14,000 BP (cf. Gamble 1987). The relocation of populations to refuges, such as southwest France, is seen as a catalyst for cultural transformation, mainly in response to social and demographic stress. Equally, in the southern hemisphere significant changes in climate in Africa, resulting from the glacial cycle, have also been argued to result in major resource restructuring and changes in demography (Hubbard 1989; Parkington 1987).

We believe that late Pleistocene Sahul also experienced significant changes in demography and that these changes are fundamental to our understanding of postglacial economies and territorial organisation.

Whether one favours the rapid population growth model of Birdsell (1977) or the slow growth models of Lourandos (1987) and Beaton (1983), none of these expresses appreciable demographic change in the terminal Pleistocene. Given the convincing arguments that have been made for population shifts in response to climate change in South Africa (Deacon et al. 1984; Hubbard 1989; Parkington 1987) it seems curious that, in Australia, major demographic changes should only have occurred in the first or last 5000 years of occupation.

In this paper we will describe a new population model which, in contrast to those of Birdsell (1977) and Lourandos (1987), does not assume either population equilibrium or a slow growth rate (Fig. 1). While population growth during periods of the Pleistocene and Holocene is likely to have been comparable, we argue this would have been punctuated by stasis, and eventual decline, as a result of human responses to the last glacial maxi-

mum. Davidson (1990) has recently discussed the likelihood of reversals in positive population growth in the prehistory of Australia.

On the basis of the archaeological evidence we argue that different regional systems had developed by 25,000 years ago in Sahul and that these under-

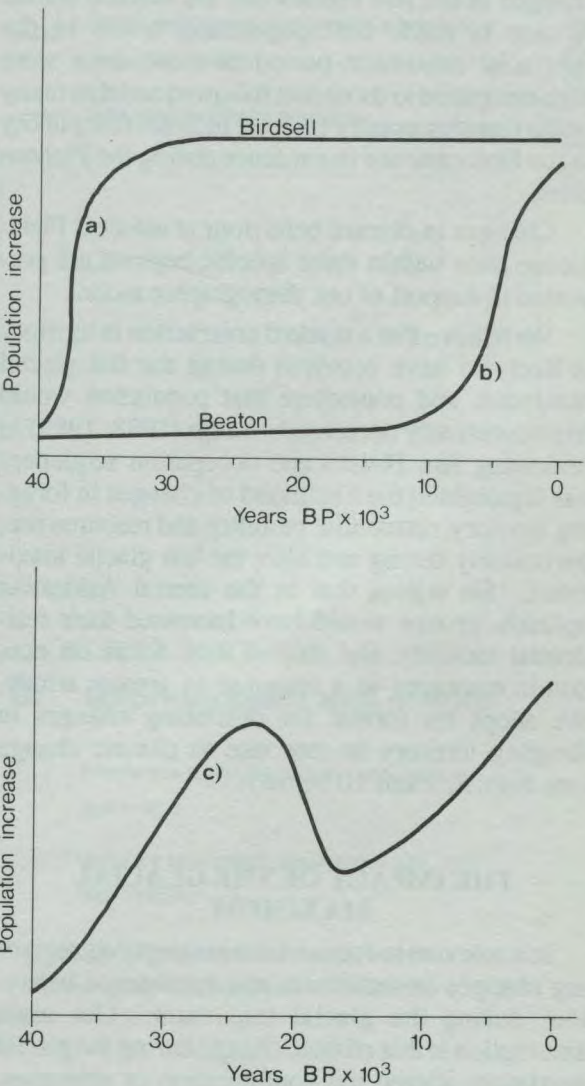


Figure 1 Alternate models for population growth.

went change during the last glacial maximum. Horton (1986) originally raised this possibility, focussing on the need to explore the archaeological record for indications of change before the well documented transformations of the mid Holocene. He summarised supporting evidence for high population levels and strongly territorial and culturally differentiated groups in the late Pleistocene (1986:9). This evidence includes a greater range of human morphologies, restricted distribution of the edge-ground axe and Kartan industries, differences in Pleistocene-aged engravings and burial types and the presence of complex cremation burials. In reconciling the competing Birdsell (1957) and Lourandos (1983)/Beaton (1983) population models he notes (1986:10)

a high Pleistocene population density and mid Holocene population increase could be reconciled if there had been a period of low population in the late Pleistocene/early Holocene period.

The archaeological correlates for predicted changes in the late Pleistocene are defined below. A case is made that population levels in the preglacial maximum period in some areas were high compared to those that followed and that many of the features usually taken to indicate complexity in the Holocene are in evidence during the Pleistocene.

Changes in discard behaviour at selected Pleistocene sites within three specific regions are presented in support of our demographic model.

We believe that a marked contraction in territory is likely to have occurred during the last glacial maximum and conjecture that population would have eventually decreased. Smith (1988, 1989) in reviewing late Pleistocene occupation sequences has highlighted the likelihood of changes in foraging territory, residential mobility and resource use, particularly during and after the last glacial maximum. He argues that in the central Australian uplands, groups would have increased their residential mobility and shifted their focus on economic resources as a response to greater aridity. We adopt his format for describing changes in foraging territory in response to climate change (see Figs. 8, 9 and 10 below).

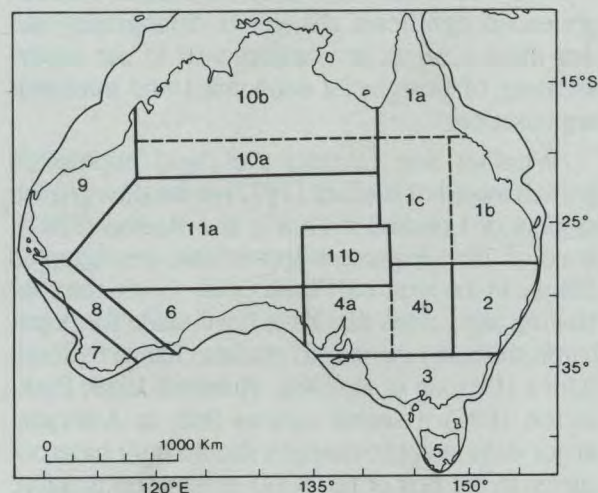
THE IMPACT OF THE GLACIAL MAXIMUM

It is relevant to focus on our assumptions regarding changes in settlement and subsistence behaviour during the glacial maximum. Our main assumption is that climate change during the glacial maximum altered the configuration of resources. In summarising Steward's (1938) model, Ambrose and Lorenz note:

Different configurations of resource structure appear to select for different organisational responses in hunter-gatherer adaptations. The structural characteristics of the resources that dominate the subsistence base may grade from one basic configuration to another in different habitats, or in the same habitat at different times within a group's range (as among the Northern Shoshone and Efe). One can thus model variation in subsistence and settlement within and between populations. This approach is therefore not deterministic but is flexible and suitable for modelling functional, seasonal and longer term (e.g. inter-annual, glacial/interglacial) changes in human foraging strategies and socio-economic organisation (Ambrose and Lorenz 1990:13).

The shift of a region towards a more arid climate during the glacial maximum would result in a restructuring of resources. While plant life in terrestrial ecosystems might respond directly to aridity, higher order consumers may exercise resistance to change. As Parkington (1987:350) notes, however, 'gradually, complex ecosystems become different and offer more or less attractive resource patterns to prehistoric people'.

Hubbard's climate reconstructions for Australia at 18,000 BP allow us to define relative differences in summer and winter regimes within the three regions. In a forthcoming paper she presents data from the 18,000 BP run of a climate model developed by the National Centre for Atmospheric Research (Hubbard *nd*). This is used to reconstruct regional palaeoclimates for each of 12 Australian regions (Fig. 2).



KEY TO REGIONS

1. Queensland
2. New South Wales
3. Humid South Coast
4. Southeast Dogleg
5. Tasmania
6. Arid South Coast
7. Southwest (Leeman to Point Henry)
8. West Diagonal Shark Bay to Cape Pasley
9. Northwest (Pilbara Region to Broome)
10. North and North Central
- 11a. Central and Western Desert
- 11b. Special Case of the Eyre Basin

Figure 2 Palaeoclimate regions of Australia.

Specifically, she has examined output for temperature and pressure changes at 18,000 BP. Shifts in circulation are described and then, by analogy with the present day, the climates of the different regions are considered. A basic assumption of the work is that separate areas of Australia would have

	Summer	Winter
1 Queensland	(a) drier, cooler (b) same, colder (c) moister, colder	moister, colder wetter, colder wetter, colder
2 New South Wales	drier, colder	same, colder
3 Humid South Coast	drier, cooler	same, colder
4 Southeast Dogleg	(a) drier, colder (b) much drier, colder	same, colder moister, colder
5 Tasmania	drier, colder	same, colder
6 Arid South Coast	same, colder	wetter, colder
7 Southwest	wetter, colder	same, colder
8 West Diagonal	slightly moister, colder	same to wetter (inland), colder
9 Northwest	drier, colder (coast), colder	drier-same
10 North and North Central	(a) same to slightly drier cooler (b) drier, colder	slightly moister, colder colder
11a Central and Western Deserts	slightly drier, colder	slightly moister, colder
11b Eyre Region	slightly drier, colder	wetter, colder

Table 1 Regional palaeoclimates 18,000 to 12,000 BP. Revised model: from Community Climate Model Output.

responded differently to the same changes in atmospheric circulation.

These reconstructed palaeoclimates have been compared with available atmospheric models, geomorphic data, subfossil records and archaeological economic faunal sequences and revisions made. The most significant difference presented in this paper is that the westerlies move north at 18,000 BP, instead of south. Table 1 shows the predicted changes in climate for 18,000 BP. The

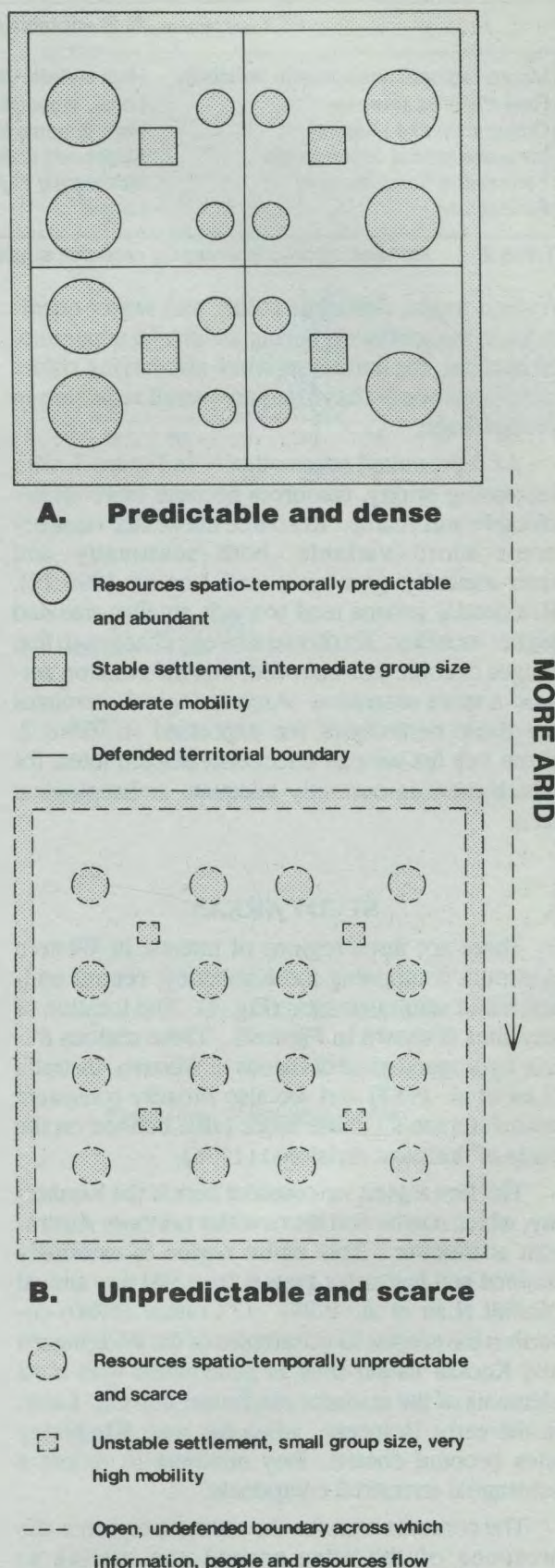


Figure 3 Resource structures and organisational responses.

	A. Predictable and Dense	B. Unpredictable and Scarce
Macro-regional assemblage variability	High stylistic variability	High stylistic uniformity
Raw material sources	Local, embedded procurement	Local and distant exotics
Occupation site intensity	High at home base	Very low at home base
Intra-site spatial organisation	Structured activity and discard locations	Poorly structured
Faunal and floral diversity	Moderately high	Very high, mostly plant
Faunal size	Larger	Smaller

Table 2 Archaeological correlates for resource structure (from Ambrose and Lorenz 1990).

revised model describes colder and wetter conditions in the southwest during the glacial maximum. In contrast, the northwest while also having colder conditions would have had an overall reduction in precipitation.

As represented schematically in Figure 3, with increasing aridity, resources become more unpredictable and scarce. Resource encounter rates become more variable, both seasonally and inter-annually (Ambrose and Lorenz 1990:18). Residential groups tend towards smaller size and higher mobility. Territorial strategy changes so that ranges become less bounded, and information networks more extensive. Archaeological correlates for these behaviours are expressed in Table 2. From this list we can select one, discard rates, for which there is currently adequate archaeological data.

STUDY AREAS

There are three regions of interest in Western Australia comprising the Kimberley, central aridlands and southwest bloc (Fig. 4). The location of key sites is shown in Figure 5. These regions follow hydrogeological divisions in Western Australia (Lau et al. 1987) and are also broadly consistent with Peterson's culture blocs (also defined on the basis of drainage divisions) (1976).

The first region we consider here is the Kimberley, which can be tied into a wider northern Australian adaptation. This entire region is externally drained and has today greater than 500 mm annual rainfall (Lau et al. 1987). O'Connor (1990) describes the preglacial economies of the Widjigarri and Koolan sites as generalised with most elements of the resource catchment utilised. Later, in the early Holocene, when the west Kimberley sites become coastal, they continue to reflect a substantial terrestrial component.

The common trait for the northern region is the presence of the edge-ground axe, dating to 28,000 BP in the west Kimberley (see also Morwood and Trezise 1989). This implement has an inferred correlation with northern woodlands. The presence of transported pearl and baler shell, a ground sea urchin spine and ochre in the Kimberley

shelters, all older than 18,000 BP, suggests that distribution networks were in place before the glacial maximum.

The central aridlands stretch from North West Cape to Geraldton but do not include the Pilbara uplands. While they have co-ordinated external drainage, they do not provide the large alluvial valleys and flats which characterise the Kimberley (Lau et al. 1987). Today, this region receives less than 400 mm average rainfall.

The three Pleistocene sites in this region are Mandu Mandu and Pilgonaman shelters at North West Cape (Morse 1988, this volume) and the Sil-

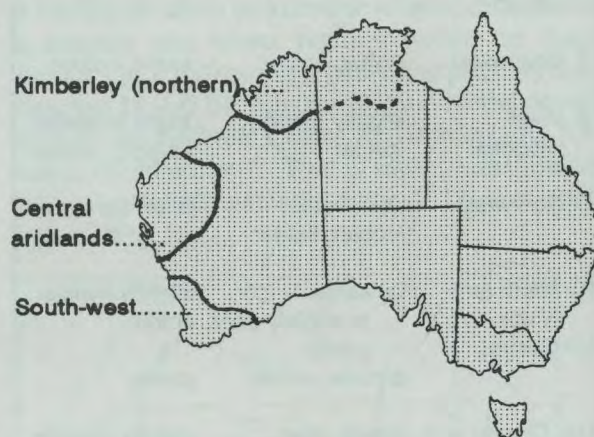


Figure 4 Location of regional systems.

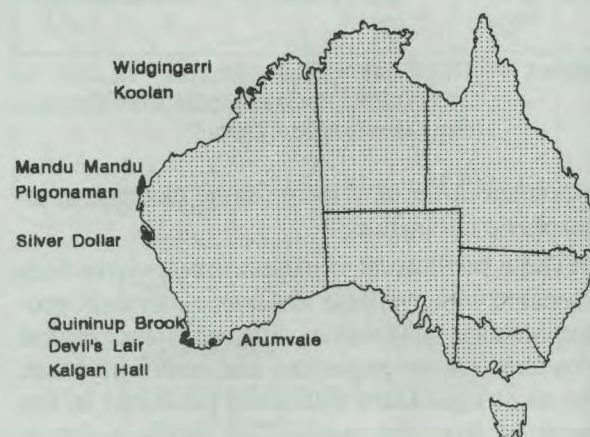
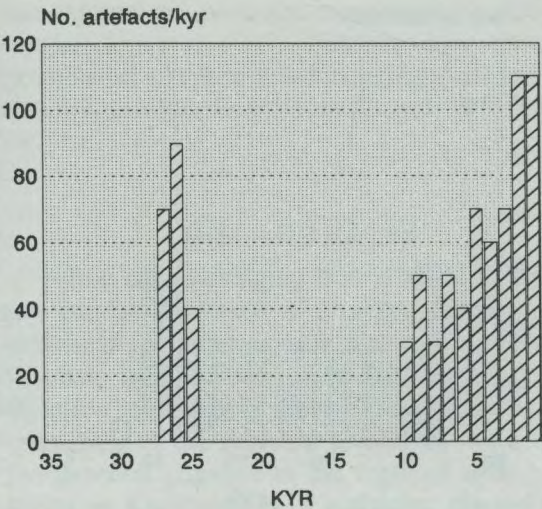
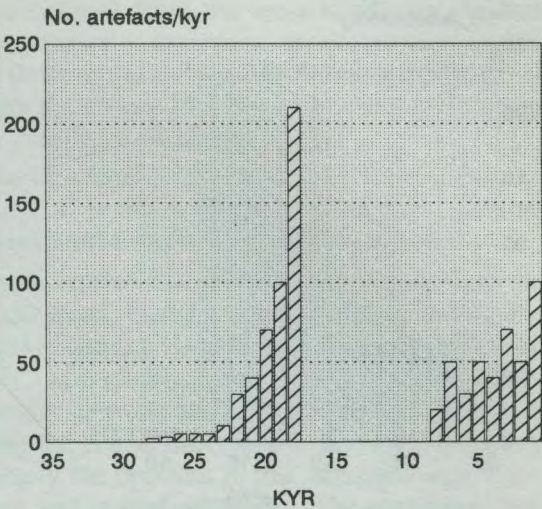


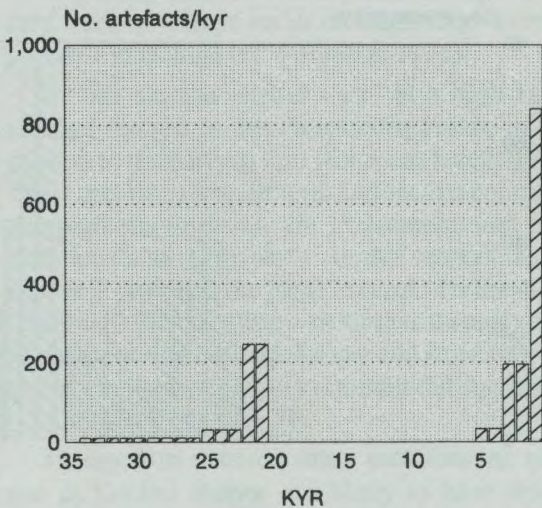
Figure 5 Location of sites.



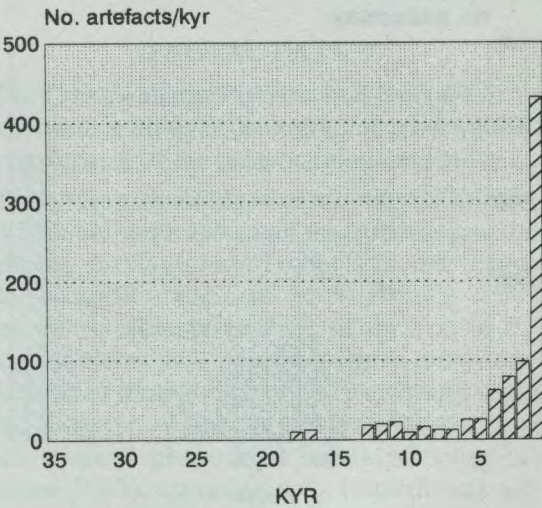
Koolan Shelter 2



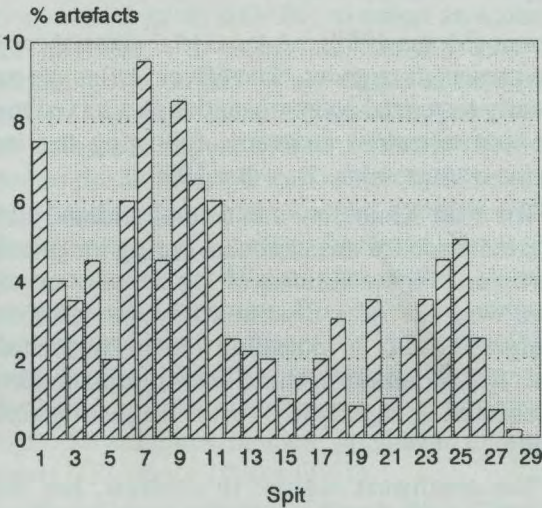
Widgingarri Shelter 2



Mandu Mandu Rockshelter, Squares C1, C3, E2

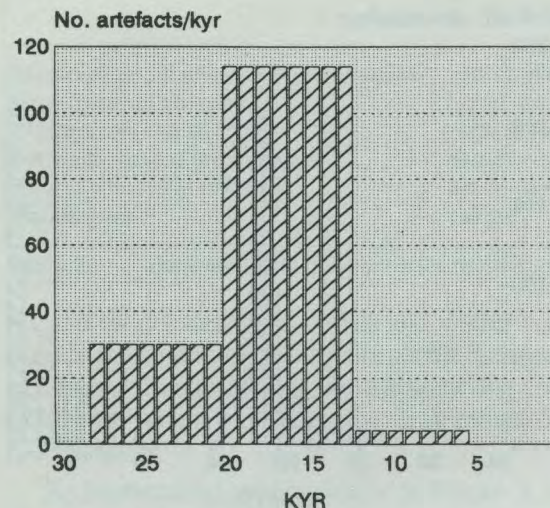


Pilgonaman Creek Rockshelter

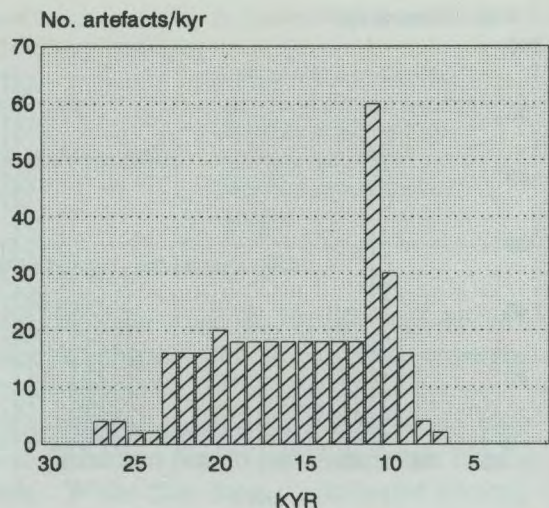


Silver Dollar Trench M-97

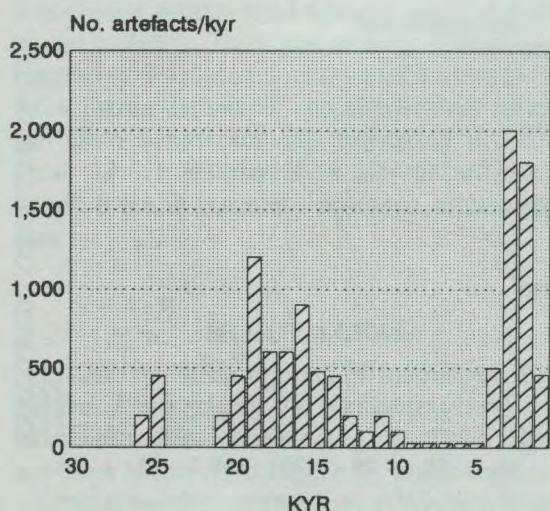
Figure 6 Artefact discard rates for sites in Kimberley and central aridlands systems climate zone 9. For Silver Dollar site the upper unit comprises spits 1-15; the lower unit spits 16-29.



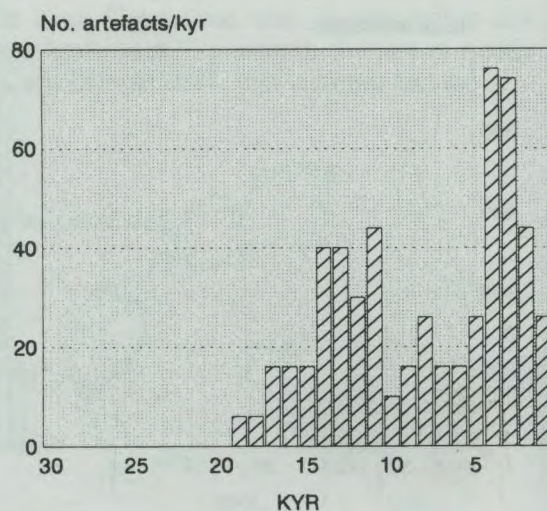
Devil's Lair



Quininup Brook, Site 4



Kalgan Hall Trench 2



Arumvale Trench 2

Figure 7 Artefact discard rates for sites in the south west system climate zone 7.

ver Dollar open site at Shark Bay (Bowdler 1990a, 1990b, 1990c).

The North West Cape sites have evidence for early movement of goods in the form of ochres which are known to have been transported from over several hundred kilometres away (Morse, this volume).

A strand of shell beads recovered from the base of Mandu Mandu dates to 32,000 BP. Long distance movement of baler shell is also registered at the Silver Dollar site at Shark Bay at 18,000 BP, when the site would have been over 100 km from the Pleistocene coastline.

The North West Cape sites demonstrate a reliance on marine fauna between 33,000 and 17,000 years ago, and between 10,000 years ago and the

present (Morse 1988). A terrestrial component is also present throughout. The Silver Dollar site has an early terrestrial economy and then a mixed marine and terrestrial economy, following the last marine transgression (Bowdler 1990a).

The west Kimberley and central aridland sites have evidence for abandonment during the glacial maximum. In the absence of lag deposits or any other evidence of a disconformity we view the stratigraphic data as indicating a hiatus in occupation. Abandonment of these sites appears to have occurred at, or slightly before, the height of glacial aridity.

The southwest region, in contrast, has unequivocal evidence for continuous occupation from the Pleistocene through to the present. This region

has external drainage and receives above 500 mm rainfall (Lau et al. 1987). Evidence for early trade, portable art and personal ornamentation is found in the early levels of Devils Lair (Dortch 1976, 1979a, 1979b).

DISCARD RATES

While acknowledging that changes in discard rate can be the result of changes in technology, settlement patterns or raw material access (e.g. Hiscock 1981, 1986), when the magnitude and direction of change in discard rates are **internally consistent** at the regional level, this must signal fundamental changes in the regional system. In acting as a summation of activities, discard rates provide a signature of community. Because they are an unconscious attribute, they cannot be changed by an act of community will. In this paper we explicitly assume that regional changes in discard rates of a large order of magnitude do reflect population change (cf. Ferguson 1985).

In the Koolan shelter there is a high rate of artefact discard in the Pleistocene levels, in comparison to the early to mid Holocene levels (Fig. 6). There are, of course, several factors that complicate comparisons between the Pleistocene and Holocene levels at many sites. In this respect, Koolan shelter 2 provides the ideal control. Its location in relation to the coastline was similar throughout the Pleistocene and early Holocene and stone tool technology remains relatively constant during this time (O'Connor 1990:429-30).

Changes in the frequency and duration of site use at Koolan shelter are likely to have resulted from its eventual isolation from the mainland. However, as this does not affect the site until between 8000 and 6000 BP, we would expect the terminal Pleistocene/early Holocene levels, that is, from 11,000 BP to 8000 BP, to reflect an economy and an intensity of occupation similar to the levels predating 23,000 BP. What we see in this period, though, is a significant decrease in discard. Even an increase in the use of quartz and bipolar reduction in the Holocene levels, which would result in increased debitage and therefore a higher artefact discard rate, does not offset this trend. Provisional discard curves for Widgingarri shelters 1 and 2 suggest a similar pattern. However, this interpretation awaits further dating of the Pleistocene/Holocene interface at both sites (Fig. 6). Some of the Arnhem Land sites also demonstrate comparatively high discard rates in their preglacial maximum levels (O'Connor 1990:439-41).

The discard patterns at North West Cape and Shark Bay (unadjusted for volume) show a similar

trend to those from the west Kimberley, in that some preglacial maximum levels are also higher than those of the early to mid Holocene (Fig. 6). It is only by the late Holocene that rates again reach their preglacial maximum levels.

As with Koolan, the North West Cape sites were located a constant distance from the coastline throughout the Pleistocene/early Holocene.

In the southwest, regional discard rates show the reverse trend, increasing substantially during the glacial maximum (Dortch 1979a, 1979b; Ferguson 1985). Importantly, these rates drop by the early Holocene to levels much lower than those recorded during the glacial maximum (Fig. 7). This pattern is clearly the opposite to that from the west Kimberley and central aridlands. The magnitude and direction of changes in discard rates from all three regions are consistent with the predictions of the resource structure model as set out above.

FAUNAL DATA

The faunal remains from the sites do not directly contribute to testing the demographic model but act as a crosscheck of the palaeoclimatic modelling.

The wide range of fauna represented at Widgingarri includes large and small macropods, possum, bandicoot, dasyurid, murid rodents, snake, lizards, turtle, crocodile, fish and birds (Prince 1991). When either presence/absence of species, or frequency of elements is examined, there are general consistencies through time. There are more subtle shifts, however, in that species such as the bilby, which currently have arid habitat distributions (Johnson 1983), appear in spits immediately predating the height of the glacial maximum and abandonment of the site (Prince 1991).

In the southwest region, the reverse situation is seen in the available faunal data. The Devils Lair mammalian fauna demonstrates forest species from 25,000 to 14,000 BP (Baynes et al. 1975). We have excluded the earliest levels of Devils Lair, 35,000 BP to 25,000 BP, from consideration as Balme et al. (1978:54) suggest that these accumulations are predominantly due to owl predation.

Balme et al. (1978) suggest that the prevalence of forest species can be explained by an increase in forest to the west of the site due either to climatic changes or to increased land area from lowered sea levels. We argue that forest increase would not be expected to occur under the presumed colder and windier conditions of the last glacial maximum unless there was an accompanying increase in precipitation, regardless of the availability of land area. Drier and colder conditions would have resulted in an increase of low tree and scrub forma-

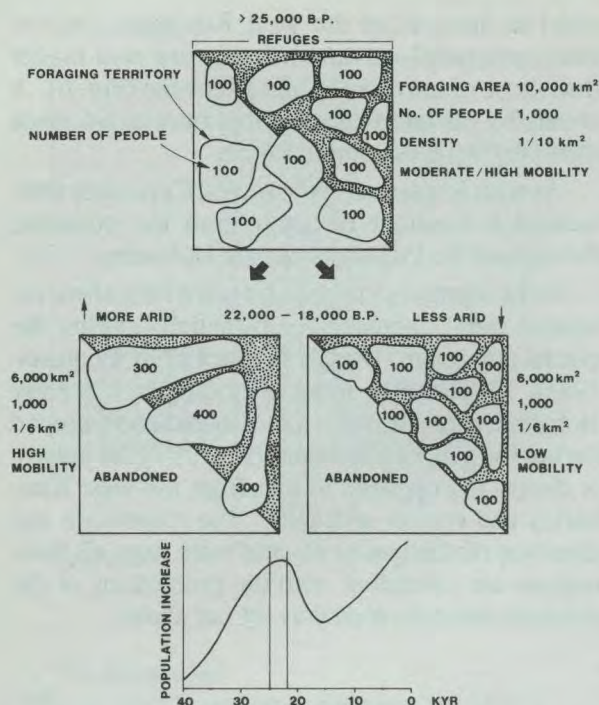


Figure 8 Schematic fluctuations in foraging territory and population levels: >25,000 BP to 18,000 BP.

tions – the reverse of what we see reflected in the Devils Lair fauna.

During this same period there is an increase in the size of mammals in the deposit (Balme et al. 1978:53; Fig. 8). While it might be argued that this is the result of a change with new predators (Devil or human) selecting for larger mammals, we believe not. Of the well-represented animals in the deposit, three of the eight non-forest species were large whereas ten of the 16 forest species were large.

If forest was declining due to colder drier conditions, as has been suggested, we would expect to see a gradual decrease in the larger forest species in favour of the larger non-forest species. In fact the converse appears to be the case. Large forest mammals are well represented throughout this period with non-forest mammals increasing slightly only after 15,000 BP. Thus we conclude, that

1. there is no evidence from the mammalian data (whatever the cause of accumulation) for drier conditions at 18,000 years ago,
2. if the mammalian changes are climatically controlled then it must have been wetter, and
3. if the mammalian changes are controlled by human selection, then the area was likely to have been at least as forested as at present.

Further, we would add that if the climatic reconstructions which suggest colder and windier conditions during this period were correct, there is an

argument to be made that some increase in precipitation would have been necessary to maintain an environment similar to the present, whether there was an increase in land area to the west of the site or not.

While the Holocene faunal sequence from Devils Lair is incomplete, evidence does exist from the Swan River and from Hastings Cave, north of Perth, for a later arid phase, in the early to mid Holocene (Baynes 1979; Kendrick 1977). Faunal trends from the southwest are not inconsistent with an assumed restructuring of resources and are also consistent with the revised climate model (Table 1).

DISCUSSION

Discard rates from Pleistocene sites in three different regions show one major trend; late Pleistocene discard rates are often higher than those in early to mid Holocene levels and are only matched by the late Holocene. One explanation for this trend is that population declined during the glacial maximum. This may also have been the case for the continent as a whole, as illustrated in the population curve shown in Figure 1.

Figure 8 illustrates projected changes in foraging territory, population density and residential mobility in response to shifts in glacial climate. A distinction is made between those regions that experienced greater aridity during the glacial maximum and those, such as the southwest, that experienced an increase in precipitation.

At 22,000-18,000 years ago, we argue that a net contraction in territory took place and that populations changed their residential mobility. In the short term it is likely that population density would have increased.

In the longer term, population levels would have declined in those zones affected by increasing aridity and remained relatively constant in those that were not. Figure 9 illustrates high residential mobility and wide foraging ranges in arid refuges and low residential mobility and small ranges in non-arid refuges.

In the arid refuges high mobility, lower population levels and wider ranges would have resulted in low discard rates at base camps. In regions with improved conditions a combination of low residential mobility, static population levels and decreased foraging ranges would result in higher average discard at base camps. The contrasting trend observed in sites from the southwest and northwest climate zones provides some support for these views.

Following post-glacial amelioration we argue that population levels would have begun to rise

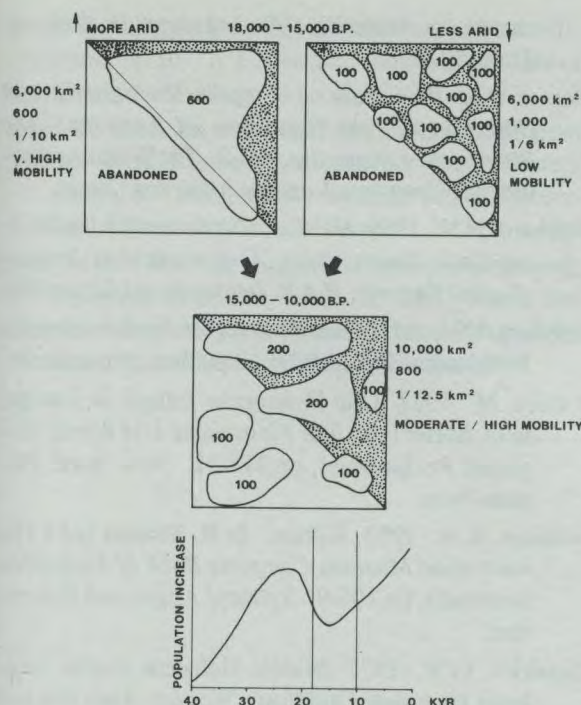


Figure 9 Schematic fluctuations in foraging territory and population levels: 18,000 BP to 10,000 BP.

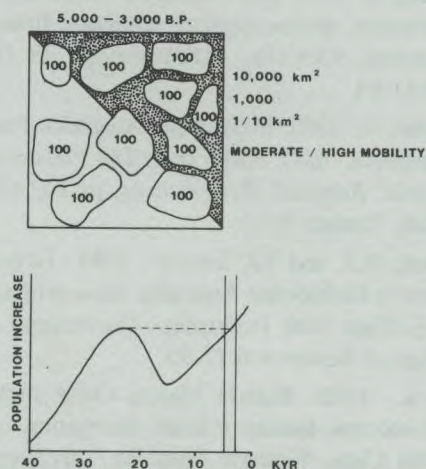


Figure 10 Schematic fluctuations in foraging territory and population levels: 5 000 BP to 3 000 BP.

(Fig. 9). Expansion into previously abandoned areas is likely to have taken place at this time. Population density after the glacial maximum would have been the lowest since 25,000 BP. Finally, we argue that it is only by the mid to late Holocene that population reached its preglacial maximum levels (Fig. 10).

Returning to our population model, two points should be stressed. First, the steady state or cumulative growth models of Birdsell and Lourandos are not supported by these regional Pleistocene se-

quences. Secondly, Lourandos' (1987) contention that occupation at all Pleistocene sites is markedly ephemeral before 20,000 and 15,000 BP is not borne out.

We aim to draw attention to the probability of significant cultural transformations having occurred well before the mid Holocene, as has Horton (1986) in an earlier review. Despite the obvious difficulties, we think it is important to make a start in defining archaeological correlates for changes arising from shifts in human organisational strategies.

We suggest that regional systems were well in place by 25,000 years ago and that major restructuring of resources during the glacial maximum would have required changes in organisational strategies. Rather than a period of stasis, the terminal Pleistocene may have been a major period of demographic and cultural transformation in Australian prehistory.

ACKNOWLEDGEMENTS

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PLEISTOCENE VEGETATION CHANGE AND EARLY HUMAN OCCUPATION OF A TROPICAL MOUNTAINOUS ENVIRONMENT

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The major highland valleys of New Guinea have diverse prehistoric human occupations and a rich pollen record. Pollen analysis reveals a dramatic vegetation change with the onset of pollen zone C1-1F and the widespread burning of vegetation about 10,000 years ago. The impact of the vegetation change on an indigenous population of the forest is less well understood. Despite the large number of archaeological sites in New Guinea (Table 1), the second century AD onwards has been often overlooked as the time of major change in the highland environment. This is the period of the arrival of the Austronesian people from the south-east Asian archipelago and the spread of agriculture.

NEW GUINEA AND ISLAND MELANESIA

In contrast to the processes of human colonization, which have been well studied in the highland valleys of New Guinea, the impact of the arrival of the Austronesian people has been little studied. The spread of agriculture and the impact of human occupation on the environment are still poorly understood.

The highland valleys of New Guinea have a rich pollen record. Pollen analysis reveals a dramatic vegetation change with the onset of pollen zone C1-1F and the widespread burning of vegetation about 10,000 years ago. The impact of the vegetation change on an indigenous population of the forest is less well understood. Despite the large number of archaeological sites in New Guinea (Table 1), the second century AD onwards has been often overlooked as the time of major change in the highland environment. This is the period of the arrival of the Austronesian people from the south-east Asian archipelago and the spread of agriculture.

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Figure 1. Location of major archaeological sites in New Guinea.

NEW CUTS AND ISLANDS

PLEISTOCENE VEGETATION CHANGE AND EARLY HUMAN OCCUPATION OF A TROPICAL MOUNTAINOUS ENVIRONMENT

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The major Highland valleys of New Guinea, with their dense populations, have undergone considerable vegetational changes related to climatic developments associated with the last glaciation at 18,000 BP and the subsequent warming of conditions about 10,000 years ago. The impact on the vegetation resulting from anthropogenic influences over this period is less well understood. Despite the large number of palynological sites in New Guinea (Table 1), the record remains fragmentary due to the often truncated or disturbed nature of sedimentation in wetland environments. Most of the pollen analytical and archaeological evidence comes from the substantially settled areas of the central Highlands of Papua New Guinea or from elevations above the limit of agriculture (Tables 1 and 2). In addition to the problems of site distribution and continuity, there are no pollen types for the cultivars that occur in the pollen record. These two factors have made the separation of anthropogenic, climatic and natural successional changes in the available pollen records very difficult.

It is not until the mid Holocene that clear indications of anthropogenic clearance and burning activity are shown in the pollen diagrams. The earliest evidence for human impact on the vegetation comes from the Baliem Valley, Irian Jaya (Fig. 1 for major place names referred to in the text), where clearance of forest occurred around 7000 BP (Haberle et al. 1991) nearly 2000 years after the earliest archaeological indications of agricultural activity at Kuk, 600 km to the east in Papua New Guinea (Golson 1977). The archaeological appearance of agriculture at Kuk, immediately after Holocene warm conditions were established, presents three possibilities: that similar activities were developed earlier at lower altitudes and brought to the Highlands when conditions were more suitable; that the Highlands population had developed agricultural techniques and adapted crops from the immediate forest during the late Pleistocene but that these are not visible in the archaeological record; or that the Kuk results represent the true beginnings of agriculture in the Highlands.

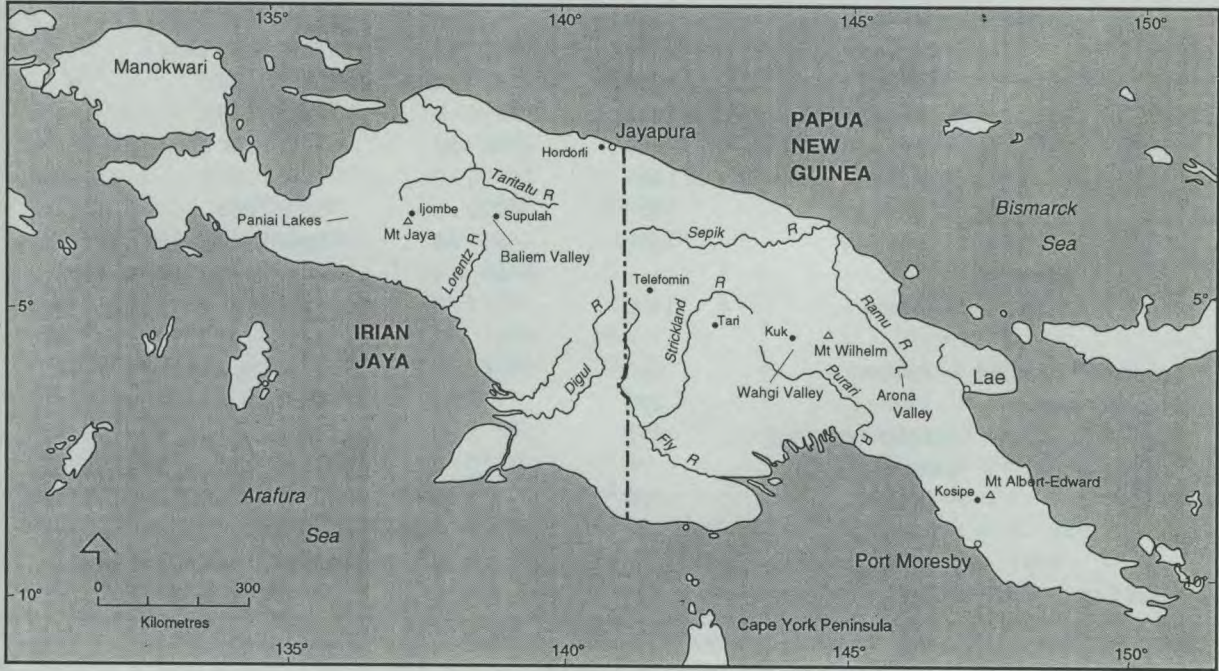


Figure 1 Location of major valleys and sites in New Guinea.

The degree to which early agriculture would be visible in the pollen record has been discussed briefly by Walker and Flenley (1979). They suggest that the disturbance associated with the earliest phases of agriculture would not alter the natural regeneration pattern of the forest. Therefore, it would be very difficult to separate these changes

from the natural successional patterns which follow climatic change or catastrophic events. However, if the Pleistocene Highland inhabitants were already manipulating their environment for food production, with the aid of fire and clearance implements, then the possibility remains that the palynological record would show this activity.

Present Vegetation	Site	Altitude m asl	Age Range ka BP	Reference
Sub-Alpine and Alpine Non-Forest	Summit Bog	4420	9 - 0	Hope 1976
	Giluwe Summit	4300	10 - 7	Hope (in prog.)
	Yellow Valley	4270	3 - 1	Hope and Peterson 1976
	Brass Tarn	3910	11 - 0	Hope 1976
	Laravita Tarn	3620	13 - 0	Hope 1980c (in prog.)
	Yakas Tarn	3480	12 - 1	Hope 1980c (in prog.)
	Mt. Wilhelm	3300-3800	1 - 0	Corlett 1984
Mid-Upper Montane and Sub-Alpine Forest	Ijombe Mire	3630	14 - 0	Hope and Peterson 1976
	Imbuka Bog	3550	13 - 0	Hope 1976
	Lake Pindaunde	3510	4 - 0	Hope 1976
	Neon Basin	2980	11 - 0	Hope (in prog.)
	Komanimbun	2740	22 - 0	Hope 1976
Lower Montane Rainforest	Lake Inim	2550	12 - 0	Walker and Flenley 1979
	Kayamanda	2500	14 - 0	Flenley 1972
	Sirunki	2500	30 - 0	Walker and Flenley 1979
	Lake Ipea	2500	10, 4, & 2 - 0	Worsley and Oldfield 1988
	Kosipe	2000	36 - 0	Hope 1980a; (in prog.)
	Nurenk	1950	5 - 0	Gillieson et al. 1989
	Lake Birip	1900	2 - 0	Walker and Flenley 1979
	Draepi-Minjigina	1890	36 - 18, 5 - 0	Powell 1982
	Lake Egari	1800	2 - 0	Worsley and Oldfield 1988
	Pipiak	1800	2 - 0	Worsley and Oldfield 1988
	Norikori	1750	5 - 0	Haberle (in prep.)
	Haeapugua	1650	30-0	Haberle (in prog.)
	Lake Ambra	1620	32 - 25, 5 - 0	Powell 1982
	Kindeng	1600	2 - 0	Powell 1982
	Tari	1600	40 - 32	Williams et al. 1972
	Manton	1590	5 - 0	Powell 1982
	Telefomin	1500	20 - 0	Hope 1983
	Supulah	1450	28 - 26	Haberle et al. 1991;
	"		33-26, 2-0	Swadling and Hope, 1992
	Kelela	1400	7 - 0	Haberle et al. 1991
Lowland Rainforest, Savanna and Coastal Swamps	Hordorli	560	60 - 0	Swadling and Hope, 1992
	Yeni	320	5 - 0	Gillieson et al. 1989
	Lake Yanamugi	170	2 - 0	Garrett-Jones 1979
	Lake Wanum	35	10 - 0	Garrett-Jones 1979
	Waigani	20	1.4 - 0	Osborne and Polunin 1986
	Lahakai	<20	6 - 0	Southern 1988
	Maibad Swamp	<20	6 - 0	Barham and Harris 1985
	Lake Carpentaria	0	35-12	Torgersen et al. 1988

Table 1 Quaternary pollen analytical sites from New Guinea, ordered according to (a) vegetation type in which they now lie and (b) altitude. The list is considered to be complete, including some work in progress, at the time of publication.

In a paper on the human colonisation of forested environments in New Guinea, Groube (1989) established a theoretical framework for the transformation from forest foraging to gardening and pointed to a possible model of late Pleistocene human exploitation of plant resources and the development of agriculture in New Guinea. Groube develops the concept of 'minimal forest exploita-

tion', one that envisages the slow emergence of forest horticulture from foraging through forest management. This process involves the manipulation of vegetation to maintain resources with the use of fire and implements such as the large stone waisted axes found as early as 40,000 BP on the New Guinea coast (Groube et al. 1986). With both mechanism and purpose for forest disturbance pro-

Present Vegetation	Site	Altitude m asl	Age Range ka BP			Reference
			Rock-shelter	Open	Swamp	
Alpine Non-Forest	Mapala	3996	5.5-0	-	-	G. and J. Hope 1976
Sub-Alpine Forest	Hamid	3450	0.8-0	-	-	G. and J. Hope 1976
Lower Montane Forest	Lemouru	2450	2 - 0	-	-	Gillieson et al. 1986
	Tugeri	2450	2.5-0	-	-	Christensen 1975
	Tambul	2240	-	-	4 - 0	Bayliss-Smith 1985
	Etpiti	2200	2 - 0	-	-	Christensen 1975
	Pukl Kumanga	2200	1.5-0	-	-	Gorecki and Gillieson 1989
	QCD	2100	11 - 0	-	-	Mangi (in prog.)
	Tuman Quarries	2100	-	2.5-0	-	Burton 1984
	Kamapuk	2050	4.5-0	-	-	Christensen 1975
	Kosipe	2000	-	26 - 9	-	White et al. 1970
	Draepi-Minj.	1890	-	-	2.3-0	Powell et al. 1975
	Waiak	1800	-	0.3-0	-	Mangi (in prog.)
	Manim	1770	10 - 0	-	-	Christensen 1975
	NGM	1725	-	0.2-0	-	Watson and Cole 1977
	Wanlek	1710	-	15 - 0	-	Bulmer 1977
	Imbiben	1700	-	4 - 0	-	Mangi (in prog.)
	NGG	1680	-	3.3-0	-	Watson and Cole 1977
	NGH	1680	-	4 - 0	-	Watson and Cole 1977
	Nombe	1660	26 - 0	-	-	Gillieson and Mountain 1983
	NFB	1650	-	4 - 0	-	Watson and Cole 1977
	Aibura	1640	4 - 0	-	-	White 1972
	Mugumamp Ridge	1600	-	-	6 - 0	Harris and Hughes 1978
	Manton	1590	-	-	5 - 0	Golson et al. 1967
	NFX	1550	-	18 - 0	-	Watson and Cole 1977
	Kuk Swamp	1550	-	30 -20?	9 - 0	Golson 1977
	Kiowa	1530	10 - 0	-	-	Bulmer 1975
	Kafiavana	1350	11 - 0	-	-	White 1972
	NVF	1350	-	1 - 0	-	Ballard (in prog.)
	NVD	1350	-	4 - 0	-	Ballard (in prog.)
	Batari	1300	16/8-1	-	-	White 1972
	Yuku	1280	15 - 0	-	-	Bulmer 1975
Lowland Rainforest and Savannah	Rui Kumanga	800	0.4-0	-	-	Gorecki and Gillieson 1989
	Yeni Swamp	320	-	-	5 - 0	Gorecki and Gillieson 1989
	Ritamauda Shelter	300	3.5-0	-	-	Gorecki and Gillieson 1989
	Huon Peninsula	200	-	40 - 0	-	Groube et al. 1986
	Matenkupkum	15	33 - 0	-	-	Allen et al. 1988
	Kilu	8	-	28 - 0	-	Wickler and Spriggs 1988

Table 2 Archaeological sites from New Guinea, ordered according to (a) vegetation type in which they now lie, and (b) altitude. This list includes only those sites that have been dated (ages not corrected) and only a few selected sites from the lowland zone.



Plate 1 Aerial view of swamp drainage networks at Haeapugua, Tari Basin, Southern Highlands Province. Garden boundaries commonly 150 m to 200 m long making the average garden area less than 2 to 3 ha.



Plate 2 Aerial view of swamp drainage networks in the Baliem Valley, Irian Jaya. Canals may be up to hundreds of metres in length and be part of a field complex of up to 1.5 km².

posed in this model it is appropriate to investigate this model further by drawing on the Pleistocene palynological and archaeological record.

In order to investigate this model, palynological results from recent investigations in the Tari Basin, Papua New Guinea are presented. This work includes data from the critical time period from the last glacial to the early Holocene where there is little evidence available from the Highlands. Evidence from other Pleistocene sites in New Guinea is also incorporated into the analysis. This provides the first opportunity to investigate a model of human colonisation and adaptation in a mountainous tropical environment by integrating both pollen analytical and archaeological findings.

VEGETATIONAL CHANGES IN THE TARI BASIN

The Tari Basin, in the Southern Highlands of Papua New Guinea, is occupied by a high density human population practicing wetland and dryland cultivation with a staple of sweet potato (*Ipomoea batatas*). Extensive areas of wetland in the basin, drained by networks of ditches, are highly suited for crops such as sweet potato and taro (*Colocasia esculenta*). The Tari Basin is one of several areas in the Highlands where wetland subsistence sys-

tems are operational (see Plates 1 and 2; Powell and Harrison 1982). The basin has a wet tropical climate with a mean annual rainfall of around 2600 mm. The natural vegetation of the area is largely montane and subalpine forest where *Nothofagus* is an important forest element. Forest covers most of the steeper slopes and ridges though most forest within the basin has been disturbed in some way by pigs or human activity. Wood (1984) recognises two major forest types in the basin. At lower altitudes the forest is dominated by *Castanopsis*, *Lithocarpus*, *Conandrium*, *Sloanea* and *Symplocos*. At higher altitudes around the northern parts of the basin, forests have a more mixed composition with *Astronia*, *Cryptocarya*, *Elaeocarpus*, *Beilschmiedia* and *Planchonella* dominant. Swampland, grassland, gardens and regrowth forest form a mosaic of vegetation types in the lower parts of the basin. Mixed regrowth forest is restricted in area though *Casuarina* is widely planted around gardens and *Dodonaea* commonly forms monospecific stands in abandoned garden plots. Under natural conditions open areas would be almost absent, except for some very wet habitats that may have supported sedgeland or grassland swamp communities.

A site suitable for pollen analysis was selected 5 km west of Tari township (Plate 3). The swamp



Plate 3 Haeapugua, looking southwest over the drained wetland to gardens and abandoned drainage networks. Anthropogenic grassland and disturbed forest can be seen on the hillslopes opposite. Core site is marked with black arrow.



Plate 4 Coring site at Haeapugua, looking northeast.

site, locally known as Haeapugua (or Haiapugwa), has been dammed by a Pleistocene lava flow allowing organic, volcanic ash and lacustrine sediments to accumulate in the basin throughout the Pleistocene (Williams et al. 1972). Haeapugua lies at an altitude of 1650 m above sea level, about 600 m below the maximum treeline depression during the Pleistocene. The coring location was near the margin of the swampland (Plate 4) that has an area of around 10 km² with active drainage for gardening at the margins and evidence of previously extensive drainage networks across the swamp. The very wet areas of the swamp are dominated by *Leersia hexandra* short grass community. The sedges *Schoenoplectus mucronatus* and *Machaerina rubiginosa* dominate towards the centre of the swamp.

An 8.5 m core (Core H6) was recovered from the site. By radiocarbon dating, it appears to have continuous sedimentation extending beyond 30,000 BP. Figure 2 presents a summary of the stratigraphy with results from radiocarbon dating, magnetic mineral analysis, pollen analysis and carbonised particle density (a full analysis of these results will be presented elsewhere). The basal laminated clays of lacustrine origin are overtopped by shallow-water swamp sequence with wood remains towards the top suggesting that the swamp was forested at different times. Volcanic ash is also

visible in the upper sediment and has been visually identified as Tibito Tephra (Blong 1982). The tephra was deposited at a time when inorganic influx to the swamp had increased possibly as a result of catchment instability resulting in hillslope soil erosion.

The radiocarbon dates (Table 3 and Fig. 2) support the stratigraphic interpretation, showing continuous accumulation of sediments in Haeapugua from the basal lacustrine clays through to the coarse detrital peats at the top of the sequence. The rate of sediment accumulation throughout the Pleistocene is remarkably constant at around 0.15 mm per year, a rate comparable to that of Lake Hordorli in the lowlands of Irian Jaya (Hope et al. 1988) where there are little or no allochthonous nutrient sources to facilitate rapid peat growth. This suggests that volcanic activity and slope instability were at a minimum in this region during the late Pleistocene period represented in this core. The early to mid Holocene rate of sediment accumulation increases to around 0.30 mm per year, about double that of the Pleistocene rate. A dramatic 10 to 20 fold increase in the accumulation rate occurs above 120 cm depth (1.0 to 2.2 mm per year) when volcanic ash is deposited in the basin. This accords well with observations of other swamps in New Guinea where allochthonous nutrient input increases the rate of sediment accumulation.

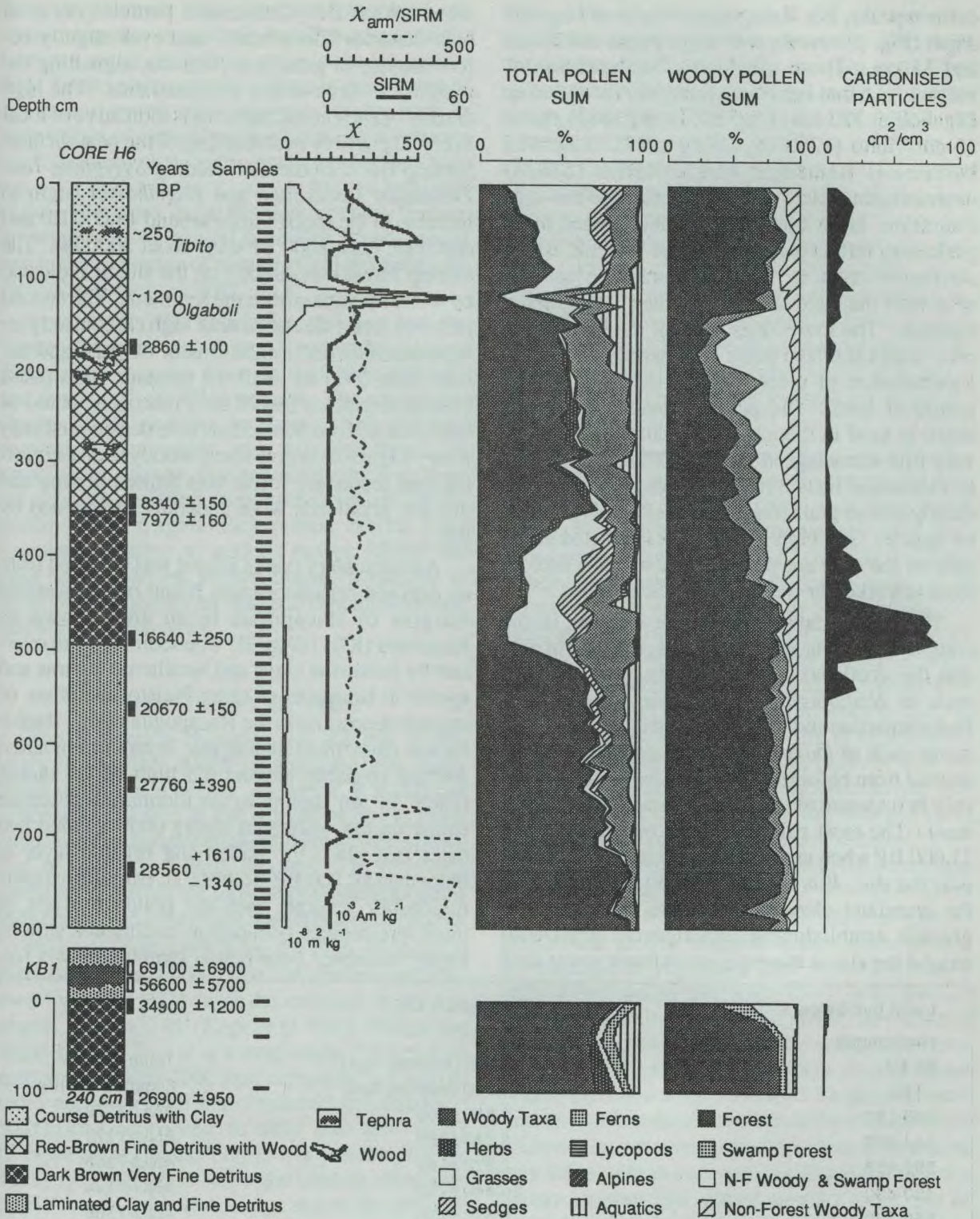


Figure 2 Stratigraphy, summary pollen diagram using total pollen sum and woody pollen sum, mineral magnetics and carbonised particle density for Haeapugua.

Mineral magnetic analysis reveals a good deal about the nature of material accumulating in the swamp (Fig. 2). The technique has been applied in New Guinea as a means of studying aspects of sedimentation including core correlations, distinguishing between different types of sediment, and

in some case identifying sediment source (Oldfield 1988). Mass specific susceptibility (χ) records the approximate volume of ferrimagnetic minerals in the sediment. Overall the concentration of magnetic minerals in Core H6 is low due to the high organic content. The exceptions are several clearly

defined peaks. For Haeapugua, the plot of χ against depth (Fig. 2) reveals two major peaks at 120 cm and 55 cm. These are due to the deposition of volcanic ash that has been tentatively identified as Olgaboli at 120 cm (1200 BP, Blong 1982) and at 55 cm Tibito (~250 BP, Blong 1982). Saturated Isothermal Remanent Magnetisation (SIRM) measurements relate to both mineral type and concentration. High χ and SIRM values around these peaks may reflect the reworking of volcanic ash by catchment erosion. This interpretation accords well with the field texture and their stratigraphic position. The low values for χ at the base of the core within the lake clays are possibly due to the accumulation of older volcanic ash over a long period of time. The plot of $\chi_{\text{arm}}/\text{SIRM}$ against depth is used in this case to identify any input of very fine ferromagnetic minerals that may be due to catchment instability. The volcanic ashes are clearly coarse grained as no peaks for this parameter appear. The high values for $\chi_{\text{arm}}/\text{SIRM}$ at the base of the core are possibly due to clays derived from reworked or weathered volcanic ash.

The pollen data shows major changes in the composition of the surrounding vegetation. In general, the woody taxa which includes forest elements such as *Nothofagus*, *Castanopsis*, *Elaeocarpus*, Podocarpaceae and Myrtaceae and disturbance elements such as *Dodonaea*, *Trema* and *Macaranga*, decline from before 30,000 BP to the present, probably in response to developments within the catchment. The most striking change occurs at around 21,000 BP when grassland begins to be established near the site. It is not until around 17,000 BP that the grassland elements dominate, indicating the gradual establishment of extensive grasslands around the site at the expense of forest cover until

around 8000 BP. Carbonised particles occur in high densities concurrently, and even slightly before the rise in grassland elements, signalling the presence of fires within the grasslands. The high density of carbonised particles is indicative of local fires and possibly even burning of the peat surface. Swamp forest elements including *Syzygium*, *Ilex*, *Pandanus*, *Dacrydium* and *Engelhartia* begin to increase in the spectra from around 14,000 BP and dominate from 8000 BP until about 2000 BP. The swamp forest was directly on the site as indicated by wood remains within the sediment. The second phase of forest clearance with high carbonised particle densities and establishment of grassland occurs from 2000 BP until the present. This phase closely resembles that of the Pleistocene phase as there is a high carbonised particle density and only a very slight rise in non-forest woody taxa, suggesting that secondary forest was limited in area and that the grasslands were generally maintained by fire.

A fragmentary pollen record was obtained from an exposed organic section found on the western margins of Haeapugua in an area known as Kugubaru (KB1) (Fig. 2). The sediments are overlain by lacustrine clays and weathered tephra and appear to belong to an older Pleistocene phase of organic deposition in the Haeapugua basin. Radiocarbon dates from the organic layers are inverted and are probably beyond the limit of C^{14} dating (Table 3). An attempt to use thermoluminescence dating on the weathered tephra clays yielded two dates that place the underlying organic layer at older than 50,000 BP. If these TL dates prove to be reasonably accurate then the pollen analysis of these pre-human occupation sediments will be highly valuable. Four pollen samples show a for-

Level (cm below surface)	Date (years BP)	Lab. No.
Haeapugua		
55-60	~250 (Inferred Age)	Tibito Tephra
~120	~1,200 (Inferred Age)	Olgaboli Tephra
185-190	2,860 $\pm$ 100	ANU-7372
344-350	8,340 $\pm$ 150	ANU-7373
352-358	7,970 $\pm$ 160	ANU-7368
480-490	16,640 $\pm$ 250	ANU-7194
550-560	20,670 $\pm$ 150	ANU-7366
642-650	27,760 $\pm$ 390	ANU-7367
730-740	28,560 $\pm$ 1610	ANU-7365
	-1340	
Kugubaru		
0-10	34,900 $\pm$ 1,200	ANU-7225
240-250	26,900 $\pm$ 950	ANU-7226
A (80)	69,100 $\pm$ 6,900	W-976*
B (100)	56,600 $\pm$ 5,700	W-975*

Table 3 Radiocarbon dates from the Tari Basin (*Preliminary thermoluminescence dates from Wollongong Lab.)

ested environment with some open grassland and alpine elements suggesting that this sequence relates to a major cold phase, prior to the last glaciation. In this short sequence there is an absence of any indicators of anthropogenic activity such as high values of carbonised particles. This supports the hypothesis that open vegetation communities can exist in the absence or even limited influence of fire. Therefore, in the Highlands of New Guinea, the argument that natural fires play a fundamental part in the formation of natural grassland during the Pleistocene does not hold.

In summary the vegetation changes and fire history demonstrate two sustained anthropogenic disturbance episodes from ca. 21,000 to 8000 BP and from ca. 2000 BP to present. The record also shows major changes in surrounding dry-land vegetation, compatible with expected broad palaeoclimatic change, that are clearly separate from the changes resulting from anthropogenic disturbance. The fragmentary pollen record from Kugubaru relating to periods before 50,000 BP, prior to the earliest known human habitation of New Guinea, shows an absence of anthropogenic and burning indicators.

THE UTILITY OF FIRE

The vegetation changes over the last 30,000 years in the Tari Basin demonstrate two major forest disturbance events. However, it is difficult to separate changes in the vegetation due to influences such as climatic changes from those responding to anthropogenic change. It is worth considering further the indicators of anthropogenic influence in the light of the results presented above.

Palynological work from the high altitudes of New Guinea has shown that the treeline was lowered by up to 1500 m at the extreme of the last glacial, at 18,000 BP (Hope et al. 1983; Walker and Hope 1982). This is at a time when glaciers covered an estimated 2000 km² compared to 8 km² of today and the area of high mountain grassland was 50,000 km² compared to only 800 km² today (J. Hope and G. Hope 1976). It is possible that the valley floors, located below the treeline, were subject to severe cold air drainage due to the effect of the large area of ice caps in the mountains of New Guinea (Löffler 1982). The floor of the Tari Basin lies at 1650 m asl, about 600 m below the maximum treeline depression during the Pleistocene when it might have been possible for frosts to affect the vegetation occasionally. The damage to vegetation is difficult to determine from the pollen record but the presence of both *Nothofagus* and especially *Castanopsis* forest suggests that temperature variation near the site varied by less than

8°C. One would expect that this phenomenon would be widespread throughout the Highlands though this appears not to be the case as a pollen record at 1890 m asl from Draepi, near Mt. Hagen shows *Nothofagus* forest at 18,000 BP, which was subsequently replaced by a more mixed forest including *Castanopsis* at an unknown time between 18,000 BP and 6000 BP (Powell et al. 1975). This suggests that in the large valley floor systems such as the Wahgi Valley, Baliem Valley and the Tari Basin, cold air drainage was not a major factor controlling the formation of grasslands during the Pleistocene. However, this may have been a significant factor in smaller closed basins where cold air flow has less potential to be disrupted by vegetated slopes and may be highly concentrated in the lowest point of the basin.

Another major question raised by this anthropogenic interpretation of the data is why should fires be ascribed to a human origin? It is certain that natural fires have occurred throughout prehistory as a result of lightning strike, rockfall, volcanic activity and combustion of fuel during drought. In the wet tropical environments of New Guinea it is likely that the frequency of natural fires would be low and not widespread. Distinguishing between natural and anthropogenic fires is complicated by the adaptation of some vegetation types to fire. In New Guinea the importance of fire in affecting the composition of many vegetation types is well established (Walker 1982). The widespread tree fern shrublands and the apparently fire adapted short grassland and *Coprosma* heath are presumably the result of long-term fire adaptation in the mountains of New Guinea (Hope 1980b). The carbonised particle record from the high altitude sites such as Ijombe and on Mt. Wilhelm demonstrates clearly the response of vegetation after burning; opening of the forest canopy and expansion of grass and tree ferns. At lower altitudes the charcoal record is generally directly related to anthropogenic firing as the primary rainforest does not burn readily. Hope (1983) provides some isolated examples of presumably natural rainforest fires in the central Highlands region but even these cases were shown to be very infrequent in occurrence. The signature of a human induced fire regime appears to be one of frequent firing over an extended period of time associated with disturbance elements and reduced forest cover in the pollen record.

Records of burning are available from a number of sites within the Highlands (Fig. 3). These records show that fire was a major factor in the formation of grasslands during at least the last 30,000 years. At high altitudes, near Mt. Jaya, burning was apparent by 13,500 BP showing that people entered cold mountainous regions during

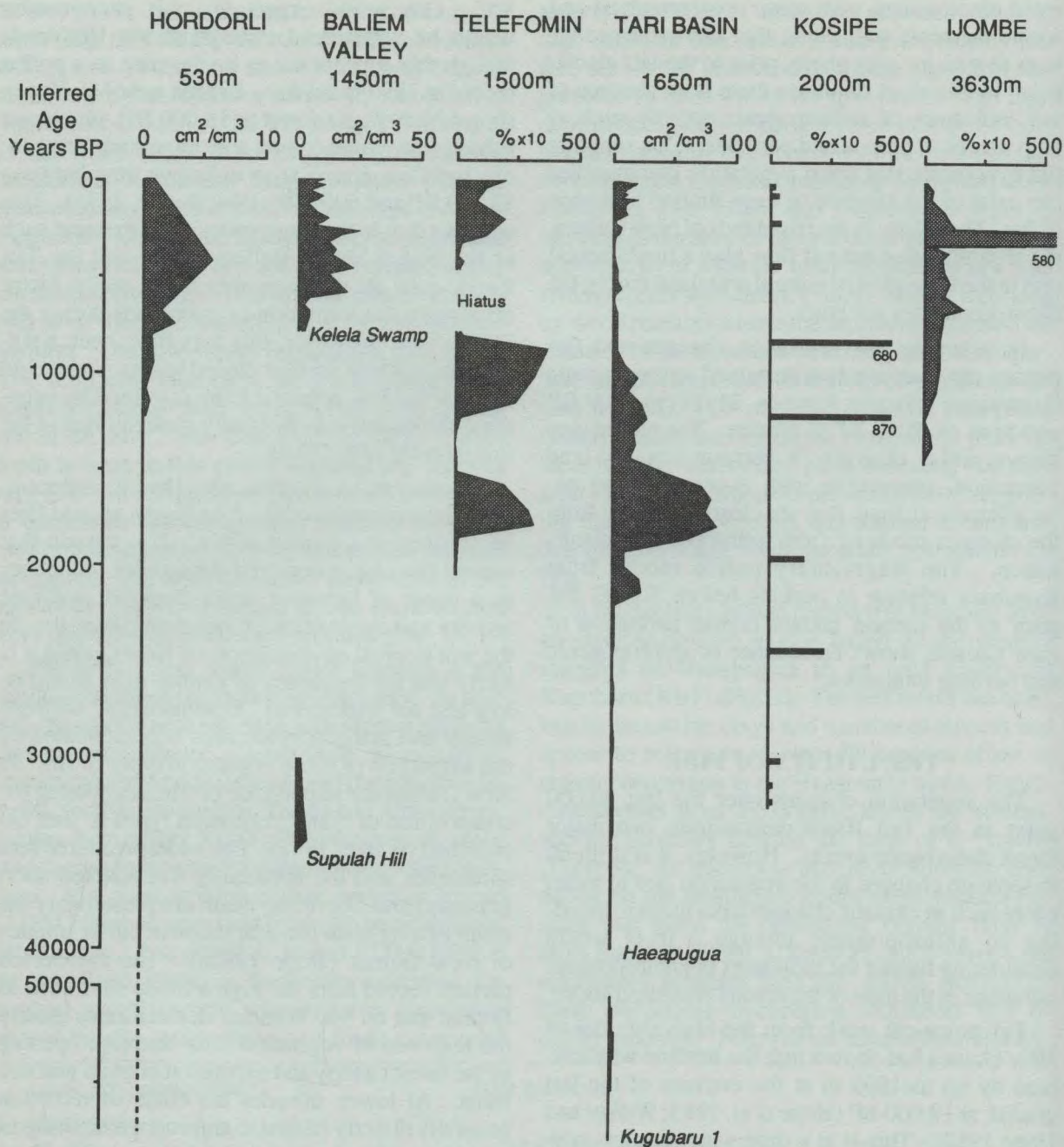


Figure 3 Carbonised particle records from six Pleistocene records in New Guinea. The ages have been estimated from radiocarbon dates on the sediment cores.

the Pleistocene (Hope and Peterson 1976; Plate 5). At Kosipe in the southeast of New Guinea forest clearance seems to have been maintained from at least 24,000 BP until 10,000 BP when the site was apparently abandoned (Hope 1980a). In the Baliem Valley a steep hillslope was reoccupied by forest after disturbance about 26,000 BP (Swadling and Hope 1992) and at Telefomin a site shows evidence of three clearance and burning episodes; 18,000 to 15,500 BP, 11,500 to 8200 BP and 3000 BP to present (Hope 1983). These differing responses across the Highlands may be indicative

of differing human adaptations to each region. This does not support the climatic explanation (that would require a more uniform response across the Highlands) but accords well with the notion that plant manipulation, by clearance and burning, was an important part of Highland Pleistocene human subsistence.

It is worth noting that long continuous records such as Hordorli, Kosipe and Haeapugua, show virtually no carbonised particles before 30,000 BP suggesting that human burning activity may have been absent in these areas prior to this time. It

seems relatively safe to suppose that the late Pleistocene populations were smaller and less dense than in subsequent times and that there was less impact on the environment than during the Holocene. Nevertheless, these records are compelling evidence that the early inhabitants of the Highlands were actively manipulating the environment rather than playing a passive role.

Another line of evidence that has a bearing on the development of early agriculture comes from the measurement of erosion rates as an indicator of hillslope instability. Hughes et al. (1991) propose that a significant rise in sedimentation rates at Kuk Swamp during the period from 9000 to 6000 BP is the direct result of agricultural use of the catchment. There appears to be little indication of increased erosion rates during the period from 30,000 to 9000 BP in any site, which tends to contradict the hypothesis that agriculture was being practiced during this period. However, it is possible that the mobilisation of sediment at the end of the Pleistocene may have been the result of earlier changes that created instability at a time of rapid readjustment by vegetation (Swadling and Hope 1992).

DISCUSSION

In terms of the nature of human interference with vegetation cover, mechanism and purpose rep-

resent two key problems. The former can be tackled by both archaeological and palynological evidence. The discovery of large distinctive flaked blades, or waisted axes, in a number of Pleistocene sites, including the 40,000 BP site in the Huon Peninsula (Groube et al. 1986), puts a new perspective on possible mechanisms for Pleistocene subsistence. The purpose of these implements is more elusive. Groube (1989) suggests that these artefacts represent the existence of a technological capability for forest clearance and envisages a slow emergence of forest horticulture from foraging through forest management during the late Pleistocene. Hunting and gathering was undoubtedly a major strategy for obtaining food, but Groube (1989) suggests that tree-felling or ring-barking was also an important activity. Certainly by trimming, canopy thinning, ring-barking and with the use of fire, restricted natural stands of plants such as *Colocasia* taro, banana, yams, sago and *Pandanus* could be promoted. The only crop that may have been viable in any of the major Highland valleys during the late Pleistocene is *Pandanus*, a tree that would have served as a major, though probably seasonal, nut source. The earliest stage of forest clearance may have involved the extension of existing grasslands or herbaceous swamps to enhance the growth of plants such as *Pandanus*. Forest may also have been cleared for reasons other



Plate 5 Mt Ne covered with *Nothofagus* forest and pyrogenic grassland with *Cyathea* ferns following creek line. This is above the limit of agriculture in the Tari Gap at 2750 m.

than cultivation: to aid communication or to facilitate hunting.

The nature of human settlement is also an issue that needs addressing in the context of the palynological data. The earliest archaeological evidence for human occupation in the Highlands of New Guinea comes from two sites in the eastern part of the island; Kosipe, an open site at 2000 m asl (White et al. 1970), and Nombe, a rockshelter at 1660 m asl (Gillieson and Mountain 1983, this volume). Both of these sites date to around 26,000 BP and contain evidence of exploitation of local resources, possibly in a seasonal manner, during a period that was much colder than the present (see below). White et al. (1970) suspect that full use of the Highlands was probably being made by 30,000 years ago or even earlier. Most other work has been carried out in the central Highlands of Papua New Guinea where many rockshelters were first inhabited 14,000 to 10,000 years ago (see Table 2). There is evidence for human occupation from one site in the eastern part of the Highlands where the remains of posts belonging to a probable house and hearth complex were dated to about 18,000 BP (Watson and Cole 1978). This suggests that settlement patterns in the Highlands during the Pleistocene may have been of a permanent or semi-permanent nature.

The four Pleistocene pollen and fire records that are currently available for the Highlands region give a tantalising indication that human adaptation to the Highlands environment was as complex and varied during the Pleistocene as it is today and that concepts of uniform Highlands-wide development do not accord well with this evidence. Proof of the hypothesis that early human occupants of the Highlands were not only hunting and gathering but were actively manipulating the environment to enhance food procurement and possibly even practicing a form of subsistence agriculture must come from archaeological research. The archaeological study of open sites in the Highlands has yielded some of the oldest evidence for occupation in this region (Table 2). The difficulty with open sites stems primarily from the difficulty of locating suitable areas. Palynological studies in localities such as the grasslands and swamps of Telefomin, Baliem Valley and Tari Basin have proven to be of considerable palaeoenvironmental interest and this work could serve as a basis for further archaeological research into Pleistocene human occupation in Highlands New Guinea.

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BONES, HUNTING AND PREDATION IN THE PLEISTOCENE OF NORTHERN SAHUL

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There is no doubt that modern humans were present on the main island of New Guinea before 40,000 BP (Groube et al. 1986) as they were in the more southerly regions of the Sahul continent (Roberts et al. 1990). There is little further information as to activities of people in northern Sahul during the following 10,000 years and we can only speculate on the gradual expansion of people from the northern coasts into the Highlands of New Guinea and through the areas north of the main island into the island chains to the north and east. By 30,000 BP there is evidence of settlement in New Ireland (Gosden and Robertson 1991) and soon after in the Solomon Islands (Wickler and Spriggs 1988). Coordinated research along the north coast of New Guinea, in regions particularly well preserved by uplift, may well reveal further evidence of early human activities. Bowdler (this volume) discusses the 'common culture' of the people who moved through south China, southeast Asia and Australasia around 50,000-40,000 years ago. Their shared 'cultural baggage' must have included techniques for building water craft and the skills necessary to guide these craft in both coastal and deep sea conditions. Certainly there is little doubt that water travel, both along coastlines and between islands which were often considerable distances apart, was an important part of the earliest strategies for survival of the modern human populations of Sahul.

FIRST DOCUMENTED HUMAN ACTIVITY IN HIGHLAND NEW GUINEA

It is not known how long it took for people to spread inland away from the initial sites along the coast. There is evidence that people were present in the Highlands of New Guinea (regions over ca. 1350 m asl) by about 30,000 BP or soon after. There are two well documented archaeological sites which contain artefactual data from between 30,000 and 20,000 BP: Kosipe (White et al. 1970) and Nombe (Gillieson and Mountain 1983; Mountain 1983, 1991); a date of ca. 30,000 BP from

charcoal at Kuk, associated with imported rocks but unsubstantiated by artefacts (Golson and Hughes 1977:16); and three palynological sites, with data which suggest that people were clearing small patches within the forest during the same time period: Kosipe (Hope 1982), Supulah Hill (Haberle et al. 1991) and Tari (Haberle, this volume). These clearances appear to have been produced by deliberate firing and may possibly have involved exploitation of the nutritious products of the mountain Pandanus trees (Mountain 1992; Haberle, this volume), although no direct evidence for this has yet been documented. After 20,000 BP another similar small-scale forest clearance is indicated by the changes in the pollen record with extensive charcoal in the Telefomin Valley (Hope 1983) and there is a tantalising glimpse of an open settlement site in the eastern Highlands, with stone artefacts and wooden structures (Bulmer 1991; Watson and Cole 1977), which would have required small scale, probably temporary, forest clearance. The palynological evidence supports, but clearly cannot prove, Groube's (1989) hypothesis that from the first stages of settlement, people in northern Sahul were exploiting the plant resources of the area, gradually developing their techniques of plant management and manipulation during the late Pleistocene until full agriculture occurred in the early Holocene period (Golson 1991). Following the last glacial maximum at about 18,000 BP there is a small but gradual increase in the number of known archaeological sites in the Highlands and in the density of archaeological debris within these sites (Mountain 1991). This suggests that the human population of the Highlands was beginning to increase towards the end of the Pleistocene period and that therefore subsistence activities must have also increased during the period following the last glacial maximum.

Small local clearances in the forest cover of the Highlands could have been used for the successful exploitation of faunal resources as well as the deliberate management of plant resources. Organised community hunting of large species is probably

quite a late development within hominid evolution although exactly how recent is, at present, a matter of debate (see discussion in Nitecki and Nitecki 1987 and Chase 1989). There is no question that Upper Palaeolithic people in late Pleistocene Europe were capable of planned hunting of large species. Straus believes that:

In western Europe and southern Africa our best evidence for significant changes in hunting, involving the regular, planned efficient slaughter of large numbers of herd animals and the taking of elusive or dangerous game, appears in the archaeological record around the time of the Last Glacial Maximum. (Straus 1987:148 in Nitecki and Nitecki).

In the same volume Klein states that:

Analysis of Late Pleistocene and Holocene bone assemblages from the southern African caves, suggest that there was a quantum advance in the human ability to extract animal protein from nature, probably coincident with the advent of the Later Stone Age 30-40,000 years ago or more. (Klein 1987:39 in Nitecki and Nitecki).

PLEISTOCENE HUNTING WITHIN HIGHLAND NEW GUINEA

Within northern Sahul, prior to the last glacial maximum, there were a number of relatively large, now extinct, species in the montane forest near and above the treeline in the Highlands (Hope et al. in press; Mountain 1991), including diprotodontids, such as *Hulitherium tomasettii* (Flannery and Plane 1986) and *Maokoptodon ronaldi* (Flannery in press) and macropodids such as *Protemnodon nombe*, *P. tumbuna* and *Dendrolagus noibano* (Flannery et al. 1983) and *Protemnodon hopeii* (Flannery in press; Hope et al. in press). Such animals were not as large as many of their contemporaries in America, Africa or Europe from whom the term megafauna sprang. The New Guinea species described so far, although larger than any surviving species, were actually fairly small in size, and the range of species discovered suggest that the Pleistocene megafauna of New Guinea was far more limited than that documented from Australia (Flannery 1990; Hope et al. in press). Nevertheless, at an adult weight range of maybe 40-300 kg many would have presented formidable opposition for hunters as well as a welcome source of food and raw materials for any community. They inhabited a series of high altitude environments within the late Pleistocene landscape of highland New Guinea including montane forest edge, alpine grasslands, subalpine tundras and periglacial zones, at times from sites nearly 3000 m above sea level (Hope et al. in press).

STATING THE PROBLEM

Horton (this volume) has referred to the 'Holy Grail' of Australian megafauna studies: the attempt to find absolute proof of the nature of the association between the early human occupants of Sahul and their undoubted co-inhabitants, the extinct mammalian species. The problem also exists in the northern regions of Sahul since most of the New Guinea Pleistocene extinct faunal remains have not been found in clear association with evidence for human presence, let alone with data that can be interpreted as representing direct human predation on these species.

I wonder however, whether this particular 'Holy Grail' is the most profitable to pursue. One major problem is clearly the emphasis that has been placed on the larger species. We are now certain that the larger animals were present in the Highlands of New Guinea during the initial period of human colonisation of northern Sahul but so were many more medium and smaller species, from large possums to frogs and small lizards. All are included as targets for human hunting within New Guinea today (Dwyer and Minnegal 1991). Although it is obvious that patterns of modern hunting in what are now basically agricultural societies need have little relation to those of the late Pleistocene, it is most probable that Pleistocene hunters would have made full use of all available resources. It can certainly be argued that it is necessary today to include the medium and smaller species to ensure success in hunting expeditions since the larger species, such as the tree kangaroos (*Dendrolagus sp.*) and cassowary, are becoming rare and usually only survive in remote regions well away from human settlement. It can also be argued that their inclusion in present day hunting is at least partly due to the effects of increased human predation in the Highlands. However, it is likely that the larger species were always fairly rare and not easy to locate in dissected and difficult terrain. Human hunters, therefore, have always depended more on successful and regular predation of the medium and smaller species to provide supplies of flesh and other animal products. Such arguments require that archaeologists at least attempt to interpret the development of hunting within the Highlands to see what trends may be suggested by the data.

The results may often, as in this case, be tentative and open to debate since the exigencies of taphonomy cause multiple problems with interpretation. Nevertheless, unless we begin to examine the meaning of the variability within the species size and range within the faunal record we cannot begin to interpret the Pleistocene and Holocene hunting patterns of Sahul. Many techniques are



Plate 1 Excavations at Nombe, November 1979. (Photo: B. Shaw).

being applied to faunal data in parts of the world with Pleistocene records (see for instance, Bailey and Gamble 1990; Barton et al. 1991; Chase 1986; Hayden et al. 1987; Jochim 1987; Mithen 1990), perhaps we need more imaginative approaches to Pleistocene reconstruction in Sahul.

STUDY METHODS

In order to document the range and extent of human hunting it is necessary to use excavation recovery techniques that are suitable for all possible animal remains. All but the finest mesh will lose evidence such as individual teeth and limb bones from many of the tiny species. Wet-sieving will increase the recovery rate of the smallest material evidence although it necessarily reduces the amount that can be excavated. In the excavations at Nombe regular sieves of about 5 mm were used in the first excavations (during the early 1970s), although hand sorting was substituted for some extremely thick clay deposits. In later seasons a complete section of deposits was wet-sieved through a mesh of 1 mm, and the recovery rate of bone increased in some areas over seven times in weight with the number of species that were recorded also increasing dramatically.

Faunal analysis from Sahul sites has often been restricted to cranial identification, which reduces the sample numbers for analysis. At Nombe a larger sample was produced by post-cranial identification wherever possible, although this was normally not possible to species level. One of the problems encountered is the creation of broad computer classifications for comparative purposes to take advantage of the largest samples, whilst still being able to identify individual species for study when necessary. For this purpose a normal database computer program was adapted by Dr Barry Shaw to enable flexible grouping of data from species level to family or class level as required. Since many of the more than 25,000 identified bones were both small and damaged by heat and movement, it was unnecessary to create a separate field for every bone, which would have resulted in over 375,000 discrete items of information. Instead, the faunal data were analysed as a series of assemblages each from a discrete (and, in the case of the wet-sieved units, small) quantity of sediment, often less than a bucket load. The identification level of taxon was necessarily conservative. Post-cranial fragments were often recorded only from a family rather than attempting to identify their genus or species. Species identification depended very largely, although not entirely, on dental features. Unique species, such as *Zaglossus bruijnii* or *Casuarius bennetti* were recognisable in post-cranial

as well as cranial pieces. Two special categories were recorded along with the Linnaean categories of Class, Order, Family, Genus and Species; the first, named Sub-Family, was in order to be able to

LARGE BODY WEIGHT

(over 5 kg adult body weight)

PREDATOR: *Homo sapiens* (1 species)

PREDATOR: *Thylacinus cynocephalus* (1 species)

PREDATOR: *Canis* species (1 species)

Diprotodontids (1 species)

Protemnodon species (2 species)

Dendrolagus species (3 species)

Large macropods (MACL) (5 species)

Zaglossus bruijnii (1 species)

Sus species (1 species)

Casuarius bennetti (1 species)

MEDIUM BODY WEIGHT

(ca. 1 - 5 kg adult body weight)

PREDATOR: *Harpyosis novaeguineae* (1 species)

Medium macropods (MACM) (1 species)

Small macropods (MACS) (1 species)

Phalangeridae (PHAL. SP) (3 species)

Pseudocheiridae (POSL) (2 species)

Large murids (MURL) (2 species)

Snakes

SMALL BODY WEIGHT

(ca. 300 g - 1 kg adult body weight)

PREDATOR: *Dasyurus albopunctatus* (1 species)

PREDATOR: Owls (STRI) (3 species)

Medium possums (POSM) (2 species)

Large bandicoots (PERL) (2 species)

Small bandicoots (PERS) (1 species)

Medium murids (MURM) (6 species)

Large fruit bats (PTEL) (2 species)

Medium birds (AVEM) (3 species)

Turtle (1 species)

TINY BODY WEIGHT

(under 300 g adult body weight)

PREDATOR: Small dasyurids (DASS) (1 species)

Small possums (POSS) (2 species)

Small murids (MURS) (2 species)

Small fruit bats (PTES) (1 species)

Small birds (AVES) (7 species)

Lizards

Skinks

Frogs

Table 1 Classification of species present at Nombe by body size. Taxa and family size abbreviation in brackets.

group similar sized species with different names. For example in the Pseudocheiridae family there were only two members present which grow much larger than 1 kg adult body weight. These were classified as a separate grouping of Large Possum (POSL), as opposed to Medium sized (POSM) or Small Possum (POSS), which contain members from different Linnaean families. Another category called Size was based on four divisions of approximate adult body weight; large body weight (over 5 kg), medium body weight (1-5 kg), small body weight (300 g - 1 kg) and very small body weight (under 300 g). Table 1 sets out these classifications. This allowed the data to be grouped according to size categories showing significant patterns of change over time. The computer classification is being written up at the present time but can be briefly described here. The information from each assemblage was entered with five columns of site detail, followed by seven columns of information to classify the faunal remains (Class, Order, Family, Sub-Family as described above, Genus, Species and Size), followed by the weight of the cranial and postcranial fragments and the identification of body parts recovered.

Another function of the Size classification was to identify which predators were likely to have targeted the members of each size range. In Table 1, therefore, each size class list is headed with the predators present.

Information about the habitat and ecological niche of species can also assist in the identification of particular groups of species which may represent the actual inhabitants of certain climatic and vegetational zones in prehistory. Recent ethnographic information may provide some hints of technological skills, or ideas on the shift of momentum from one area to another, as resources come into season or decline in abundance. However, since research into Pleistocene hunting involves investigation of a set of circumstances which do not exist today due to the changes in population, socio-cultural factors, climate, vegetation patterns and associated faunal shifts, great care must be taken in the use of recent ethnographic data.

An example of long-term change in Pleistocene faunal data: Nombe rockshelter

Table 2 provides background information about the broad chronological divisions in the Nombe data and summary conclusions concerning human activity during late Pleistocene use of the site. Table 3 shows the results of using a body size classification to chart long-term change in the proportions of different sizes of species. It is clear that a number of predators, both large and small, must have been responsible for individual additions to

Stratum	Date range kyr BP	Human activity
B	ca. 4.5-10	Base camp
C	ca. 10-14.5	More frequent occasional hunting
D1/5	ca. 14.5-25	Very sporadic occasional hunting
D2/3/4	ca. 25-33+	Prehuman stratum

Table 2 Summary of main periods of human activity at Nombe.

the overall accumulation of bone, especially in the build up of the various parts of Strata D, which were deposited before human arrival at the site and continued to accumulate during the last glacial maximum when human use of the site was most probably very sporadic and of short duration. Table 3 shows several trends during the late Pleistocene and into the early Holocene. Climatic change was undoubtedly a factor leading to vegetation and faunal change in the locality, and human hunting has also contributed to changes in the landscape. The most obvious patterns of change are:

1. An overall decline in numbers of large animals present.
2. A similar trend in numbers of tiny fauna.
3. A rise in numbers of medium and small species.
4. A dramatic rise in the actual amounts of bone present in post-Pleistocene levels.

These trends suggest that there were changes in human-environment relationships between 25,000 and 10,000 BP. There is little difference in the proportions of the different size categories from the pre-human strata to that which contain slight but incontrovertible evidence for human presence (stone artefacts). This suggests that a range of predators, including humans, were using the site and leaving the remnants of a very wide range of species, including the larger, now extinct species of mammal that must have been the prey of either thylacines or human hunters. At present it is impossible to be certain exactly who or what was preying on the extinct species, but I cannot believe that modern people were hunting in the area where these species lived without at least attempting to hunt the larger species as well as the smaller ones. During the last glacial maximum the alpine shrub and grassland habitat must have reached its maximum extent. It was apparently utilised by several extinct species (Hope et al. in press) and presumably by many of the medium and small species known to inhabit the zone today (Hope 1976). Data in Table 3 show that bone from both the large and tiny species was becoming rare and that from medium and small species was rising in proportion. The sample for Stratum C is very small and there

Strata	B		C		D1/5		D2/3/4	
Large species	771	5	24	4	643	18	92	16
Medium species	10182	65	256	48	1950	53	221	38
Small species	4463	28	174	33	299	8	101	18
Tiny species	255	2	81	15	769	21	171	29
	15671	100%	535	100%	3661	100%	585	101%
							(due to rounding)	

Table 3 Summary of faunal data from Nombe by body size and strata. Number and Percentage of Number of Identified Specimens. For definitions of faunal categories see Table 1.

may have been extensive erosion at work on the site but the trend would uphold the theory, already well established by palaeontologists (Hope and Hope 1976), that the forest was responding to increased temperature and that the treeline was gradually increasing in altitude. Nombe, at 1720 m asl, was no longer suitable as a retreat or lair for predators from the alpine vegetation zone. Instead, the predators using the site (probably both animal and human) were targeting the medium and small occupants of the surrounding forest in far greater numbers. By the Holocene period between 80% and 90% of the faunal remains came from the medium to small range. These trends are also borne out by the species lists which show a decline in the species which live in the higher, colder altitudes today and a growth in the number of species known to occupy montane forest. Another factor which might be influencing the increase in medium and small species is the total absence of the extinct species after Strata D. This suggests that these species had already become extinct in the Nombe region by about 16,500 BP and that predators needed other strategies to replace those sources of meat and bone. One particular group of species that increased greatly in numbers during Stratum C was the fruit bats, which now roost in large numbers in local limestone sinkholes and caves. It is unlikely that any predator other than human hunters could be responsible for such an increase in bat bone. There is an important increase in the percentage of bone that is burnt from Stratum C and the site itself would not have been large enough to support large populations of breeding bats. Nombe seems to have been used in the early Holocene period as a base camp for human settlement as the densities of burnt bone, human refuse and artefacts increased dramatically at that time.

CONCLUSION

Even broad scale faunal analysis can suggest changes in human-environment relationships in the late Pleistocene period and the small role that human hunters and gatherers were beginning to take

in shaping environmental changes in particular landscapes. As the evidence for human presence at Nombe increases (levels of burning on bone, presence of artefacts and ochre), there is a reduction in the proportions both of the largest species and of the smallest species. Several of the largest species had become extinct by the end of the Pleistocene, probably due to a combination of climatic change, causing ecological niche decline, and predation. Other large species may already have begun to withdraw to less vulnerable environments away from human settlement. The decline in proportion of the smallest species, especially frogs, which it is believed are either natural inhabitants of the cave or the prey of smaller predators such as raptorial birds or dasyurids, may indicate a more permanent human presence at the site. Analysis of the Nombe data is beginning to reveal some interesting aspects of human-environment relations during the late Pleistocene. It is hoped that this can be expanded and tested with other relevant regional studies.

There needs to be a thorough and careful examination of human-environmental relations of the late Pleistocene of Sahul, through all forms of evidence, before firm conclusions can be drawn about hunting and gathering strategies of the period. It may then be possible to begin to explore the part that humans played in the extinction of a few mammalian species that have unfortunately become so dominant in the popular image of the Pleistocene.

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UNDERSTANDING THE SETTLEMENT OF PACIFIC ISLANDS IN THE PLEISTOCENE

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In this paper I shall look at the first movements of people off the larger continent of Sahul and onto Pacific islands. In doing so I shall consider two themes: the sets of constraints imposed by islands on the one hand and colonisation as a social process on the other. Before turning to the data it is necessary to make a few theoretical points.

INITIAL CONSIDERATIONS

A growing interest of recent sociology and anthropology has been the human creation of time and space (Agnew and Duncan 1989; Giddens 1984; Gregory and Urry 1985). Time and space are increasingly seen not as abstract and passive media in which social action takes place but as products of social systems. Landscapes are ordered into social configurations which set up particular rhythms of life. Social processes do not take place on the head of a pin but extend in space and in doing so they also unfold in time. The use of the landscape and of material culture give time and space a concrete nature which make them visible to archaeologists. The process of primary colonisation, that is people moving into an uninhabited landscape, gives us a perfect opportunity to study the process of social creation of time and space. By moving off the edge of the inhabited world people had the disadvantage of stepping outside any existing network of social ties, but the advantage of being able to arrange themselves on the landscape as they liked.

CONSTRAINTS IMPOSED BY ISLANDS

Before considering the archaeological evidence I want to think about the general problems people faced in moving off the continent of Sahul onto its bordering islands. The first and least of their difficulties was in getting there. To make initial sea crossings to New Britain and New Ireland required a shorter sea journey than that from southeast Asia into Sahul. There is also early evidence that people

made somewhat longer journeys in this area (Wickler and Spriggs 1988). In getting to islands and surviving, the Pleistocene inhabitants of Melanesia accomplished two 'firsts' when compared with the rest of the world. One was to successfully settle on islands earlier than in any area outside of southeast Asia (Keegan and Diamond 1987). The other was to move into rainforests, which do not seem to have been successfully inhabited elsewhere before the early Holocene (Bailey et al. 1989; Headland and Reid 1989). Rainforests are not poor in sources of food, but the latter are widely dispersed and found in small packets. The rainforests of the Bismarck Archipelago are especially poor as they contain very few animals, even in comparison with the Sahul mainland. Plant foods and marine resources would have provided the majority of people's diet. Islands covered in rainforests represent relatively small landmasses with dispersed sets of resources.

Small land areas and the lack of clumping of food sources would have posed particular problems for people with extensive economies, such as those normally associated with hunter-gatherer groups. In the Mediterranean, for instance, it is thought that people were unable to live on islands in a continuous manner until the development of farming (Cherry 1990). Farming or gardening allowed the intensive use of relatively small areas which meant that biologically and socially viable units were possible. The occupation of the western Pacific islands at a period when it is presumed people were still hunters and gatherers thus raises questions about both our definitions of hunting and gathering lifestyles and also how far the patterns of colonisation seen in island Sahul were different from elsewhere in the world. Central to our present definition of hunters and gatherers is their supposed passivity in the face of environmental constraints, unlike farmers who are seen to work actively to change their environment (Bender and Morris 1987). In the case of the Pacific islands, this assumption may not be tenable.

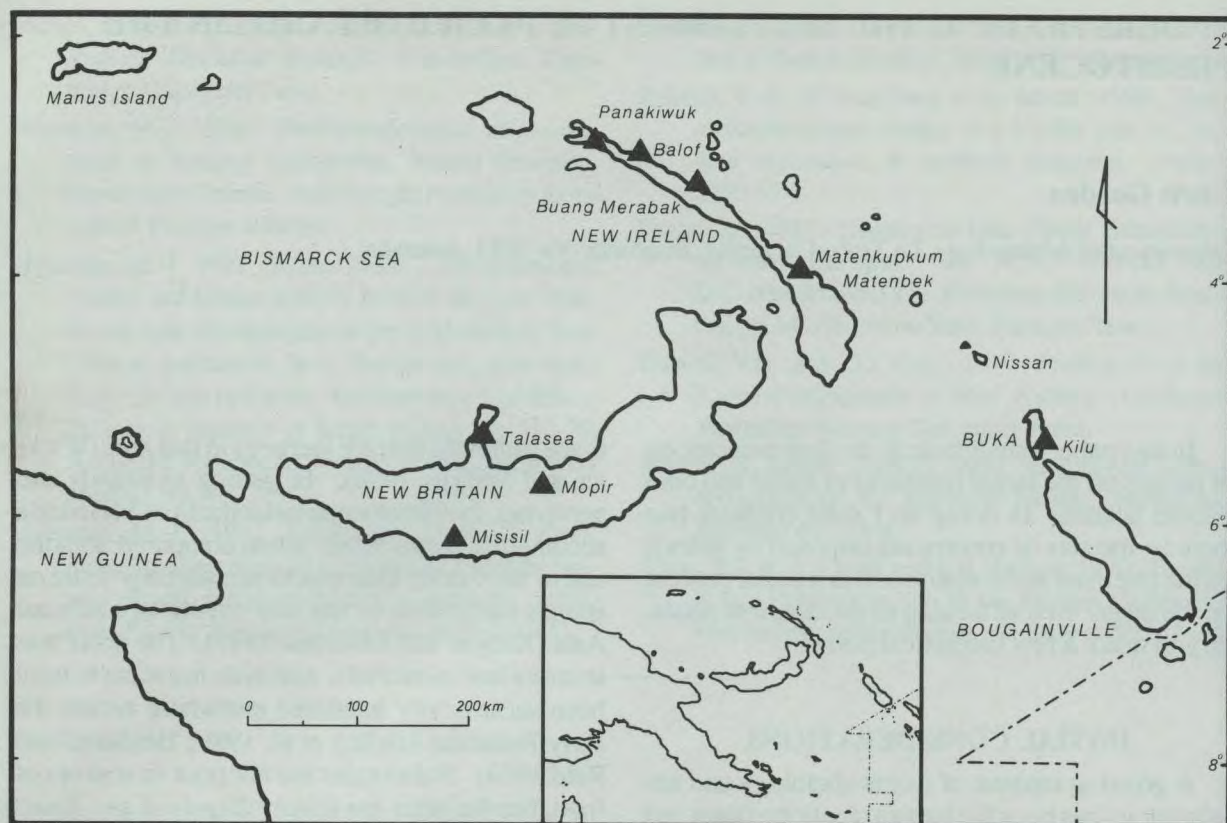


Figure 1 Sites of Pleistocene age in island Melanesia.

ARCHAEOLOGICAL DATA

Having mentioned the problems people faced, what can we say about their responses on the basis of the data available? In the earliest phase of settlement, some 30,000 years ago, three sites are known: Matenkupkum, Buang Merabak and Kulu (Fig. 1). The first two are on New Ireland, the third is on Buka at the northern end of the Solomon Islands chain. All are near the coast. Getting to Buka could have involved an open ocean journey of up to 180 km, which means that seafaring abilities of people at this time would have allowed them to reach the end of the Solomons, although we have no evidence from further down the Solomons chain as yet (Wickler and Spriggs 1988). Intriguing evidence comes from the site of Pamwak on Manus, (Fredericksen et al., this volume). Here there is a terminal Pleistocene date part way down the sequence and we can only speculate as yet as to what the basal date will be. To reach Manus involves an open sea voyage of 200-230 km which would potentially open up the Pacific as far as Vanuatu to human settlement. It will be interesting to see what future dates bring.

It seems increasingly that people were not constrained in their ability to move by sea even at an early stage and if we find that people did not move it is likely to be due to lack of motive or lack of

ability to survive on the smaller poorer islands east of the Solomons (Irwin 1991). The evidence for the Pleistocene occupation of New Ireland connects it to problems of the colonisation of Sahul as a whole. Knowledge of how far people moved out into the Pacific in the Pleistocene will throw light on their abilities as colonisers within Sahul. The real test here being remote Oceania, the area east of the Solomons (Green 1991). Here sea journeys do become more difficult, with larger sea crossings and the size of target islands decreasing. But of greater import is the absence of any large land mammals in this area and indeed very few terrestrial fauna of any type. The greatest constraint of all would have been imposed by the structure of plant communities: poorer and less diverse plant communities start at the southern tip of the Solomons chain and consequently the range of resources open to human foragers diminishes. It seems unlikely that people could have moved east of the Solomons without some ability to manipulate their environment. Should this area prove to have been settled in the Pleistocene this will necessitate a considerable re-think as to the sorts of societies and subsistence forms we are dealing with in this early period.

By 20,000 BP one extra site is known, Matenbek, some 70 m from Matenkupkum. There is a major increase in numbers of sites after the glacial

Site name	Date range	Reference
Matenkupkum	33,000-10,000 BP	Gosden and Robertson 1991
Buang	31,000-Holocene	Balean 1989
Merabak		
Kilu	28,000-Holocene	Wickler and Spriggs 1988
Matenbek	20,000-Holocene	Allen et al. 1989
Panakiwuk	15,000-Holocene	Marshall and Allen 1991
Balof	14,000-Holocene	White et al. 1991
Pamwak	>12,000-Holocene	Fredericksen et al., this vol.
Misisil	11,000-Holocene	Specht et al. 1981

Table 1 The sites and their dates of occupation.

maximum (Table 1). All the sites mentioned so far continue in use except Kilu, and two others, Panakiwuk and Balof, are first used after 15,000 BP. On New Britain the only direct Pleistocene evidence is that from Misisil cave 11,000 years ago (Specht et al. 1981). However, obsidian from New Britain was reaching New Ireland some 20,000 years ago and therefore some use of the island was being made at that time, although we have no direct evidence of sites. The contrasts between New Ireland and New Britain are intriguing. All the cave sites excavated so far on New Ireland have produced Pleistocene evidence, but only one cave on New Britain has done so, despite a very rich Holocene record. This may well be to do with sampling or a different geological history or it may in fact have to do with a different pattern of settlement. Manus was definitely settled by the terminal Pleistocene and so all parts of the Bismarck Archipelago had been reached.

What can we say about the evidence to hand, mainly that from New Ireland? The earliest evidence is of relatively low levels of occupation, along the coast. Few sites have evidence of occupation and those that do have less material in them than later on. Shell and fish bone show that people were using marine resources. There is a limited suite of animal and bird bones, which reflects the limited suite of animals and birds on the island. Material for stone tools was obtained locally and there is no evidence for care and sophistication in flaking. It seems likely that we are dealing with small numbers of people who may well have moved over large areas. They used their seafaring abilities to move between dispersed resources and could thus be labelled maritime hunters and gatherers. Movement would also have been necessitated by small group numbers. It is unlikely that any group

was biologically or socially self-sufficient. They therefore had to keep up contact with others on a regular basis. It may well be that our usual notion of socially bounded groups is inappropriate to a situation such as this one. People may have been not just physically, but also socially, mobile. In any case, people lived in a spatially extensive world with a few dispersed social contacts. It is a world without any ethnographic parallel and it lasted for over 10,000 years.

After 20,000 BP there is evidence of a different strategy. Instead of moving people to resources, resources were moved to people. This is best represented in its earliest form by Matenbek. In its basal levels were found New Britain obsidian which had moved some 350 km in straight-line distance. Together with this are the bones of a cuscus (*Phalanger orientalis*). This was not found in the earlier levels of the neighbouring cave Matenkupkum and it is possible that people introduced the animal to the island. It should be noted that these early movements of animals may represent the start of a strategy that continues through to the Holocene. The history of introductions and extinctions is too complex to go into here, but the Holocene evidence from other New Ireland caves shows the introduction of a wallaby. Rat species are found which did not occur earlier and these may also be human introductions (Flannery and White 1991; Flannery et al. 1988; Wickler 1990).

These animals may not have been that important to the Pleistocene diet. What is of note is that they signal an active attitude towards the constraints of the environment. People did not passively suffer the problems of island life but developed strategies to overcome them and these strategies date back well into the Pleistocene. By the end of the Pleistocene there is also evidence for the genetic manipulation of plants. Various *Canarium* species, which have a Gondwanaland origin (Yen 1990:261), are cultivated today throughout Melanesia as far as Vanuatu and one species, *C. harveyi*, is found as far as Samoa. A large fruited domesticated form of *C. indicum* has been found by Gorecki in a level dating to 14,000 BP in a site in the Sepik-Ramu area (Yen 1990:262). Out in the Melanesian islands Wickler and Spriggs (1988) have evidence of *C. indicum* between 9400 and 6000 years ago and Roe has found the same species 6000 years ago on Guadalcanal in the main Solomon Islands (Yen 1990:268). Not only was *Canarium* domesticated back in the Pleistocene, but it had been dispersed over a considerable area by the mid Holocene. In addition, there is evidence of the use of *Colocasia* taro from starch grains and raphides on the edges of stone tools dating back to the Pleistocene at Kilu cave, Buka (Wickler 1990:140).

The plant remains provide hints that at least by the late Pleistocene people had brought about genetic alteration in some plant species and may have been utilising others that were to become staples in the Holocene. The animal and plant evidence together works to undermine the idea that Pleistocene populations were passive hunters and gatherers and that only in the Holocene were groups able to make major subsistence and social changes (Spriggs, this volume).

With the introduction of foreign resources we get evidence that people were spending more time in the coastal caves: there are increased levels of deposition and more structure to the debris in the caves, with evidence of hearths, dumping areas and so on (Gosden and Robertson 1991). Also after the glacial maximum there was an extension of settlement away from the immediate coastal strip and into the rainforest. At least one of these sites, Panakiwuk, has the appearance of a hunting and foraging camp rather than a site of more permanent habitation (Marshall and Allen 1991).

Thus between 20,000 and 15,000 BP the old mobile form of life contracted somewhat and people could now draw on resources from beyond the local area. A more differentiated use of space came into being with special purpose sites away from the coast. In this period people reshaped their use of space and time and in doing so may have set some of the foundations for later forms of Pacific life. We can sum up the changes that took place around 20,000 years ago by saying that before this time people moved themselves to dispersed resources, after this point people started to move resources to them. Such a major change in strategy has a series of demographic and social causes and effects. It may be that higher population levels restricted mobility after 20,000 years ago. Alternatively, the development of new forms of dealing with the world, such as the extension in the natural range of some animals and plants and the extinction of others, may lie at the root of the new forms of life. People thus used the Bismarck Archipelago and the Solomon chain, as a whole, differently. Individual sites may also have been used differently, with some regional differentiation of activities taking place and special purpose sites coming into existence. A more packed and settled landscape would have created a new social world in which to live, although the movement of New Britain obsidian indicates that this was still a world with wide spatial horizons.

Returning to the points made at the beginning of the paper, the Pleistocene evidence may open a window onto two different forms of the creation of time and space. The initial forms of colonisation created a spatially extensive and mobile world, in

which the definition of groups and social identity would have been quite unlike anything we know of today. Spatially extensive and temporally long lasting, this world was then transformed in the glacial maximum to a way of life with different spatial and temporal rhythms. People started to treat various parts of the landscape differently and took a more active attitude to the material world, altering its spatial configuration by moving animals and raw materials. The point of these speculations is twofold. First, I am attempting to show that colonisation is not simply a process of adapting to a new physical environment, but is rather to do with creating a social world with its own spatial extent and temporal rhythms. Second, some of these rhythms may be extremely long lasting, and the Pleistocene evidence can be seen as being interesting not just in its own right but for the light it throws on the Holocene. When people moved out into the rest of the Pacific 3500-3000 years ago they took all the plants and animals with them that they needed, as well as engaging in the long distance movement of materials. These strategies go back 20,000 years and despite all the changes in Pacific forms of life over tens of millennia the active shaping of island worlds provides a thread of continuity right through Pacific prehistory.

FURTHER IMPLICATIONS

The Pleistocene evidence from the Bismarck Archipelago has much to tell us about Pacific prehistory. Can it also throw light on the archaeology of Sahul? The island evidence can refute at least one line of thought. This is the idea that the initial settlement of Sahul might have been accidental. There is good evidence that by 30,000 years ago people had few problems crossing stretches of water which may have been up to 180 or even 230 km wide. It is estimated that the maximum island-hopping distance between Sunda and Sahul at periods of low sea level would have been 90 km, although most island hops were of 10 km or less (White and O'Connell 1982:46). These distances could have been crossed easily by 30,000 BP given the Buka evidence. There is no reason now to think that Sahul represents a case of adaptation in isolation. Any peculiarities of Sahul prehistory occurred despite contact with the north. This makes the divergent Holocene histories of southeast Asia, Papua New Guinea and Australia even more intriguing.

A second area of investigation is opened up by the fact that people were able to orientate themselves on the landscape to overcome physical constraints and to alter the structure of the landscape to meet their needs by moving animals and stone from

one place to another. It would be fascinating to know how far these strategies were pursued in other parts of the region. This is especially true given the relict Pleistocene landscapes in Australia. Most of Australia has not been glaciated and therefore offers the potential for detailed landscape reconstruction going back to the first occupation of the continent. In other parts of the world hints have been found that Palaeolithic groups were altering the structure of their environment (Dennell 1983). However, the massive phases of erosion and deposition brought on by the last glaciation in the terminal Pleistocene and early Holocene make detailed reconstruction difficult. Such practical problems are less constraining in Australia. The possibility exists that in a number of areas within the continent it will be possible to gauge how far people reshaped their physical environment and re-ordered themselves within that environment during the Pleistocene. The island Melanesian evidence provides an initial indication that the re-creation of time-space systems has been a constant feature of the human occupation of the continent. However, it will not provide a model for how that manipulation took place and we can expect a mosaic of responses due to the ebb and flow of human groups and the material changes they made to the local structure of resources.

Colonisation involves the active creation of a human and a physical world over millennia. Each new move altered life for people in already settled parts of the region. In order to understand the full dynamism of this process we need not just data, but ideas on how time and space are shaped. Sahul and its offshore islands provide the ideal situation in which both ideas and data can be pursued to look at the process on a continent-wide scale and in its detailed regional manifestations.

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PLEISTOCENE AGRICULTURE IN THE PACIFIC: WHY NOT?

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More comprehensive means than we have at present have to be devised to trace in the archaeological record the range of plant-exploitative activities that make up the continuum (between foraging and agriculture). At present relatively few of those activities are open to direct archaeobotanical or palaeoenvironmental investigation (Harris 1989:22-3).

The archaeological record speaks of no cultivation or herding in the face of major and minor climatic fluctuation, resource stresses of all imaginable magnitudes and durations, occurring in all possible environments for two million years. Why should any such perturbations result in food production in the last 10,000 years? I argue that they should not and did not (Hayden 1990:35).

DEFINITIONS

Among the many definitions of terms such as 'agriculture' and 'domestication' which have been used by students of the origins of agriculture, I have chosen to use the recent schema of David Harris (1989, 1990) as he is one of the few familiar with the archaeological record in this part of the world. Two features of this evolutionary continuum need some discussion, however. One is the fetishisation of domestication as an important threshold between cultivation and agriculture. Although Harris admits problems with this, he uses it as being clearly defined and with the merit of getting rid of the deterministic term 'incipient agriculture' (1989:19).

Crop domestication is defined by Harris (as by many others) as having occurred

when the reproductive system of the plant population has been so altered by sustained human intervention that the domesticated forms – genetically and/or phenotypically selected – have become dependent upon human assistance for their survival (1989:19).

He acknowledges the lack of an absolute distinction here as the processes leading to domestication are cumulative.

In relation to Pacific cultigens thought to have been derived from wild forms in the area, Yen (1985:323) questions whether they are in fact wholly domesticated today:

Firstly, in many cases the wild species still exist, taxonomically classifiable with cultivated forms, and economically with identical uses. Secondly, the genetic fixation that ensures, if not agricultural stability, then at least consistency in classification, has not been achieved ... The application of such criteria in the categorisation of 'degrees of domestication', however, may prove an inconsistent and unsatisfactory exercise.

In view of Blumler and Byrne's (1991) argument that under certain circumstances domestication might precede cultivation, it might be irrelevant to ask whether a particular cultivated plant was morphologically domesticated and when that happened. It is more important to identify when cultivation began, as this has greater implications for changes in human behaviour and organisation (Byrd 1991:38). In the following discussion I will subsume agriculture within Harris' definition of cultivation, thus downplaying the importance of morphological domestication as a significant threshold in the continuum of plant-exploitative activities in the Pacific.

So what is cultivation? Given the nature of a continuum, a sharp break between it and 'wild plant-food production' is somewhat arbitrary. The latter 'stage' can involve transplanting, weeding, and even drainage and irrigation but this soil disturbance only amounts to minimal tillage and is small-scale. Cultivation represents significantly greater energy inputs in systematic clearing of the land and tilling of the soil along with planting of crops (in Harris' schema [1989:20-2], undomesticated ones).

Another problem with Harris' scheme is that the continuum from foraging (wild plant-food procurement) through to agriculture is also a kind of 'Hawkes' ladder' of inference (Hawkes 1954:161-2). One can be confident that people in the late Pleistocene were hunting and gathering and ample evidence might be evinced to support this. But what if they were engaged also in cultivation/agriculture? As the Harris quotation at the beginning of this paper suggests, relatively few of the activities along the continuum between the two are open currently to archaeobotanical and palaeoenviron-

mental investigation; and as the Hayden quotation points out, why should food production have only come about in the last 10,000 years?

MODELLING PLEISTOCENE PACIFIC SUBSISTENCE

It is useful to set up models of possible Pleistocene subsistence systems and then see what evidence is available to support or perhaps more importantly at this stage of research to knock them down. The model developed here is a cultivation/agriculture one, to be contrasted with foraging and wild plant-food production models. Other papers in this volume are examining the Pleistocene archaeology and palaeoecology of mainland New Guinea (Haberle, this volume; Mountain, this volume; see also Mountain 1991) and because of this, and also because it can be argued that the situation further out in Island Melanesia is somewhat different, I will limit my discussion to the latter area. I define Island Melanesia here as the Bismarck Archipelago (New Britain, New Ireland, Manus and satellite islands), the Solomon Islands, Vanuatu and New Caledonia. The latter two archipelagoes for which we lack evidence of human occupation in the Pleistocene or early Holocene will not feature in the discussion, except in contrasting the biogeography of Near and Remote Oceania (Green 1991; cf. Spriggs, in press).

The cultivation/agriculture model is based on a range of crops of Melanesian origin which we know to have been in cultivation at European contact. Yen (1990) has discussed these in some detail noting four characteristics. First, they arose in all altitudinal areas (perhaps more relevant for the New Guinea mainland). Secondly, there is a preponderance of vegetatively-reproduced plants. Third, apart from taro, some yams and *Pueraria* there was a concentration on tree and tree-like plants (pandanus, banana, breadfruit and sago); and finally, a number of important tree species did not have genotypes allowing for vegetative reproduction (*Burckella*, *Pometia* and *Canarium*). The *Canarium* species (*C. indicum* and *C. salomonense* in particular) spread from New Guinea to much of Melanesia (Yen 1990:261-2).

The natural range of taro (*Colocasia esculenta*) may have included the Solomon Islands, and domesticated forms may have derived from wild-type *C. esculenta* var. *aquatilis* (Matthews 1991). This variety is recorded as producing very little starch and Matthews suggests that other properties such as the edibility of shoots and leaves and medicinal uses may have led to its initial cultivation, with selection for starch content occurring under cultivation (1990:6-7). The residues on stone tools

from Kilu Cave on Buka (north Solomons) suggest that by 28,000 BP more starchy varieties were available and could have provided a major staple food (Loy et al. 1992). Natural distribution in swamps and along streams could have suggested artificial irrigation to recreate the natural habitat, and ditched beds in swamps could have developed from efforts at extending plantings or reducing competition from other swamp vegetation.

Other naturally occurring aroids may have also suggested themselves for cultivation: *Alocasia* (also detected on the Kilu tools) and *Cyrtosperma*. The currently cultivated *Cyrtosperma merkusii* may have come into cultivation independently in the Solomons, given that it has a split distribution in west Malesia and Island Melanesia and that one of its most closely related species is from Bougainville (Hay 1988:434). It is interesting to note that *C. merkusii* does not occur anywhere on the island of New Guinea. A range of cultivation techniques could have been applied to *Cyrtosperma* and *Alocasia*; vegetation clearance by fire, tillage of the soil and selection of non-spiny (*Cyrtosperma*) or less acrid (*Alocasia*) varieties for replanting.

Sago (*Metroxylon*) occurs as several different species in the archipelagoes of Island Melanesia, suggesting a wide natural distribution and local domestication (Yen 1985:316). Rhoads (1982) documents the range of management practices involved in sago exploitation, from cutting of natural stands through to planting and tending of palm suckers by canopy clearance and/or creation of artificial swamps. Sago can thus be transplanted from its natural habitat of alluvial, freshwater swamps to areas it would not naturally colonise. Sago may have formed an alternative or complementary staple to taro in lowland parts of the region (cf. Townsend 1990).

Fragments of *Canarium* almond endocarp have been identified in terminal Pleistocene and early Holocene Island Melanesian sites from morphologically distinctive carbonised remains (Yen 1990:268). Yen has suggested (1985:320; 1990:262, 268) that edible *Canarium* species were most likely introduced to the Bismarcks and Solomons from New Guinea where they may have been naturally widespread. In Island Melanesia *Canarium* often forms an important food resource because it can be stored. If Yen is correct then it must have been deliberately planted, tended and harvested from at least the terminal Pleistocene onwards, on evidence from Pamwak shelter (Fredericksen et al., this volume) on Manus and from Kilu Cave on Buka (Wickler 1990:140). In the north Solomons the *Canarium* (pidgin: *galip*) fruiting season runs from July/August to November/December. Management practices of the re-

cent past in the Bougainville interior suggest both the potential importance of this crop and ways in which it might have been used. The description is from Guava, home village of Francis Ona, President of the rebel 'Republic of Bougainville'.

During this period the people leave their hamlets and live in rough shelters in the forest adjacent to the trees from which they have the right to gather the fruit.

Their equipment consists of long bamboo rods with wooden hooks lashed to the end, and long ropes. Many ropes, newly made in readiness for the present harvest were seen by the patrol. The men climb the trees with the aid of the ropes and shake or pull the fruit down with the hooked poles. They are gathered by women and children. Over the years falls from trees have caused many deaths. When the shiny black fruit are gathered the kernels are removed and cracked by a blow with a stone ... The seeds thus obtained ... are smoked and then tamped into bamboo tubes, and sealed in with leaves and a cement of wet ashes. The tubes are then placed in the roofs of houses, where smoke will constantly deposit tar on the outside. After this process the nuts keep three or four years.

Many of these filled tubes are sold for cash, but others are kept until enough are ready for a feast. This may occur at the end of each season if the harvests have been good, or if bad seasons occur, it may be deferred two or three seasons until enough nuts are available.

The ownership of the trees is traditional – it is vested in the clan, and the clan elders thus control the source of wealth – the young men haven't been able to ignore their elders ... and so the Guava elders have been able to retain much of their old power (Kieta, Patrol Report 1 of 1955/6. C.W. Kimmorley, Guava, Aug.-Sept. 1955).

An earlier patrol report gives an idea of the quantities produced:

The central Ebo [Eivo] and Nasioi areas smoke galip nuts in huge quantities. During the galip season (Aug.-Dec.), the natives live for the greater part of the time in the bush collecting the nuts. The writer counted 750 long bamboos full of smoked galips in Paura alone (Patrol Report 3 of 1949/50. W.I. Westerman, Nasioi-Ebo, Aug.-Sept. 1949).

Based on the Bougainville example, one could develop the kind of model for the place of *Canarium* and other nut species in the economy that Soffer put forward in her paper on 'Storage, sedentism and the Eurasian Palaeolithic record' (1989). She points out that data on the use-life of foods cross-cut the distinction often mentioned in the literature between use of r- or k- selected species: 'It is not the size of the food package or its reproductive rate that are significant, but rather what one can or wants to do with the food' (1989:729). Soffer notes that nuts (and cereals) are comparatively non-perishable and offer greater advantages to surplus amassers: 'They allow for many more long-term social manipulations than do animals or fish products, or roots and tubers' (1989:723).

In Harris' (1977) discussion of alternative pathways towards agriculture, he does not find evidence for any development towards domestication and food production based on a system of harvesting of nuts from wild trees (1977:206-8). Island Melanesia might provide the exception in this. It would certainly be possible, based on even current finds of *Canarium* in sites, Yen's (1974) ethnographic evidence from Santa Cruz, that from Bougainville cited above, and Soffer's storage arguments, to model a pathway to agriculture based on arboriculture.

PROBLEMS OF EVALUATION

But what evidence might allow one to evaluate the cultivation/agriculture model as opposed to one of wild plant-food production or even foraging? The major difference from wild plant-food production is one of scale, and here our first difficulty arises: for Island Melanesia only eight Pleistocene sites have been investigated (Allen and Gosden 1991; Allen et al. 1989; Specht et al. 1981; Wickler and Spriggs 1988) and there is essentially no pollen coverage for the region from this time period. Even if we had the pollen record what would it tell us? Evidence for burning and vegetation clearance consonant with a scale suggestive of cultivation might relate to other cultural practices such as hunting. Harris' (1989) definition of foraging also includes the burning of vegetation. Evidence for the spread of sago in the record might relate to successional trends in swamps controlled by sea level changes, uplift or coastal progradation.

Wild plant-food production would at least be distinguishable from foraging if evidence of more than casual dispersal of propagules to new habitats were found: the *Canarium* remains could certainly be interpreted in this way. If evidence for drainage or irrigation were found, as at Kuk in the New Guinea Highlands at 9000 BP (Golson 1990), even this would not necessarily indicate cultivation. As Harris notes in his scheme, these techniques might also fall under the rubric of wild plant-food production based on ethnographically-recorded practices. How big does a Kuk-like system have to be before it must be accepted as cultivation? Obviously no single indicator is going to be enough to 'grade' the economy at particular times.

Harris (1989:23) lists some possible techniques for addressing these problems: palynology and charcoal frequencies, phytolith analysis, macroscopic plant remains, and field archaeology to locate irrigation, terracing, and other physical remains of garden types. In an earlier paper (Spriggs 1982) I suggested a range of avenues for the identification of taro in the archaeological re-

cord but most of these would not necessarily detect whether it was wild or cultivated, but merely the presence of the plant. I did note, however, that the presence within swamp sediments of concentrations of leaves and leaf fragments known to be used as mulch species often used in swampland cultivation would suggest a degree of ground preparation and tillage beyond the minimal levels of wild plant-food production (1982:7-8).

Another possible marker of the importance of an early arboricultural component might be an increase in the available catch of fruit bats and some birds which forage on the fruits. Yen (1974) pointed out the role of tree products in the 'husbandry' of fruit bats in bush areas in Santa Cruz.

Further development of residue analysis of stone tools might identify plants which could not be natural to Island Melanesia or which, given their high starch content relative to wild forms, could be considered as possibly domesticated. Continuation of the work of scholars such as Hather (1988, 1991), using Scanning Electron Microscopy to identify parenchymous tissues of root vegetables and other plants from charred samples, would form an independent and complementary approach.

One possible way of examining whether cultivation was being undertaken in the Pleistocene rainforests of Island Melanesia is inadvertently suggested by Bailey et al.'s (1989) hypothesis that foragers cannot live in tropical rainforests except by maintaining interaction with agricultural groups. This is because resources, particularly carbohydrates, may be so poor, variable and dispersed in undisturbed tropical rainforests that they cannot support viable populations of hunters and gatherers. A major problem with their definition of 'undisturbed' is that it is unlikely that such an environment ever existed in Melanesian rainforests (or perhaps anywhere): they exclude rivers, swamps and lakes, being near the coast or near any non full-on canopy rainforest vegetation type. Also, as Blumler and Byrne note (1991:24), ecologists are becoming increasingly aware that disturbance is so pervasive in natural environments that **most** plant species are maladapted to completely undisturbed conditions.

Despite their clearly overstated criteria for a 'real' rainforest, Bailey et al. (1989) do establish that tropical forests are not the Gardens of Eden which they are sometimes portrayed as. Their view of possible early inhabitants of these forests, however, presents far too passive a picture. Changes in vegetation attendant on the opening of the canopy through natural tree-fall or along rivers and other natural clearings would have been apparent to early settlers. Cutting, ringbarking or burning of vegeta-

tion would extend such habitats where various edible species might be expected to grow. In the depauperate forests of Island Melanesia, transplanting of useful nut trees and other species from more productive habitats may have been necessary from initial occupation of areas beyond the coastal fringe. Thus, there may never have been true foragers in the Island Melanesian rainforests, a condition of regular exploitation being a form of wild plant-food production from the beginning. The apparently deliberate introduction of wild animal species into these forests from 20,000 BP onwards (Flannery and White 1991) should also be noted in this respect. The overall effect was to mimic the greater diversity of the New Guinea forests from whence the early settlers presumably came.

Bailey et al. (1989) therefore may be right in one sense. Perhaps foragers could not have lived in these forests, but people did not have to wait for the advent of agricultural colonists to open up the canopy through clearance for gardens. Wild plant-food production may have been developed early on as a set of strategies to allow occupation of the forests, starting with initial settlement in Island Melanesia (cf. Groube 1989:299, 301 for mainland New Guinea). Making a conscious move to recreate the richer environment from whence they came or at least to compensate for the poverty of the ones they fetched up on, they broke through the natural limits of the forest environment to become more than the 'non-affluent foragers' Piperno (1989) describes for the Panamanian tropical forests.

Examination of what agriculture looks like archaeologically on Pacific islands where there was no earlier occupation might also give clues as to what the signature is of particular practices or scales of subsistence exploitation. If we look at Lapita settlement pattern in Remote Oceania (beyond the main Solomons) we can note the existence of quite large villages sustained by agriculture, and rapid population growth from initial settlement (see for instance Spennemann's [1989] settlement pattern study of Tongatapu). Domestic animals (pig, dog, chicken) were present but their importance within the subsistence system from early settlement is unknown. In some areas, however, when pottery use stops so does the visibility of village settlements. If there were Pleistocene villages would they be archaeologically detectable? Perhaps, as pre-Lapita open sites are known from mid Holocene contexts at Yambon and the Willaumez Peninsula of New Britain (Specht et al. 1981; Torrence et al. 1990) and from Papitalai on Manus (Kennedy 1983). They contained dense scatters of stone artefacts and possible postholes. These finds are usually serendipitous, however, and sampling

strategies designed specifically to look for such sites have yet to be developed.

Another signature of agricultural settlement on Pacific islands which may turn out to be quite general is a 'pioneering' pattern of initial settlement followed by serious erosion, abandonment of an area for sometimes many hundreds of years and a later more conservation-oriented re-use with sustained occupation (Spriggs 1991). This appears to reflect large-scale clearance for agriculture leading to serious environmental degradation. The response to this was to move to another area where presumably the process was repeated. In a more fully-occupied environment such profligacy would no longer be possible and conservation practices such as terracing had to be developed to allow sustained agriculture in one location.

Major impacts on vegetation and direct evidence of erosion are witnessed in the pollen records of various Pacific islands soon after initial evidence of occupation by agricultural groups, either Lapita or later (see for instance Flenley et al. 1991). Several Lapita sites in Island Melanesia, generally on small off-shore islands, also show sudden changes in depositional regimes, suggested as erosion following agricultural clearance and certainly representing changed land use practices (Gosden et al. 1989:573).

Lack of similar evidence in earlier phases of occupation would suggest major subsistence changes attendant upon the more obviously agricultural, later Holocene Lapita expansion. But could this just represent a different kind or a more intensive form of cultivation/agriculture? Would an earlier developed arboriculture, or a system based on management of sago or planting of taro in swamps, be expected to provide the same kind of archaeological signature? What degree of sedentism is necessitated by these possible earlier systems, particularly in the absence of pigs? What degree of landscape disturbance?

If the question of whether there was pre-Lapita occupation of Vanuatu and New Caledonia is settled in the affirmative then this would also have implications for our understanding of Pleistocene economies in the region (Spriggs, in press). Beyond the main Solomons is 'Remote Oceania' (Green 1991; Pawley and Green 1973:5), across a major biogeographic boundary. Beyond San Cristobal there are no naturally occurring terrestrial mammals except bats, the number of bird species decreases significantly (although the potential fossil record needs to be considered), and floristic diversity is also much less. Many naturally occurring edible plant foods found in the main Solomons do not occur in Santa Cruz or Vanuatu.

The reason for the boundary relates to the large sea gap between San Cristobal and Santa Cruz (in excess of 300 km) and the small size of potential 'stepping stone' islands between the main Solomons and Santo in Vanuatu. Recent research on Manus (Fredericksen et al., this volume) has shown Pleistocene occupation of this isolated island group, and suggests that Santa Cruz and Vanuatu could have been within voyaging range of Pleistocene settlers. The biogeographic boundary, however, may have represented an absolute boundary to successful settlement by foraging groups. If this was the case, then any evidence of occupation across the boundary implies an economy based on cultivation or at least a developed form of wild plant-food production involving transplantation of many useful plant species. Evidence of simple presence of human occupation would thus be enough to inform us about subsistence practices to the other side of the 'Remote Oceania' barrier.

CONCLUSION: WHY NOT?

We can be certain that the Pleistocene inhabitants of Island Melanesia must have at least been engaged in foraging activities. Evidence for the deliberate transplantation of *Canarium* from New Guinea and for the limitations of natural tropical rainforest productivity strongly suggest that wild plant-food production was practised. Cultivation/agriculture is hinted at by the starch-full taro residues on stone tools, suggestive of selection from less-starchy wild forms, but this is hardly conclusive. The two quotations at the beginning of the paper necessitate consideration of the possibility of Pleistocene agriculture in Island Melanesia. Hayden really poses the question 'Why not?' Harris suggests that using current archaeological techniques we usually are unable to tell where any particular group of people using a site might be placed on a continuum from foraging to agriculture.

The possibility of movement in either direction should also be considered. Yen (1989:59) suggests that,

The naturalisation of a dominant crop in traditional Pacific Island systems, the great yam *D. alata* into the gathering systems of the northern Australians may indicate a receptivity to desirable species and a resistance to agricultural production.

It might, on the other hand, represent a relic of a previously agricultural system in northern Australia, transformed into a wild plant-food production or foraging system. It is after all merely an assumption that Australia has always been a continent of foragers.

Given that we are subject to a subsistence equivalent of Hawkes' ladder of inference in rela-

tion to the foraging to agriculture continuum, it is certainly premature to dismiss the possibility of Pleistocene agriculture in Melanesia or even Australia. There is no general agreement as to why agriculture developed, and so one must ask how there can be an argument limiting **when** it might have happened? Pleistocene agriculture: why not?

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PAMWAK ROCKSHELTER: A PLEISTOCENE SITE ON MANUS ISLAND, PAPUA NEW GUINEA

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Pamwak rockshelter is 4 km inland from the south coast of Manus Island in the Admiralty Islands, Manus Province of Papua New Guinea (Figs 1 and 2). The site was located in 1989 by Ambrose and Spriggs during a survey of possible occupation sites relating to the period of Holocene sea level stabilisation around 6000 BP. Pamwak is a large overhang shelter in a Miocene limestone outlier. It is presently 30 m above sea level, 100 m from the Losa River (called Chobur River on topographic maps) and near the edge of a swampy lowland plain which extends south to the coast (Fig. 3). The Losa River is navigable by canoe to the vicinity of the shelter. Terrain north of Pamwak consists of rugged upland, cloaked in secondary forest interspersed with cleared garden areas. Pam-

wak is used today as a temporary campsite during gardening activities.

THE EXCAVATION

Excavation of two square metres in 1989 revealed deep and rich cultural deposits but failed to reach bedrock. This prompted a second season of excavation, undertaken by Ambrose, Spriggs and Fredericksen in 1990 (Plate 1), in which the area was extended to four square metres. Bedrock was reached in only part of one of the squares (Square 1 – Fig. 4) at a depth of nearly 4 m. The excavation proceeded in 5 cm spits by quadrant for all four squares. Excavated material was wet-screened through mosquito wire (1.4 mm mesh) and sorted

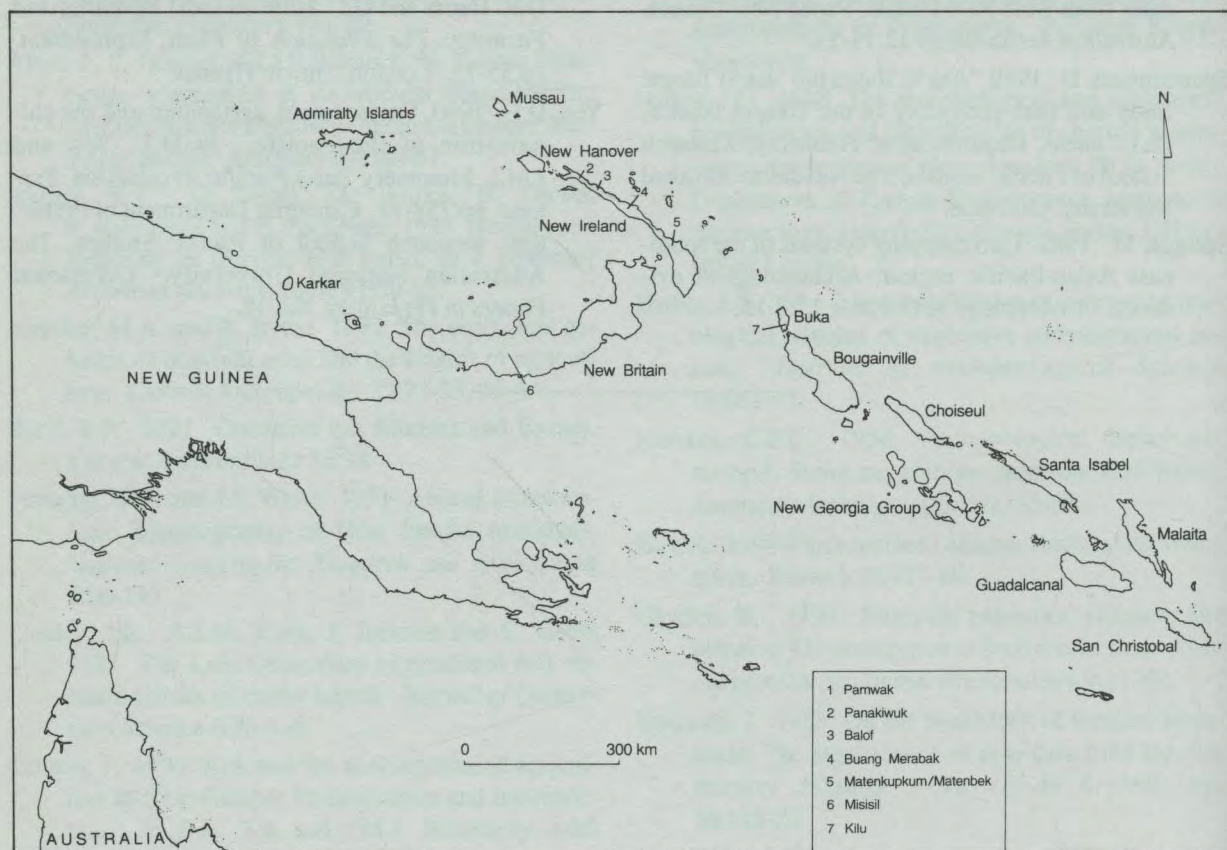


Figure 1 Location of the Admiralty Islands and sites mentioned in the text.

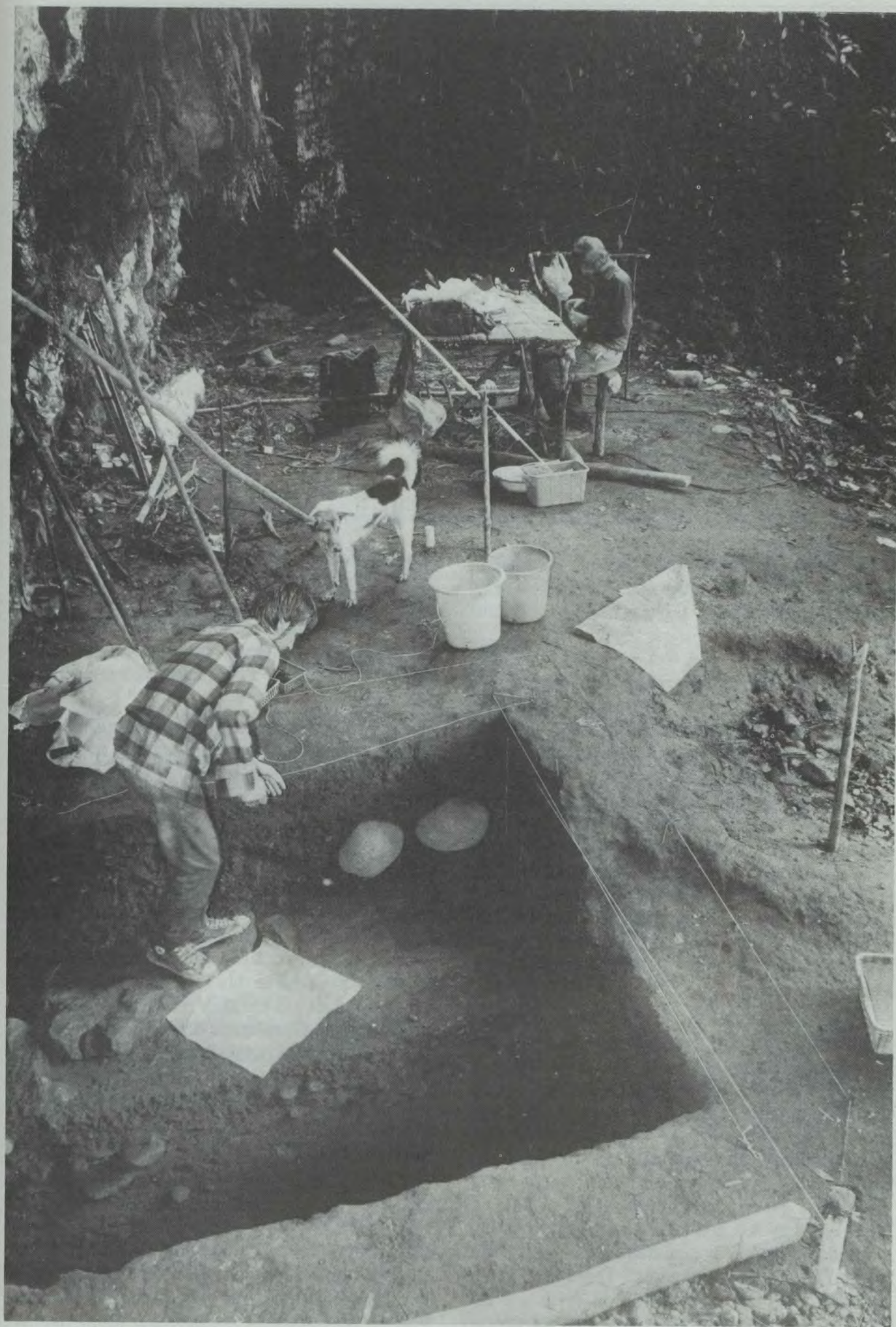


Plate 1 | Excavations at Pamwak Rockshelter, 1990 (photograph by W. Ambrose).



Figure 2 Admiralty Islands showing Manus and the location of Pamwak Rockshelter.

in the field. In addition bulk samples of screened residue were retained from selected quadrants for laboratory sorting.

Stratigraphy

Analysis of the stratigraphy is continuing, but seven main layers can be defined on the basis of obvious visual differences and (in some cases) on cultural composition (Fig. 4). The pronounced differences between Layer 7 and those above it are certainly the result of diagenesis and this may also be involved in some of the other layer divisions. The stratigraphy slopes down from north to south and west to east. Discussion of the depth of the layers from datum (just above ground surface) would therefore not be instructive without a more detailed exposition than is possible here. Figure 4 gives an impression of the general depth and thickness of each layer.

Layer 1 is a dark, loose deposit with shell, some obsidian and flaked stone, pottery, occasional bottle glass and a few trade beads. The layer relates to sporadic use of the shelter over the last 2000 years. Layer 2 is a dense marine and mangrove shell midden of mid Holocene age with associated oven stone fragments and obsidian flakes. Four radiocarbon dates on charcoal and *Celtis* (native elm) seeds have produced calibrated ages of 5500 to 7000 BP. Layer 3 is a mixture of mangrove shell midden and dark grey sediment, again with obsidian and oven stone fragments. There is as yet no consistent pattern of radiocarbon dates for this layer. It may represent a mixed or churned deposit or evidence of intermittent use of the shelter be-

tween major occupations represented by Layers 2 and 4. Layer 4 is a brown, fine-textured sediment with scattered shell in its upper part, and obsidian and small quantities of flaked stone throughout. Six radiocarbon samples on charcoal and *Celtis* cluster around 11,000 BP (calibrated after Stuiver et al. 1991).

Layer 5 is a dark grey to brown sediment with flaked stone and a very small quantity of obsidian. Numerous limestone fragments are present, the product of spalling from the shelter wall and ceiling. Although the section illustrated in Figure 4 shows Layer 5 thinning out towards the shelter wall, this was not the case in the southern part of the excavation, where the layer was the same thickness from the front to the rear of the shelter. Layer 6 is lighter in colour than Layer 5 and distinguished by numerous indistinct lenses. Nearly all the flaked material in this layer is stone, with only a few obsidian microflakes recovered. These are presumed to have filtered down through the section. Two charcoal dates, one from Layer 5 (ANU-6980, 12,400±80 BP) and the other from the top of Layer 6 (ANU-7124, 11,730±280 BP), suggest the change from flaked stone to obsidian occurred shortly after 12,000 BP (14,000 BP calibrated).

Layer 7 is a dense, rigid orange-brown clay almost devoid of organic material apart from occasional pockets of tiny charcoal fragments. Flaked stone continues nearly to bedrock within this clay. The layer appears to represent in situ weathering of the shelter sediments to clay, perhaps associated with the movement of groundwater along the surface of the limestone bedrock. No reliable radio-

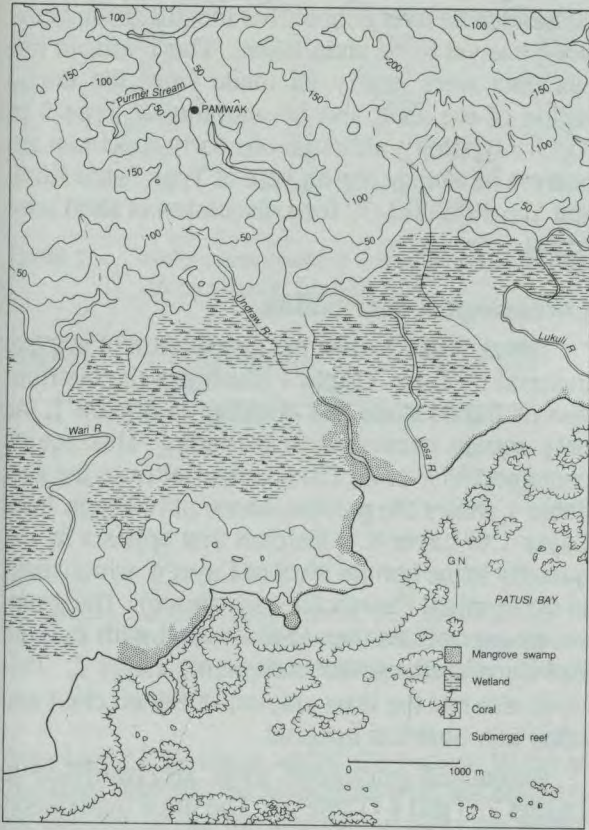


Figure 3 Local environs of Pamwak Rockshelter.

carbon dates are available for Layer 7 or the lower levels of Layer 6. Three dates on charcoal associated with these layers and obtained from more than 2 m below the surface of the rockshelter deposit fall within the early to mid Holocene, which is inconsistent with the series of 17 dates from the upper 2 m of the deposit. Possible sources of contamination for the lower dates are under investigation. Further charcoal samples from these lower levels will be submitted for accelerator mass spectrometry (AMS) dating.

Faunal and botanical evidence

Faunal material from Pamwak is being analysed by Corrie Williams of Monash University, while Dr Jon Hather of the University of London, Institute of Archaeology, is undertaking a pilot study of charcoal identification. The results of these studies are not yet at hand but some preliminary observations can be made. Faunal material is common in the site down to the top of Layer 6 and becomes progressively more weathered with depth. Sorting in the field suggested that bandicoot (cf. *Echymipera kalubu*) first appears in the sequence at approximately the time of the shift from flaked stone to obsidian. Bandicoot was presumably a human introduction from mainland New

Guinea. In these same levels charcoal deriving from carbonised *Canarium* nut fragments was first identifiable during field sorting. *Canarium* is also suggested as being a human introduction (see Spriggs, this volume).

THE ARTEFACT ASSEMBLAGE

Pamwak yielded a rich artefact assemblage. A total of 27.7 kg of flaked stone (mainly chert) and 28.8 kg of obsidian was recovered. Some chert bears evidence of water-rolling, indicating a stream or river source. During a one hour survey of a section of the Losa River numerous potentially usable cobbles of good quality chert were located. Further chert is available from the Purmet Stream which drains to the Losa north of the site (Fig. 3). A chemical characterisation study to ascertain possible geological sources for the obsidian is currently underway. Apart from the suite of pitchstone tools discussed below, very few retouched items are present among the flaked material (one notable exception is the tip of an obsidian spearpoint recovered from Layer 1). Most of the assemblage therefore falls within the general pattern for rockshelter sites in New Guinea and Island Melanesia. A quan-

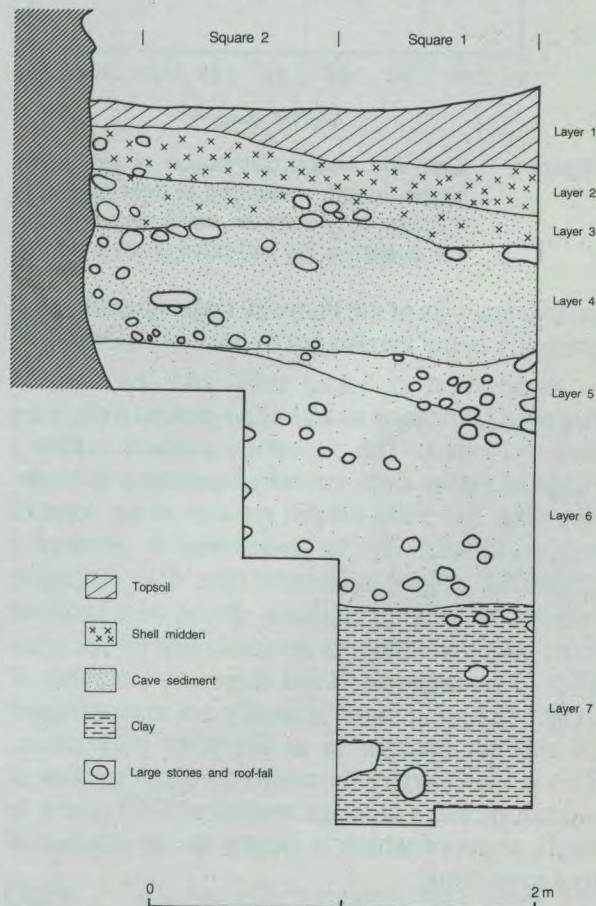


Figure 4 Pamwak, northern face of Squares 1 and 2 (see text for details of stratigraphy).

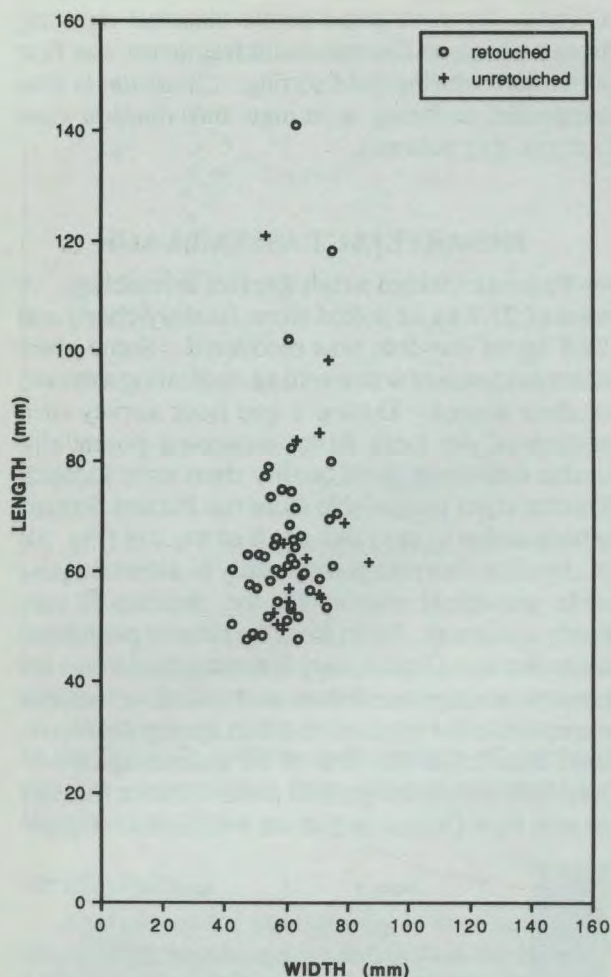


Figure 5 Size and shape distribution of pitchstone flakes (length measured at right angles to the point of percussion, width perpendicular to this across the mid-point of the artefact).

titative analysis of the Pamwak flake assemblage is presently being carried out by Fredericksen.

In addition to flaked stone and obsidian, 65 flakes of pitchstone and 21 edge-ground tools were also recovered. The pitchstone artefacts exhibit a range of forms, from virtually equilateral to blade-like (Fig. 5). Fifty exhibit retouch in the form of either unifacial flaking undertaken to produce a 'discoidal' shaped implement (Fig. 6) or flaking to remove the striking platform. Some were knapped from prepared cores, as demonstrated by the presence of pronounced dorsal ridges on a number of tools. The tools were probably not manufactured on site but brought in as complete implements. This is indicated by the relatively small amount of pitchstone flake debitage recovered (103 pieces in total), some of which is clearly the by-product of tool reworking.

The edge-ground implements consist of 16 *Tridacna* shell and five stone axes or adzes (Figs 7b, 7c; 8). One ground stone implement possesses side

notching or 'waisting'. Most appear to be manufactured from river cobbles but identification of the stone has yet to be undertaken. The *Tridacna* implements were nearly all made from the dorsal region of the shell and are variants of Type 3 in Kirch's typology, although one early specimen appears to be a hinge region adze of Type 7 (see Kirch and Yen 1982:211-30 for a discussion of shell adze types).

Chronological distribution

Tables 1 and 2 show the distribution of artefact material by layer. Table 1 illustrates the distribution of flaked stone and obsidian in Square 1, the only square excavated to bedrock. This square contained 35% of all flaked material from the site. Table 1 shows the predominance of obsidian from Layer 1 to Layer 4. Obsidian first appears in any quantity in the bottom level of Layer 4, which dates to the terminal Pleistocene (see above). The greatest amount of obsidian is associated with the mid Holocene shell midden comprising Layer 2. This layer also has the least amount of flaked chert and other non-obsidian material.

Retouched pitchstone tools are restricted to Layers 2, 3 and 4 (Table 2). The three implements

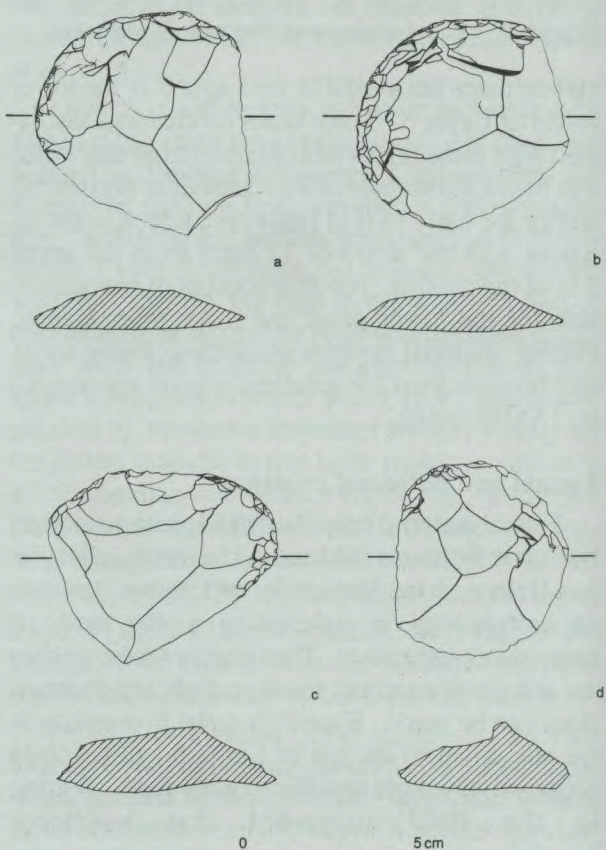


Figure 6 Retouched tools of pitchstone (illustrated with distal ends down). a and c are from Layer 3, b and d from Layer 4.

Layer	Stone		Obsidian	
	Weight (gm)	Count	Weight (gm)	Count
1	83.0	21	177.9	308
2	9.5	6	2121.0	1201
3	191.8	72	598.4	542
4	197.6	65	850.1	1209
5	554.8	379	4.1	8
6	9254.4	6180	1.4	3
7	5877.3	2415	0	0

Table 1 Weight and count of flaked stone and obsidian by layer in Square 1.

Layer	Edge-ground		Retouched
	Stone	Shell	
1	0	0	0
2	2	12	3
3	0	2	18
4	3	2	29
5	0	0	0
6	0	0	0
7	0	0	0

Table 2 Number of edge-ground implements and retouched pitchstone tools by layer for all squares.

from Layer 2 all occur within the bottom 10 cm of this layer and may be associated with the underlying deposit, where the majority of tools are found. Retouched implements occur throughout Layer 3 but are restricted to the top 50 cm of Layer 4. The appearance of these therefore postdates the introduction of obsidian but still lies within the terminal Pleistocene. These tools may be restricted to this period or may have continued in use until the mid Holocene. No definite conclusions can be drawn until the difficulties encountered in dating Layer 3 are resolved.

The vertical distribution of edge-ground tools shows a concentration in Layer 2 (Table 2). These implements occur throughout the shell midden constituting this layer. A late Pleistocene association for edge-ground tools is demonstrated by the presence of two *Tridacna* shell and three stone implements within the top 30 cm of Layer 4. Two of the stone tools from this layer have grinding only along their cutting edges while the third is a small fully ground chisel (Fig. 8a).

Assemblage variation

A number of models to explain assemblage variation at Pamwak are currently under consideration. If the site were to be viewed in isolation a simple model of terminal Pleistocene/early Holocene economic intensification might be entertained. But when the effects of post-17,000 BP sea level rise are taken into account, a model which incorporates Pamwak's position relative to the changing shoreline is more persuasive. During initial occupation

of Pamwak (we would suggest probably sometime prior to 20,000 BP), the site would have been approximately 10 km inland. The rockshelter would have perhaps functioned as an occasional overnight camp for a hunting or foraging coastally-oriented group. The stone technology at this time (evident in the lower levels of Layer 7) involved the use of mainly locally available chert for manufacturing unmodified flake tools. A similar pattern of stone-using behaviour (evident in Layers 5 and 6) remained until toward the end of the Pleistocene.

With the marine transgression, by 11,000 BP Pamwak would have been between 6 km and 7 km from the coast and perhaps more accessible to expanding mangrove swamps. At this time new resources may have been introduced in the form of the bandicoot and the valuable nut tree *Canarium*.

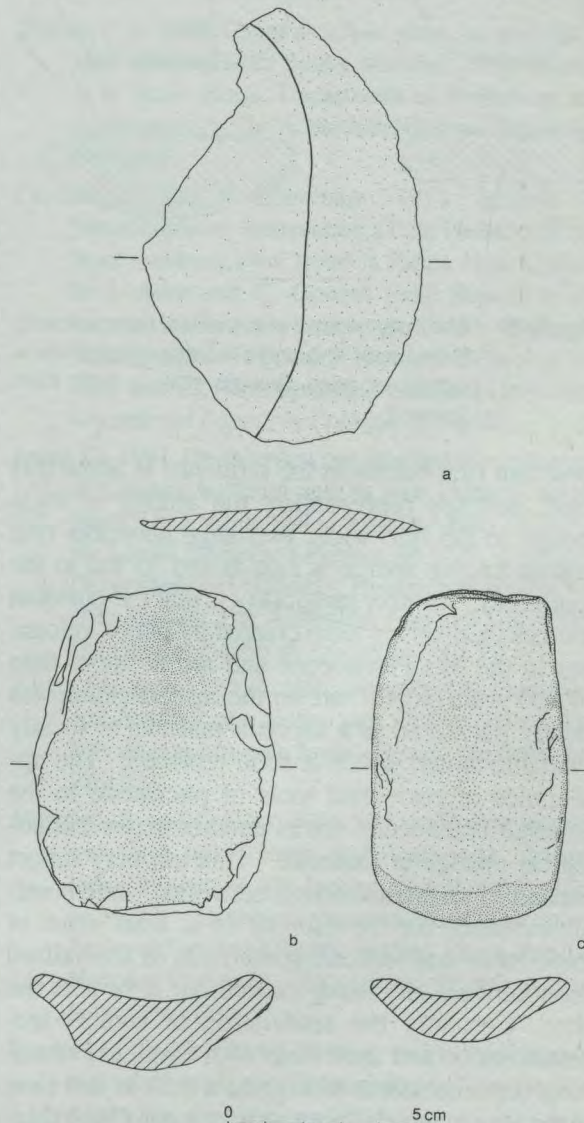


Figure 7 a = Blade-like pitchstone flake (distal end down), from Layer 3; b and c = *Tridacna* adzes or axes (bevels down), both from Layer 2.

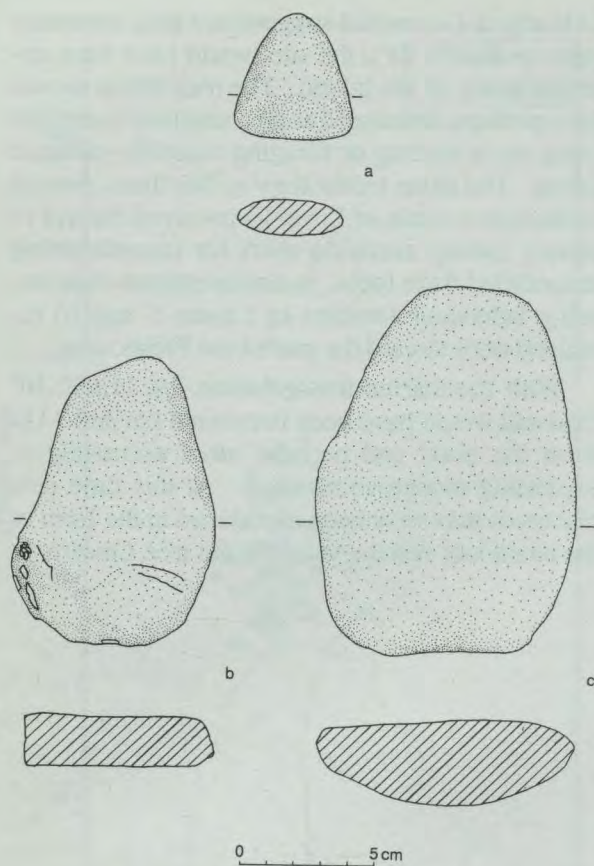


Figure 8 a = Fully ground stone chisel (bevel down), from Layer 4; b and c = Edge-ground stone adzes or axes (bevels down), both from Layer 2.

Obsidian first occurs in the sequence at about this time, perhaps representing the ability of local groups to tap into wider exchange networks (the nearest known source is Lou Island 35 km to the southeast). Another possibility is that the obsidian sources themselves were created by major volcanism in the late Pleistocene and are no more than 14,000 years old. Whatever the case, obsidian was clearly perceived as a superior material to locally available stone, which it soon replaced. The appearance of retouched tools of pitchstone in the terminal Pleistocene marks another major technological change at Pamwak. This too may reflect expanding communications networks, while possible evidence for the caching of at least some of these tools may indicate some form of specialised economic activity being carried out at or near the site. Certainly the association of some edge-ground stone and shell tools with terminal Pleistocene deposits seems to suggest a shift at this time in the way in which Pamwak was used. One explanation for the appearance of these implements might be the undertaking of forest clearance for agriculture in the vicinity of the site (see Spriggs, this volume).

The decreasing distance to the coast and changing balance of inland and sub-coastal areas made Pamwak an attractive location as a base camp or frequent visitation campsite. By approximately 6000 BP the coast may have been only about 1 km from the site. Access to coastal resources at that time is attested by the dense shell midden deposit of Layer 2. While not relevant to the theme of this volume, the subsequent abandonment of Pamwak and its only occasional use in the last 2000 years represents a common pattern in Island Melanesian rockshelter sites.

BEYOND PAMWAK

The quantity of stone flake material reported from other Pleistocene Island Melanesian sites is notably less than that at Pamwak. This can be illustrated by considering the density of flake material for all layers in these sites; between 36 and 109 pieces per cubic metre in Panakiwuk, Balof 2 and Kilu (Marshall and Allen 1991; White et al. 1991; Wickler 1990), as against more than 5000 per cubic metre from Pamwak. Artefact density may be more comparable at Matenkupkum (Gosden and Robertson 1991) where approximately 5600 gm of flake material were recovered per cubic metre in comparison with 8500 gm for the Pleistocene levels of Pamwak. A more striking contrast can be seen in the presence of a large number of formalised retouched and edge-ground tools in late Pleistocene and Holocene deposits at Pamwak. This suite of tools is absent from early contexts in other Island Melanesian sites. These major differences probably relate to the position of individual rockshelter and cave sites within local settlement patterns.

Of the known Island Melanesian rockshelter sites occupied in the Pleistocene, only Misisil on New Britain is situated further inland than Pamwak, and that only shows the most ephemeral use during the terminal Pleistocene (Specht et al. 1981). Kilu on Buka, and Matenkupkum, Matenbek, and Buang Merabak on New Ireland have always been near-coastal (Balean 1989; Gosden and Robertson 1991; Wickler and Spriggs 1988). Also on New Ireland, the Balof shelters (White et al. 1991) have never been much more than 2.5 km from the coast, and Panakiwuk (Marshall and Allen 1991) never more than approximately 4 km from the coast. In contrast, during Pleistocene occupation Pamwak was up to 10 km inland. This site may therefore have been the focus of different occupational uses to the other Pleistocene rockshelters and caves so far excavated in Island Melanesia. These sites may never have been the loci for activities which required an emphasis on the use or storage of stone tools.

These contrasts warn against simple extrapolation of models derived from Pamwak to other situations in Island Melanesia. Clearly more archaeological fieldwork is needed before a regional picture of inter-site variability can be obtained, although this does not mean that formulation of general models should be discouraged (see Gosden, this volume; Spriggs, this volume).

IMPLICATIONS FOR PLEISTOCENE COLONISATION

One area where the Pamwak evidence is of wider than regional relevance is that of Pleistocene voyaging range and abilities. As discussed by Irwin (1991:11-12), during the period for which we have evidence of human occupation the enlarged Pleistocene landmass of Manus was some 200 km from Mussau (for which there is as yet no evidence of pre-Lapita occupation), 230 km from New Hanover in the Bismarck archipelago and 220 km from Karkar Island just off the New Guinea mainland (Fig. 1). In voyaging to Manus neither two-way or even one-way intervisibility could have been maintained, necessitating a blind crossing of some 60-90 km. These distances represent the longest minimal open ocean crossing for which we have evidence in the Pleistocene world, and suggest that more direct routes from southeast Asia to Sahul (such as Timor to north Australia) across equivalent open sea distances could have been within the ability of Pleistocene seafarers of the region. The appearance in Pamwak of bandicoot and *Canarium* nuts possibly only towards the end of the Pleistocene suggests that more than a single, accidental voyage was involved in the process of settlement. Dating of the lower deposits at the site might tell us whether the settlement of Manus was appreciably later than the rest of the Bismarcks or whether the voyaging abilities attested for the terminal Pleistocene were possessed by the region's earliest settlers.

CONCLUSION

Analysis of the rich materials from Pamwak is still at an early stage but the potential provided by the assemblage for examining changes in Pleistocene to mid Holocene technology and economy can be clearly seen. Further dating (including AMS) should help clarify questions of the timing and rate of these changes. The evidence already to hand shows some important contrasts with other Bismarck Archipelago sites, suggesting caution should be exercised to avoid over-generalising from what is still a very small regional data set for the Pleis-

tocene. Pamwak does allow us, however, to appreciate more fully the voyaging abilities of the early seafarers who first settled the region.

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NORTHERN AUSTRALIA

1. The first part of the report deals with the general situation of the country and the results of the survey. It is followed by a detailed description of the various types of land use and the distribution of the population. The report also contains a list of the various types of land use and the distribution of the population.

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NORTHERN AUSTRALIA

NEW RADIOCARBON DATES FROM NORTH WEST CAPE, WESTERN AUSTRALIA: A PRELIMINARY REPORT

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In 1985, excavations at Mandu Mandu Creek rockshelter demonstrated that human occupation of the western coastal margin of the Cape Range Peninsula was well established by at least 25,000 years ago by people exploiting a variety of coastal resources including fish, crab and at least three species of marine mollusc (Morse 1988). As the arid conditions of the last glacial period intensified, the site was abandoned and not re-occupied until late Holocene times, although midden sites on the coast indicate that people were in the area by at least middle Holocene times (Kendrick and Morse 1982, 1990; Morse in press, a).

North West Cape Peninsula forms a finger of land, once known as Madmans Corner, which stretches into the Indian Ocean on the western extremity of the Australian arid zone. The backbone of the peninsula is formed by Cape Range, an extremely rugged limestone range dissected by numerous intermittently flowing creeks. Its western coast is bordered by Ningaloo Reef and on its eastern margin is Exmouth Gulf. Accessible fresh water is scarce on the Peninsula and to a great extent is dependent on cyclones. Yardie Creek is today the only above ground permanent source of fresh water.

Of major significance to archaeological research at North West Cape is the proximity of the edge of the continental shelf to the modern shoreline. At a distance of only 10 km, it is the nearest point on the Australian continent to the edge of the continental shelf.

In 1989 further excavations were undertaken at Mandu Mandu Creek and two other rockshelter sites in the foothills of Cape Range (Fig. 1). This paper briefly describes these sites and presents some preliminary excavation results and new radiocarbon evidence for human occupation.

MANDU MANDU CREEK ROCKSHELTER

The main purpose of the 1989 excavations at Mandu Mandu Creek rockshelter was to extend and attempt to duplicate the stratigraphic and archaeological sequences identified in the original exca-

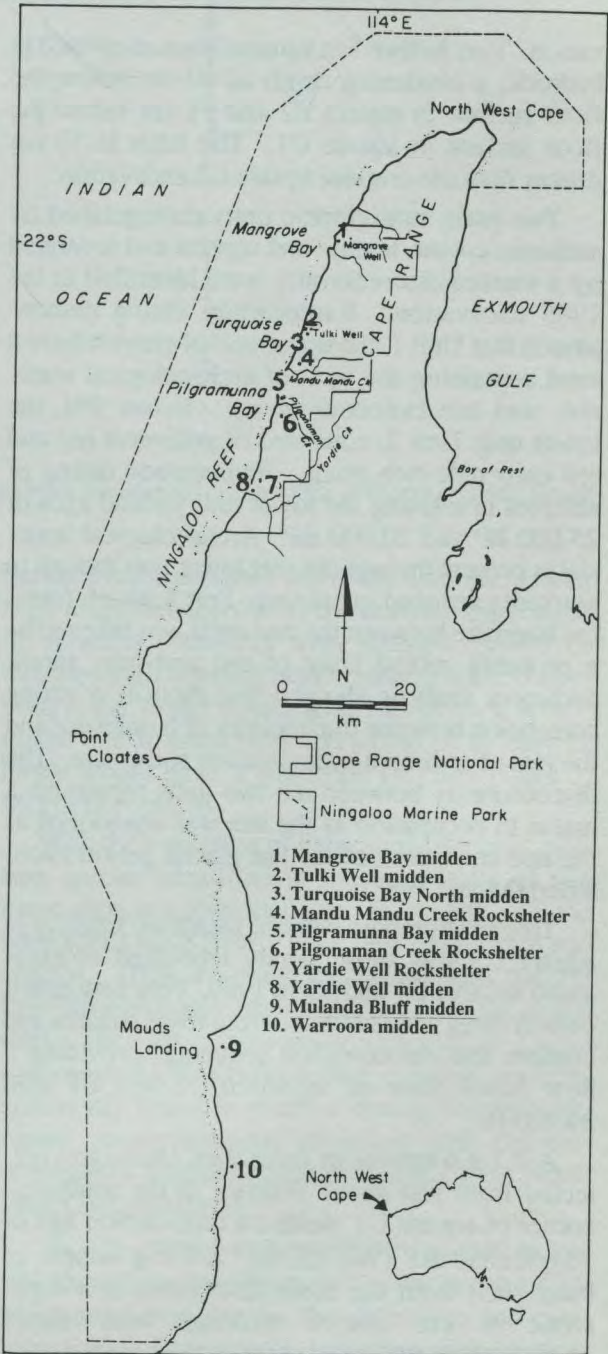


Figure 1 North West Cape peninsula showing excavated sites and coastal midden sites. Sites 2, 3, 9 and 10 date to the early or middle Holocene. Sites 1, 5 and 8 are undated.

Lab. Code	Square	Spit	Unit	Depth cm	Material	Conv. Age
WAIT 116	C3	2/3	1	10	charcoal	430 ±130
Wk 1512	E2	6	1	25-30	marine shell	1960 ±80
WAIT 117	C3	7	1	30-35	charcoal	2420 ±200
Wk 1511	E2	8	1	35-40	marine shell	5490 ±80
SUA 2614	C3	9	2	40-45	marine shell	20,040 ±440
Wk 1575	C1	14	2	65-70	marine shell	22,100 ±500
SUA 2354	C3	16/17	2	81	marine shell	25,200 ±250
Wk 1513	C1	18	2	85-90	marine shell	34,200 ±1050
Wk 1576	C1	19	2	91	marine shell	30,000 ±850

Table 1 Radiocarbon dates from Mandu Mandu Creek rockshelter. Depths are in cm below floor surface. None of the shell dates have been environmentally corrected.

vation. Two further 1 m squares were excavated to bedrock, a maximum depth of 80 cm below the floor surface in square E2 and 91 cm below the floor surface in square C1. The latter is 10 cm deeper than the original square C3 excavation.

Two main stratigraphic units distinguished by sediment colour, texture and content and separated by a marked disconformity were identified in the 1985 excavation. Radiocarbon dating demonstrated that Unit 1, the upper unit of greyish brown sand containing the bulk of archaeological material, was late Holocene in age. Below this, the lower unit, Unit 2, consisted of yellowish red and red carbonate rich sands. Radiocarbon dating of samples bracketing the lower unit yielded ages of 25,000 BP and 20,000 BP. Archaeological material is present throughout this lower unit though in markedly reduced quantities. Spit 8 which forms the interface between the two units was taken to be a probably mixed layer of red and grey sands. Sediment analysis showed that there is a strong correlation between the intensity of human use and the rate of sediment accumulation at this site. The disconformity between the two units represents a hiatus in occupation as the site was abandoned as the arid conditions of the last glacial period intensified (Morse 1988).

This stratigraphic pattern, identified initially in square C3 was subsequently replicated in excavated squares C1 and E2 in 1989. Five new radiocarbon dates were obtained from these squares and confirm the chronological sequence, providing a new basal date of between 30,000 BP and 34,200 BP.

A 2.7 g fragment of baler shell (*Melo* sp.) collected from just above bedrock in the southwest corner of square C1 yielded a radiocarbon age of 30,000±850 BP (Wk 1576). A 9.1 g sample of baler shell from the northwest corner at a depth some 6 cm above bedrock was dated 34,200±1050 BP (Wk 1513). X-ray diffraction analysis demonstrated that the dated samples consisted of primary aragonite. However isotopic analysis indicated that there was a 30% contamination with groundwater carbon dioxide leading to the

older sample appearing to be between 950 and 1250 years too old (C. Hendy pers. comm.). A date of ca.32,000 BP is taken as an approximate age for this occupational horizon. Table 1 lists the nine radiocarbon dates available from Mandu Mandu Creek rockshelter. With the exception of an inversion of the two basal dates the chronological sequence is internally consistent.

A date of 5490±80 BP (WK 1511) from spit 8 in square E2, indicates that the site was in fact re-occupied in mid Holocene times and was therefore being used at the same time as the midden sites on the adjacent coastline.

Archaeological material including stone artefacts, marine shell and marine and terrestrial fauna is present in both stratigraphic units, although the vast majority was recovered from the upper Holocene unit (Fig. 2). The Holocene marine fauna is represented by at least four species of fish, crab, sea urchin and rare fragments of turtle bone and shell. In the Pleistocene layers fish bone occurs only in spit 10 and above. Crab and sea urchin are first found in spit 13. Below this the only marine fauna represented are fragments of marine mollusc shell. Holocene terrestrial vertebrate fauna includes macropod, bandicoot (*Isodon auratus*), bettong (*Bettongia lesueur*), brush-tailed possum (*Trichosurus vulpecula*) and at least five species of native mice or rats. Several of these species are now locally extinct. Bone in the Pleistocene unit is sparse, extremely brittle and fragmented and covered in a red carbonate cement. No bone at all was recovered between spits 10 and 18 in square C1 and only 1.3 g was present in the basal Pleistocene layers in square E2. In spits 18 and 19, the basal two spits of square C1, bones of a thylacine (*Thylacinus cynocephalus*) and of an agile wallaby (*Macropus agilis*) were identified. This latter is presently restricted to areas of tropical coastal Australia (Strahan 1991:242).

Ochre and fragments of emu eggshell are present in the deposit, peaking in layers dated between 25,000 BP and 20,000 BP. No local sources of ochre are known on the Cape Range Peninsula. The nearest known sources are in the Hamersley

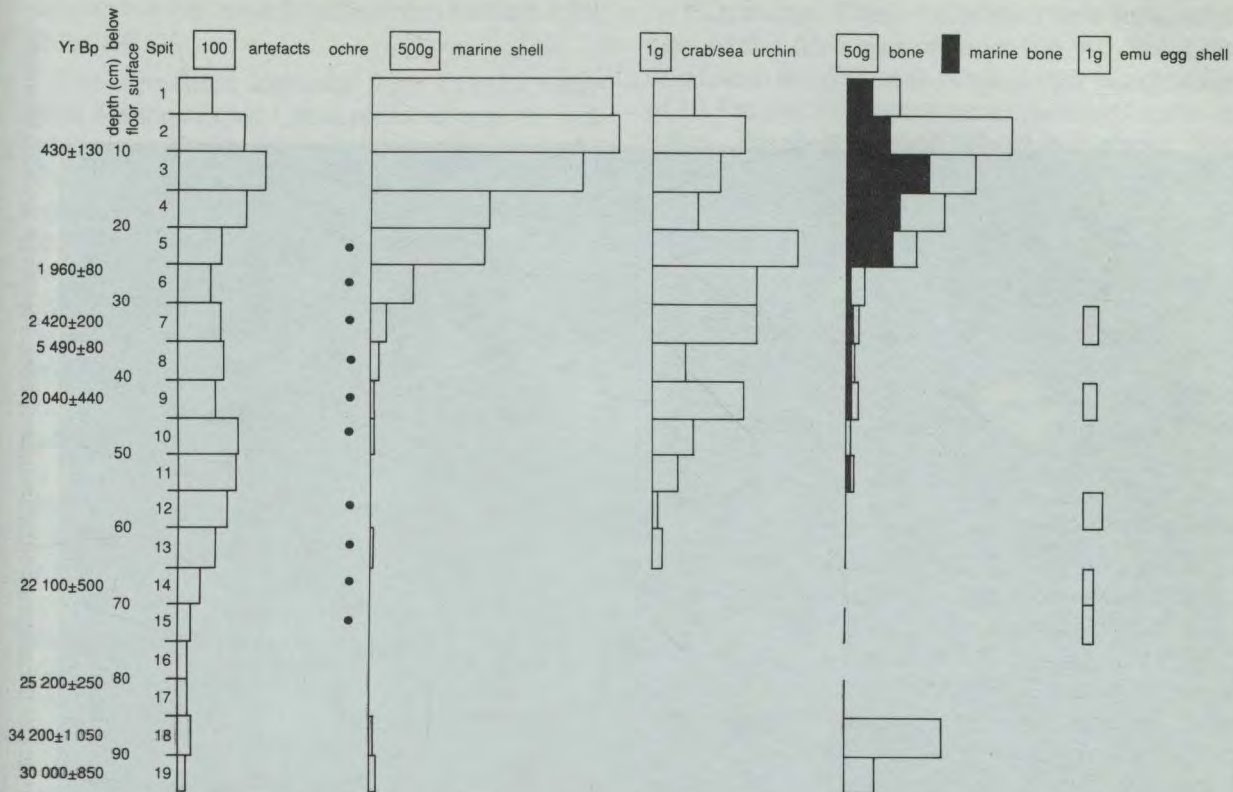


Figure 2 Distribution of archaeological material excavated from squares C1, C3 and E2 at Mandu Mandu Creek rockshelter.

Plateau some 300 km to the north east or at Wilgie Mia some 850 km to the south east. No other ochre sources are known or are considered likely to occur in the region. The presence of ochre in both stratigraphic units points then to the existence of long distance trading networks during both Pleistocene and Holocene times.

In spits 18 and 19 in the basal 9 cm of deposit in square C1, in the same layer as the dated baler fragments (85-95 cm below the floor surface) a marked abundance of archaeological material including 23 small cone shells (*Conus* sp.) and fragments was recovered. With the exception of one very small shell, all the *Conus* material has been deliberately modified as beads. The majority consist of a section of shell spire. Their apex has been perforated with a rounded hole and their body whorl removed to form a shell ring between 2.9 and 9.6 mm long (mean length 6.3 mm) and between 7.2 and 12.7 mm in diameter (mean diameter 10.06 mm).

Six of the shell-beads are whole. Their apex is perforated and their internal structure cleanly broken to form a hollowed out shell with a rounded hole in the top. One of these shells is broken in half lengthways; the largest shell measures 21.1 mm long; the maximum diameter is 12.4 mm. Two of the intact shells have a notch worn into the edge of

the shell at the posterior end of the aperture. Under high magnification (40 x) the notches show signs of abrasion consistent with notches formed on threaded shell artefacts held in ethnographic collections at the Western Australian Museum. It is estimated that if assembled, the strand of at least 22 beads would have a length of 180 mm (Plate 1; Morse in press, b).

With the exception of baler shell, the only mollusc species identified in the basal spits of this excavation are cone shells and fragments. All the cone shells have clearly been selected for size and species. Their worn and etched surfaces suggest they have probably been collected from the beach drift. They are provisionally identified as *Conus dorreensis* (G.W. Kendrick pers. comm.), a species commonly found in shallow waters on reef platforms, an environment consistent with the predominantly reefed western shoreline of the North West Cape peninsula.

Though clearly well established in mid to late Holocene Australia (Pretty 1977; Macintosh 1971), Pleistocene evidence for the decorative and ceremonial use of ornaments, including shell beads is sparse (Dortch 1979; Bowler et al. 1970). The shell beads from Mandu Mandu Creek rockshelter extend the age of human use of ornamentation in Australia to a time comparable to some of the

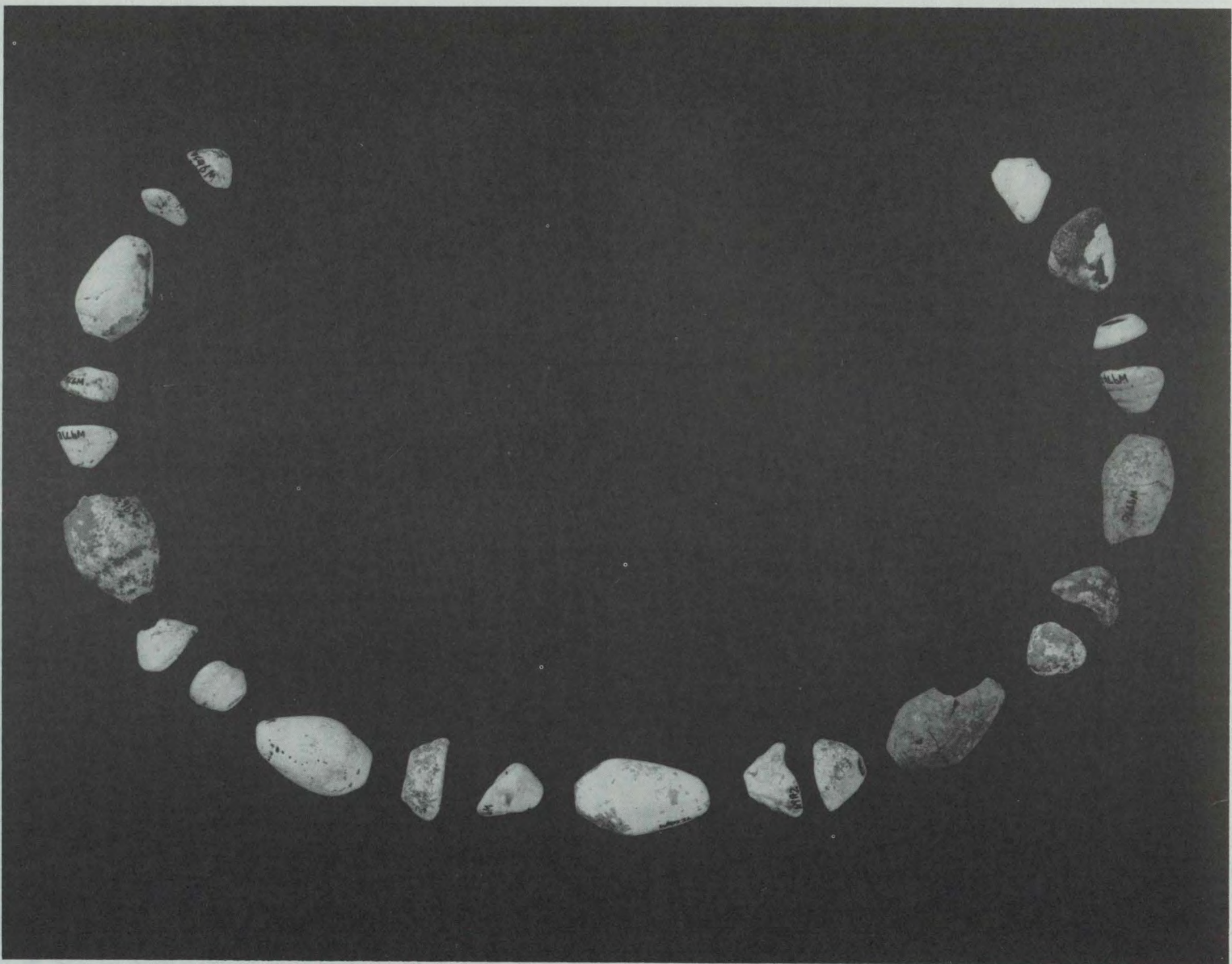


Plate 1 Hypothetical reconstruction of the shell beads, dated to ca. 32,000 BP, as an ornament (Photographed by Douglas Elford, Western Australian Museum).

earliest such evidence from Europe (Mellars 1989; Soffer 1985).

The new dated sequence from this site establishes Mandu Mandu Creek rockshelter as the oldest securely dated site in northwestern Australia. While the new dates extend and also confirm the sequence from the original excavation, a date from the top of the lower red unit in square C1 could provide an important test for the chronological sequence. The three available dates from this square are all obtained from the basal 30 cm of deposit. Above the upper most of these dates ($22,100 \pm 500$ BP Wk 1575) is a further 40 cm of undated red sediment. The amount of archaeological material, notably marine shell, present in the upper levels of the red unit compared to that found in the lower levels, suggests that a sample from this part of the deposit would yield an age more or less contemporaneous with the date of 5490 ± 80 BP obtained from spit 8 in square E2. The striking reduction in shell and other archaeological material beneath spit 8 in square C1 suggests that this marks the interface between the Pleistocene and Holocene units. The depth of sedimentation between the spit 14 date of $22,100 \pm 500$ BP (Wk 1575) and spits 8 and 9 is seen as a reflection of the intensity of site use at this time. Artefact discard rate in this part of the deposit is second only to that in the terminal Holocene (cf. O'Connor et al., this volume). However in the context of evidence from the other two excavated sites, the possibility of an earlier Holocene date from the top of the red unit in square C1 cannot, at this stage, be completely discounted.

PILGONAMAN CREEK ROCKSHELTER

Pilgonaman Creek is one of the many intermittently flowing creeks which drain from gorges in Cape Range down to the sea. About 500 m south southwest of Pilgonaman Creek are a series of rockshelters. The largest of these, Pilgonaman Creek rockshelter, was selected for excavation. Located in the Milyering Terrace about 35 m above the coastal plain, this site commands a panoramic view to the shoreline some 1.75 km to the west.

Pilgonaman Creek rockshelter is a substantial cave with a floor area of some 105 m². From the drip line to the very back of the shelter is a distance of 10.5 m and the shelter has a maximum width of 9.5 m. The shelter is well lighted throughout. The inside roof maintains its height of 2 m almost all the way to the back, although around the side walls it is just over 1 m above the ground. Inside the shelter entrance on both the northern and southern walls, rock ledges form shelves at about eye-level height. A large fragment of baler shell was found on one of these shelves.

Two 1 m² pits, squares D3 and C2, were excavated at this site. During excavation the stratigraphic sequence identified in the excavated squares appeared to replicate more or less the stratigraphy described for Mandu Mandu Creek rockshelter. On the basis of the colour and texture of the sediment the deposit can be divided into two stratigraphic units, an upper grey unit and a lower red unit.

Attempts to obtain a coherent dated sequence at this site are proving problematical and at present the timing of human occupation remains unresolved. Only one date has been obtained from the upper grey unit. A charcoal sample collected from the base of spit 7 in square D3 yielded a radiocarbon age of 480 ± 65 BP (Wk 1474).

All available visual evidence, that is, the absence of charcoal, the texture and colour of the sediment, the marked decline in the amount of faunal and artefactual material and the presence of carbonate cement encrusted on all archaeological material, pointed to a Pleistocene age for the lower red unit. Table 2 lists radiocarbon dates currently available from this site.

The charcoal date of 4950 ± 300 BP (Wk 1475) from spits 14 and 15 is clearly at odds with the stratigraphic and archaeological context and is inconsistent with the dated sequence. The sample consisted of less than 1 g of charcoal obtained by amalgamating all charcoal collected from spits 14 and 15. This sample did not derive from a feature but consisted of discrete fragments retrieved during sieving. Two unidentified nacreous fragments of marine shell recovered from spits 15 and 13 have

Lab Code	Square	Spit	Depth cm	Material	Conv. Age
Wk 1474	D3	7	30-35	charcoal	480 $\pm$ 65
R16098/2	D3	9	40-45	shell	10,150 $\pm$ 66
Wk1520	C2	12	60-65	shell	9990 $\pm$ 270
R16098/1	D3	13	65-70	shell	31,770 $\pm$ 390
Wk1475	D3	14/15	65-75	charcoal	4950 $\pm$ 300
R11879/1	D3	15	70-75	shell	17,410 $\pm$ 330

Table 2 Radiocarbon dates from Pilgonaman Creek rockshelter. Depths are in cm below floor surface. None of the shell dates have been environmentally corrected.

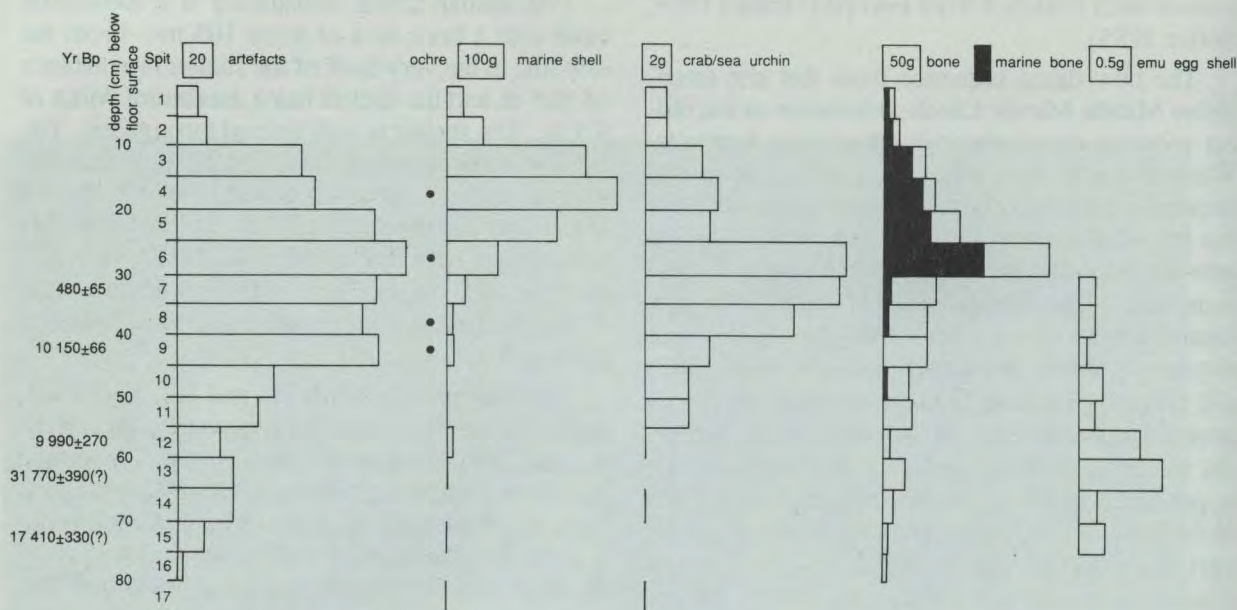


Figure 3 Distribution of archaeological material excavated from squares C2 and D3 at Pilgonaman Creek rockshelter.

since been dated using accelerator mass spectrometry. While both samples have yielded Pleistocene dates (R16098/1; R11879/1) they are significantly different and the age of this part of the deposit remains as yet unresolved.

Although there are no sterile layers in the archaeological deposit at Pilgonaman Creek rockshelter, the present sequence suggests that, throughout its occupational history, use of the site has been at best ephemeral. The Holocene dates from both squares point to an occupation that, unlike Mandu Mandu Creek rockshelter, has spanned all or most of the Holocene. The case for abandonment of this site during the glacial maximum is yet to be made. A shell date of 17,410 BP from spit 15 provides tantalising evidence of a human presence at North West Cape at the height of the Pleistocene arid phase. Moreover, if confirmed, it will provide the first hard evidence that, people on some parts of the Australian coast, followed the retreating Pleistocene shoreline in response to the increasingly arid glacial conditions (cf. Veth 1989:85).

The date of 31,770±390 BP (R16098/1) from spit 13 clearly calls this interpretation into question. Close scrutiny of the dated samples for possible contamination and dating of further selected samples must be considered before the chronological tangle outlined here can be unravelled.

The great majority of archaeological material at this site is concentrated in the topmost spits of the upper grey unit (Fig. 3). Faunal material in these most recent layers includes marine shellfish, crab,

sea urchin, fish, turtle, euro (*Macropus robustus*), rock wallaby (*Petrogale* sp.), bettong (*Bettongia lesueur*), quoll (*Dasyurus hallucatus*) and a number of native rats and mice. Shellfish, crab and sea urchin are present throughout much of the lower red unit. Identified bone includes fish, two species of bandicoot (*Macrotis lagotis*; *Isoodon auratus*), bettong (*Bettongia lesueur*) and a medium sized macropod. Below spit 13 the bone is unidentifiable. Fragments of marine mollusc shell continue to bedrock.

Ochre and emu eggshell were also recovered from the deposit, the latter concentrated in the basal layers of the site (Fig. 3). Today emus at North West Cape breed during the months of April and June and are always found within a 20 km radius of a water source. The presence of emu eggshell fragments is therefore an indication of both the seasonality of occupation and the availability of freshwater at North West Cape.

The absence of ochre in the lower levels of the red stratigraphic unit is also worth noting and would appear to tie in with the date of 17,410 BP. Given the presumed restriction on movement during the time of glacial aridity, one would not expect to find ochre in these levels if the site was in fact utilised during the height of arid conditions. The absence of ochre then, is consistent with arguments (Hiscock 1984; Veth 1989) that during arid conditions people reduced their territories, and long distance trade networks established prior to the glacial period, as shown at Mandu Mandu Creek rockshelter, were no longer operational.

YARDIE WELL ROCKSHELTER

Yardie Well Rockshelter, the third site excavated, was the largest limestone rockshelter we could find near Yardie Creek. Located in the Jurabi Terrace some 2.2 km north of Yardie Creek, it is best described as a small limestone overhang. Massive slabs of limestone roof fall at the front of the site clearly indicate that today we are looking at the very back of a site which was much larger in the past. The front of the shelter is 6 m wide, though it opens to a width of nearly 9 m. From front to back it measures only 4 m and roof height is a maximum of 1.94 m above the floor declining to 1.18 m at the back wall.

A 1 m grid was laid out. Square C2, located just under the edge of the existing roof in what is today the central front section of the site, was selected for excavation. Despite its forward location, the excavated square was barely 2 m from the back wall. After an initial surface layer of soft, easy-to-dig grey sandy soil, the deposit was cemented by insect cases. Excavation continued but the deposit had to be loosened continually using a geological hammer before trowels could be used effectively. As available time was limited the excavation was reduced, at the base of spit 10, to cover only the two northerly quadrants (NE and NW) of the original square. The insect cases, formed most probably by wasps or bees (T. Houston pers. comm.), effectively cement the surrounding sediment, and continued to a point some 65 cm below the floor surface. Bedrock

Lab Code	Spit	Depth cm	Material	Conv. Age
Wk 1476	7	30-35	shell	5530 ±80
Wk 1477	11	50-55	shell	7290 ±110
R11879/2	20	95-100	shell	10,490 ±100

Table 3 Radiocarbon dates from Yardie Well rockshelter. Depths are in cm below floor surface. None of the shell dates have been environmentally corrected.

was finally reached at the bottom of spit 20, at a depth of just over 1 m from the modern floor.

Visually the Yardie Well deposit can be broken into three stratigraphic divisions. Beneath spit 1, the disturbed surface spit, the upper unit consists of dark brown (7.5 YR 3/2) fine to very fine sands extending irregularly to a depth of some 30-35 cm below the floor surface. Below this, soil colour changes to a dark reddish brown (5YR 4/4) to reddish brown extending to the base of spit 10 – a depth of some 50 cm below the floor surface. Both of these upper units are cemented hard with insect cases. Sediment in the basal unit, from spit 11 to bedrock at spit 20, consists of loose yellowish red (5 YR 5/8) carbonate rich sand. Insect cases cease approximately in spit 13. Table 3 lists radiocarbon dates available from this site.

Archaeological material is sparse throughout the Yardie Well deposit (Fig. 4). Like both Pilgonaman Creek and Mandu Mandu Creek rockshelters the great majority of archaeological material is

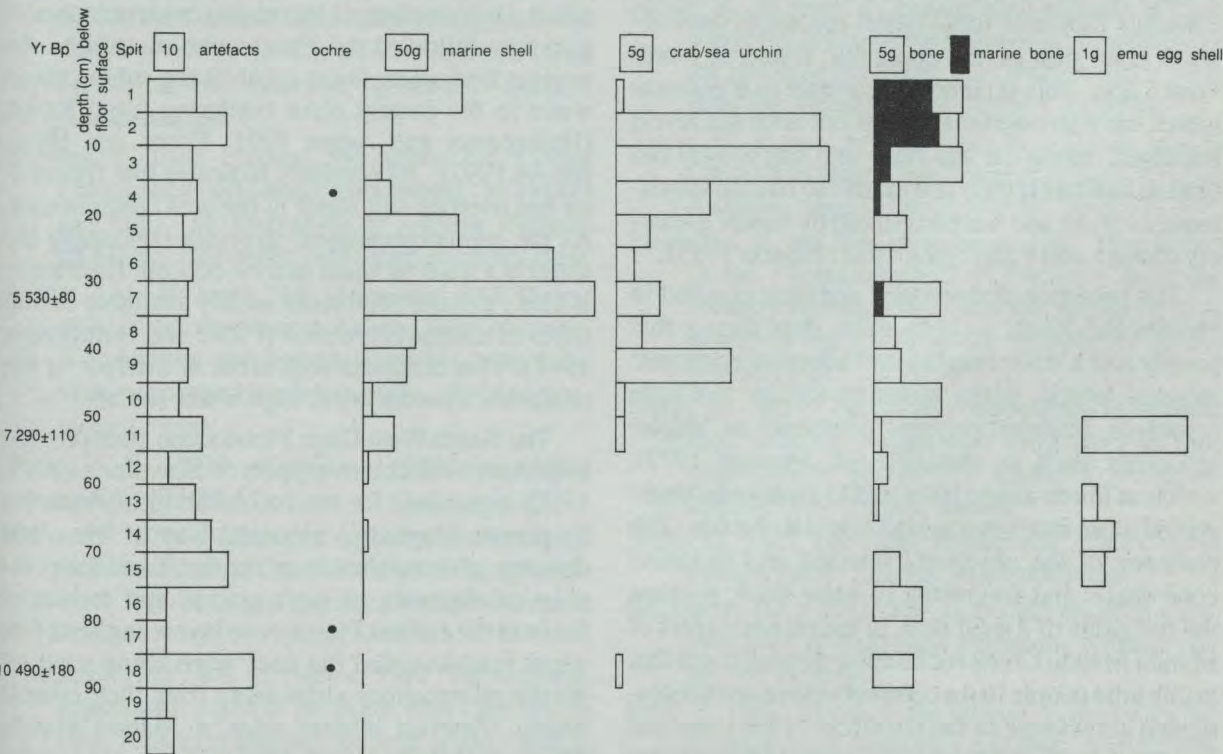


Figure 4 Distribution of archaeological material excavated from square C2 at Yardie Well rockshelter.

found in the upper unit. With the exception of a fragment of crab carapace in spit 18, mollusc shell, crab and sea urchin are only present in spits 15 and above. Spit weights for this material peak in levels immediately above the date of 5530 ± 80 BP (Wk 1476) from spit 7. In the earliest Holocene layers shell material is identifiable only as mollusc fragments. Bone is extremely sparse throughout the deposit. With the exception of fish (*Scarus* sp.) in the upper unit, the only other identifiable fauna are a bandicoot (*Isodon auratus*) in spit 3 and a macropod in spit 10. While this scarcity may in part reflect the intermittent or low level pattern of occupation of this site, it is also probably in part a function of the location of the excavated square at the back of the rockshelter.

The archaeological sequence at Yardie Well rockshelter differs from both that of Mandu Mandu Creek and Pilgonaman Creek rockshelter in providing evidence for intermittent human occupation that spans the Holocene only.

A PRELIMINARY INTERPRETATION

Some 32,000 years ago the Pleistocene coastline would have been located some 4–5 km west of the foothills of Cape Range. At this time, and perhaps slightly earlier, sites such as Mandu Mandu Creek and possibly Pilgonaman Creek rockshelters were first occupied. Occupation of these sites has always been at best intermittent, but the available evidence indicates that coastal resources have always been part of the economic round at North West Cape. This is clearly in contrast to arguments which have stressed that it was not until sea levels stabilised during the late Holocene that coastal and marine habitats highly favourable to human subsistence evolved and were exploited by hunter gatherers (Bailey and Parkinson 1987; Beaton 1985).

The presence of macropod and emu eggshell in Pleistocene levels in both these sites shows that people had a wide ranging and adaptive economic strategy which, while targeting locally available resources, included perhaps 'preferred' or 'staple' resources such as shellfish (cf. Meehan 1977), which at times would have had to have been transported more than several kilometres to the site. The presence of the obviously selected and modified cone shells and fragments of baler shell, perhaps the remnants of a shell dish, in the earliest layers of Mandu Mandu Creek rockshelter demonstrates that at this time people had a comprehensive and sophisticated knowledge of the resources of the coast and that some form of decorative or ceremonial activity was an integral part of life.

Trade and art are commonly taken as indices of complexity in Holocene Australia (Lourandos 1985). The presence of ochre in Pleistocene levels in Mandu Mandu Creek rockshelter indicates that the inhabitants of North West Cape were part of what must have been a wide ranging trading and social network which operated in both Pleistocene and Holocene times. The shell ornaments establish the antiquity of decorative traditions in Australia, and demonstrate that behavioural patterns commonly linked with biologically modern human populations were established at an early age in both northern and southern hemispheres.

The Holocene evidence from Yardie Well and Pilgonaman Creek rockshelters and from the coastal midden sites, documents a strategy of flexible and adaptive occupation which targeted the changing shoreline. I suggest that a similar strategy was operating during the Pleistocene. The offshore reef system at North West Cape would have provided a local resource able to support viable social groups on the coast and use of the hinterland is likely to have become increasingly opportunistic during glacial conditions.

While it is possible that dating of the upper layers of the lower red unit in square C1 in Mandu Mandu Creek rockshelter may provide evidence of an earlier Holocene occupation, this would not greatly change the pattern of occupation and abandonment documented for this site. And if we ask where the one time occupants of this site went as the arid conditions of the last glacial period intensified, I believe there is increasing evidence to show that they followed the Pleistocene shoreline. An ancient freshwater fauna inhabits the subterranean water in the coastal plain bordering Cape Range (Humphreys and Adam 1991; Poore and Humphreys 1992). Its presence indicates that freshwater has overlain salt water in the area continuously. As the geomorphological structure containing the water is a shallow water marine deposit, freshwater is likely to have been more widely available during times of marine regression (Poore and Humphreys 1992). This contrasts with areas at the foot of the peninsula where there is high water salinity.

The North West Cape Pleistocene sites provide important evidence in support of Bowdler's (1977, 1990) arguments for the colonisation of Australia by people adapted to a coastal way of life. The distance of these sites from the coast and the presence of elements of both marine and terrestrial fauna in the earliest Pleistocene layers suggests that when first occupied the sites were being used by people on transitory visits away from their coastal bases. Artefact discard rates at Mandu Mandu Creek rockshelter and, as has been argued by O'Connor et al. (this volume), at many north west-

ern Australian Pleistocene sites, show that the intensity of occupation just prior to the glacial maximum was second only to that during the late Holocene. Yet the evidence for a human presence in the arid zone during the last glacial period is sparse (cf. Veth 1989). The question must be asked then, where did these people go? Perhaps we should look to the Pleistocene coastline as a major refugia of the arid period.

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THE HUMAN OCCUPATION OF CUCKADOO 1 ROCKSHELTER, NORTHWEST CENTRAL QUEENSLAND

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Cuckadoo 1 rockshelter is situated 120 km south of Cloncurry on the west bank of Sandy Creek, which drains south from the Selwyn Range into Lake Eyre by way of the Georgina River (Fig. 1). Davidson and Sutton recorded the site in 1986, and excavated it in 1987 and 1989. Radio-carbon dates, obtained after the first season from charcoal close to the bottom of the deposit, gave a value of $15,270 \pm 210$ BP (Beta 25058). This date is

the oldest associated with artefacts in the Lake Eyre basin. In this paper we discuss the stratigraphy, the artefacts and the pattern of dates of occupation revealed by the excavations of Cuckadoo 1.

SETTING

Cuckadoo 1 is a rockshelter formed in an isolated outcrop of highly weathered Proterozoic

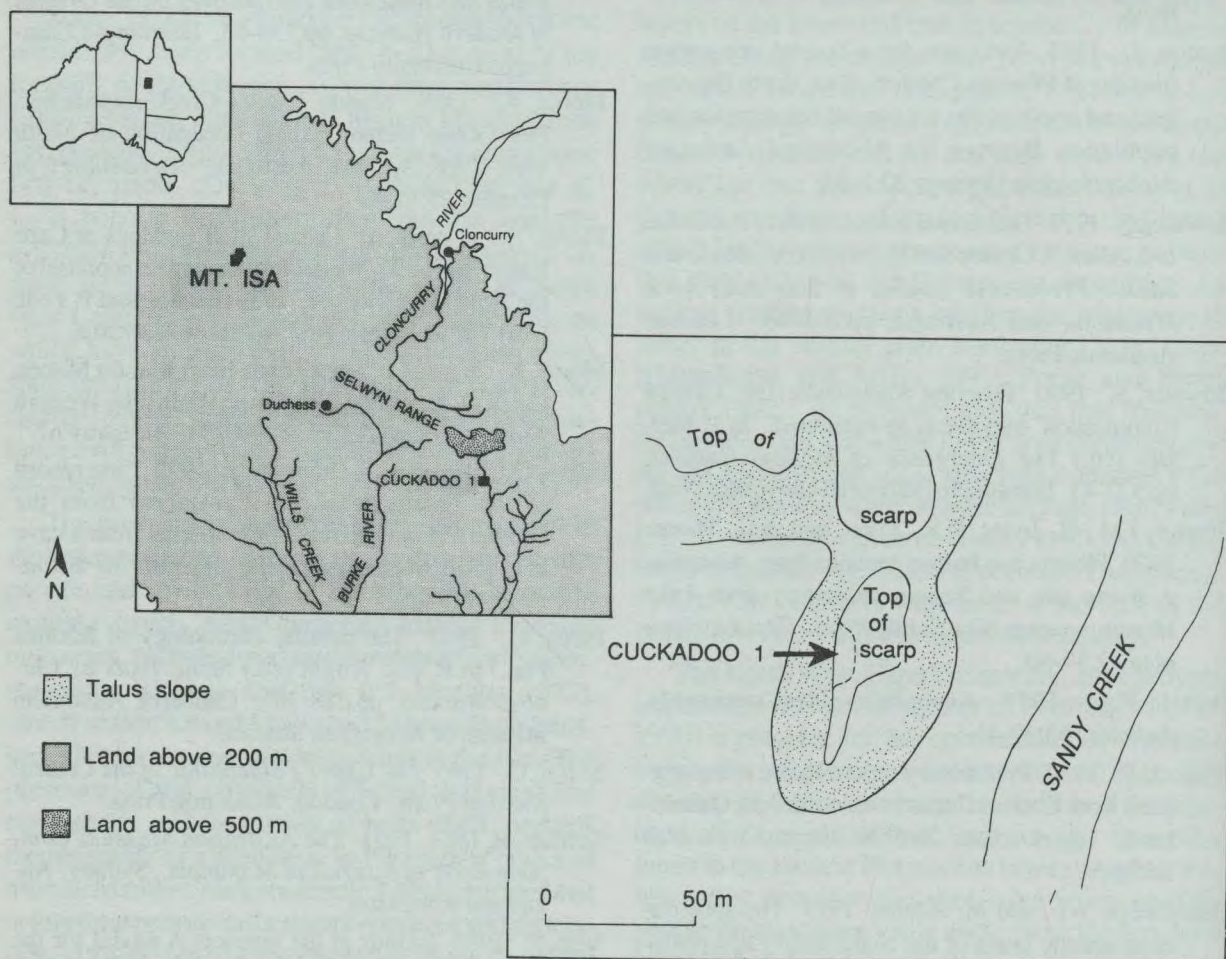


Figure 1 Location of Cuckadoo 1 rockshelter, northwest central Queensland.



Plate 1 Cuckadoo 1 rockshelter, view looking southeast. (I. Davidson).

granite (Plate 1). This granite is unconformably overlain by the fluvial sandstones and conglomerates of the late Jurassic-early Cretaceous Gilbert River formation, outcrops of which occur within 50 m of the rockshelter. To the north of the shelter and elsewhere in the central part of the range, metamorphosed Proterozoic sedimentary rocks are intruded by the granites. To the south of the shelter, in the foothills of the range, Quaternary alluvial plains are predominant. In the range itself, the major valleys are deeply incised, forming steep cliffs and isolated mesas. The valleys are infilled by Quaternary alluvium, which, locally, is largely derived from the granite.

Gale's study of the Gilbert River formation across the Selwyn Range has shown that the present major valleys are largely developed along the lines of the pre-Gilbert River formation valleys, suggesting that the major drainage lines have maintained their position over a period of 150 million years. The only exception to this is along the main divide, where tectonic warping in the late Mesozoic-early Cenozoic had the effect of shifting the continental drainage divide to the south. This truncated the southward-flowing channels and reversed the direction of flow of the northward-flowing channels in the highest part of the range. Within the valleys, the modern streams appear to have experienced

frequent lateral shifts, a process which probably continues to the present. The channels are stable only where they pass through rocky barriers, as at Cuckadoo 1 itself. Here a waterhole, known as Wildman Soak, provides the most reliable water in the valley.

Detailed studies of the vegetation and land systems will be presented elsewhere. The granite tablelands are relatively simple floristically, with a low open snappy gum (*Eucalyptus leucophloia*) woodland, hardly any shrubs, and spinifex (*Triodia* sp.) in the herb layer. The granite hills, however, have low open western grey box (*E. leucophylla*) woodland to shrubby woodland, with substantial amounts of bloodwood (*E. terminalis*), and a shrub layer dominated by turpentine bush (*Acacia chisholmi*). There is high floristic diversity in the ground- and mid-strata. The wide alluvial and colluvial plains have a low open woodland of bloodwood and whitewood (*Atalaya hemiglauca*) with occasional beefwood (*Grevillea striata*). There are hardly any shrubs. River redgums (*E. camaldulensis*) are found along the major watercourses, and gidgee (*Acacia cambagei*) along minor ones.

The metasedimentary regions are characterised by very open, low snappy gum woodland, with substantial amounts of western grey box and mallee (*E. normantonensis*), and some bloodwood and

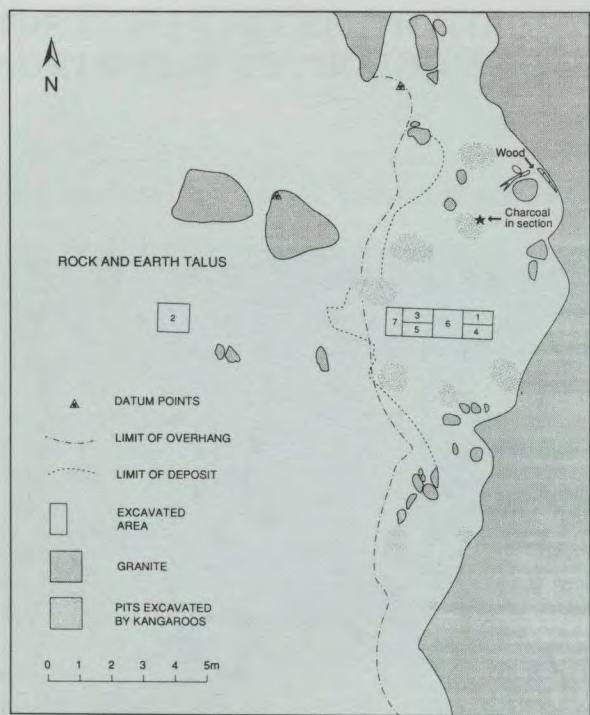


Figure 2 Cuckadoo 1 rockshelter, showing position of excavated trenches.

whitewood. Shrubs are dominated by turpentine bush, with turkey bush (*Cassia* spp.) dominant in places. Narrow alluvial flats confined within the metasediments support a medium-height western grey box woodland with river redgums along the stream channels.

EXCAVATIONS

Excavations at Cuckadoo 1 took place in November 1987 and July 1989. Two areas have been excavated: a single large trench inside the shelter and a smaller one at the base of the talus slope outside the shelter (Fig. 2).

In the first season of excavation the objective was to determine the extent of the sediments and obtain some indication of the chronology of deposition. Three trenches were excavated: Trench 1 and Trench 3 (both 1.0 m x 0.5 m) within the shelter; and Trench 2 (1 m²) at the base of the talus slope. The methods were the standard archaeological ones of excavating by removals (in the sense of Frankel 1988:42) of arbitrary sub-horizontal units of about one bucket of sediment (e.g. Johnson and Jones 1985), taking account of observed stratigraphic breaks. The depth of sediment excavated during each removal varied between 45 mm and 65 mm. The date of 15,270 BP was obtained from the penultimate removal in Trench 1. Three other dates were obtained from Trench 1 (Table 1).

Trench	Removal	Lab. No.	Depth (mm)	Date (¹⁴ C years BP)	Error (uncalibrated ¹⁴ C years)	Calibrated Date (years CAL BP)	Comment
1	10	Beta 25057	147 below top	1170	50	1067	charcoal from excavations
1	12	Beta 28454	188 below top	1690	60	1590	charcoal from excavations
1	16	Beta 28455	294 below top	5430	130	6284	charcoal from excavations
1	23	Beta 25058	528 below top	15270	210	17900	charcoal from excavations
6	2	Beta 38560	270-238 above datum	770	60	688	charcoal from excavations
6	6	Beta 38561	170-159 above datum	1780	50	1711	charcoal from excavations
6	14	Beta 38562	~130 above datum	4270	70	4858	charcoal from excavations
6	16	Beta 38563	134-110 above datum	5990	110	6877	charcoal from excavations
6	29	Beta 38564	58-82 below datum	12250	80	14500	charcoal from excavations
6	39	Beta 40086	286-315 below datum	12120	510	14400	charcoal from excavations
6	40	Beta 38566/ ETH 6955	315-349 below datum	12430	95	14700	AMS charcoal from excavations
3		ANU 7851	50-75 below top	3090	70	3349	charcoal from column sample
3		ANU 7852	100-125 below top	4360	80	4950	charcoal from column sample
3		ANU 7853	175-200 below top	4270	250	4858	charcoal from column sample

Table 1 Radiocarbon dates from Cuckadoo 1.

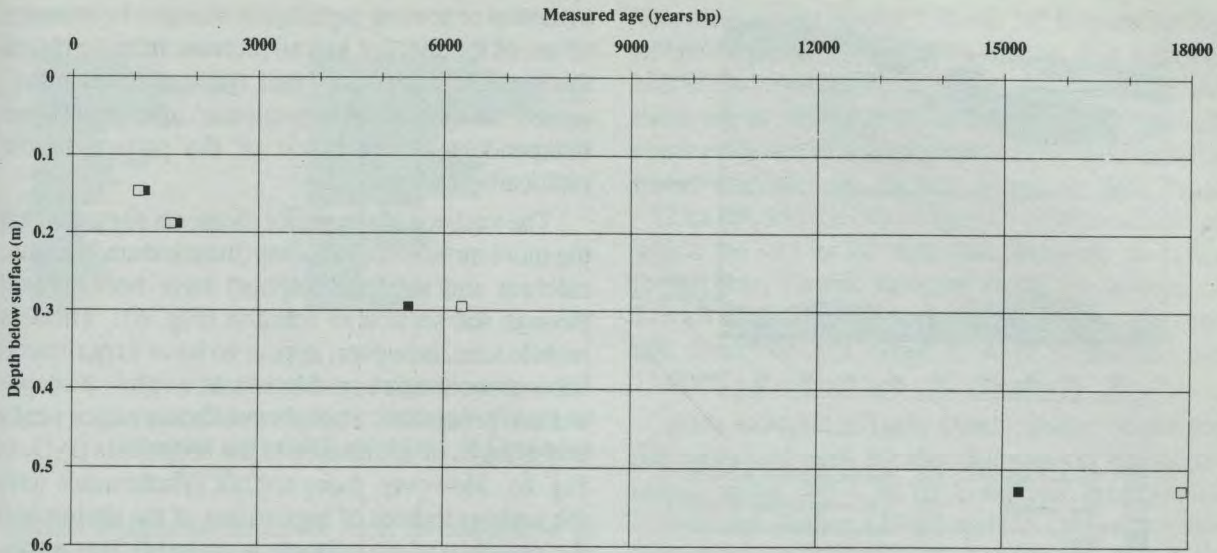


Figure 3 Calibrated (open squares) and uncalibrated (filled squares) radiocarbon ages on charcoal samples from Cuckadoo 1, Trench 1, plotted as a function of depth.

These indicated a systematic increase of age with depth in this trench (Fig. 3).

The nearest sites known to be occupied at comparable times are Colless Creek (>18 ka BP) and Louie Creek (~18.6 ka BP), both near Lawn Hill, 400 km to the north west (Hiscock 1989); Mickey Springs (8.3 ka BP), near Hughenden, 400 km to the north east (Morwood and Godwin 1982; Morwood 1990); Kenniff Cave (~19 ka BP), in the central Queensland highlands, 900 km to the south east (Mulvaney and Joyce 1965); Puritjarra (~22 ka BP), in central Australia, 900 km to the west (Smith 1987); and JSN (~14 ka BP), in the Strzelecki dunefield, 800 km to the south (Wasson 1983; Smith, Williams and Wasson 1991) (Fig. 4).

In the second season of excavation there were two major objectives. The first was to obtain a

series of dates which would enable us to determine the reliability of the basal date. By reopening the previously excavated area we also had the opportunity to determine the stratigraphy of the lowest part of the sediment with greater precision. The second objective in 1989 was to observe features that might tell us more of the activities carried out at the site at different times. Trenches 1 and 3 were enlarged to 1 m² by excavating Trenches 4 and 5 (Fig. 2). The 1 m² area separating the two enlarged trenches was subsequently excavated to form Trench 6. Trench 7 (1.0 m x 0.5 m) was excavated outside the dripline. At the completion of excavations, the trench inside the shelter was 3.5 m by 1.0 m in area, and approximately 0.6 m deep.

Seven radiocarbon dates were obtained from Trench 6. These showed a major episode of sediment deposition around 12 ka BP, and a sequence of deposits laid down after 6 ka BP. The dates from the upper part of Trench 6 are consistent with those obtained from the top of Trench 1. Three further dates obtained during the analysis of sediments added greater precision to the dating of the upper part of the sequence (Table 1).

STRATIGRAPHY AND SEDIMENTOLOGY

The excavations have revealed a consistent stratigraphic sequence within the shelter. Although this is complex in detail, the broad picture is of a series of hearths and burning areas unconformably overlying a thick unit of gravelly muddy sand (in the sense of Folk 1954, see Gale and Hoare 1991:62) (Fig. 5). A column of sediments from the



Figure 4 Pleistocene archaeological sites closest to Cuckadoo 1.

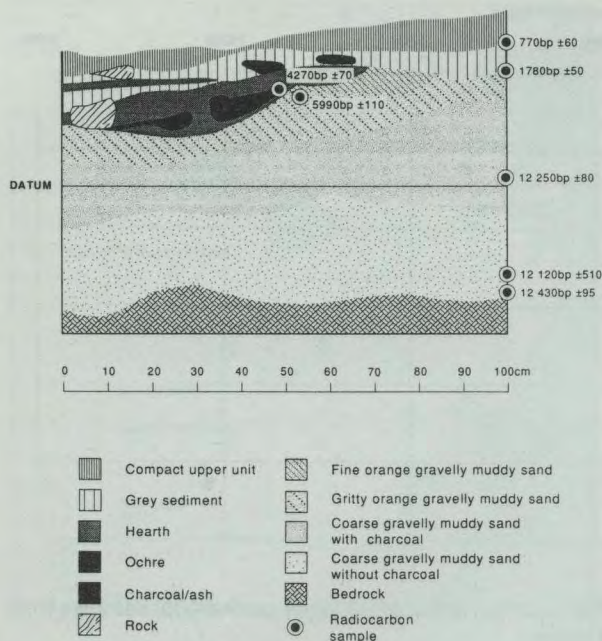


Figure 5 Stratigraphic section through north face of Trench 6. This shows the general pattern of the sedimentary sequence at Cuckadoo 1.

east face of Trench 3 was taken by Gale prior to the excavation of Trench 6.

Several physical and chemical parameters have been determined on the sampled material, including sediment texture, magnetic mineralogy, major and trace element geochemistry, plant organic content and charcoal content. This work has revealed

evidence of several significant changes in intensity of use of the site, not just an increase in more recent times. Gale's comment that the sediments represented 'as much gap as sequence' agrees with our independent interpretation of the pattern of the radiocarbon dates.

The analysis of the major elements suggests that the more mobile components (magnesium, sodium, calcium and sulphate-sulphur) have been moved through the section in solution (Fig. 6). The less mobile ions, however, appear to have experienced little concentration or dilution as a result of depositional processes. Phosphorus shows major peaks and troughs of abundance in the sediments (P_2O_5 in Fig. 6). However, these are not synchronous with the various indices of human use of the shelter and the presence of phosphorus is probably best attributed to faeces and carcasses of animals rather than to any human activity. Iron is present in the sediments at approximately three times its concentration either in the granite of the roof of the shelter or in the alluvium outside the shelter (Fe_2O_3 in Fig. 6), and its concentration may be due to accumulation in the sediment as a result of the use of ochres during the occupation of the site.

Measurements of mass magnetic susceptibility show the sediments to possess values up to two orders of magnitude greater than those of the weathered granite from the cave roof and the alluvium from outside the cave. Susceptibility may be significantly enhanced by heating. This converts

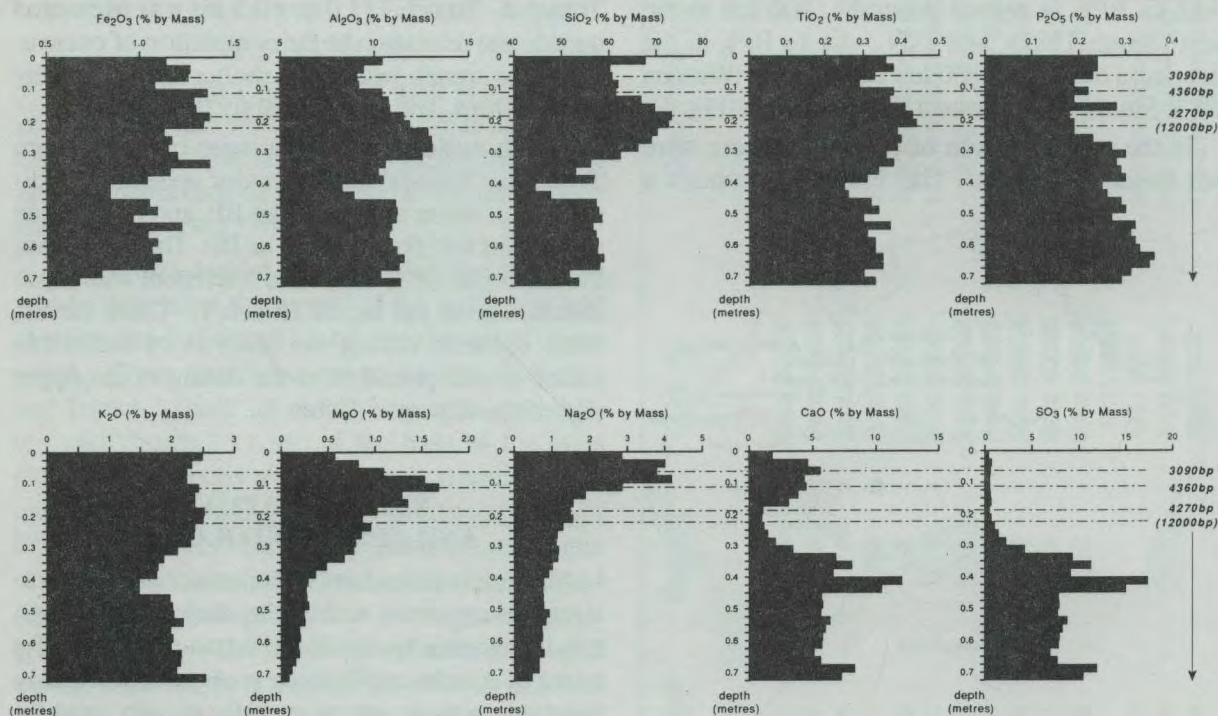


Figure 6 The variation of major element concentration with depth, east face of Cuckadoo 1, Trench 3. Radiocarbon dates are uncalibrated.

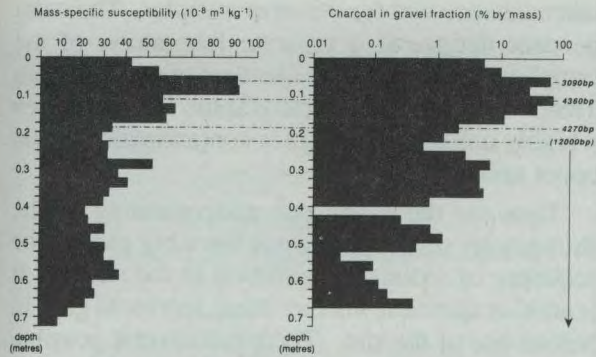


Figure 7 The variation of mass magnetic susceptibility and abundance of charcoal in the gravel fraction with depth, east face of Cuckadoo 1, Trench 3.

antiferromagnetic minerals such as haematite to ferrimagnetic minerals such as magnetite. The correspondence between the incidence of charcoal in the sediment sequence and peaks in sediment susceptibility suggests that the magnetic susceptibility measurements may provide a baking history of the cave floor and thus a record of heating and burning events in the shelter (Fig. 7).

Detailed results of the sediment analyses will be presented elsewhere.

DATES

Three separate series of radiocarbon dates have been obtained from Cuckadoo 1, a total of 14 dates (Table 1). As the charcoal samples were removed from different parts of the sequence, the relationships between the dates are not straightforward.

The oldest date of $15,270 \pm 210$ BP is from the basal part of the sequence at the back of the shelter.

The most recent date of 770 ± 60 BP is from the top of the sequence in Trench 6, in the first removal below the loose surface material. On the whole, the dates are in stratigraphic order. However, there is some evidence of a stratigraphic break between the basal deposits in Trench 6 which date from ~ 12 ka BP, and the basal deposits in Trench 1, from which the ~ 15 ka BP date was obtained. In order to test this, further samples from the bottom of Trench 1 have been submitted for dating. We cannot, therefore, yet claim to have confirmed the 15,000 year occupation of Cuckadoo 1.

Also included in Table 1 and Figures 3 and 8 are the calibrated ages for the radiocarbon dates, obtained using the CALIB computer program of Stuiver and Reimer (1986) and the calibration values for the late Pleistocene of Stuiver et al. (1991). These show that the most recent radiocarbon ages are probably slight overestimates of calendar years, while the older determinations are underestimates. Calibrated dates probably compare well to thermoluminescence dates (e.g. Davidson and Noble 1992; Roberts et al. 1990).

INTERPRETATION OF DATES

If we exclude the two stratigraphically lower dates of about 12 ka BP from Trench 6, apparent rates of sediment deposition in Trench 1 and Trench 6 are similar (Figs 3 and 8). We could use this result to suggest that there was a constant rate of sedimentation over 15,000 years and thus argue that occupation was continuous. However, there is clear stratigraphic evidence, supported by the pattern of distribution of dates, for discontinuity in sedimentation.

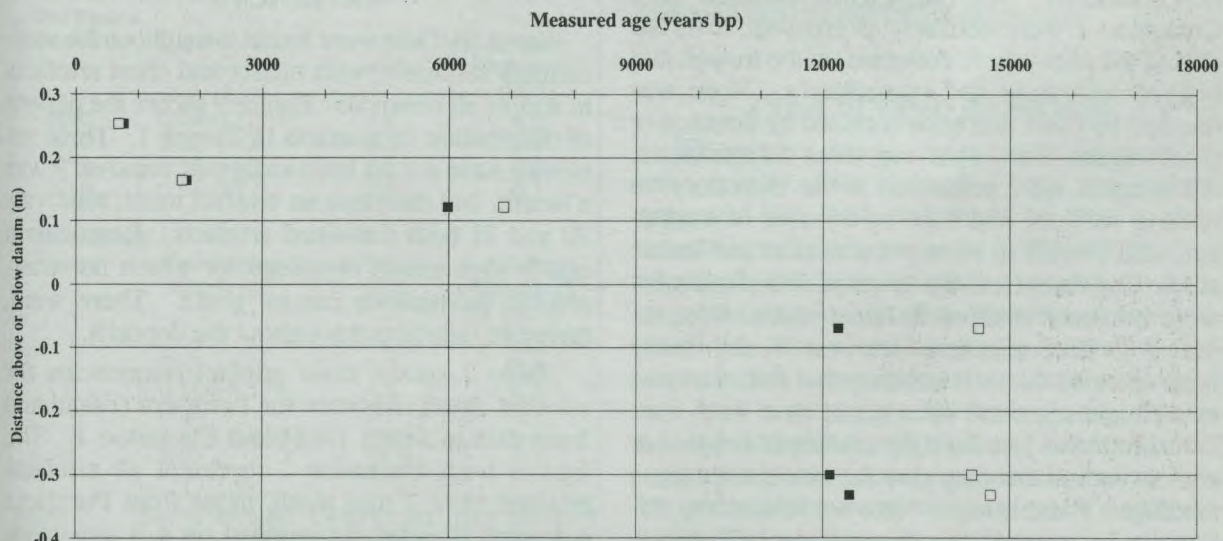


Figure 8 Calibrated (open squares) and uncalibrated (filled squares) radiocarbon ages on charcoal samples from Cuckadoo 1, Trench 6, plotted as a function of depth.

First, consider the packet of sediment represented by the lowest part of Trench 6. This seems to have been deposited very rapidly, and perhaps 3000 years later than the lowest dated sediment in Trench 1. We cannot just ignore the different dates of sedimentation in this part of the site. The error margins on the dates do not suggest that an explanation can be found in the statistics associated with the uncertainties inherent in radiocarbon estimates. There appear to have been two short phases of rather rapid sedimentation separated by an unconformity. Deposition could have continued in the intervening period, but if so the products of that deposition have been removed by erosion.

Secondly, look at hearth 5 in Trench 6, dated to 4270 ± 70 BP. This hearth was a heat treatment pit, containing chert artefacts, including backed blades, cobbles for heat retention, and heated red ochre. It was dug into sediments dated at 5990 ± 110 BP. The samples that provided these two dates were separated by a matter of centimetres horizontally and the more recent date was actually from a position vertically lower than the older date. Only careful excavation permitted us to recognise that these dates are in stratigraphic order. Gale submitted charcoal samples from the sediment column sample in Trench 3 without knowing the relation between his stratigraphic profile and the dates obtained from Trench 6. Two of his samples were from the same hearth, and gave dates of 4270 ± 250 BP and 4360 ± 80 BP. We thus have three determinations from the same stratigraphic feature at dates statistically indistinguishable from each other, at approximately 4.3 ka BP.

Although we do not believe that contamination should be the first explanation for dates that do not conform to our expectations, this possibility must be considered. All radiocarbon samples from Cuckadoo 1 were obtained as charcoal observed during the excavation, collected on the trowel, and bagged separately and immediately. None was touched by hand, and none obtained by flotation or other means that might introduce contaminants. All samples were pretreated in the laboratory, to remove rootlets, and then by a series of acid/alkali/acid washes to remove carbonates and humic acids. The dates from the lower packet of sediment were obtained at three different times, from removal 39 first, then from removal 29 and finally from removal 40. It is unlikely that three samples of different ages and sizes could have been contaminated with just the right amount of modern or ancient carbon that they give the same radiocarbon readings. These samples were not treated any differently from any of the other samples in Trench 6, and if contamination is invoked as an explanation of the older determinations, then it must also be

taken into account for the other samples. The independent dating, at a separate laboratory, of the samples from Trench 3 as identical to the ages from Trench 6 for the same stratigraphic feature makes it highly unlikely that there is contamination of the upper samples.

Thus the dates and our understanding of the stratigraphy suggest that there were big gaps in the sequence of sediment deposition in the shelter. It is another question whether these represent gaps in human use of the site. There are several possible explanations for these gaps: sediment may have been deposited continuously, but occasionally removed by one or more of a variety of mechanisms including human activity; sediment may have been deposited discontinuously as a result of human actions or other factors; sediment may have been deposited at different rates in different parts of the site; or some combination of these processes may have occurred.

Because of our understanding of the chronology of deposition at the site, it is clear that any attempt to force fit the deposits into a linear age-depth relationship, or to define a single rate of sediment accumulation, would be foolish and inappropriate. Davidson (1990) argued that discontinuous occupation of sites and regions, especially in the arid zone, should be expected. It is a minimum expectation of this argument that there should be sites with discontinuous sequences of dates of occupation. Because of the variety of mechanisms that can possibly produce such discontinuity, we cannot say that discontinuous occupation is confirmed at Cuckadoo 1, but, at least, Cuckadoo 1 seems to conform with this minimum expectation.

ARTEFACTS

Stone artefacts were found throughout the sedimentary sequence, with quartz and chert artefacts in almost all removals. Figure 9 shows the pattern of distribution of artefacts in Trench 1. Three removals have not yet been analysed: removal 3 was a hearth, and therefore an artefact itself; removals 20 and 21 both contained artefacts. Removals 6 and 9 were trench cleanings for which no stratigraphic provenance can be given. There were, therefore, artefacts throughout the deposits.

Table 2 shows stone artefact frequencies for selected dated removals for Puritjarra (calculated from data in Smith 1988) and Cuckadoo 1. The figures from Cuckadoo 1 represent all artefacts retained on a 2 mm mesh, those from Puritjarra represent all artefacts retained on a 3 mm mesh (Smith 1988). The difference in sieve size probably has little effect on the relative frequency of

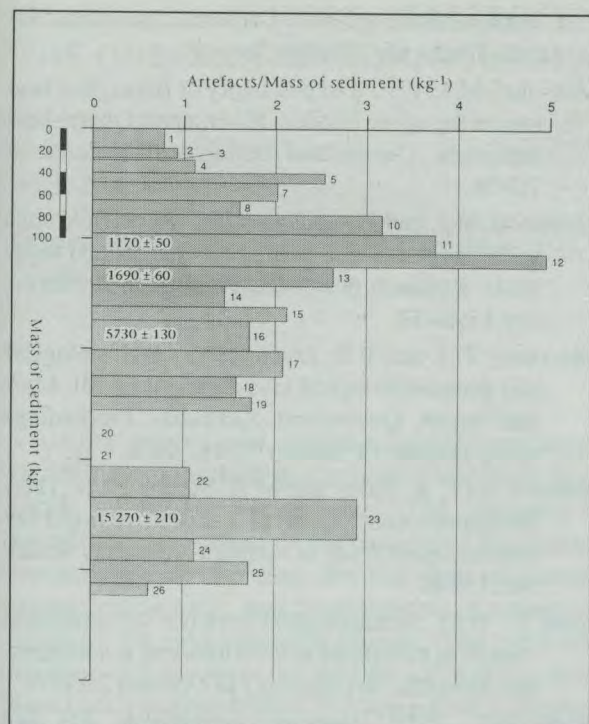


Figure 9 Stone artefact frequencies in Cuckadoo 1, Trench 1. The abscissa shows the mass of sediment in each removal. The ordinate shows the number of artefacts in each removal normalised by the mass of sediment in each removal. The area of each bar is, therefore, proportional to the total number of artefacts in that removal. Also shown are the uncalibrated radiocarbon ages for the dated removals.

artefacts at the two sites. Although we do not believe that artefact frequencies provide a reliable measure of intensity of occupation (Hiscock 1981; Ross 1985; Davidson 1990), differences as great as

an order of magnitude for the Pleistocene sediments at these sites seem to suggest great differences in the nature of their occupation. Further work is needed to elucidate the reasons for these differences, including an assessment of the significance, if any, of the sizes of the occupied areas in each rockshelter.

Hearth 5, the heat treatment pit dated to 4.3 ka BP, contained chert artefacts but no quartz artefacts. Among the chert artefacts were backed pieces, and a core that fragmented into a flake and a core as it was removed from the sediment. We believe that hearth 5 was a pit used for the heat treatment of small chert pieces as a strategy to increase the efficiency of flaking.

Also found in hearth 5 was a patch of powdered red ochre. We have discussed previously the effects of heating in changing the colour of yellow goethite to red haematite (Cook et al. 1989, 1990). The practices of roasting yellow ochres, as well as that of sun-drying them, were reported by Roth (1904:14) from the Pennefather River, north of Weipa in western Cape York. Our experiments have shown not only that the colour change can be reproduced in the laboratory, but that there is another effect of heating. Both red and yellow ochres contain substantial quantities of the mineral kaolinite, the main constituent of white ochres. On heating, this mineral is destroyed. This substantially improves the ability of the ochre to adhere to painted surfaces. At the ochre quarry north of the Selwyn Range, both red and yellow ochres occur in the sedimentary rock sequence. Thus, it seems likely that heat treatment would have been used not in order to obtain red ochre, but rather to obtain material for paint that would endure.

Full analyses of the stone artefacts and other materials will be published elsewhere.

CONCLUDING REMARKS

We have not demonstrated continuity or discontinuity of use of the Cuckadoo 1 site, but we have suggested how difficult it might be, first, to show it, and secondly to account for it. We will continue to address this issue, which we consider to be an important one for the understanding of the processes of human adaptation to the Australian environment. It is not necessary to assume that the basal date from a site represents the beginning of continuous occupation of a region. Davidson (1990) suggested that we should expect discontinuity of occupation, because of the severity and stochasticity of short and long-term variability of environmental conditions. This view is supported by shreds of evidence of the effects of environmental

Puritjarra			
Trench	Depth (m)	Age (ka)	Artefact frequency (kg ⁻¹)
N10	0.04-0.12	0.6	4.5
N10	0.32-0.42	5.9	0.9
N10	0.52-0.58	12	0.2
N10	0.66-0.77	22	0.1
Cuckadoo 1			
Trench	Removal or depth (m)	Age (ka)	Artefact frequency (kg ⁻¹)
1	R10	1.2	3.2
1	R12	1.7	5.0
3	0.100-0.175	4.3	6.5
1	R16	5.7	1.7
3	0.225-0.650	~12	1.0
1	R23	15.3	2.9

Table 2 Stone artefact frequencies from selected dated removals from Puritjarra rockshelter, central Australia (calculated from data in Smith 1988) and Cuckadoo 1 rockshelter.

stress on Aboriginal groups recorded in the period of contact with non-Aborigines. Frankel (1988) drew attention to the tendency of our methods of analysis to mask the evidence that might indicate discontinuity. Many of the arguments about Australian prehistory are crucially altered if there is not continuity of occupation (intensification; processes of adaptation to particular environments; rates of population growth; biological continuity of human morphology). What we have shown here is that, even in a well-dated sequence, there are empirical problems in demonstrating either continuity or discontinuity, and a prior problem of appropriate methodologies for interpreting such sequences.

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CAUSE AND EFFECT: PLEISTOCENE ABORIGINAL OCCUPATION IN THE QUINKAN REGION, SOUTHEAST CAPE YORK PENINSULA

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In this paper I will outline a model for changes in Aboriginal landuse in southeast Cape York Peninsula during the Pleistocene. The construct is based upon analysis of recent patterns of Aboriginal resource use in the area, the mapping of current resource structures, and consideration of a range of evidence for environmental change. The predicted patterns of Aboriginal occupation will then be compared with archaeological evidence from a number of excavated sites across the region for resource use, artefact technology, measures for occupational intensity, and the nature of social interaction at various stages during the Pleistocene. The paper will conclude by focussing on the terminal Pleistocene/early Holocene period from ca. 13,000 BP when major changes in depositional regimes signal more intensive management of resources and far greater impact upon local environments.

THE STUDY AREA

The southern part of Cape York Peninsula contains a diverse range of environments reflecting major differences in climatic and geological influences (Fig. 1). Much of the peninsula is formed by unconsolidated Tertiary and Quaternary plains, but bedrock forms a central spine of hills.

The focus of this study is the dissected sandstone plateaux which form the uplands on the southern rim of the Laura Basin which run south from Princess Charlotte Bay then west below the township of Laura. This is known as the Quinkan region after the distinctive rock painting style found in many of the rockshelters throughout the plateau (see Trezise 1971). Adjacent resource zones include outwash Tertiary and marine plains to the north, alluvial plains associated with the major rivers, folded sediments to the south which include a narrow belt of limestones running from the Palmerville area to Chillagoe, and wet tropics to the southeast.

PAST ENVIRONMENTS

As part of this project, detailed resource mapping has been undertaken in two main sections of the study area – in the Quinkan Reserves near Laura and on the upper Endeavour River north of Cooktown (e.g. Abel 1989; Morgan 1984; Morgan and Terrey 1989). A range of palaeoenvironmental information based on the study of pollen from swamps and excavated rockshelter sites (Stephens 1990), the study of mineral crusts on rockshelter surfaces (Watchman 1990), and the coring and dating of sand plains is yielding data at the local level for comparison with more general evidence for climatic change.

Evidence from a number of north Australian sites suggest drier conditions during the Pleistocene as far back as 70,000 years ago (Hiscock and Kershaw 1992). On the Atherton Tableland rainforest decreases from 38,000 BP and by 26,000 BP was almost totally replaced by sclerophyll vegetation. This suggests that a further decrease in effective precipitation occurred, although associated changes in charcoal particle counts show that the onset of Aboriginal firing is also likely to have been a contributing factor (Kershaw 1986:48). Aridity peaked sometime between 25,000 and 15,000 BP. Contemporaneous peaks in occupational intensity at Colless Creek Cave in the Gulf country to the west and at Fern Cave near Chillagoe to the south seem to indicate the closer tethering of Aboriginal groups to areas with permanent water (David 1990:47; Hiscock 1985:89). Between 13,000 BP and 14,000 BP there is evidence for increased rainfall, possibly from a southward movement of the monsoon, but this increase is delayed in the Atherton Tableland sites until ca.10,000 BP indicating regional variability (Hiscock and Kershaw 1992:54). Effective precipitation seems to have peaked about 5000 BP, with decreased rainfall ca.3000 to 2000 BP, then the establishment of modern conditions.

Local palynological evidence obtained by Lesley Head and Kerryn Stephens in the Quinkan

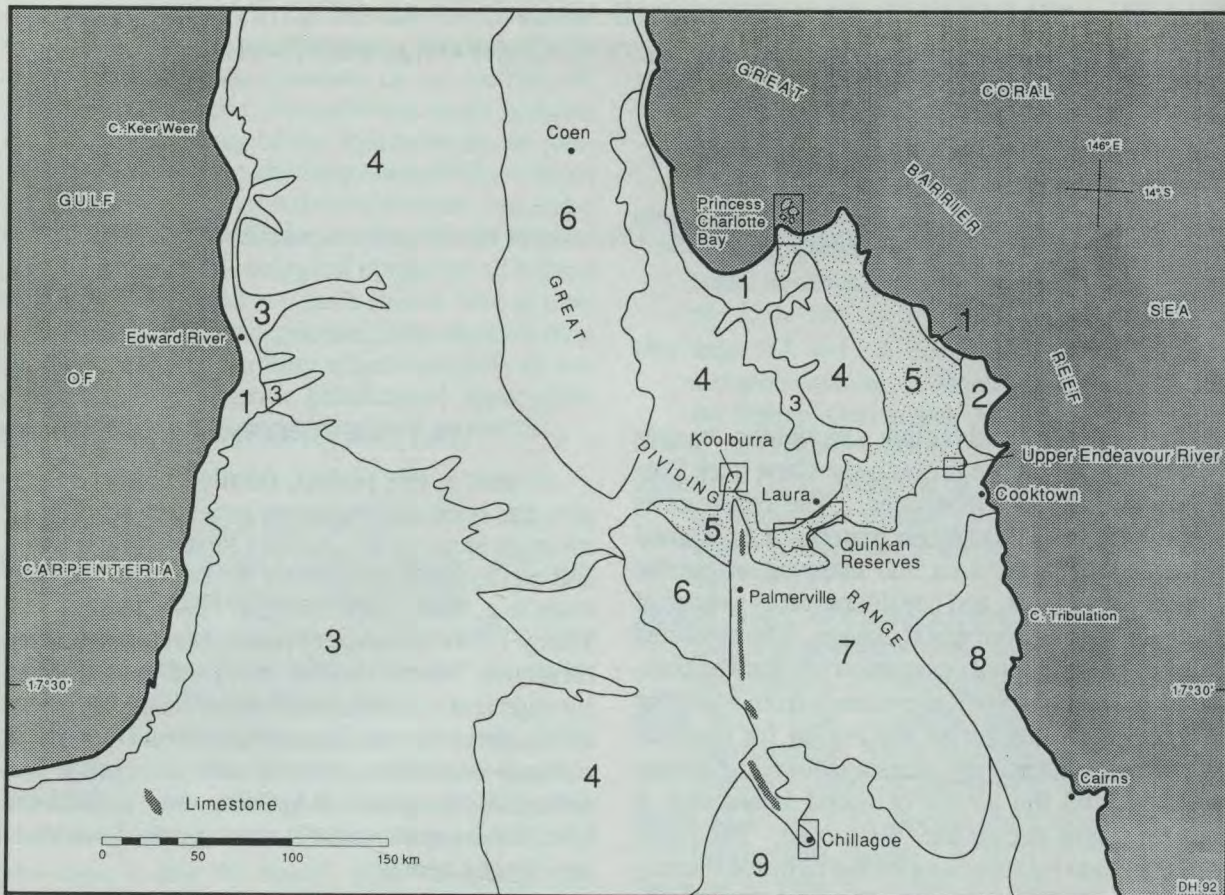


Figure 1 General resource zones of southeast Cape York Peninsula. 1: Marine plains, 2: High sand dunes, 3: Alluvial plains, 4: Outwash plains, 5: Dissected sandstone plateau, 6: Central Hills and plains, 7: Broken ranges, 8: Wet tropics, 9: Einasleigh uplands. (After Morgan and Terrey 1989).

region supports this general scenario but has demonstrated a basic stability in local vegetation structure and components (Stephens 1990). Back to at least 32,000 BP the local environment was predominantly woodland, while at the height of the last glacial maximum ca. 17,000 BP the vegetation contained the same components as at present, but was more open. From the end of the Pleistocene there has been little overall change in vegetation structure or components. However, basal dates for a number of cored swamps near Cooktown and Laura indicate a progressive increase in water availability during the Holocene beginning about 8500 BP without any major impact on dryland vegetation. A further increase in water availability is apparent after 2500 BP. The stability in the charcoal record also suggests historically observed burning regimes were established by mid Holocene times.

ETHNOGRAPHY AND ABORIGINAL RESOURCE USE

Local and more general ethnographic information can be used to model recent Aboriginal demo-

graphic, economic and technological responses to seasonal/geographic changes in resource levels and distribution as a means for predicting long-term responses to environmental change. Although data on Aboriginal groups in the Quinkan region is sparse, some of the most detailed accounts in Australia concerning Aboriginal landuse, economic scheduling and material culture come from southern Cape York Peninsula (e.g. Anderson 1984; von Sturmer 1980; Thomson 1939). In combination with various levels of information on resource character, these studies can serve as the basis for modelling patterns of Aboriginal landuse in specific areas of interest.

Despite intra-regional differences in specific resource types and scheduling, the regular patterning in plant resource and water availability led to common features in Aboriginal landuse. In the wet season, more or less permanent camps with good resource catchments were established. This is said to be the period in which rockshelters were most intensively used (Haviland and Haviland 1979; Trezise 1971:7). At the end of the wet season these camps were abandoned and groups became pro-

gressively smaller and more mobile as the dry season progressed. In the late dry season bands began to congregate at more permanent water sources close to strategic resources.

This pattern of response to resource availability is likely to have characterised Aboriginal response to longer term climatic fluctuations during the Pleistocene in which food plant and water availability was probably less than that historically observed. Geologically permanent water sources would have been crucial to the pattern of landuse at times of greater aridity and much reduced biological carrying capacity. Many of the springs at the headwaters of creeks throughout the dissected sandstone plateaux are geologically permanent. These springs would have enabled low density, intermittent use of some sections of the Laura Basin sandstone country to have continued throughout the Pleistocene from the time of initial colonisation. Such refuges would have comprised areas with suites of permanent springs found at convenient walking distances.

In contrast, water sources in the extensive alluvial and outwash plains of southern Cape York

Peninsula are not geologically permanent, and Aboriginal occupation is likely to have fluctuated in response to both long and short term water availability.

From 13,000 BP increased precipitation and swamp formation would have led to scope for population increase and the more permanent occupation of adjacent outwash and alluvial resource zones. This trend is likely to have accelerated after 2500 BP.

THE ARCHAEOLOGICAL EVIDENCE

The occupational history of southeast Cape York Peninsula is outlined in Figure 2, which summarises aspects of occupational sequences from all excavated sites in the Quinkan region. It can be seen that Aboriginal occupation of the region commenced before 32,000 BP at Sandy Creek 1 near Laura (Morwood and Trezise 1989; Pearson 1990). The initial occupation of Yam Camp, with a non-basal date of 17,000 BP may be of similar antiquity (Pearson 1989).

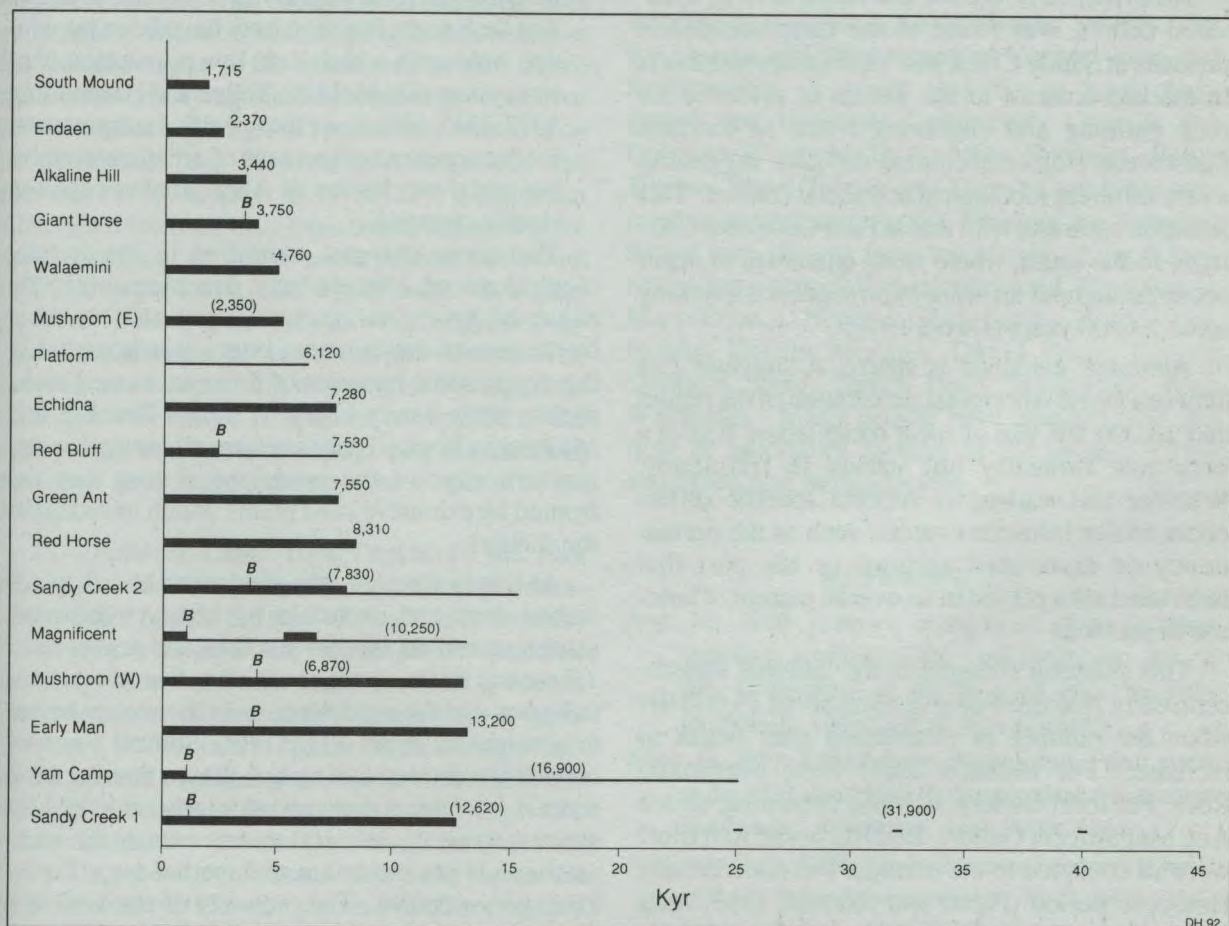


Figure 2 A summary of evidence from excavated sites in southeast Cape York Peninsula (after Beaton 1985; Flood and Horsfall 1981; Jung 1990; Morwood and Trezise 1989; Pearson 1989, 1990; Rosenfeld et al. 1981; Woolston 1965; Wright 1971). B: appearance of burren adze slugs.

It is notable that the pattern of occupation at these early sites differs markedly. At Sandy Creek 1, Pleistocene occupation is sporadic and fleeting, with systematic use of the shelter only beginning in the terminal Pleistocene/early Holocene. In contrast, there is low intensity, but persistent use of Yam Camp from initial occupation and this use does not appear to change until 1000 years ago, when a massive increase in occupational intensity occurred. Yet these sites are only 13 km apart.

At Sandy Creek 1, the earliest dated evidence for Aboriginal site use is a discrete knapping floor of high quality crystalline quartz dated to 32,000 BP. An edge-ground axe was deposited some time prior to this but has not been dated (Morwood and Trezise 1989). Above the crystalline quartz artefact scatter an isolated quartz core was the only artefact found until systematic use of the site began just prior to $12,620 \pm 370$ BP (Beta 51089). At Yam Camp the early knappers utilised silcrete, chert and quartz pebbles from local conglomerates.

No evidence of artistic activities, such as excavated ochres, was found in the early occupation deposits at Sandy Creek and Yam Camp, and this is in marked contrast to the wealth of evidence for rock painting and engraving found in terminal Pleistocene/Holocene cultural deposits, suggesting a very different ideological and social context. This situation contrasts with that at Fern Cave near Chillagoe to the south, where small quantities of ochre occur throughout an occupation sequence spanning some 29,000 years (David 1990).

Although evidence is sparse, it suggests that between initial Aboriginal penetration of the region and 13,000 BP, use of local rockshelters was at a very low intensity but varied in frequency. Whether this variability reflects specific differences in site resource context, such as the permanency of associated springs, or the part that individual sites played in an overall pattern of land-use is not clear.

This situation changed in the terminal Pleistocene/early Holocene period, from about 13,000 BP, when the number of established sites began to increase. For instance, Early Man, Mushroom Rock, Platform Gallery, Echidna Dreaming, Green Ant, Magnificent Gallery, Red Horse and Red Bluff were all occupied in the terminal Pleistocene/early Holocene period (Flood and Horsfall 1986; Jung 1990; Rosenfeld et al. 1981; Woolston 1965; Wright 1971). Although each site is characterised by periods of heavy and light use, the increase in range of evidence and in the rate of accumulation

seems to suggest the first systematic Aboriginal use of the region. This system is characterised by:

1. Stone artefact manufacture was mainly on local materials with minimum evidence for conservation of raw material. However, evidence for edge-ground axes is now common. These were typically made of non-local volcanic or metamorphic materials.
2. There is no evidence for labour intensive economic strategies, such as use of cycads or the grinding of grass seeds (see Beaton 1982 and Smith 1986 for general discussion of implications).
3. There is evidence for painting, as shown by excavated ochre fragments. In addition, buried panels or fragments of deeply pecked engravings emphasising non-figurative and track motifs have been found at Early Man (Rosenfeld et al. 1981:30), Green Ant (Flood and Horsfall 1986:39), Yam Camp and Sandy Creek in deposits of this age. Broadly speaking, these engravings can be designated as of Panaramitee style (Maynard 1979). The fact that these may be part of a widespread and geographically homogeneous rock engraving tradition suggests that their main function may have been population linking in a high risk, low population density system (Smith 1989; Yellen and Harpending 1972:251). Whatever the specific interpretation for the appearance/increase of artistic activities, the social mechanics of Aboriginal occupation clearly changed.

That these changes, identified in the archaeological record, concern basic developments in the nature of Aboriginal resource use is also hinted at by the human-environment interaction apparent in the depositional histories of three excavated rockshelter sites: Sandy Creek 1, Sandy Creek 2 and Mushroom Rock. These sites are all located on the northern edge of the sandstone plateau and are fronted by extensive sand plains which intrude into the shelters.

At Sandy Creek 1, the sand sheet is 1.5 to 1.8 metres deep and underlain by highly weathered, sandstone rubble, laterite pisoliths and gravel up to 1.2 metres thick. A sequence of radiocarbon dates indicates that the sand deposits in the shelter began to accumulate about 13,000 BP. Some 12 metres outside the shelter, coring has shown that the sand sheet is 2.5 metres deep and similarly underlain by a rubble/gravel, while 100 metres outside the shelter the sand is a minimum of 7 metres deep (David Price pers. comm.). The recovery of charcoal and leaf material at this latter depth indicates that there has been massive sand accumulation in the Sandy Creek vicinity relatively recently. Thermoluminescence dates from samples at 1 m intervals are cur-

rently being processed by David Price (Department of Geography, Wollongong University).

At Mushroom Rock a similar situation prevails. Wright (1971) found sand 3 to 4.5 metres deep overlying a truncated gravel deposit. No cultural material was recovered in this gravel during his excavation or in the re-excavation, which I undertook in 1991. Aboriginal occupation of the site commenced in earnest at the same time as accumulation of the sand deposits. On the basis of the three radiocarbon dates now available, deposition of the sand sheet and Aboriginal occupation at Mushroom Rock commenced about 13,000 years ago. Coring in the sand plain outside the shelter has indicated that a similar gravel to sand sequence occurs throughout the vicinity and is not just site-specific. A series of thermoluminescence dates from 1 m intervals will be used to compare the rate of sand plain build-up with sediment and artefact accumulation rates within the shelter.

The evidence indicates that these sand plains only began to accumulate **after** the first systematic occupation of the sites at the end of the Pleistocene and that the rate of sand accumulation in the shelters may be correlated with occupational intensity. This geomorphic situation is analogous to that found in the Kakadu region of the Northern Territory where sandsheets overlying basal rubbles or gravels have been found at a number of rockshelter sites and on the floodplain (e.g. Hope et al. 1985; Jones and Johnson 1985). Hope et al. (1985:239) suggest that Aboriginal burning may have been responsible for the deposition of these sand sheets, but Allen (1991:4) argues that this would only have been possible if Aboriginal impact was magnified by associated changes in vegetation and climate. The fact that sand deposition at one site, Malakunanja II, began well before Aboriginal occupation of the region indicates that local topography also needs to be taken into consideration (see Roberts et al. 1990).

In southeast Cape York Peninsula the root causes should become clearer once thermoluminescence dates enable the rate of sand plain accumulation to be compared with indices for occupational intensity within shelters, and with local evidence for changes in climate and vegetation over time. However, at this stage it appears that developments in the pattern of Aboriginal landuse, probably involving increases in the frequency of firing, were prime factors in destabilisation of in situ sand sheets on sandstone plateaux and in the formation of the extensive alluvial plains, which are such a notable feature of the region today. This is a situation in which Aboriginal landuse appears to have had significant geomorphic effects. If so, the associated changes identified in the archaeological re-

cord involving individual site use, artistic activities, and so on, reflect changes, not only in the use of specific sites, but in use of the general landscape.

CONCLUSION

In the terminal Pleistocene a fundamental restructuring of Aboriginal occupation seems to have occurred in the Quinkan region of southeast Cape York Peninsula. While this may have been initiated by a quantitative demographic response to climatic amelioration, the changes seem to have had an impact on core elements of local Aboriginal society. Once established, this pattern of resource use seems to have persisted until the late Holocene, when further changes in stone artefact technology, economic intensity and art occurred.

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PLEISTOCENE ARCHITECTONICS IN THE MURRAY-DARLING BASIN

Abstract

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The Murray-Darling Basin is a large area of low-lying land in south-eastern Australia, bounded by the Great Dividing Range to the north and west, and the Southern Ocean to the south. It is one of the most important agricultural regions in Australia, and its development has been a major factor in the country's history. The basin is characterized by its flat topography and its extensive network of rivers and waterways. The climate is semi-arid, with hot summers and cold winters. The soil is generally poor and infertile, and the vegetation is sparse and scrubby. The basin is home to a large number of native animals and plants, many of which are now endangered.

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MURRAY-DARLING BASIN

THE CENTRAL MURRAY-DARLING BASIN

The Central Murray-Darling Basin is a large area of low-lying land in south-eastern Australia, bounded by the Great Dividing Range to the north and west, and the Southern Ocean to the south. It is one of the most important agricultural regions in Australia, and its development has been a major factor in the country's history. The basin is characterized by its flat topography and its extensive network of rivers and waterways. The climate is semi-arid, with hot summers and cold winters. The soil is generally poor and infertile, and the vegetation is sparse and scrubby. The basin is home to a large number of native animals and plants, many of which are now endangered.

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THE SOUTHERN MURRAY-DARLING BASIN

The Southern Murray-Darling Basin is a large area of low-lying land in south-eastern Australia, bounded by the Great Dividing Range to the north and west, and the Southern Ocean to the south. It is one of the most important agricultural regions in Australia, and its development has been a major factor in the country's history. The basin is characterized by its flat topography and its extensive network of rivers and waterways. The climate is semi-arid, with hot summers and cold winters. The soil is generally poor and infertile, and the vegetation is sparse and scrubby. The basin is home to a large number of native animals and plants, many of which are now endangered.

MURRAY-DARLING BASIN

PLEISTOCENE ARCHAEOLOGICAL SITES IN THE CENTRAL MURRAY-DARLING BASIN

Jeannette Hope

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The purpose of this paper is to review the chronology of Pleistocene archaeological sites in the Murray-Darling Basin. This region includes the Willandra Lakes where the discovery in 1969 of human remains in sediments of indisputable Pleistocene age confirmed a high antiquity for human settlement in Australia. In spite of the central role of the Willandra in contributing to both paradigm and myth about the Australian Pleistocene, there is in fact still relatively little known about the Pleistocene occupation of the region, especially during the purported pre-glacial maximum Eden when the fishing was easy. On the other hand the period covering the Pleistocene-Holocene transition, between about 8000 and 15,000 BP, is comparatively well-represented by sites which would reward more intensive study.

THE CENTRAL MURRAY-DARLING REGION

The Murray-Darling River, the major river system of Australia, is characterised by low and variable water flow compared with the world's other large river systems. The Murray River and its eastern New South Wales tributaries rise in the high rainfall areas of the uplands of southeastern Australia and flow westward across their western slopes and the alluvial riverine plains beyond. The Murray then winds across semi-arid sand plain and dunefields, where it is joined by its most western tributary, the Darling, before turning south to flow into the Southern Ocean through Lake Alexandrina. The Darling gains most of its water from the eastern highlands, but its westernmost tributaries, the Warrego and Paroo, rise in semi-arid areas to the north.

Twenty million years ago, the lower Murray-Darling Basin was a marine embayment; the rivers flowed separately into the sea about 300 km inland from the present coast. When the sea retreated, it was replaced by a series of large inland lakes, whose sediments were later covered with aeolian sands as the continent desiccated through the Pleistocene. Rivers cut channels through the sand plains as they flowed south and west to the sea.

Because of the low relief, river channels have shifted through time, and the modern low discharge channels now run parallel to or criss-cross abandoned higher discharge Pleistocene channels. These high discharge ancestral channels are characterised by large, now dry lake basins up to 10-20 km in diameter. The Willandra Lakes form a chain of overflow lakes fed from the north by Willandra Creek, an ancestral channel of the Lachlan River. The Pleistocene ancestral channels of the Darling, such as the Great Darling Anabranch and Talyawalka Creek, fed Lake Tandou and the Anabranch Lakes. In contrast, the Murray remained in a single deep channel throughout high and low discharge phases, although associated lakes, notably Lake Victoria, may represent high discharge phases.

The lakes on these old channels effectively acted as rain-gauges, recording changing climatic conditions in the sediments that built up in the lake-side lunettes. Some of the oldest archaeological sites in Australia have been found in these lunettes, notably at the Willandra Lakes. However, Pleistocene sites, especially in the period after the glacial maximum, are not restricted to the lunettes and have been found in a range of landforms related to the lake and river system.

The sites discussed in this paper lie in the centre of the Murray-Darling Basin, where the northern tributaries, the Darling and Murrumbidgee-Lachlan, join the Murray. The region extends from Wilcannia in the north to the Murray in the south, and from the New South Wales-South Australia border on the west to Kow Swamp, on the Murray, on the east.

SOURCES AND RELIABILITY OF RADIOCARBON DATES

The radiocarbon dates discussed here come from a variety of sources. Most are now published or listed in publicly available reports, though not necessarily accompanied by archaeological interpretations. The dates have been obtained by the following workers: H. Allen, J. Balme, M. Bar-

betti, J. Bowler, P. Clark, E. Gill, J. Head, J. Hope, K. Kefous, I. McBryde, M. McIntyre, D.J. Mulvaney, G. Pretty, F.W. Shawcross, R. Tedford, A. Thorne and K. Walker.

The Willandra dates used below are derived from a list compiled by Clark (1987) for the as yet unfinished Regional Environmental Plan for the Willandra Lakes World Heritage Region. This list incorporates all radiocarbon dates for the Willandra to that time.

The Darling dates are from Balme and Hope (1991). This lists all radiocarbon dates obtained for the lower Darling River and its anabranches and lakes to that time. Clark and Hope (1985) is the source for the shell dates included for the central Murray River, and Kefous (1983) for the dates from Lake Victoria.

Pleistocene sites in the region consist of burials, shell middens, hearths, stone tool scatters, or more complex camp sites containing mussel shell, animal bone, hearths and artefacts. A large number of radiocarbon dates have been obtained on mussel shell, charcoal, bone apatite and collagen, soil carbonate and other organic residues. Because details about some of the sites are unavailable to me, I have only included dates based on shell and charcoal from explicitly identified archaeological sites such as shell middens, hearths and burials.

Detailed research by the ANU Radiocarbon Dating Laboratory has demonstrated that dates on the two freshwater mussel species (*Velesunio ambiguus* and *Alathyria jacksoni*) from this area are reliable (John Head, quoted in Balme and Hope 1991). However, dates on bone and soil carbonate are highly susceptible to contamination. For this reason soil carbonate dates and the small number of bone dates from the region have been excluded.

Charcoal, particularly the finely disseminated charcoal common in the sandy sediments, can also be affected by contamination from younger organic materials moving through the sediments. Discrepancies have been found in paired samples of charcoal and shell from some sites at the Willandra, with the charcoal samples tending to give younger ages.

In spite of this the large set of charcoal dates from the Willandra has been included on the graphs at their face value because they represent a control sample for the shell dates. Sites dated by charcoal are, at least theoretically, less likely to be restricted to high water periods than are shell middens. Where relevant, comment is included below on the issue of discrepancies between shell and charcoal dates.

CHRONOLOGICAL DISTRIBUTION OF DATES

This section deals specifically with the chronological distribution of radiocarbon dates from archaeological sites in the central Murray-Darling. The following section discusses the broader pattern of spatial and temporal distribution of sites across the region.

The total assemblage of dates is shown in Figure 1. The graphs provide simple histograms of the temporal distribution of radiocarbon dates on mussel shell and charcoal from archaeological contexts, in thousand year sets.

The dates are discussed below in arbitrary four thousand year time blocks. In both the diagrams and the following discussion, dates are analysed or referred to by the thousand year period into which the date falls, so that a date quoted here as, say 26,000 BP, may be anywhere between 26,000 and 26,999 BP. Errors on dates have been ignored, with the result that a date published as 26,900±590 years BP (ANU 3000) will be quoted here as 26,000 BP.

The aim of this exercise is to examine general trends, not details of individual dates or sites. It should be kept in mind, however, that as a general rule, the older the date, the larger the error, so that

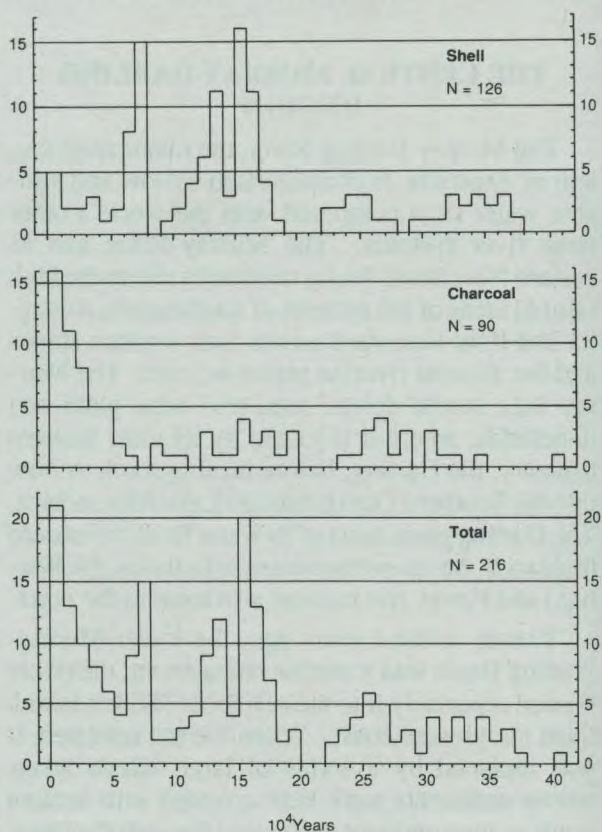


Figure 1 Archaeological radiocarbon dates from the central Murray-Darling basin.

the likelihood of the age of the dated material actually falling within the allocated thousand year period decreases with increasing antiquity.

The spatial distribution of the dated sites is shown in Figures 2 and 3. Only the shell dates are included on these figures for simplicity, but these give a clear picture of the distribution of dates. Nearly all the archaeological charcoal dates come from the Willandra. While technically the Pleistocene-Holocene boundary is set at 10,000 BP, the youngest block of sites discussed here is 8000-12,000 BP, because 8000 BP rather than 10,000 BP seems to represent the most significant point of change in the river system at the end of the Pleistocene.

36,000-40,000+ BP

For the Murray-Darling Basin, 40,000 years of occupation – now a political catch-phrase seen everywhere from posters to T-shirts – is in fact mainly an extrapolation from a number of dates in the mid-30,000s. This tendency to 'round-up' dates is encouraged by the possibility that material giving dates close to the limit of radiocarbon dating is in fact older, since a very small amount of contamination in old samples can result in a younger apparent age.

There is one charcoal date from the Mungo lunette which is 'beyond limit', that is more than 40,000 BP. In terms of archaeological charcoal dates this is an anomaly, since the next oldest is 34,000 BP. Dates quoted as 'more than 38,000' have been obtained from natural shell beds on the floor of Lake Mungo, these beds being exposed by deflation of younger lake sediments to form the clay layers in the lunette.

Elsewhere in the Willandra, one date of 37,000 BP has been obtained from a shell midden at Lake Prungle. The largest number of dates of this antiquity, falling at 35,000-36,000 BP, come from shell midden sites on the Outer Arumpo lunette, excavated by McBryde. These are shell dates and as such, should be reliable, but associated charcoal samples gave dates of half that age. Current re-analysis of material from these sites using new techniques should help resolve the discrepancy and provide a more reliable age for the sites.

Circumstantial evidence from the geomorphology of the Willandra suggests that other archaeological sites may also be of this antiquity but no definitive information is available. However, the exposure of older sediments is limited and there are few known sites that cannot be slotted into younger age brackets on stratigraphic grounds. There are no grounds at the moment for assuming that human

occupation at the Willandra was substantially earlier than 36,000-37,000 BP.

Away from the Willandra, only one date has been obtained for this time period. This is 36,000 BP for a shell sample from the Diprotodon locality at the south end of Tandou lunette. This sample did not comprise a midden, but is stratigraphically associated with probable archaeological material.

32,000-36,000 BP

The bulk of the dates within this time period are from the Willandra from indisputable shell middens in the Mungo lunette, Outer Arumpo, and the Garnpung-Gogolo interlake area between Lakes Garnpung and Leaghur.

Again the only other locality to provide dates of this antiquity is the Tandou lunette, where two 34,000 BP shell dates of probable archaeological derivation have been found at the Diprotodon locality, dating the same event as the 36,000 BP date above.

Combining the Willandra and Tandou dates, and allowing for the small sample, the total of 13 shell dates is spread remarkably evenly through the period 32,000-36,000 BP. In comparison there are only three archaeological charcoal dates older than 32,000 BP.

28,000-32,000 BP

The only dated sites during this time period are from the Willandra. The ratio of shell to charcoal dates is reversed, with only three shell dates, from Mulurulu, Garnpung South and Garnpung-Leaghur. In contrast, there are five charcoal dates from the Mungo lunette. The preponderance of charcoal dates at this time is a result of Barbetti's intensive dating project on hearths, but the lack of shell dates reflects a change in lacustrine and sedimentary conditions (Barbetti 1973; Barbetti and Allen 1972).

This is clear at Tandou, where a major soil horizon developed in the lunette at this time, bracketed by dates of 26,000 and 34,000 BP. No sites have been recorded within this soil and no dates at Tandou fall into this time frame. It is probable that any organic matter of archaeological derivation, such as shell or bone, would not have survived soil-forming processes, and as yet no stone artefacts have been observed in situ in this soil horizon.

24,000-28,000 BP

The majority of the Pleistocene shell midden dates from this period are from the Tandou lunette. The distinctive Tandou soil marks a major division in archaeological visibility in the lunette. Along the

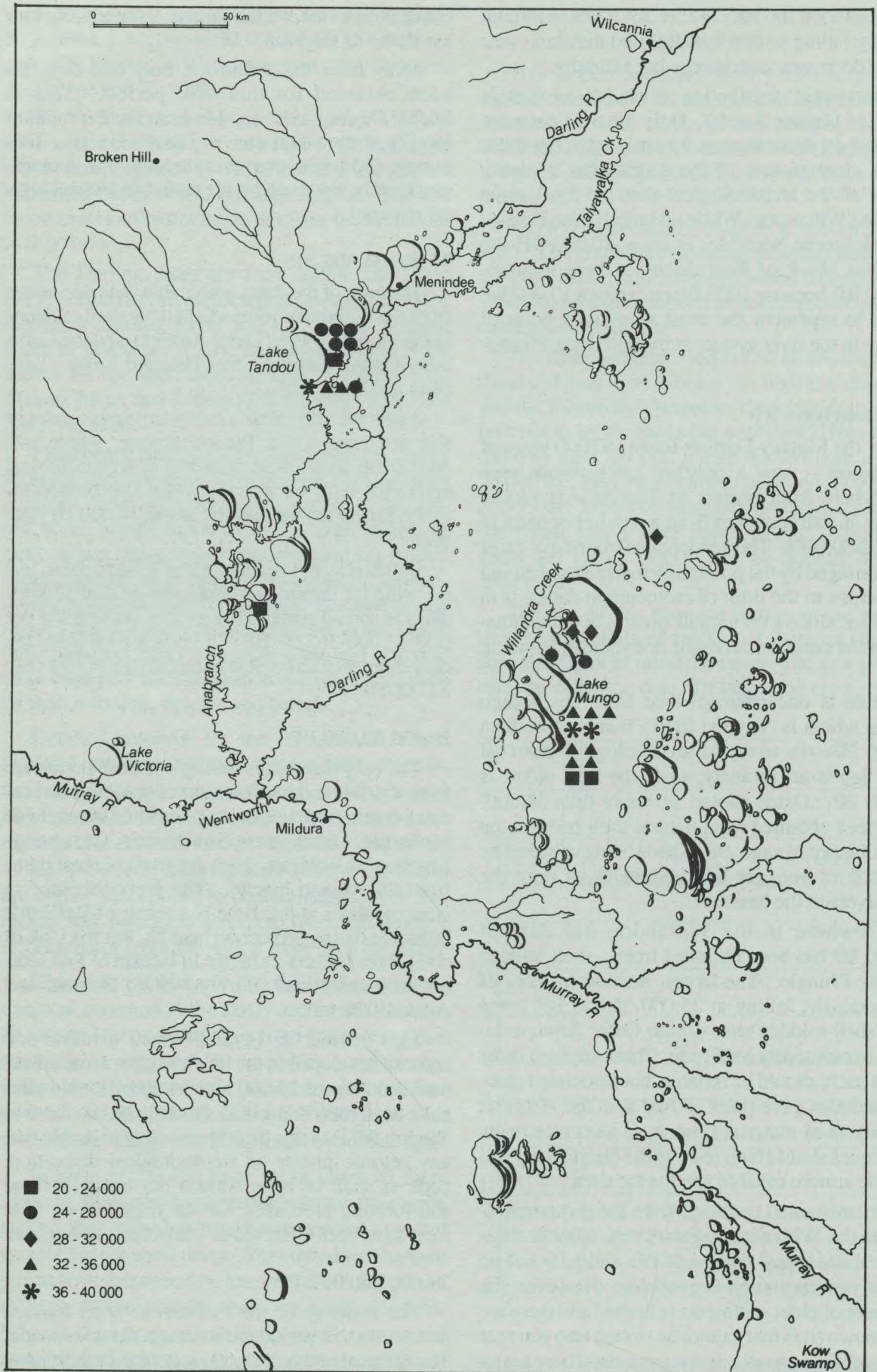


Figure 2 Distribution of shell midden dates older than 20,000 BP in the central Murray-Darling Basin.

25 km length of the lunette, archaeological sites appear at the very base of the sandy aeolian sediments that were laid down immediately above the soil horizon. Even where no sites have been preserved in situ, scattered archaeological material can be seen above the red soil, or deflated onto exposures of it, but not beneath it (Hope et al. 1983). So far material of probable archaeological derivation has been found beneath the red soil at only one place, the Diprotodon Locality. This is the source of the dates in the mid-30,000s.

In the Willandra, there are actually fewer archaeological radiocarbon dates in this four thousand year period than in the preceding 12,000 years, and only two of these are on shell. It is difficult to tell whether this reflects the real distribution of sites, or whether it is a result of sampling bias, with more research effort directed to the actual dating of sites in stratigraphically older units. A systematic analysis of site numbers and distribution throughout the different stratigraphic units at the Willandra Lakes would clarify this.

Again, the Willandra and Tandou remain the only localities with confirmed archaeological sites falling within this time period. However, finely disseminated charcoal in sediments at the Tedford site, Lake Menindee, which may represent a hearth, gave a date of 26,000 BP (Tedford 1967).

20,000-24,000 BP

There is a striking drop in the number of sites dating to this period, which covers the lead-up to the peak of the glaciation. In fact there are no dated sites at all in the central Murray-Darling between 20,000-22,000 BP, and given the large sample of dates overall, this is likely to be a true reflection of the lack of sites.

At Tandou one shell midden produced a date of 22,000 BP; in terms of its characteristics and stratigraphic position, it relates to the group of sites dated between 24,000 and 27,000 BP. Another locality appears at this time, with a 23,000 BP date from Lake Nitchie, a lake attached to the Anabran channel to the south of Tandou. The lunette at Nitchie is very similar to that at Tandou, and the dated shell midden is in a comparable stratigraphic position to the sites of comparable age (22,000-27,000 BP) at Tandou. However, this is the only shell midden site which has been located on any of the lower Anabran lunettes, in spite of the large number of lakes and good exposures of Pleistocene lunette sediments.

At the Willandra, there are two shell and one charcoal date from Outer Arumpo of 22,000-23,000 BP, but these are associated with the very

old dates still under study, and must be treated with caution at the moment.

16,000-20,000 BP

There are no shell midden sites in the Willandra system or at Tandou at the beginning of this period. For the Willandra, this represents a gap of 5000 years, between 17,000 and 22,000 BP. However, for this period there are five charcoal dates from the Willandra, two of 19,000 BP and one of 17,000 BP from the Mungo lunette, one of 17,000 BP from Mulurulu and one of 19,000 BP from Outer Arumpo. The reliability of these is unclear. The Outer Arumpo date is associated with the older set discussed above, and one of the 19,000 BP dates from Mungo is paired with older bone dates from the Mungo 1 burial. The 17,000 BP date from Mulurulu is associated with shell dates of 15,000 BP.

At Tandou Lunette itself, there is a similar gap in shell dates from 15,000-22,000 BP, but this period marks a major change in the distribution pattern of Pleistocene sites, away from the Willandra and Tandou systems. Sites appear at nearby Kangaroo Lake at 17,000 BP, in source-bordering dunes within the anabran channel at 18,000 BP and at Lake Victoria at 18,000 BP. At 16,000 BP there is a sudden reappearance of shell middens throughout the Willandra, and the number jumps in the subsequent thousand year period.

12,000-16,000 BP

In terms of the number and geographic spread of dated sites, this period marks the peak of the Pleistocene record of occupation in the Murray-Darling Basin. Although there are some specific environmental reasons involved in the good preservation of sites from this time, the significance of this period needs to be stressed because it has been overshadowed by an emphasis on the pre-glacial maximum sites from the Willandra.

Sites of this age occur throughout the river and lake system of the central Murray-Darling, with one major exception, the modern channel of the Darling River, between Menindee and Wentworth. For the anabran channels the number of sites recorded and dated north and south of Menindee reflects the intensity of survey there (Fig. 3); similar densities can be predicted elsewhere on the Pleistocene system. The sites occur on a wide range of landforms: lunettes, non-lunette lake shores, beaches, river banks and source-bordering dunes.

The shell dates exhibit a striking bimodal distribution, peaking at 15,000 and 13,000 BP. The 15,000 BP peak represents sites on major lake sys-

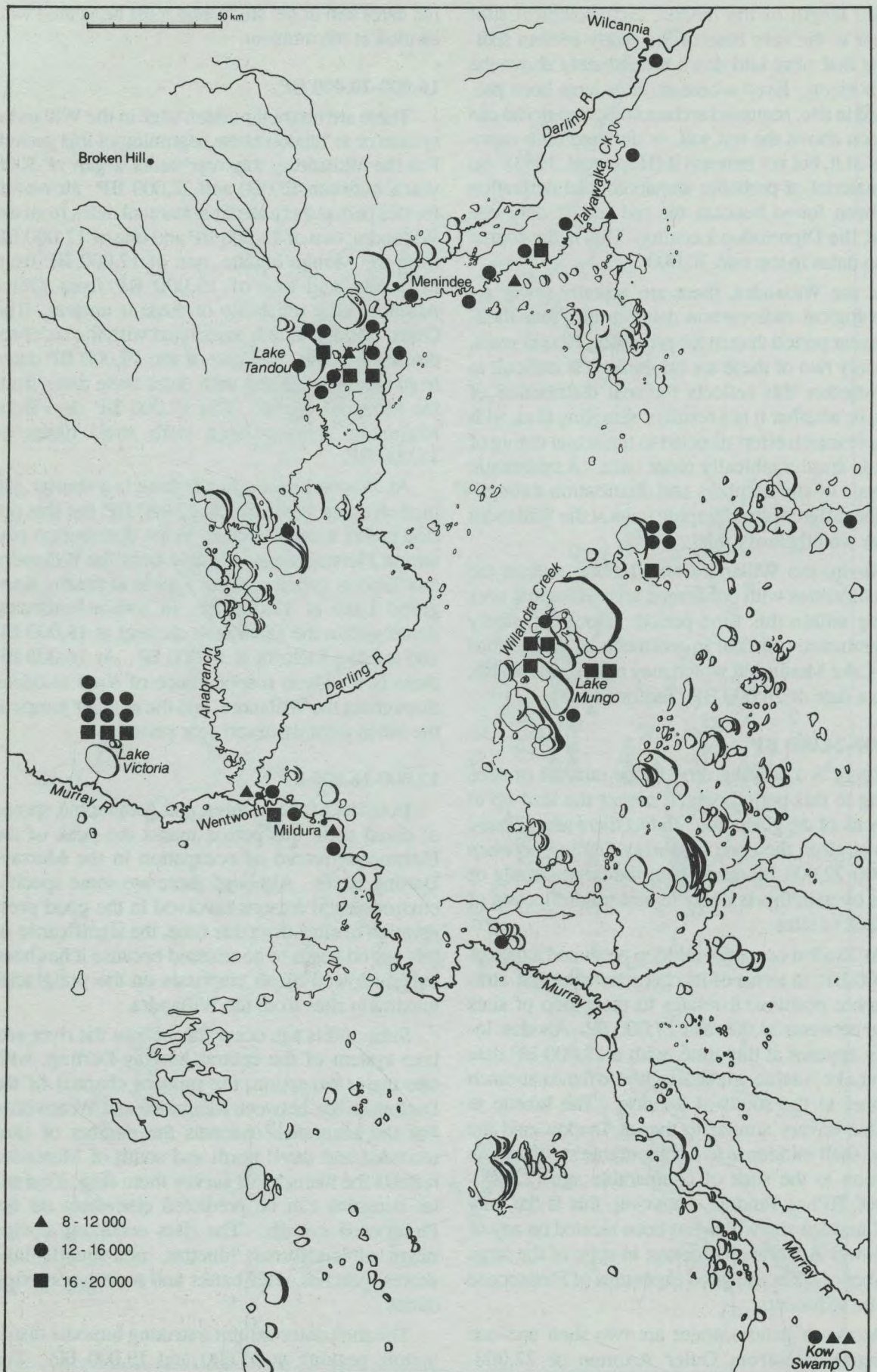


Figure 3 Distribution of shell midden dates between 8000 and 20,000 BP in the central Murray-Darling Basin.

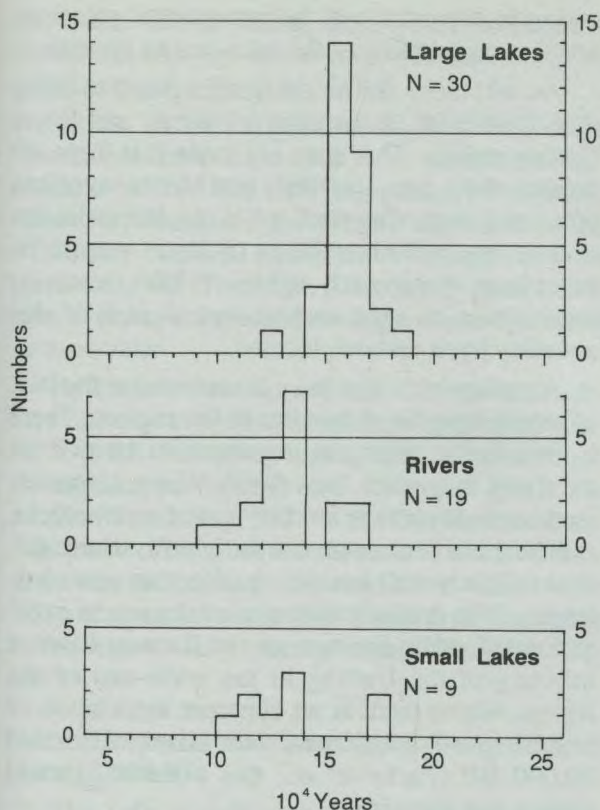


Figure 4 Bimodal distribution of shell midden dates from large lakes and rivers and small lakes between 8000 and 18,000 BP.

tems, dominated by the Willandra lakes; the 13,000 BP peak represents sites on river channels, and on small lakes tied to channels (Fig. 4).

At the Willandra, shell middens dating to 15,000-16,000 BP occur in a variety of locations: on the lunettes, on the western non-lunette lake shores and on beaches (Fig. 5). They represent a high water phase subsequent to the peak of the glaciation. This period is less well-represented at Tandou, with only two shell middens dated from this time. At Tandou these were the only middens recorded at a younger stratigraphic level in the lunette than the set of sites dating between 22,000 and 27,000 BP.

However, at nearby Kangaroo Lake there is an interesting archaeological complex of sites with charcoal, stone and bone, and some shell middens, dated between 11,000 and 13,000 BP. This material lies above a distinctive brown soil horizon, which in turn overlies the older dates of 17,000 BP.

8000-12,000 BP

The sites dated in this period represent a tailing-off of the distribution of riverine and small lake sites which commence at 18,000 BP and peak at 13,000 BP. The graph for the dates from these locations is skewed, with a steep build-up and a

more gradual decline (Fig. 4). The mean of the dates from riverine and small lakes sites graph is 12,000 BP and the mode is 13,000 BP.

There are no shell dates from this period from the Willandra, but two charcoal dates of 8000 and 9000 BP have been obtained from fireplaces on the Willandra Creek channel, and a 10,000 BP date on charcoal from Garnpung/Leaghur is associated with 15,000 year old shell middens.

There are no dates within this period at Tandou either (nor any suggestion that archaeological material on the Tandou Lunette could be as young as this), but at nearby Kangaroo Lake a shell midden in the complex of sites described above is dated at 11,000 BP.

The youngest shell date associated with this late Pleistocene phase is 9000 BP from a source-bordering dune on the Talyawalka. As can be seen in Figure 1, a resurgence in shell middens commences only a thousand years later, between 7000 and 8000 BP, with the bulk of dated sites coming from

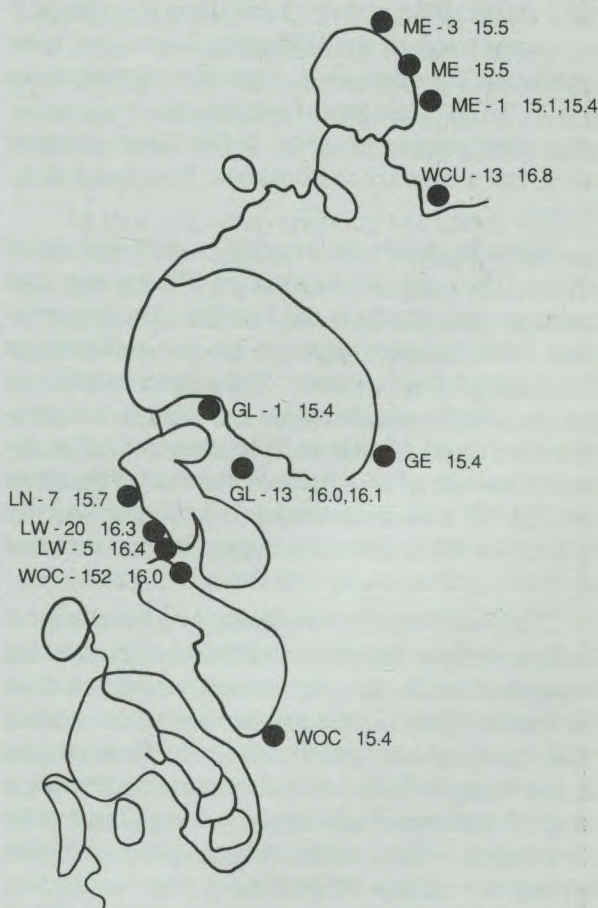


Figure 5 Distribution of shell middens between 15,000 and 17,000 BP at the Willandra Lakes. Locality codes: GE - Garnpung East, GL - Garnpung Leaghur, LN - Leaghur North, LW - Leaghur West, ME - Mulurulu East, WCU - Willandra Creek Upstream, WOC - Walls of China.

the Teryawynia Lakes system, off Talyawalka Creek. This reflects post-Pleistocene environmental changes in the river system, probably beginning close to 8000 years ago.

REGIONAL PATTERNS

The Pleistocene archaeological sites in the central Murray-Darling Basin fall into two distinct sets, pre-dating and post-dating the glacial maximum, around 18,000-22,000 BP. The two periods are distinct in the absolute number of sites dated, their geographic spread and the variety of landforms represented. The data demonstrates that the Pleistocene should not be treated as a single uniform period, but as a time of considerable climatic, environmental and probably cultural variation.

Before the glacial maximum (sites older than 22,000 BP)

There are fewer dated Pleistocene sites older than 20,000 BP and their distribution is geographically restricted to the Willandra Lakes and Lake Tandou on the Anabranch. The only exceptions are the 23,000 BP date from Lake Nitchie, in an analogous stratigraphic situation to the Tandou lunette sites, and a dubious charcoal date from Lake Menindee.

There is clearly an extreme bias in this set of sites. They are all located on Pleistocene lake systems, and mostly in the lunettes. The preservation of these sites depends on the sedimentary build-up of the lunettes. Since lunette build-up cycles with the water regime in the lakes, a discontinuous record of sites is to be expected. The apparent paucity of sites in the Willandra before about 36,000 BP may indicate that the system was dry before that time. Subsequent gaps in the site record probably reflect changes in deposition rates.

The discovery of sites depends on the erosional deflation of the lunettes. In general there is a bias towards sites in the higher and younger lunette sediments, because these have been more exposed than the deeper and older sediments. Sheet erosion in the younger sediments has often opened up larger areas of exposure than has gully erosion in the older sediments. This differential exposure applies within the earlier Pleistocene period as well as between the earlier and later Pleistocene phases. It is particularly significant at Tandou, where sediments younger than 26,000 BP, above the marker soil horizon, are well exposed by broad-scale erosion, but the deep sediments below are poorly exposed, mainly in gully sections. In spite of these problems, the earlier Pleistocene record for the

region is dependent on the exceptional preservational circumstances of the lake-lunette systems.

As yet, there are no other sites dated to more than 20,000 BP in the central Murray and lower Darling region. This does not mean that there are no sites of this age. It is likely that Mootwingee and other rock engraving sites are as old, but estimates of their age depend on dating of desert-varnish on engravings (Dragovich 1984a, 1984b), since no rockshelters or open archaeological sites of this antiquity have yet been located.

A variety of factors have contributed to the lack of prospecting for older sites in the region. There is little major mining or development away from the rivers in western New South Wales, so hinterland contract surveys are few and of small extent, and there is a perception that the Murray-Darling is either already well-known, or offers no new challenges. The dramatic outcome of the recent excavation at Cuddie Springs, on the Barwon River, a tributary of the Darling to the north-east of the region, where there is an apparent association of artefacts and megafauna with dates of around 30,000 BP (Furby et al., this volume), should change that perception.

During the glacial maximum (18,000-22,000 BP)

Whether we consider the reliable shell dates, or the less secure charcoal dates, there is general continuity of archaeological dates in the region from 37,000 to 22,000 BP. Then, there is a gap of three thousand years, between 22,000 and 19,000 BP, for which there is no recorded shell date. If charcoal dates are added, there is a region-wide absence of dated sites for two thousand years, from 22,000-20,000 BP.

Bowler (1980) concluded that the Willandra Lakes dried up completely at about 20,000-18,000 BP, then refilled briefly at 16,000-15,000 BP before finally drying completely. The absence of shell middens at the former time, and their widespread presence at the latter time contributed to this interpretation. Does the five thousand year gap in dated shell middens at the Willandra between 22,000 and 17,000 BP mean that people abandoned this area because the lakes were dry? Since there are only four shell midden dates from the Willandra in the preceding 7000 years (between 28,000 and 22,000 BP), it may be just a matter of sampling bias.

It also depends on how the charcoal dates of this age are interpreted. There are 17 charcoal dates from the Willandra during this 12,000 period (28,000-17,000 BP), compared with the four shell dates. Some of these dates are part of discrepant

pairs as described earlier, and are likely to underestimate the real age of the sites, but others may be valid, including those of 17,000-19,000 BP.

At the Willandra, the fine detail of the Mungo lunette sediments shows that there were major fluctuations in this lake over the period in question. However, Mungo is not directly connected to the Willandra channel, but filled by overflow from Lake Leaghur. Therefore it was much more sensitive to changes in river discharge, evaporation and groundwater.

At Tandou there is only one uniform sedimentary unit covering the period from about 27,000 to 14,000 BP, indicating stable lake-full conditions throughout, but there is an even greater gap in the midden dates, from 22,000-16,000 BP, than at the Willandra. Therefore the absence of middens does not alone indicate dry lake conditions. There is no body of charcoal dates from Tandou, or elsewhere in the region, to compare with those from the Willandra.

After the glacial maximum (sites younger than 18,000 BP)

The bulk of radiocarbon dates for the archaeological sites in the central Murray-Darling Basin fall into the period 9000-18,000 BP. The temporal distribution of these dates falls into a clear bimodal distribution, distinguishing the last shell middens sites on the large now dry Pleistocene lake basins, from the later peak of sites on the river channels and the associated smaller lakes.

The Willandra is the main source of the information about the last phase of the major lake-systems. Here the excellent preservation of the suite of midden sites at 16,000-15,000 BP is due to complete drying and subsequent total abandonment of the lakes. Many of these sites occur on the western lake shores or on beaches. Any older sites in these locations would have been destroyed by the dynamic erosional environment of lake-shore and beach during the last lake full stage.

In effect, these sites at the Willandra provide a snap-shot of what human land use around the lakes might have been at any given point in time when the lakes were functioning. As such they should be a starting point for a study of Pleistocene lacustrine economy, in spite of possible climatic differences from the earlier Pleistocene phase.

Given that the Willandra Lakes were probably dry from 17,000-22,000 BP, the period between 15,000 and 16,000 BP may encompass both the local re-initiation of an aquatic economy and its subsequent abandonment within a period of two thousand years. There is an interesting Holocene parallel, not far to the north of the Willandra. The

Teryawynia Lakes appear to have been suddenly filled at 8000 BP and equally suddenly abandoned at 6000 BP. In both cases the shortness of the period of intensive aquatic economy may have contributed to the good preservation.

In contrast the lunette sediments at Lakes Tandou and Kangaroo suggest that these lakes remained full throughout this period. At 17,000 BP, people were fishing, collecting mussels and probably also hunting small mammals at Kangaroo Lake. It is not clear why no sites between 22,000 and 17,000 BP have been found at Tandou, but for Kangaroo Lake the reason is possibly lack of exposure of older sediments. However, one of the 17,000 BP sites at Kangaroo Lake was found in situ within slopewash deposits suggesting that erosion during that period may have destroyed sites as well as fortuitously preserving this one.

The earliest sites on the Murray are shell middens at Lake Victoria dating to the same period of 18,000-17,000 BP. The suite of midden sites at Lake Victoria extends from 18,000 to 14,000 BP. The reason for the absence of earlier Pleistocene sites in the Lake Victoria lunette is unclear; the presence of megafauna would suggest a greater antiquity than 18,000 BP for the deep lunette sediments there.

The lack of a sharp endpoint to midden sites on these lakes, as compared to the Willandra, reflects the fact that they were never totally abandoned. Although river discharges remained too low to fill them for any substantial length of time, they have often been temporarily filled by floodwaters, with consequent bank and beach erosion. However, the youngest Pleistocene dates for the large lake systems are 13,000 BP from a beach on the west shore of Tandou and 14,000 BP for middens on the Victoria lunette, compared with 15,000 BP at the Willandra Lakes.

The younger peak in the bimodal distribution of midden sites is made up mainly of riverine sites, as well as those on three smaller lakes, Kangaroo Lake, attached to the Anabranche, and Lake Benanee and Kow Swamp, attached to the Murray. The similarity of these lakes to the river channels is probably due to their small size (less than 5 km in diameter) resulting in a more sensitive response to changing river conditions (that is, these lakes could still be filled by low river discharges even after the larger lakes were abandoned).

There are three landforms associated with the rivers where archaeological sites might be expected:

1. the floodplain, sometimes divided into higher and lower terraces,

2. the higher red sand plain into which the floodplain is cut, and
3. white source-bordering dunes set in the river meanders.

Sites on the floodplain of the modern Darling tend, as might be expected, to be very young, any older ones being covered with layers of recent alluvium. This is also the case with the floodplain of the Pleistocene anabranch channels, because the superficial layers on their floodplains come from recent deposition when they act as modern flood overflow channels.

The source-bordering dunes within the anabranch floodplains are much older, and were formed when river discharges dropped in the late Pleistocene, exposing the sandy river beds to wind action. Their formation (but not their age) is analogous to lunettes, and they often form crescentic dunes on the east sides of large meanders. Sites occurring in source-bordering dunes cannot be older than the initiation of the dune, which in turn relates to the last phase of falling river flow.

The red sand plain however is a quite different situation. It is of considerable antiquity, possibly 500,000 years old (Bowler 1980) and exhibits ma-

jor pedogenesis. Geologically it is known as the Woorinen Formation and consists of the major surficial sediments, of primarily aeolian origin, throughout the region. Like most of the sediments in the region it is highly calcareous, so provides good preservational conditions for shell and bone, though pedogenesis can subsequently destroy these.

Midden sites in the time period 8000-18,000 BP occur both in source-bordering dunes and on the red sand plain, consistently close to the junction of sand plain and flood plain. Figure 6 shows an example of this pattern, the distribution of shell midden sites along Tandou Creek, the section of the anabranch channel running from Menindee on the present Darling River south to Lake Tandou. Most sites on the creek are on the edge of the sand plain rather than in the source-bordering dunes, simply because the latter are small and localised.

The oldest riverine sites, at 15,000-16,000 BP, occur in source-bordering dunes on the Talyawalka Channel and Tandou Creek. The oldest sand plain edge sites are somewhat younger at 14,000 BP on the Anabranch system, though there is a 16,000 BP sand plain midden on the Murray. The youngest

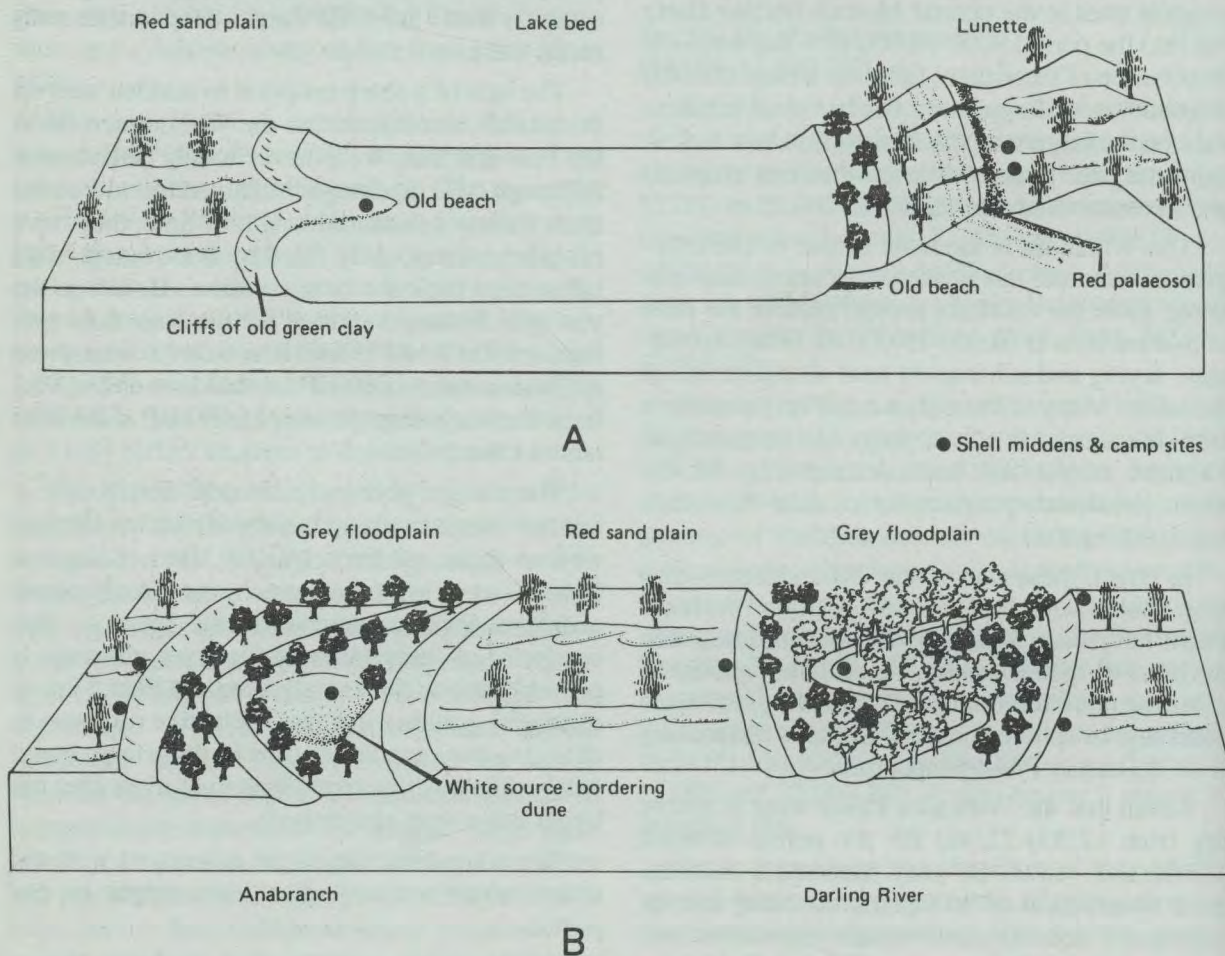


Figure 6 Site location relative to land form: Darling and Anabranch channels. (From Balme and Hope 1991).

riverine site in this suite (9000 BP) is located on the Talyawalka Channel. Within this time period mid-den sites appear on all river channels in the area except the modern Darling and the Willandra Creek downstream of Mulurulu.

A specific initiation date for the presence of sites in source-bordering dunes, representing the point when river discharge decreased and sand deposition started, is to be expected. An explanation for the lack of time-depth for sites on the sand plain is not so obvious. There are several possible explanations for the apparent absence of older Pleistocene sites along the river banks.

1. The first possibility is that sites older than 16,000 BP do exist on the sand plain edge, but are covered with sediments and have not yet been found. This is unlikely, because of the severe erosion that has occurred along the river frontages since white settlement. This erosion has exposed the recorded sites, and it would be expected that by chance alone some older sites in particularly badly eroded areas might be found if they were there. Erosion in some cases has stripped the sand plain down to a carbonate hard pan on which shells, stone tools and bones have deflated but no older shell has yet been found.
2. The second possibility is that older sites were located only on the floodplain and are now covered over with floodplain sediments. This would imply cycles in river discharge permitting occupation of the floodplain. It does not provide an explanation for the absence of occupation of the sand plain.
3. There may have been no older shell middens anywhere on the river channels. It is highly unlikely that mussels were absent from the rivers, since *Alathyria jacksoni* is a genus endemic to the Murray-Darling system. However, it is possible that mussels were inaccessible, especially if the rivers maintained a continuously high flow. Today, *Alathyria* is more easily harvested when rivers are very low; ethnographically Aboriginal people were observed diving for them, but even this is only possible when the rivers are not in flood. It is a reasonable assumption that river mussels would have been more difficult to get at during periods of high river discharge, so riverine shell midden sites may have been rarer when the lakes were full during the Pleistocene.
4. Older sites may have occurred on the sand plain edge, but were subsequently eroded as the river cut into it. This would require that the rivers before 16000 BP were actively cutting into the sand plain and in the process removing any sites on the edge, but ceased such sand plain erosion

at about 16,000 BP. This in turn implies a high discharge through the time of glacial maximum, or immediately after, followed by a low discharge after 16,000 years. This mechanism is consistent with the commencement of formation of the source-bordering dunes, which process also requires a decrease in river flow.

Whether the absence of sites on the river channels before 18,000 BP is real or due to removal by erosion, the same reason is likely high river discharge before that time. Did this high river flow continue through the glacial maximum, or was there a decrease before 18,000 BP and a brief increase afterwards, before the later decline? At Tandou there is no indication of a dry lake phase until after 14,000 BP, so sufficient water must have been flowing down the ancestral Darling channel to keep that large lake in existence (if fluctuating) through the peak of the glaciation. At the Willandra, Bowler (1980) has demonstrated that there was a dry period at the glacial maximum, followed by a short high lake phase around 16,000-17,000 BP.

On the Darling there was a decrease in river flows, most markedly between 13,000 and 15,000 BP. This is the period when the large lakes dried as indicated by the cessation of lunette building. The Anabran and Talyawalka continued to be the main river channels through this period, albeit with a reduced flow. These channels had been abandoned by 9000 BP. This was probably due to a return to high river discharge in the early Holocene. The older channels choked with sediment could not handle the increased discharge, which cut a new channel for itself, the present Darling River.

This pattern, clearly seen on the Darling, should be matched on the Willandra Creek which was also abandoned sometime in the late Pleistocene. Unfortunately, in spite of the detailed work on the Willandra Lakes, no equivalent site survey or dating has been carried out along the upper Willandra Creek or the Lachlan River. It is therefore still unclear whether the Willandra Creek kept flowing with a lower discharge between 10,000 and 15,000 BP after it had ceased to fill the lakes. A single date of 15,000 BP from Gunnaramby Swamp, on Willandra Creek to the east of Lake Mulurulu, suggests that the Willandra Creek may turn out to be similar to the Darling.

The Murray River does seem to match the Darling, although it remained within the same channel rather than switching. It was able to fill Lake Victoria between 15,000 and 18,000 BP and again around 6000 BP, on the basis of the shell midden occurrences, but apparently not in between those dates. This gives a comparable period of low river discharge for the Murray between 15,000 BP and

the early/mid-Holocene. Further geomorphological work at Lake Victoria would be useful.

The differential preservation of sites between the large lake systems and the rivers can be summarised as follows:

1. Before 17,000 BP relatively high river discharges filled the large lake basins. This high discharge moved sand down the river channels, preventing the formation of source-bordering dunes, and actively eroded the sand plain edge, removing sites that had formed there. Wave action in the full lakes eroded western shores and beaches, removing any sites that had formed there. This explanation is consistent with a dry lake phase at the Willandra between 18,000 and 22,000 BP, but does require a high discharge phase after that time.
2. River discharge declined after about 17,000 BP, resulting in the drying of the lakes at about 15,000 BP at the Willandra, 14,000 BP at Lake Victoria and 13,000 BP at Lake Tandou. This decline allowed the commencement of building of source-bordering dunes from river-bed sands, and possibly easier access to river mussels.

A concomitant increase in stability of the red sand plain river banks resulted in preservation of sites at this point. Even so, river discharges were high enough to maintain the smaller lakes and to support river mussels, which are intolerant of dry or saline conditions. Preliminary analyses of $\delta^{13}\text{C}$ on mussel shells from Darling sites of this age indicate fresh water and high flows. The differences between the Willandra and Darling may reflect catchment differences.

3. An increase in river discharge sometime after 10,000 BP, possibly at about 8000 BP, resulted in abandonment of the now choked anabranch channels, especially downstream from the Menindee lakes, and rerouting of the main flow down the modern channel. While this paper is not concerned with the later Holocene, it should be said that an analogous model of a period of high discharge followed by one of low discharge for the Darling River during the Holocene can also explain the temporal distribution of Holocene shell midden sites along that channel.

AVENUES FOR FURTHER WORK

Irrespective of whether or not people inhabited the river banks and lake shores before 17,000 BP, after that time they would have had a reduced choice of water frontages and fewer options for the exploitation of aquatic resources. With the disappearance of the large lakes, the river channels and small lakes would have become more important.

The most likely result may have been an increased concentration of people along the river banks where, as river discharges declined, access to riverine resources was becoming easier. While the preservation of riverine sites dating after this time is clearly influenced by environmental factors, the nature and contents of the sites may reflect social choices or changes.

There have been two major archaeological studies focussing on the sites of this time period. Keefous (1983) investigated the lunette sites at Lake Victoria, and Balme (1990) recorded and analysed the Darling lake and river sites as part of her study on the aquatic economy of that system. Her analysis focussed on faunal remains. The Willandra sites of this time period were originally investigated by Allen (1972) and have more recently been examined by Johnston (this volume). However, there has been no comprehensive study of the regional archaeology of the post-glacial maximum Pleistocene period. The following comments list some of the characteristics of these sites, all of which would repay further investigation.

Many of these late Pleistocene shell middens seem to be much larger in size than earlier Pleistocene ones, or are components in larger site complexes. This applies to lunette sites such as those at Lake Victoria, possibly western shore sites such as those at Leaghur, and river bank sites, such as Tuckers Creek, on the Murray. There has been little work on the structure of such sites.

There has also been a neglect of stone tool assemblages in sites of this time period. Balme (1991) demonstrates that there is a differential distribution of grindstones between sites on Pleistocene rivers and lakes along the Darling system. Grindstones are rare in the Pleistocene lunettes, but the majority of Pleistocene riverine sites have grindstones associated (Table 1).

The distinction between the lake and river sites is a temporal one, with the Pleistocene lake sites being mainly older than 15,000 years and the riverine sites, in the source-bordering dunes and on the sand plain edge mainly younger than this.

Balme noted the potential for Holocene lag material on these Pleistocene riverine middens and was cautious about accepting a Pleistocene age for these grindstones. However, given the very large number of late Pleistocene riverine sites with associated grindstones (67.5% of all such sites, and 81.8% of sites with artefacts), it is equally possible that the association of grindstones with these late Pleistocene sites is genuine.

The percentages of sites with grindstones on the late Pleistocene anabranch sites are remarkably similar to the figures for sites on the Teryawynia

	Pleistocene		Holocene	
	Lakes	Anabranches	Teryawynia Lakes	Darling River
Approx. age years BP	15,000 +	9000-16,000	6000-8000	0-3000
Total sites	46	40	86	24
Sites with artefacts	14 (30.4%)	33 (82.5%)	67 (77.9%)	14 (58.3%)
Sites with grindstones	1 (2.2%)	27 (67.5%)	55 (63.9%)	10 (41.6%)
Artefact sites with grindstones	7.1%	81.8%	82.1%	71.4%

Table 1 Distribution of grindstones in Darling River sites from Balme (1991).

Lakes in the early Holocene. Most of these lakes seem to have formed by water backing up in river meanders when the system was rejuvenated by early-Holocene high discharge, and are structurally distinct from the enormous kidney shaped Pleistocene lakes.

In economic terms they may have been more similar to the river channels than to the bigger lakes. Balme's (1990) study supports this to some extent, in that both the Pleistocene river and early Holocene lake sites contain less terrestrial species than do the earlier lunette sites, however, the early Holocene sites have a more diverse range of aquatic resources.

If the grindstones are contemporary with the shell middens at both the late Pleistocene anabranch sites and the early Holocene Teryawynia sites, what were they being used for? Allen (1972) noted the apparent absence of grindstones in the Pleistocene at the Willandra, and suggested that the introduction of seed grinding postdated the Pleistocene lake-full phase and was related to increasing aridity.

Balme (1991) showed that the majority of grindstones associated with both the Pleistocene river sites and the Holocene Teryawynia sites are amorphous in type, and that there were very few identifiable mortars, mullers and millstones from both areas. She concluded that the evidence for Pleistocene seed-grinding is still ambiguous.

Increasing aridity has been cited as an explanation for the widespread appearance of grindstones during or after the late Pleistocene, but it should be noted that whatever the age of the grindstones from the sites discussed above, they have all been found in close association with water resources. However, it is difficult to think of a use other than seed-grinding to explain the large number of grindstones recorded.

Apart from the issue of age and function of grindstones, the economics of their production and transport also deserves attention. For the central Darling, grindstones would have to have been transported for at least 50-300 km (quarries are known in the Scropes Range and at Mootwingee), implying extensive trade connections. When did this long-distance heavy transport start, before or after the glacial maximum?

The same question applies to all stone materials found in sites along the lower Darling, from south of Wilcannia to the Murray, where there are no local stone sources at all. However, silcrete quarries occur at the Willandra, and this area may have been an exporter of stone to surrounding areas without local sources. This may be the reason why the Willandra continued to be attractive even after the lakes had dried, as indicated by the large number of Holocene sites there (the majority of charcoal dates shown in Figure 1 are from hearths at the Willandra).

Finally, large burial grounds along the Murray first appear at the time of the peak of riverine sites in the late Pleistocene. These include well-known sites such as Kow Swamp and Coobool Creek, and less well-studied ones such as Lake Benanee and Tuckers Creek which are of the same age, about 12,000-13,000 years old. The oldest date at Snaggy Bend is slightly younger (10,000 BP) but it may also be grouped with this set. Pardoe (1988, see also this volume) has suggested that the existence of repeatedly used burial grounds cemeteries along the Murray may indicate stability in land ownership. If so, this pattern must date back to at least the late Pleistocene.

CONCLUSION

The study of Pleistocene sites in the central Murray-Darling region, as elsewhere in Australia, began with a focus on searching for the oldest

evidence of occupation. The continuing uncertainty surrounding the dates of the Arumpo sites, at the limit of radiocarbon dating, demonstrates how difficult that can be. A different line of approach was followed by Balme on the Darling (Balme 1990; Balme and Hope 1991) and Kefous (1983) at Lake Victoria, in attempting to look at regional patterns in the use of aquatic resources. Subsequently Pardoe (1988) has addressed past human demography and social behaviour in the region through the analysis of burials. The most neglected area is that of the stone tool assemblages, especially the questions of their sources and distribution.

There is now an excellent chronological framework for the region especially for the later Pleistocene and the time is ripe for intensive study of particular periods. The most intriguing is the post-glacial maximum phase between 8000 and 18,000 BP, for which many sites are known. For the Murray-Darling Basin, the combination of extensive information about environmental change and good preservation of a large number of sites over a wide geographic area provide an opportunity for further exploration of this significant period of the Pleistocene.

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PLEISTOCENE SHELL MIDDENS OF THE WILLANDRA LAKES

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The prehistory of the Willandra (Allen 1972, 1974; Bowler et al. 1970) shows that Aboriginal exploitation of the lacustrine resources of the region commenced ca. 36,000 years ago and continued until the viability of the resource base was reduced by falling lake levels and rising salinity levels in the late Pleistocene. Beyond this general picture there is little detail available on the exploitation of lacustrine resources, and especially about the nature of shell bed exploitation. A number of questions immediately come to mind; Where are shell middens located? What are their characteristics (size, volume, species composition)? How much shellfish was gathered and consumed in each archaeological event? Are the middens that are visible today an accurate reflection of the original archaeological deposit, or have they been modified by taphonomic processes? What was the role of lacustrine resources in the diet? Was exploitation seasonal, akin to the nineteenth century Darling River ethnographic model (Allen 1968), or as White and O'Connell (1982:39) suggest, is there no ethnographic parallel for the Pleistocene economic system?

This paper begins to address some of these questions by presenting preliminary results of a survey of middens located in the Willandra Lakes World Heritage Area (Fig. 1). The survey was conducted for management purposes and is part of a continuing programme of site monitoring and protection. This paper is concerned only with the mussel shell component of the middens. Some middens, particularly those towards the northern end of the Willandra Lakes system, contain considerable quantities of fish and small mammals but these components of the middens are excluded from this analysis. Other aspects of the Pleistocene economy of the region, including non-molluscan components, will be discussed elsewhere.

The popular prehistory of the Willandra Lakes emphasises the Pleistocene lacustrine economy and its rich food resources, contrasting this with the modern landscape of dry lake basins vegetated by bluebush, saltbush and grasslands. The appeal of the Willandra has always lain in this dichotomy between the past and the present, between land-

scape history and Aboriginal prehistory. It is a formidable task to look at the chenopod plains today and envisage the lacustrine scenery of the Pleistocene, replete with water filled lakes, birds, fish, shellfish and large macropods. The history of people and land in the Willandra is so removed in time and in kind from the present that this popular reconstruction of events is highly evocative.

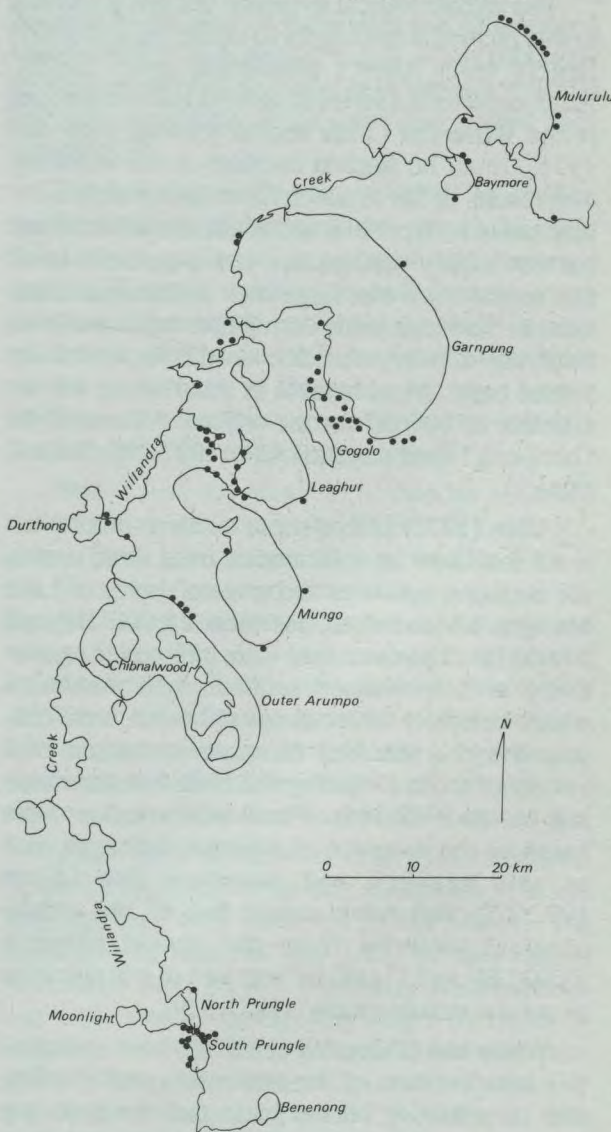


Figure 1 Location of shell middens in the Willandra Lakes recorded by Clark (1987).

Site	Midden Form	Volume (m ³)	Average Volume (m ³)	C ¹⁴ Age Years BP
Mungo I	Scattered shell	-	-	-
Leaghur I	1 in situ midden	-	-	27,160±900 (ANU 372B)
Leaghur Peninsula I	Scattered shell	-	-	-
Leaghur Backshore I	8 in situ middens	4	0.5	-
Leaghur Backshore II	Scattered shell	-	-	15,690±235 (ANU 461)
Leaghur Backshore III	Scattered shell	-	-	-
Garnpung I	In situ midden	104	-	15,480±210 (ANU 373B)
Mulurulu I	9 in situ middens	9	1.0	15,120±235 (ANU 880A)
		-	-	15,450±240 (ANU 880B)
Mulurulu IIIA	12 in situ middens	6	0.5	15,560±240 (ANU 948B)
Mulurulu IIIC	Scattered shell	-	-	-

Table 1 Shell middens investigated by Allen (1972).

The archaeological evidence that has given rise to this picture is not nearly so colourful and comes largely from Allen's pioneering study (1972). Allen undertook a series of surveys and excavations in the Willandra Lakes region between 1969 and 1971. In all he studied middens at ten locations. The results of his research have been widely summarised in both popular and academic publications, but not widely used except at a superficial level. His results show that large shell middens accumulated in the Pleistocene during lake full conditions, implying a heavy reliance on the lacustrine resource base. Most notable in this respect was his estimate of 104 m³ for the original volume of the Garnpung I shell midden (Allen 1972:295; Table 1, Plate 1).

Allen (1972) placed these middens in a framework that drew on information from three sites at the northern, southern and eastern shores of Lake Mungo, all dated to between 24,000 BP and 27,000 BP. The three sites were interpreted respectively as a specialised summer shell midden, a winter campsite where terrestrial foods were consumed and a summer campsite composed of a variety of foods including shellfish, fish and mammal (Allen 1972:284). These interpretations were based on the presence of seasonal indicators such as emu eggshell and immature fish (Allen 1972:272) and Allen argued that all the archaeological material from the period between 13,000 BP and 33,000 BP was part of a 'single type of subsistence economy' (1972:329).

White and O'Connell (1982:39) have criticised this interpretation of the seasonality and distribution of activities on the basis that the time gap between individual sites (3000 years) is too great for them to have formed aspects of a single economy. They point out that we cannot fully recon-

struct the structure of the economy as the full range of sites is probably not preserved (1982:39). Instead, later use of Allen's data plays down the variable and seasonal use of lacustrine resources by implicitly emphasising the reliance of Pleistocene groups on lacustrine resources. For instance, White and O'Connell (1982:157) challenge the argument that the lack of early Holocene shell middens on the New South Wales south coast could be due to a subsistence pattern that excluded shellfish by referring to Lake Mungo where people were eating shellfish more than 30,000 years ago. Similarly, Bowdler (1977) used a comparison of species consumed at Mulurulu I in the Willandra, and Bass Point on the coast to argue that the earliest occupants of the Willandra were heavily reliant on lacustrine resources and that the Mulurulu I evidence gave 'the impression of a transliterated coastal economy' (1977:225). Implicit in these arguments is an assumption that Pleistocene collection of shellfish and fish from lacustrine resource zones can be equated in some fashion with Pleistocene and Holocene coastal economies.

THE WILLANDRA LAKES SHELL MIDDEN SURVEY

The aim of the Willandra Middens Survey is to record in detail all the reported occurrences of mussel shell in the Willandra Lakes World Heritage Area. The only shellfish species to inhabit the Willandra Lakes region were the lake mussel (*Velesunio ambiguus*) and the river mussel (*Alathyria jacksoni*). The latter is confined to one location on the Willandra Creek upstream from Mulurulu, in a location where the water flow would be sufficient to support this species. Middens containing *Velesunio* are found throughout the Willandra Lakes

region and extensive *Velesunio* shell beds have been preserved in the lake floor sediments of Lake Mungo in their upright growth positions. These shell beds cover a considerable area of the lake bed and have been located at points up to 8 km apart. Radiocarbon dates on shells from these beds have returned ages >38,000 BP (Clark 1987).

Surprisingly few detailed archaeological studies have been made of sites containing *Velesunio* (Allen 1972; Feary 1981; Hope et al. 1983; Kefous 1983), yet they constitute some of the earliest and best preserved archaeological sites in Australia. *Velesunio* shell middens have been reported from 87 locations in the Willandra Lakes region (Clark 1987). This paper presents survey results from 73 (84%) of these locations. The middens range in age from 15,000-37,000 BP (Clark 1987). At these locations shell occurred as either in situ deposits, scattered fragments deflated from their original context by erosion, or both.

The survey was based entirely on field recording of exposed features and no excavations were undertaken for this study. For each in situ shell midden the following attributes were measured where possible;

1. length,
2. width,
3. thickness,
4. number of whole shells/m²,
5. number of superimposed shells visible in each section, and
6. shell orientation (convex side up, concave side up, or upright).

In most cases the middens were exposed in plan, by the erosion and removal of overlying younger sediments, and the length and width could be readily measured. Shell orientation was recorded from middens where plan views were available and involved noting the ratio of each orientation category. In other instances, where the midden was only visible in section, the width of the midden was determined by probing through the overlying sand, but only where this was shallow. Thickness and shell superimpositions could only be measured where the midden was exposed in section, but as the middens were thin, partial exposures of sections were common and so it was often possible to measure these attributes.

Shell scatters, without in situ shell, were recorded by measuring the length, width and average shell fragment density of the scatter. The capacity of scattered shell to provide information about past collecting behaviour is very limited as the area covered by shell scatters principally measures local wind and water erosion intensity, and bears little resemblance to the original size or distribution of

in situ middens. Shell scatters are therefore of limited value for the purposes of this study, and the focus of this paper is directed to the intact middens.

RESULTS

To date 73 (84%) of the midden localities reported by Clark (1987) have been recorded in this study. Of these, two (3%) are mussel shell beds from lake floor deposits and have been excluded from analysis below, 48 (65.5%) contain middens, and 23 (31.5%) no longer have any shell present. The best explanation for the absence of middens at the latter is that only a very small quantity of shell was originally present at these 23 locations. Most (53.5%) of the missing middens were in the Prungle Lakes area (Fig. 1). Middens in this area contained only very small quantities of scattered or in situ shell. When originally recorded in the early 1980s the shell component of these sites was often only a few shells (P. Clark pers. comm.). If any moderate to large quantity of shell had been present it would have left some trace in the form of scattered fragmented shell.

The destruction of in situ middens by erosion cannot be ruled out, but when this occurs the result is usually a scatter of fragmented and dispersed shells. The total absence of shell from so many locations can best be explained by their original small size, and the fact that the smallest middens are the most likely to disappear entirely. Larger middens are more likely to remain either as in situ horizons or scattered shell fragments.

Table 2 lists the numbers of midden locations recorded for each lake in the Willandra Lakes Region. There is a concentration of midden sites in the Garmpung/Leaghur area, and another at the Prungle Lakes, with lesser clusters at Mulurulu and Mungo lakes (Fig. 1). Middens are concentrated on lunettes (54.9%) and western lake shores (26.8%). Although not included in this analysis, further subdivision would show that very few middens are located on the main body of lunettes, and most occur on either their northern or southern tips.

Table 3 presents statistics from in situ middens. At the 48 locations containing mussel shell, in situ shell middens were observed in 214 places. The mean area of middens was 3.473 m² and ranged from 0.005 m² to 51 m². Volume of shell middens was calculated by multiplying length by width by thickness where all three measurements were possible. This shows a mean volume of 0.044 m³, or 44,000 cm³ from a sample of 125 middens. The number of superimposed shells that comprise the thickness of each shell horizon was recorded at fewer sites than the other variables but show a mean

Lake		
		%
Mulurulu	10	14.1
Baymore	2	2.8
Garnpung	14	19.7
Gogolo	1	1.4
Leaghur	10	14.1
Durthong	2	2.8
Mungo	9	12.7
Outer Arumpo	4	5.6
Chibnalwood	0	0.0
Prungle North	3	4.2
Prungle South	15	21.2
Benenong	0	0.0
Moonlight	0	0.0
Willandra Creek	1	1.4
Total	71	100
Landform		
Lunette	39	54.9
Creek bank	3	4.2
South shore	6	8.5
North Shore	4	5.6
West shore	19	26.8
Lake bed	0	0.0
Total	71	100

Table 2 Location of shell middens in the Willandra Lakes Region, by lake and by landform. With the exception of Willandra Creek, all the listed names refer to lakes in the region. The numbers refer to the number of locations where middens occur, not the number of individual middens.

midden thickness of 2.8 shells, which is consistent with the mean thickness of 13.45 mm.

The small size of Willandra shell middens is demonstrated by the results in Table 3. The mean volume and area of shell middens recorded to date is considerably less than that recorded during Allen's (1972) study. Table 4 makes a direct com-

parison between the sites from Allen (1972) and this study. This data indicates that his volumes are not consistent with any other middens in the region. The shell midden volumes recorded by Allen are five to 22 times larger than those recorded in this study. The estimated volume of Garnpung I (104 m³) (Plate 1) is 2364 times larger than the average size of middens recorded in this study. While a small part of this difference may be due to erosion, it is more likely that the midden volumes provided by Allen (1972) are overestimates.

As shown in Table 4, in all locations except Mulurulu I, more middens were recorded in this study than by Allen (1972). Erosion of the middens has undoubtedly taken place and in some cases it may have dissected some middens thereby making one large midden appear to be several smaller, adjacent middens. For example, at Leaghur Backshore I the original site map indicates eight middens (Allen 1972:Fig. 8.7), but in this study 26 middens were recorded. While Allen's original eight shell accumulations are still visible, though apparently very much reduced in volume, the additional middens occur at other, previously unrecorded positions within the site area. The actual situation is most likely to be a complex process whereby erosion continually degrades exposed middens but also reveals previously buried middens. Although Allen's (1972) middens could be expected to be smaller now than they were in the early 1970s, recently exposed middens at his sites and at many other locations are presumably closer to the original midden sizes. The complexities of this situation are also apparent in that some sites will have been subject to years of erosion while others will have only recently been exposed; some sites will be very

Midden Size	Number of Observations	Total	Mean	Standard Deviation	Minimum	Maximum
Shell Area (m ²)	127	441.057	3.473	7.417	0.002	51.00
Volume (m ³)	125	5.443	0.044	0.111	0.0001	1.02
Thickness (mm)	131	1762.000	13.450	8.000	5.000	60.00
Number of shell superimpositions	49	140.000	2.857	1.999	1.00	13.00

Table 3 Dimensions of shell middens recorded in the Willandra Lakes World Heritage Area. Numbers of observations vary between the variables as not all dimensions could be recorded for each midden.

Site	Allen (1972)			This Study		
	(n)	Total Volume (m ³)	Average Volume (m ³)	(n)	Total Volume (m ³)	Average Volume (m ³)
Leaghur I	1	-	-	6	0.32	0.053
Leaghur Backshore I	8	4	0.5	26	0.94	0.036
Garnpung I	1	104	104.0	Not yet recorded		
Mulurulu I	9	9	1.0	1	0.20	0.200
Mulurulu IIIA	12	6	0.5	23	0.53	0.023

Table 4 A comparison of data from Allen (1972) and this study on shell midden volume.

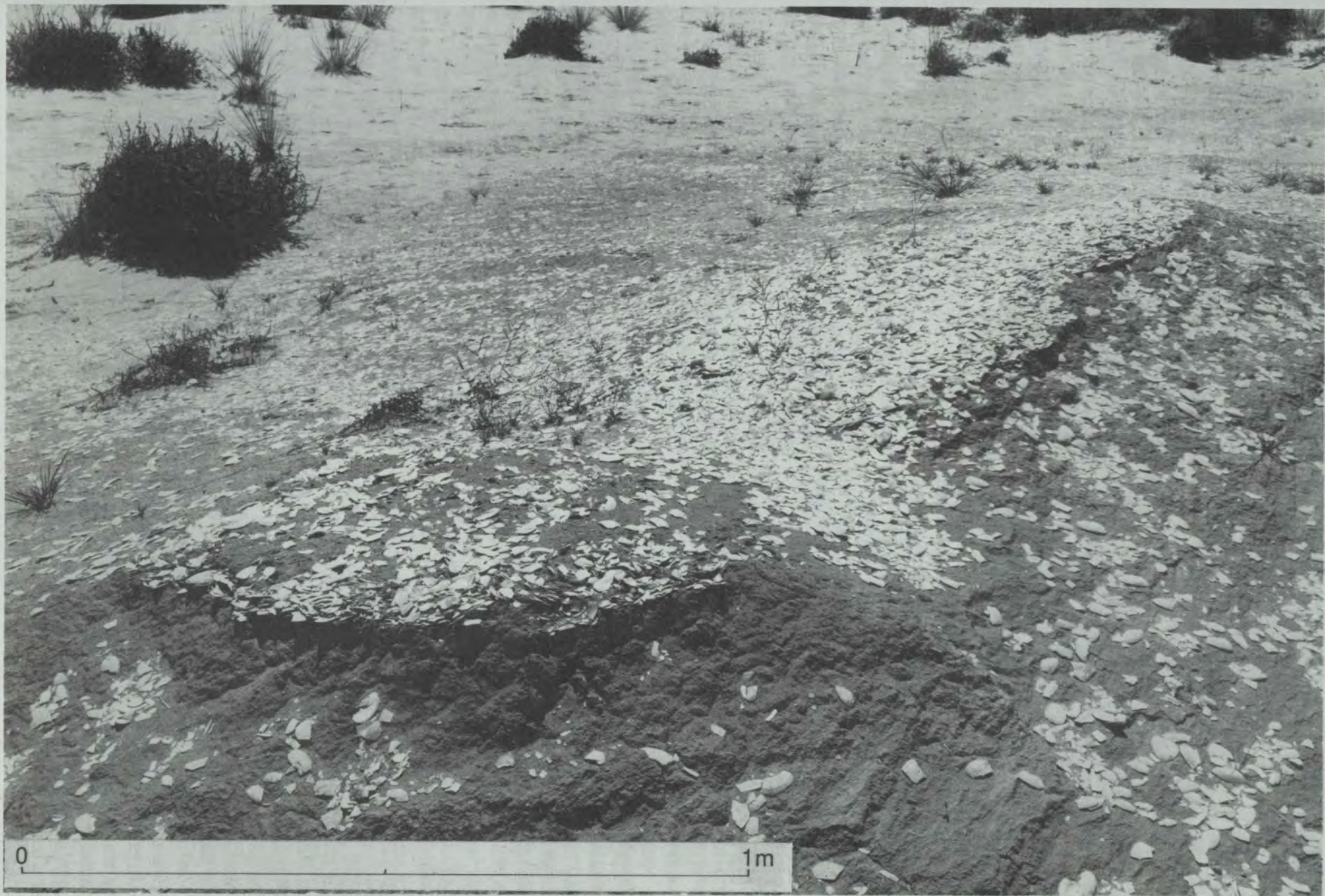


Plate 1 Part of Garmpung 1 shell midden in 1980 (Photo courtesy of the Australian Heritage Commission).

small and will rapidly disperse while others with more volume will take considerably longer to disintegrate. These intricacies indicate that while the figures in Table 3 can be used to indicate the general scale of shellfish gathering in the Willandra Lakes as a whole, they are not likely to reflect the original quantity of shell collected at any one site.

The dating of archaeological material in the Willandra Lakes has proved problematic in the past due to the discrepancies between dates obtained from charcoal and mussel shell from the same horizons. Mussel shell clearly returns more reliable dates than charcoal (Allen 1972; Balme and Hope 1990; Hope, this volume; McBryde 1975), and the shell middens discussed in this paper, based on the mussel shell dates, range in age from ca. 15,000 BP to 36,800 BP. McBryde, Head and Gillespie are currently investigating the problems revealed by the dating of paired charcoal and shell dates (Isabel McBryde pers. comm.). It is apparent from the dating of shell middens that two peaks in the frequency of shell collecting occurred, the first in the period 25,000-36,000 BP and the second from 15,000-17,000 BP (Clark 1987; Hope, this volume). No quantification of the amount of shell collecting through time has been attempted here and further analysis of the data is yet to confirm impressions that shell collecting was more prevalent between 15,000 and 17,000 BP than in the 25,000-36,000 BP period (Hope, this volume).

The concentration of shell middens in the period from 15,000 to 17,000 BP overlaps with a similar concentration of dated shell middens from the Murray River and Lake Victoria in the period 10,000-18,000 BP (Hope, this volume). The Murray River middens contain *Alathyria jacksoni*, or river mussel, and are generally found on prominent cliff tops and lake shores overlooking the Murray River or its ancestral course (Bowler 1980; Clark and Hope 1985; Coutts 1980; Gill 1973; Johnston 1990). In contrast to the Willandra middens, the Murray River middens may be up to 1 km in length and from 10 cm to 100 cm thick. The larger size of *Alathyria* middens is probably due to the ecology of the species. Walker (1981) has provided data on the density of mussels for a number of locations along the Murray River. *Velesunio* varies from 2.73/m² at Lake Alexandrina to 100/m² at Lake Mulwala. At Lake Mungo 55 mussels/m² are present in preserved mussel beds. *Alathyria* occurs at densities from 1.2/m² at Overland Corner to an extraordinary 303/m² near Mulwala and tends to congregate in locations such as sharp bends of the river where flow changes abruptly and dehydration is unlikely (Walker 1981:22-3, 28, 61, 65). Such concentrations of *Alathyria* would be an easily accessible resource, except during late winter and

spring when high river levels and strong flows make collecting difficult.

In contrast, the lake dwelling *Velesunio* is available year round, although at lower densities than *Alathyria*. The small *Velesunio* middens around the Willandra Lakes and Lake Victoria (personal observation) may indicate that the lake mussels were exploited year round rather than seasonally, or through summer, as Allen (1972:284) has suggested. As Feary (1981:74) has outlined, any future research that can define seasonality of mussel collecting will provide a powerful method of reconstructing the Pleistocene subsistence pattern of Aboriginal people in southwestern New South Wales.

CONCLUSION

No data is provided here to allow a comparison between the shellfish component of the diet and other lacustrine and terrestrial components of the diet. This paper only provides answers to basic questions about midden size, location and taphonomy.

As a result of earlier recordings and interpretations the magnitude and importance of shellfish collecting in the Pleistocene Willandra Lakes diet has been overestimated. This study shows that the Willandra middens are very small especially when compared to the riverine middens of the Murray and Darling Rivers. The recent history of middens is complex; extremely small middens are likely to be removed entirely by erosion while the larger middens are likely to be more intact. The size of the middens is gradually being diminished by continuing erosion of lakeshore sediments, but new middens are also continually being exposed. Notwithstanding these processes, it is argued here that the small average size of middens is not due to slow erosion of the original sites but generally reflects the scale of Pleistocene shell collecting behaviour.

Each shell collecting event may be interpreted as a small part of a broadly based subsistence economy that has little in common with marine economies of the Australian coastline. Lacustrine resources in general may have played a smaller part in the diet than previously interpreted and the role of terrestrial foods, and especially the small macropods and reptiles, may be greater than has been previously thought.

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THE CUDDIE SPRINGS BONE BED REVISITED, 1991

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Two important issues in Australian prehistory are (1) the timing and causes of extinction of a suite of animals in the late Pleistocene (Flannery 1990; Horton 1984), and (2) the timing and nature of human occupation of the arid zone (Bowdler 1977; Smith 1989; Veth 1989). In the case of late Pleistocene faunal extinctions, humans and climate, either together or separately are thought to have been the primary causes of extinctions in Australia as well as globally (Diamond 1989; Flannery 1990; Horton 1984; Main 1978; Martin 1984). In the Australian context, sites where humans and megafauna overlap stratigraphically are few and direct associations between them have been difficult to establish, as for example at Lime Springs (Gorecki et al. 1984), Lancefield Swamp (Gillespie et al. 1978) and Lake Tandou (Hope et al. 1983). Human occupation of the arid zone was suggested to have followed some time after initial coastal colonisation (Birdsell 1977; Bowdler 1977). The established occupation date of 22,000 BP for Puritjarra rockshelter in central Australia (Smith 1987) now demonstrates occupation synchronous with better watered regions such as Lake Mungo (Bowler et al. 1972), Keilor (Bowler et al. 1976) and Devils Lair (Balme et al. 1978).

Recent excavations at Cuddie Springs in north-western New South Wales (30°21'01"S, 147°20'32") (Fig. 1) provide additional evidence for early occupation of the arid zone and bearing on the issue of late Pleistocene faunal extinctions. The evidence includes megafaunal remains, an archaeological record, a pollen record and sediment history (Furby 1991). This paper presents a preliminary report of the 1991 excavations at Cuddie Springs.

A quest by The Australian Museum for fossil bones to supplement their collection, resulted in Cuddie Springs being first excavated in 1933. The six week excavation reported by Anderson and Fletcher (1934) involved an extensive trench digging exercise and was described by them as resembling 'the fields of Flanders' on completion. Substantial quantities of fossil bone were recovered

during their visit but no detailed records were made of spatial positioning or articulation of the bone. The ephemeral nature of the lake has hindered subsequent attempts to investigate the sediments and in late 1991 Cuddie Springs was again under water.

In December 1990, the Geological Survey of New South Wales drilled a 54 m core at the periphery of the clay pan, bottoming in Cretaceous sediments. Our interest initially lay in the palynology of the upper sediments of the core in order to reconstruct the environmental context of the fossil bone at time of deposition. The lack of preservation of the pollen in the core sediments resulted in a return trip to the site to investigate the nature of the sediments and during a drought period in 1991, further excavations were undertaken with the aim of investigating the palaeoenvironmental history and the archaeological record. Though a Dreamtime story was reported by Anderson and Fletcher (1934) no archaeological reports have previously been made for this site.

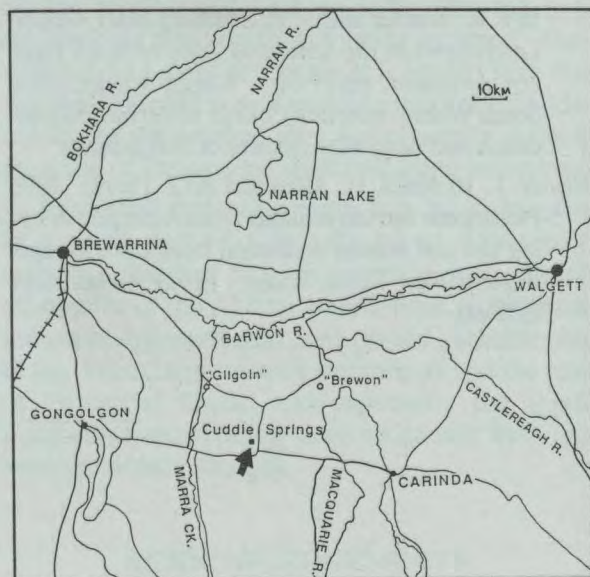


Figure 1 Map of northwestern New South Wales indicating location of Cuddie Springs in relation to regional centres.

LOCATION

Cuddie Springs is a shallow ephemeral lake situated within the semi-arid zone in northwestern New South Wales on Quaternary alluvium. The lake bed is approximately 2 km in diameter though the area which still frequently fills with water is a clay pan approximately 200 m in diameter. The annual rainfall is 350-400 mm, bordering the marked summer maximum-uniform rainfall belts.

EXCAVATION

The excavations undertaken by The Australian Museum in the 1930s involved a series of trenches across the pan ranging from 5 to 15 feet in depth. The trenches were never backfilled and the spoil heaps were still visible in 1985 (L. Green pers. comm.). Recent flooding has resulted in the spoil finally being redistributed evenly over the clay pan surface.

Although our initial interest in the site was to investigate the palaeoecological record, upon survey and excavation it became clear that there was a significant archaeological content. At the centre of the claypan a pit 1 m x 2 m was excavated to 3 m depth during two field periods. The material was excavated in spits within natural stratigraphic units (Fig. 2). The material was wet sieved at the University of New South Wales in 10, 5 and 2 mm sieves and sorted. Only a sample has yet been processed and this report comprises the results of these efforts.

STRATIGRAPHY

The upper 45 cm of deposit consists of disturbed material from the spoil heaps of the 1933 excavation (units 1 and 2). Bone fragments and stone artefacts are found scattered throughout this layer. From approximately 45 cm depth to 2.8 m (units 3 to 11), the sediments consist primarily of lake muds with varying proportions of silts, clays and structured clays. Fossil bone was found throughout the sediments and in varying concentrations. Below 2.8 m, fine sand comprises the major component of the sediments, consistent with aeolian deposits (unit 12). Four radiocarbon dates were obtained from charcoal collected from Pit 1 at Cuddie Springs and are listed in Table 1. The position of the dates in relation to the stratigraphy is shown in Figure 2. The bedding of the deposits, particularly in unit 5, sloped down towards the western side of the pit.

A pollen analysis has been completed for the upper 2.5 m of the profile, and the results in conjunction with particle size analysis indicate that

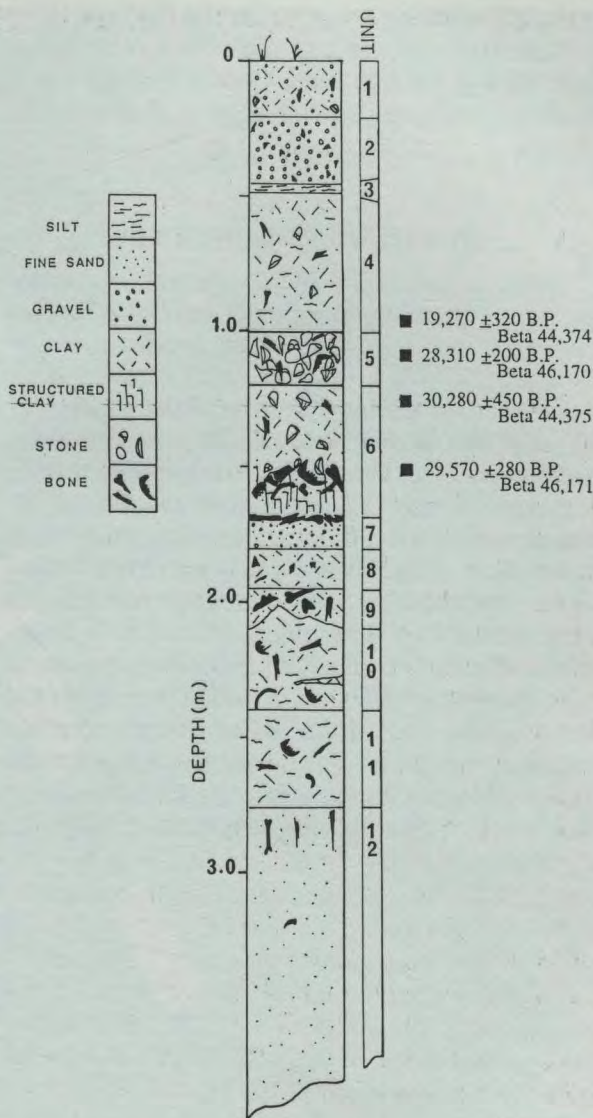


Figure 2 Section profile of Pit 1 at Cuddie Springs showing Units.

prior to the deposition of unit 5 there was an extended period of standing water/marshy conditions at Cuddie Springs (Furby 1991). Tree cover was much reduced in comparison with the current vegetation and grasses (Poaceae) and saltbush (Chenopod) were predominant. At around 28,000 BP people were living in an environment which was becoming progressively drier and cooler (Dodson et al. 1993) and unit 5 was formed after an extended

Laboratory Code	Excavation Units	Depth (m)	Radiocarbon Age (BP)
Beta 44374	Unit 4	1.05-1.10	19,270±320
Beta 46170	Unit 5	1.20	28,310±200
Beta 44375	Unit 6	1.25-1.30	30,280±450
Beta 46171	Unit 6	1.55	29,570±280

Table 1 Radiocarbon dates for Pit 1, Cuddie Springs, 1991. Depths are in m below surface.

period of standing water at Cuddie Springs. The particle size analysis and the pollen record also indicate that through time, Cuddie Springs was a shallow freshwater, gentle depositional environment.

FOSSIL BONE CONTENT

Bone is scattered vertically throughout the deposit and comprises both extinct and extant species (Tables 2 and 3). Some extant species found at Cuddie Springs (e.g. *Isoodon auratus*) have present day ranges far removed from this area, suggesting different environmental conditions compared to the present day. The fossil bone varied in preservation and most of the bone is heavily mineralised with manganese, giving it a characteristic blue-black appearance. Bone also ranged in size from the jaw of *Isoodon* and small reptile and fish vertebrae, to the mandible of a *Diprotodon*. It is yet to be determined what depositional processes were at work in relation to the fossil bone. Much of the bone is too large to have been deposited by fluvial processes and death in situ seems the most plausible interpretation. The ephemeral nature of the lake led to in situ preservation with animals becoming trapped in the muds as the lake dried.

Diprotodon
Potoroidae
 Reptile
Meiolania sp.
Phascolonus gigas
Sarcophilus sp.
Genyornis newtoni
Macropodidae
Megalanina prisca
Palimnarchus

Table 2 Species identified from the 1933 expedition collection in The Australian Museum.

ARCHAEOLOGY

Artefacts are present above 1.55 m depth in unit 6. A number of megafaunal bones were found in association with artefacts at 1.55 m depth and have been identified as *Diprotodon*, *Sthenurus* cf. *andersoni* and *Genyornis newtoni*. Several artefacts were located in the immediate vicinity of the bones and some lay below and in contact with megafaunal bones (Plate 1). The latter have been deposited in lake muds, formed above a beach lag deposit in unit 7 at 1.8 m (Fig. 2). A number of scenarios may account for the association. The bones were deposited in a structured clay typifying marshy conditions. It is feasible that the animals became trapped in the muds and were then butch-

Excavation Unit	Approximate Age	Species
Unit 4	pre-Holocene to 19,000 BP	no identifications completed
Unit 5	28,000 BP	<i>Isoodon auratus</i> <i>Palimnarchus</i> <i>Macropodidae</i> <i>Potoroidae</i>
Unit 6	>30,000 BP	<i>Diprotodon</i> <i>Sthenurus</i> cf. <i>andersoni</i> <i>Genyornis newtoni</i>
Unit 7	>30,000 BP	<i>Genyornis newtoni</i> <i>Macropodidae</i> <i>Phascolonus gigas</i>
Unit 8 and below	>30,000 BP	<i>Palimnarchus</i> <i>Quinkana</i> <i>Megalanina prisca</i> <i>Meiolania platyceps</i> <i>Macropodidae</i> <i>Diprotodon</i> <i>Zygomaturus trilobus</i> <i>Genyornis newtoni</i> <i>Phascolonus gigas</i>

Table 3 Preliminary species list from the 1991 expedition. *Trichosurus* (unprovenanced) and fish bones (indeterminate).

ered by humans. Residue analysis may clarify the question of association. An alternative explanation is that the artefacts were deposited more recently than the bones. We consider the age of the artefact/bone deposit to be greater than 30,000 BP. The date of 29,570±280 BP (Beta 46171) is thought to be a minimum age because of the small size of the sample dated and the likely underestimation of dates which are at the practical limits of conventional radiocarbon dating techniques on charcoal (Roberts et al. 1990). Relative dating methods such as fluorine analysis will be used later as an indicator of age of the bones with respect to the rest of the deposit.

At a depth of 1.0-1.2 m there is a concentration of artefacts, bone, charcoal and burnt wood. The stone tool assemblage at this level (unit 5) comprises horsehoof cores, small single and multi-platform cores and flakes with evidence of use-wear along one or more edges. The range of raw material used for stone tool manufacture includes silcrete, quartz, quartzite, chert, conglomerate, feldspar porphyry and sandstone. Silcrete is dominant, possibly because of its availability from a gibber plain located 2 km to the southwest of the site.

The quality of stone material for flaking varied considerably, ranging from coarse grained conglomerate pebbles to very fine grained chert. The flaked stone material ranged in weight from 0.02 g

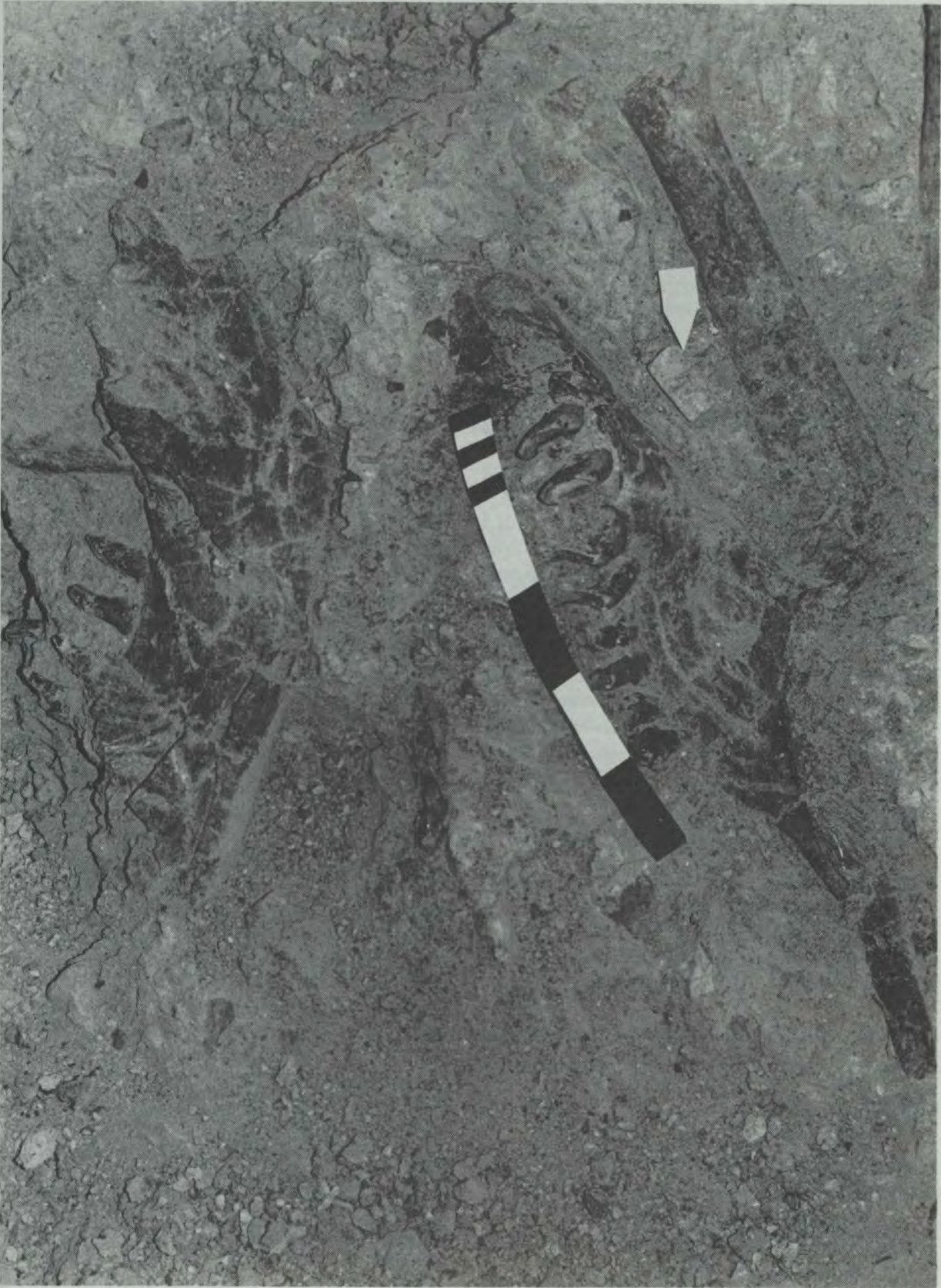


Plate 1 A stone artefact in association with megafaunal bones embedded in lake muds, at the base of unit 6 (1.55 m depth) Cuddie Springs. The arrow indicates a partially buried silcrete core. This artefact with preserved traces of blood lies beneath a *Genyornis* tarsometatarsus (upper right). Also shown are the left and right mandibles of a small *Diprotodon*. The scale bar is 25 cm long. (Photo: J. Furby).

Unit No.	No. of Artefacts /0.1 m ³	Mean Weight (g)					
		Cores	Core fragment	Whole flakes	Other flakes	Fragment	Others
3	12	22	10	3	5	7	0
4	15	23	0	2	4	11	0
	12	0	32	16	6	9	10
5	323	33	25	14	10	10	32
		79	48	7	10	15	58
		195	70	0	8	49	56
6	39	78	96	6	24	24	30
	53	40	75	75	1	1	0
	40	23	29	0	32	11	0

Table 4 Summary of artefact numbers/0.1m³ against depth and mean weight of artefact versus depth.

up to 300 g. Table 4 gives a summary of stone artefact data from unit 4 (45 cm) to unit 6 (1.6 m), where artefacts first appear. The figure for unit 5 shows the high density of artefacts at this level. Some of the artefacts have been examined for residues and on the worked surfaces, red blood cells, animal tissue and mammalian hair have been identified. These identifications provide presumptive evidence of butchering or other processing of animal tissue. Preliminary study of use-wear and residues also indicates woodworking and other plant processing.

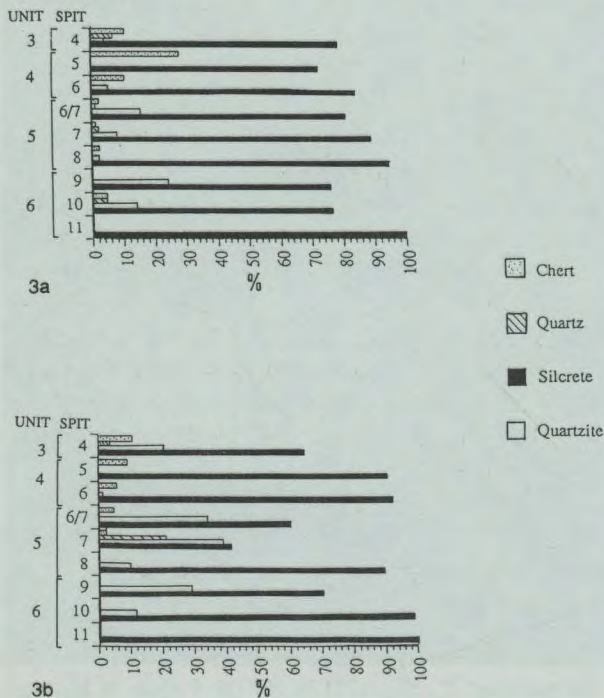


Figure 3 3a: Within spit ratio of artefact stone types versus mean numbers of artefacts.
3b: Within spit ratio of artefact stone types against weight (g).

A number of grindstone fragments were recovered from units 3, 4 and 5 (Plate 2). A preliminary microscopic study of the largest specimen from unit 5 indicates a clear association of plant tissue and starch grains on the polished surface. Starch grains could have been derived from a number of plant sources including grass seeds, *Acacia* seeds and the pounding of tubers. However, the polish is most likely to be from processing siliceous material and is similar to the polish on Holocene seedgrinders. Further use-wear and residue studies will be undertaken to determine the origin of the starch residues. The presence of grinding stones in unit 5 is interesting considering the argument put forward by Smith (1986:36) that distinctive seedgrinding implements are a Holocene innovation, a point supported by Balme (1991) in her discussion of the western New South Wales evidence. Smith notes that amorphous grinding stones are part of Pleistocene stone tool assemblages but questions the use of these for seed processing (Balme 1991; Smith 1986). Grinding stones from Cuddie Springs are dated between 19,000 BP and 28,000 BP and pre-

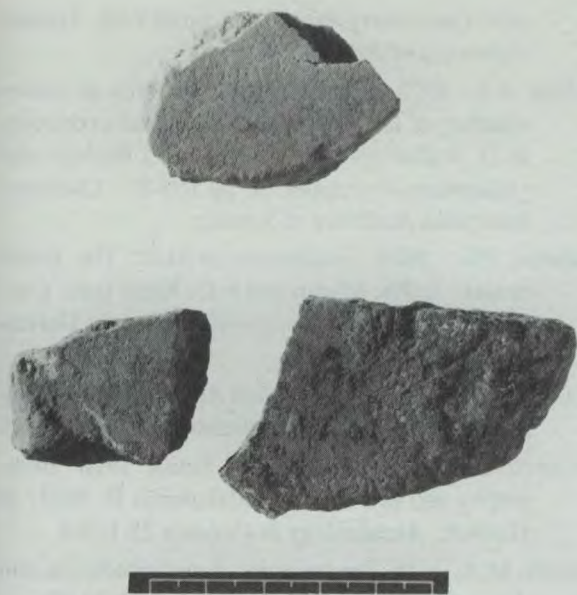


Plate 2 Grindstone fragments from Unit 5, dated to 28,000 BP. The specimen on the bottom right was examined microscopically for residues. Scale = 5 cm.

sent an opportunity to explore this aspect of Pleistocene economies. The presence of grindstones with use polish and siliceous starchy residues in a late Pleistocene context may indicate an expansion of resource use to include seeds of either grasses or *Acacia* or to include the use of *Typha* spp.

On balance the Cuddie Springs evidence does not indicate a specialist single activity such as butchering; rather, unit 5 appears to represent domestic use as indicated by the presence of grinding stones, woodworking, hearths, hardened clay balls (cf. ovenstones) in the vicinity of these hearths, and large amounts of charcoal. The presence of ochre and a weathered conical stone similar in morphology to cylcons (McCarthy 1976:66) suggests ceremonial activities.

CONCLUSION

Excavations at Cuddie Springs have revealed data with the potential to make a major contribution to a number of problems in Australian prehistory. The great antiquity of occupation and the well preserved residues on stone artefacts require further investigation. There is an apparent in situ association between stone artefacts and megafaunal bone. Though the nature of the association is still to be defined, it provides evidence that humans and megafauna were contemporaries in this part of the arid zone. It is of interest that evidence for this should come from a generalised occupation site rather than a task specific site. The evidence from

Cuddie Springs is complemented by a palaeoecological record enabling the archaeology to be placed in environmental context (Dodson et al. 1993).

ACKNOWLEDGEMENTS

Consent from the North West Region Aboriginal Land Council and a preliminary excavation permit from the National Parks and Wildlife Service allowed us to complete two field periods during drought conditions in 1991. We would also like to thank Robert Jones and Paul Willis for the preliminary identification of bone; Australian Geographic and the University of New South Wales for financial support; Margaret and Ted Johnstone and Jan Curry for facilitating access to the site; The Australian Museum for photography and the numerous volunteers who gave their time during the excavation periods.

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TASMANIA

1. The first part of the paper is devoted to a general discussion of the problem of the origin of life. It is shown that the problem is one of the most important and most difficult in the history of science. The author discusses the various theories of the origin of life, and shows that the most plausible is the theory of spontaneous generation. This theory is based on the fact that life is a complex of many different parts, and that these parts are all found in the same place. The author also discusses the possibility of life being brought to earth from elsewhere, and shows that this is also a possibility. The author concludes that the most plausible theory is the theory of spontaneous generation.

2. The second part of the paper is devoted to a discussion of the origin of the various parts of life. It is shown that the various parts of life are all found in the same place, and that they are all found in the same way. The author discusses the various theories of the origin of the various parts of life, and shows that the most plausible is the theory of spontaneous generation. This theory is based on the fact that life is a complex of many different parts, and that these parts are all found in the same place. The author also discusses the possibility of life being brought to earth from elsewhere, and shows that this is also a possibility. The author concludes that the most plausible theory is the theory of spontaneous generation.

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THE SOUTHERN FORESTS ARCHAEOLOGICAL PROJECT: AN OVERVIEW

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This paper describes work by the Southern Forests Archaeological Project (SFAP) which attempts to come to terms with the rich Pleistocene archaeology of southwestern Tasmania. It provides a broad overview of research aims and strategies, with brief descriptions of excavated sites and associated chronologies. Preliminary analyses of stone and bone assemblages are presented for selected sites. We do not refer in any detail to the implications of our work for Australian and wider prehistory. This is a deliberate omission, aimed at emphasising our concern that archaeologists have few clear ideas on how to approach Pleistocene sites in Australia, or how to interpret the evidence they provide about the deep past. When we began in Tasmania in 1988 we thought this problem was largely a question of the small **quantities** of Pleistocene data available in most Australian sites, and that the massive quantities of artefactual evidence in the southwestern Tasmanian sites would rectify this problem, at least for that area. Our conclusions touch on why this may not be the case.

AIMS OF THE PROJECT

The SFAP has deliberately sought to explore the Pleistocene of southwestern Tasmania as a broad-scale, regional study and as team research. It grew logically from the Gordon River-Franklin River surveys of the early 1980s, of which Cosgrove and Allen were members, and the establishment of the La Trobe Department of Archaeology in 1985. In 1986 Cosgrove and Allen began considering research to investigate an apparent paradox: in inland southwestern Tasmania at that time all but one of the known sites were of Pleistocene age while in southeastern Tasmania none were. While this dichotomy no longer holds, the question of defining the temporal and spatial edges of what was already a distinctive archaeological pattern along the Franklin – there defined principally by Kiernan, Jones and Ranson (1983) at Kutikina Cave – was an obvious step. By 1987 it seemed clear that there was some sort of southwestern Tasmanian Pleisto-

cene region or province. This was based not only on the Franklin surveys but also on subsequent work in the Maxwell River Valley carried out by the Tasmanian Department of Parks, Wildlife and Heritage (Harris et al. 1988). An isolated find had also been made in the Denison River Valley (Brown et al. 1989:5) which led subsequently to the discovery of further Pleistocene sites. These discoveries added to the earlier work in the Florentine Valley at Beginners Luck Cave (Goede and Murray 1977; Murray et al. 1980).

A second aim of the research was to take the excavated sequences and test inter-site variability. Such an objective was partly to define boundaries, but equally to see whether regionality thus defined was also distinguishable in the Tasmanian Pleistocene archaeological record on other levels. Put simply, might the data allow us to sub-group the southwestern sites according to proximity to each other or their catchments or stone resources or according to other factors. Beyond these aims, we were interested also in exploring notions of cultural change through the late Pleistocene, as a remedy against the tendency to use this 25,000 year period as an homogeneous unit of prehistory against which to promote Holocene diversity in Australia.

STRATEGIES OF THE PROJECT

While other more specific research questions have been defined, modified and changed over the last four years (see below), these three general goals have remained a central focus and a basis of the field strategies employed. We began our work in the Florentine and Weld River Valleys (Fig. 1) in the eastern part of the Southwest partly because Kutikina Cave already provided some baseline further west, partly simply because it was more accessible, and partly because the distinct climatic and geological boundary which today divides southeastern and southwestern Tasmania could reasonably be supposed to have provided a similarly strong ecological boundary in the past (see Cos-

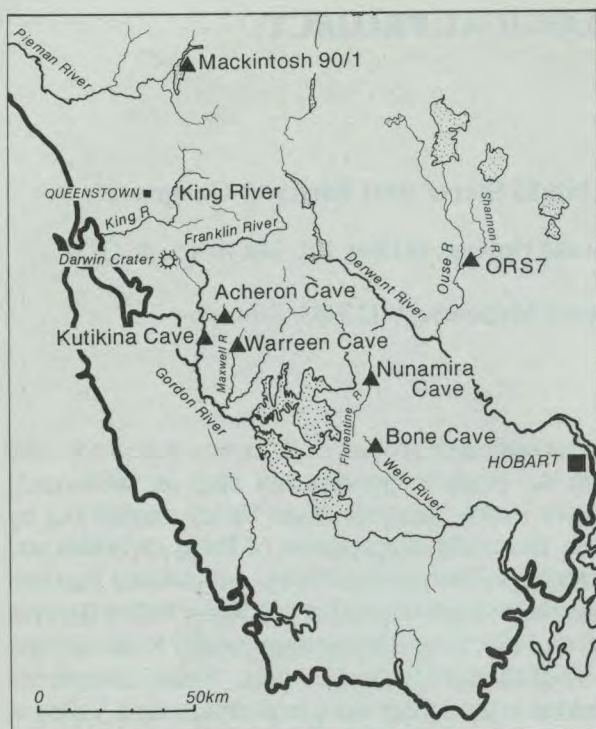


Figure 1 Regional location map.

grove et al. 1990). In other words, did this ecological division also structure past human behaviour in terms of subsistence, settlement and technology? One cave site (ORS7) east of this boundary was excavated and yielded Pleistocene remains (Cosgrove 1989). In the Southwest we subsequently surveyed or excavated further south and west, including seeking Pleistocene sites on the west coast. In 1991 we extended our investigation to the northern limits of what is usually regarded as the Southwest and recovered Pleistocene remains from a cave site on Lake Mackintosh (Stern and Marshall 1993). In 1992 we went further beyond the Southwest boundary to the north, and jointly with Lourandos, we re-tested Warragarra Shelter for possible Pleistocene occupation (see Lourandos 1983). This completes the fieldwork phase of the SFAP.

Our strategies of excavation and analysis have been influenced by a further theoretical consideration, one which has assumed increasing importance as the project has developed. The total absence of Holocene deposits in any of these sites underscores the fact that we have no basis for linking interpretations of the data, in any analogical sense, with ethnographic descriptions of Tasmanian Aborigines, nor do equivalent periglacial hunter/gatherers now exist elsewhere to provide interpretative frameworks for assessing this record. Pleistocene archaeology elsewhere in the world also provides few relevant models. We can only proceed by defining, as fully as possible, the archaeological

sequences we have and searching for the patterns in the whole database, rather than merely concentrating our efforts on the early dates, or the re-touched tools or the cutmarks on the bone. All of these things are important, but only in the matrix of the total database will we perceive their real significance. Initially at least, this means abandoning anthropological models and explanations in favour of archaeological ones.

In all we have excavated 12 sites, including Warragarra. All excavations have been small, some being merely tests of residual deposits on walls or tests of sub-surface deposits in areas of surface finds. But they also include the significant excavation of seven sites, for which detailed descriptions will soon be published. This paper offers general descriptions of the sites and their chronologies, and some basic information about the assemblages from the analyses so far carried out.

While excavation strategies have varied for site specific reasons, recovery procedures have been identical in order to facilitate comparisons between sites. Excavations followed stratigraphic divisions. Arbitrary spit units did not exceed 2.5 cm depths. Excavation squares were held constant at 50 cm by 50 cm in size. All excavated material was wet-sieved through nested 1 mm, 3 mm and 7 mm sieves. The 1 mm residues were bagged in bulk for laboratory analysis; the 3 mm residues were partly sorted in the field and residues bagged in bulk for laboratory analysis; and the 7 mm residues were entirely sorted in the field. Every stone artefact and diagnostic bone piece was individually bagged or wrapped for transporting out of the field. All charcoal was collected from each sorted sieve for all excavation units at all sites.

We thus have seven good sequences in an area of about 160 km by 80 km – still not very much, but sufficient to provide a first approximation of the archaeological resource.

THE SFAP AS TEAM RESEARCH

The need for a regional approach to southwestern Tasmania meant that multiple sites had to be sampled. Their richness, meant that we would end up with a very large collection of archaeological remains despite the fact that most of the excavations have been little more than test pits. Inevitably we had to go to a team approach. The project personnel currently comprise three members of the La Trobe University teaching staff, one Australian Research Council research associate and two graduate students, together with some casual research assistants and senior undergraduates. We anticipate some additions to this team over the next

year or so. We also have external links with specialists working on specific aspects such as the sedimentology and sourcing studies of the stone raw materials.

While team research in archaeology is common in other countries, it is uncommon in Australia, and is thus worth commenting on here. The ground rules are fairly simple. Data are controlled collectively by the members of the project and each member is expected to contribute time and effort getting the basic data into a database which is accessible to all members. Digging a site confers no proprietorial rights, merely the responsibility for getting the data into the database.

All members of the project see this team approach as having advantages and disadvantages. Foremost among the advantages, our responsibility to each other has resulted in the material from the excavated sites having already been cleaned, bagged, labelled and boxed, and preliminary weights, counts and identifications almost completed. Nearly 90 radiocarbon dates are now available and the dating program will continue, depending on research needs and the availability of funds. If many hands do not seem to make the work lighter, they at least make it faster. While we have a lot to do, the answers are beginning to come and will continue to come quite quickly. Having a team of people working jointly on the project also facilitates a lot of information flow and informal seminars occur almost on a daily basis. Pooled skills make learning new techniques a lot easier. The bottom line is that a project like this could not be done any other way.

Among the disadvantages is the need to be able to keep very clear distinctions between the project's work and the work of graduate students. The main need is to safeguard the integrity of forthcoming theses. So far this has been manageable. All members of the team need to get on with each other. As soon as people start feeling exploited at any level, fragmentation will set in. To date we have maintained the team in place at La Trobe University, but when career moves split up the team, as is inevitable, then this separation will add further strain. For this latter reason more than any other, we have maintained a high level of pressure on keeping it all going as fast as possible.

THE REGION AND THE SITES

Limestone cave sites are the dominant site type examined by the SFAP (Plate 1), although open sites have been previously identified in the Franklin River Valley dated to ca. 19,000 BP, and others of unknown age are located in the King River Valley

(Cosgrove 1985; Jones et al. 1983:80; see Freslov, Pocock this volume). The targeting of karst features for survey reflects the poor visibility of other areas which are covered almost entirely by dense rainforest or impenetrable scrub. Thus, distribution of excavated cave sites reflects in part regional geology.

Apart from visibility, initial selection of limestone areas for archaeological investigation was also based on site discoveries in similar environmental zones by earlier archaeological expeditions to the Southwest. Although our survey areas were not chosen on the basis of random sampling, some geographical stratification was obtained. For example, all the SFAP sites are located within river valleys of various sizes and shapes covering a wide altitudinal range, although none have been identified above 400 m above sea level. At present the reasons for this situation are various, and include the limited limestone geology above these heights, lack of survey and difficulty of access.

The most important consideration, however, lay in the question of the geographical limits to the Southwest archaeological system and efforts were made to locate sites on the peripheries of the Southwest zone, firstly in the east (Allen et al. 1988; Cosgrove 1989, 1991), then subsequently in the north, west and south. This strategy satisfied the other objective of the project, that of obtaining a regional selection of sites from a variety of ecological settings rather than concentrating on one or two which might be an unrepresentative sample. It should be noted, however, that the immediate environment of these sites today may bear no relationship to vegetation patterns or compositions during the height of the last glaciation. A detailed discussion on the region's palaeoecology has already been published and need not be reiterated here (Cosgrove et al. 1990). In addition, the usual practice of discussing contemporary vegetation patterns will be forgone for a discussion of the relatively more stable topographical and geological features.

Figure 1 shows the distribution of the key archaeological sites excavated. Today the sites are located within a humid temperate zone dominated by a westerly weather pattern. Annual average temperatures during the late Pleistocene period in this area were about 4°C (Cosgrove 1991:255) while precipitation was probably reduced by about half to 1500 mm per year (Galloway 1986). Permanent ice was present on the tops of the highest mountains while glaciers flowed down some of the river systems like the Mersey. However, most glaciers were confined to relatively short tongues of ice, such as the Lawrence Rivulet glacier in the Florentine River Valley. The late last glacial was



Plate 1 General view of Bone Cave (centre right) with Weld River in the foreground.

the least severe of the three periods of glaciation in Tasmania (Kiernan 1990).

The sites range in altitude from about 400 m above sea level along the eastern margin of the zone to about 100 metres in the west. The former are represented by two sites, Nunamira and Bone Caves, which are located on the banks of the Florentine and Weld Rivers respectively. They are relatively small caves, although Bone Cave (Plate 1) was probably bigger when first occupied ca. 29,000 BP. Subsequent infilling by sediments has reduced its size to about 9 m² and 1 m in height. It lies in the upper reaches of the Weld within an area of undulating upland. The river has incised its way through the underlying dolomite geology. In contrast, Nunamira Cave is located in the middle reaches of the flat and wide Florentine Valley, under the Mt Field massif which rises to an altitude of 1400 m above sea level. The shelter is small because of a sharply sloping roof, with a usable floor area of approximately 15 m². The deposits are shallow, reaching a depth of approximately 60 cm. The whole cave nestles in a bluff of Gordon limestone of Ordovician age (Cosgrove 1991).

Further to the west at approximately 200 m above sea level are Warreen Cave and Acheron Shelter, located in the Maxwell and Acheron River Valleys respectively. These were originally much larger than Nunamira or Bone Caves although the character of the cultural deposits is similar. Warreen Cave is believed to have been a very large site, but a portion of the roof has collapsed forming an enclosed chamber with an opening to the east (Allen 1990). It sits atop an outcrop of Gordon limestone and overlooks the buttongrass and tea tree plains of the flat Maxwell Valley. The interior floor area is now estimated to be about 15 m². Outside, and facing northwest, is an overhang with cultural deposit beneath which probably once formed part of the original, continuous shelter floor.

Acheron Shelter is located in a small north-south trending valley, about 1 km wide and approximately 6 km long. The site is 9 km north of Warreen Cave. It faces almost due west and has at present a floor area of 40 m². The large remnant deposit towards the rear section of the cave is at least 140 cm deep, having been truncated by stream action sometime in the past (Allen 1991).

The most northerly cave site to contain an archaeological signature similar to those in the Southwest is located on the artificial Lake Mackintosh. The site (Mackintosh 90/1) is positioned in a large limestone bluff of Gordon limestone on Brougham's Inlet, the north-eastern arm of Lake

Mackintosh. It faces east and has a floor area of about 12.5 m² (Stern and Marshall 1993).

CHRONOLOGIES

Eighty-six radiocarbon dates are presently available; most are from five of the key sequences (Bone, Nunamira, Warreen, Mackintosh 90/1 and Acheron). Nearly all dates are based on conventional liquid scintillation ¹⁴C assays of wood charcoal contained in the excavated deposits. A few were obtained using AMS dating. Together they span the time interval from approximately ca. 35,000 BP to ca. 12,000 BP, although the timing of first occupation and of abandonment varies from one site to another (Table 1). Similarly, the time of most intense occupation, measured in terms of the density of archaeological debris, varies from site to site.

These data do, however, provide unequivocal evidence for the colonisation of the rugged interior of southwestern Tasmania by at least 35,000 BP. As the land bridge connecting southeastern Australia and Tasmania was open between 37,000 BP and 29,000 BP (Blom 1988), the oldest dated evidence for human presence in southwestern Tasmania (Warreen Cave) provides a reliable estimate for the time at which anatomically modern humans established themselves on the southern margins of the late Pleistocene world.

Although Warreen Cave provides the only evidence for human presence before 30,000 BP, several sites have basal dates of approximately 30,000 BP. These include Nunamira and Bone Caves and Acheron Shelter (Allen 1989; Cosgrove 1989). A series of dates is available for each of these sequences, with most exhibiting a relatively good correlation between age and depth. Thus the antiquity of human occupation in southwestern Tasmania has been extended by almost ten thousand years since the first evidence for Pleistocene human occupation was discovered in 1983 (Kiernan et al. 1983).

While the lowermost dated levels in these caves contain abundant and unequivocal evidence of use by late Pleistocene hunters, archaeological materials are generally most abundant in the most recent levels. Some sites like Bone Cave were used inten-

Site	Time-span
Nunamira	~ 12,000 BP - ~ 30,000 BP
Acheron	~ 13,000 BP - ~ 30,000 BP
Bone	~ 14,000 BP - ~ 29,000 BP
Mackintosh	~ 15,000 BP - ~ 17,000 BP
Warreen	~ 16,000 BP - ~ 35,000 BP

Table 1 Time-spans for SFAP sites in the Southwest.

sively both before and after, but not during, the last glacial maximum (Cosgrove *et al.* 1990). Other sites like Nunamira Cave were used more intensively for a few thousand years spanning the last glacial maximum (Cosgrove 1991:111). The excavators at Kutikina Cave in the Franklin River Valley, similarly recorded higher rates of discard and a greater density of archaeological debris in sediments deposited during the last glacial maximum (Kiernan *et al.* 1983). At Warreen Cave more archaeological debris accumulated before the last glacial maximum (ca. 35,000 BP - ca. 18,000 BP) than in the late glacial period, although here collapse of the site seems to have precluded its use after ca. 16,000 BP. At least one site, Mackintosh 90/1, does not contain any evidence for human occupation until after the last glacial maximum (Stern and Marshall 1993). Thus, there are hints of shifts in land use patterns over time, not just in relation to major climatic events, such as the last glacial maximum, but also as a response to adjustments in foraging strategies following the successful colonisation of a previously uninhabited region.

There are also differences between sites in the time of their abandonment. Warreen and Mackintosh 90/1 Caves were abandoned a few thousand years before Bone Cave or Acheron Shelter (ca. 16,000 BP for Warreen cave, ca. 15,000 BP for Mackintosh 90/1 Cave, and ca. 14,000 BP - ca. 13,000 BP for Bone Cave and Acheron Shelter), while Nunamira Cave was last occupied around 12,000 BP. Until detailed local palaeoenvironmental data are available it is not possible to determine whether the abandonment of each of these sites was a response to the encroachment of the rainforest at the end of the last glaciation. The possibility that these differences are the result of shifts in land use patterns, rather than a direct response to changed ecological circumstances, should also be entertained.

Not only are there differences in the ages and time spans of these sites, but there are also differences between them in the temporal resolution that they offer. For example, Nunamira Cave contains archaeological debris spanning approximately 20,000 years in a stratigraphic sequence that is only 50 cm thick (Cosgrove 1991:Chapter 4), while Mackintosh 90/1 contains 2000 years of accumulated debris in a deposit of similar thickness (Stern and Marshall 1993). On the other hand, the archaeological sequence at Warreen Cave contains 1.7 m of deposit representing a time span of 20,000 years. Thus, these sites offer the opportunity to explore the similarities and differences that exist between palimpsests of material debris representing different time spans.

STONE ARTEFACTS

The rich stone artefact assemblages which are present at many cave sites in the Southwest allow detailed insights into technological organisation. As a result, these sites provide an excellent opportunity to assess existing notions of simplicity and unity in Australian Pleistocene stone assemblages, notions which have often been formulated using meagre evidence (see Cosgrove *et al.* 1990:59-60). Towards this end, the SFAP is supporting a series of detailed technological studies on stone artefact assemblages recovered from sites excavated by the project (e.g. Bone Cave - McNiven, Warreen Cave - Richards) (see also Cosgrove 1991:160, 184; MacDonald 1991; Thompson 1989). At a specific level, the major aim of each study is to investigate possible chronological structuring within each assemblage in terms of differing raw material procurement and the dynamics of artefact manufacture, use, maintenance and discard. At a more general level, the combined results of this research should provide broader insights into regional patterns of technological organisation. When these data are integrated with information on bone assemblages, it will be possible to address higher order questions relating to the development and operation of regional adaptive strategies and associated broader-scale socio-economic systems.

For the purposes of this paper, initial results are presented on chronological changes in stone technology from Square C at Bone Cave. These show that this assemblage is structured along both technological and typological lines. When the results are compared to the Kutikina assemblage, broad regional trends in technological organisation also begin to emerge.

Bone Cave stone

Although most artefacts at Bone Cave were manufactured by direct free-hand percussion, minor changes in differing knapping techniques are present through the sequence. For example, in the lower occupational levels (ca. 29,000 BP - ca. 23,000 BP), evidence for bipolar anvilling can be seen on fewer than 1% of flakes. However, in the upper occupational levels (ca. 16,000 BP - ca. 15,000 BP), the incidence of bipolar anvilling on flakes increases to 7% in some levels with an overall mean of 3% (Fig. 2).

At least eight raw material types have been identified. Locally available quartzite predominates numerically (62%), followed by chert (19%) and quartz (crystal and milky) (11%), with the remaining 8% comprised largely by chalcedony, silcrete and hornfels. Although no Darwin Glass

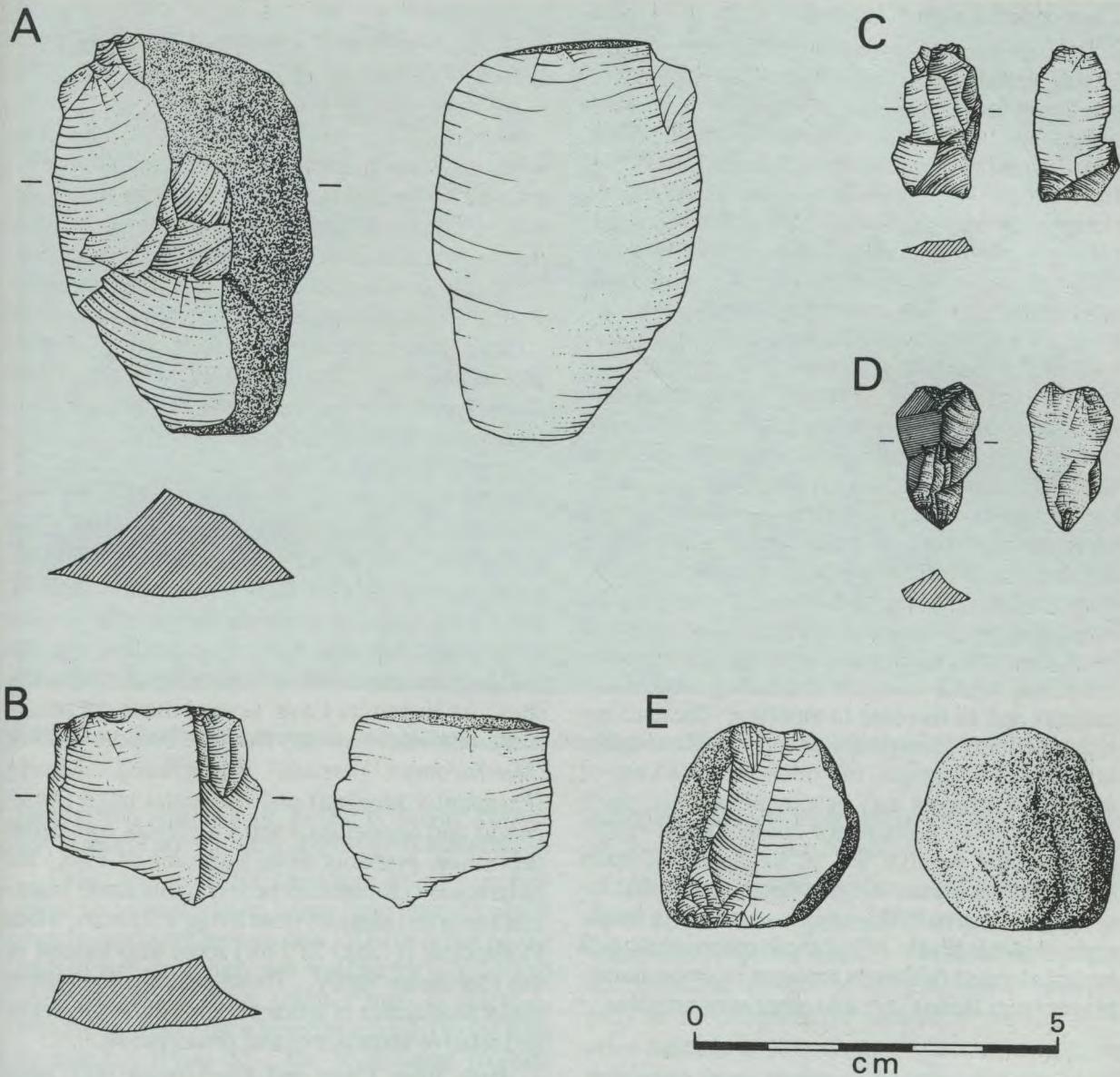


Figure 2 Selected stone artefacts from Bone Cave (A and B: quartzite flakes, C: chert bipolar flake, D: crystal quartz bipolar flake, E: milky quartz bipolar core).

was observed in Square C, a single small fragment has been recovered from Square B.

The most dramatic chronological change in raw material use is the increased discard of quartz in the upper part of the sequence. For example, in the lower occupation levels, quartz represents numerically only 5% of all artefacts, while in the upper occupation levels it increases to 14%.

The increased use of quartz in the upper parts of the sequence is interesting in light of the changes in bipolar flaking mentioned above. Given that nearly 60% and 80% of all bipolar flakes and bipolar cores respectively are made from quartz, it appears that much of the increase in bipolar flaking through time can simply be accounted for by changes towards the use of a raw material which

occurs only in the form of either small water-rolled pebbles or small isolated crystals (Fig. 2).

Chronological changes also occur in the morphological range of retouched flakes. For example, 80% of the 99 retouched artefacts identified are manufactured from large flakes of either quartzite or chert, with mean weights of 19 g and 6 g respectively. These larger artefacts are the most common in all levels of the site, with many classifiable as steep-edged scrapers. In the upper occupational levels, new retouched flake forms appear with the appearance of 16 thumbnail scrapers and at least two burins. While most thumbnail scrapers occur also after the glacial maximum at other SFAP sites, examples have been recovered from levels dated to before 22,000 BP.

Comparisons with Kutikina

The increased relative use of quartz, bipolar flaking and thumbnail scrapers in the post-glacial maximum levels of Square C parallels changes in stone technology at Kutikina. For example, in the upper Kutikina sequence dated between 18,000 BP and 15,000 BP, Jones notes an instantaneous change to quartz use, bipolar flaking, and the manufacture of thumbnail scrapers (1988:36-7, 1989:768-71, 1990:279-82). Jones suggested that these changes do not correspond to functional differences in stone tools, and speculates that the upper Kutikina sequence may 'signify an incursion into the region of a different style of manufacture of stone technology or, even more radically, of a different group of people' (1990:281, see also 1988:37). However, this suggestion is largely untestable, and a more parsimonious explanation may lie in the dynamics of technological organisation and how these reflect broad-based changes in settlement structure and mobility. For example, the increased use of exotic Darwin Glass in some Southwest sites during and after the glacial maximum may signal both a restructuring of land-use patterns and an increase in mobility. These re-adjustments may have precipitated strategic changes in stone tool curation, of which increased use of thumbnail scrapers may be a manifestation. Such a scenario may account for chronological differences in the relative use of thumbnail scrapers between sites across the Southwest given that re-adjustments in mobility can occur also at a small-scale regional level. All of these propositions will be investigated further as analyses of stone assemblages from Bone Cave and other sites progress.

VERTEBRATE FAUNA

The five main cave deposits all contain vertebrate fauna. Species lists and preliminary sequences are available for all sites, but only Nunamira and Bone Caves have been analysed in detail. Most deposits are extremely rich in bones and teeth. For most sites the majority of skeletal remains in all but the very earliest and latest periods of occupation appear to be the result of human subsistence activity. This pattern is in contrast to other late Pleistocene faunas in Greater Australia where a large proportion of the bone is non-cultural in origin.

Although bone preservation is generally excellent, it is highly variable, ranging from small unidentified fragments to complete or near-complete bones. The major processes responsible for bone degradation appear to be human butchering and related processing activities (see below), as well as burning. Mackintosh 90/1 has the poorest degree

of preservation and this may be due to the comparatively high incidence of burning. Similarly, at Bone and Nunamira Caves and Acheron Shelter, bone preservation is poorest in hearth areas.

Despite extremely slow rates of sedimentation in some sites (e.g. Nunamira Cave), the good preservation in these assemblages suggests that bone was not lying on the surfaces of caves for long periods of time before it was buried. Furthermore, the spatial distribution of bone reveals differential use of floor areas, suggesting temporal variability in activity areas within sites. This pattern is particularly evident at Bone Cave where hearths were placed towards the cave entrance and bone discard occurred more within the cave itself.

Origins

Assemblages from Bone, Mackintosh 90/1 and Nunamira Caves have evidence for bone accumulation from marsupial carnivores and/or birds of prey. Such bone is common in the upper levels and reflects less intensive human occupation and the eventual abandonment of these caves as habitation sites. At Nunamira Cave, several thousand small-mammal remains, mostly from the Broad-tooth Rat (*Mastacomys fuscus*), Longtailed Mouse (*Pseudomys higginsii*) and marsupial mice (*Antechinus* and *Sminthopsis* spp.) represent owl-pellet deposition, probably from a species of *Tyto*. We have made comparisons between this small mammal fauna and samples from Brigg's Squeeze, a late Pleistocene (11,000 BP) owl roost also located in the Florentine Valley. These examinations show major similarities in species composition (diversity and relative abundance) and preservation.

Both Bone Cave and Mackintosh 90/1 have carnivore-scat bone in their upper levels. At Bone Cave (Square C) this occurs as some 3000 pieces of highly fragmented bones and teeth, the majority from small to medium-sized mammals. The scat-bone from Mackintosh 90/1 is similar in appearance but is found throughout the sequence mixed with human food remains. The size range of these fragments at both sites suggests that Native cat (*Dasyurus viverrinus*) is the carnivore primarily responsible, although Tasmanian devils (*Sarcophilus harrisii*) may also have contributed scat remains.

In contrast to these three sequences, owl-pellet bone at Warreen Cave is most common in the lowest levels and decreases in quantity with increasing human use of the cave. It includes Ringtail possum (*Pseudocheirus peregrinus*) and bandicoot (*Perameles* spp.), none of which are common in the non-cultural assemblages from the other caves.

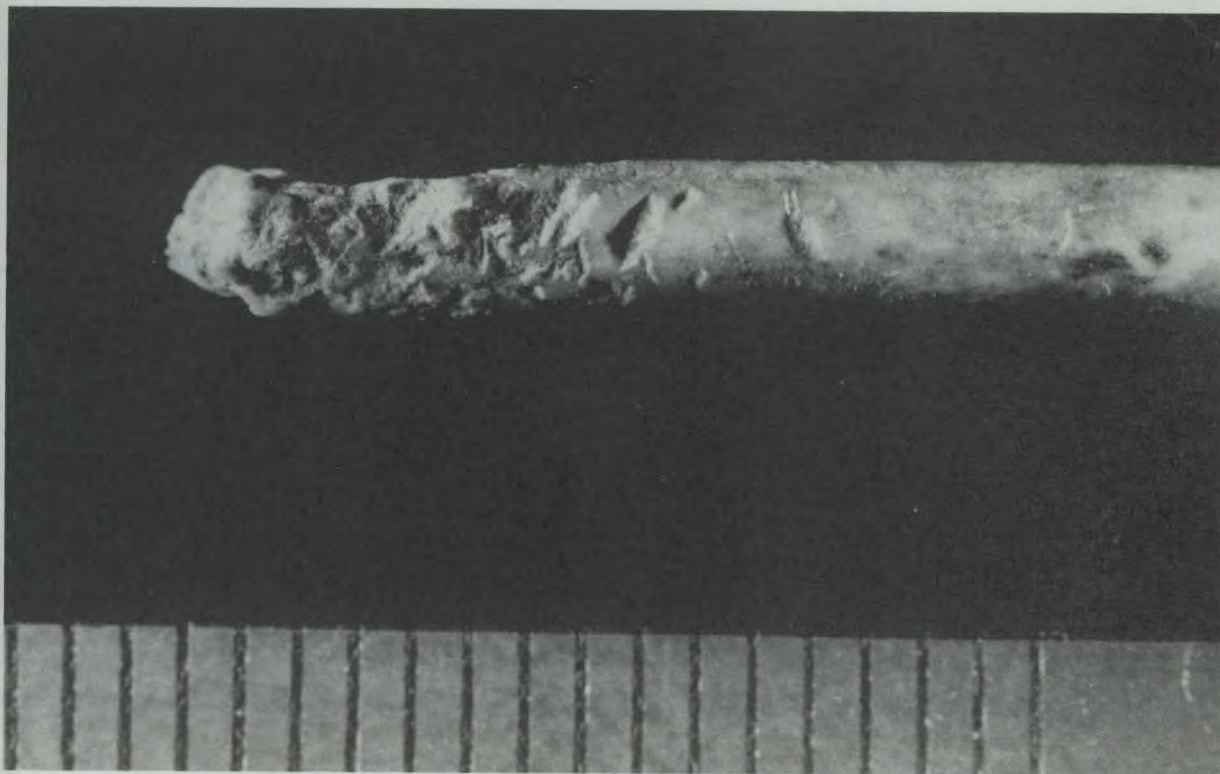


Plate 2 Carnivore toothmarks on a platypus distal ulna (Warreen Cave – post-glacial maximum period) (scale in mm units).

Preliminary analysis of Acheron Shelter reveals few bones of non-cultural origin in this assemblage.

Other evidence for carnivore activity is provided by toothmarks on bones from animals which clearly represent human prey. These occur on the ends of wallaby longbones cracked for marrow and on the bones of other animals such as platypus, which could only have been transported to the sites by humans (Plate 2). The toothmarks indicate scavenging of human food refuse and their relatively small size suggest that the native cat is primarily responsible. In Warreen Cave, toothmarks are most common in the levels with the highest density of bone.

Hunting strategies

Most assemblages are dominated by the bones and teeth of Bennett's wallaby (*Macropus rufogriseus rufogriseus*) which usually accounts for over 90% of identifiable pieces. Wombat (*Vombatus ursinus*) is the next most abundant prey followed by a small range of medium-sized animals such as Native cat (*Dasyurus viverrinus*) and platypus (*Ornithorincus anatinus*). At Warreen Cave there is greater representation of minor prey species in some periods, particularly wombat, after which the site is named. Potoroo (*Potorous tridactylus*) also occurs in this site as human food but appears to be largely absent from the other caves. Other

animals notable by their absence as human food in all five sequences are possums.

The predominance of Bennett's wallaby in all caves points to the operation of a hunting strategy with a very narrow focus. Whether or not this specialisation reflects the limited range of possible prey or the selection of Bennett's wallaby over other animals is difficult to discern at present. At this stage there appear to be few changes in the relative importance of Bennett's wallaby through time, in spite of dramatic changes in the quantity of bone in the deposits.

Animal processing activities

At all five sites there is remarkable evidence for butchering in the form of fracture patterns and surface alterations. The marrow-bearing longbones of Bennett's wallaby (femur, tibia, humerus, ulna, radius and the two large metatarsals) have been cracked at their distal and proximal ends to gain access to the marrow cavity; a practice which has left the shafts of many bones intact. Impact marks are evident on the margins of bones and small flake scars associated with this process appear in particular locations such as on the crest of the tibia (Plate 3). Marrow cracked bone appears to be less common in late Pleistocene assemblages elsewhere in Australia and its possible dietary im-

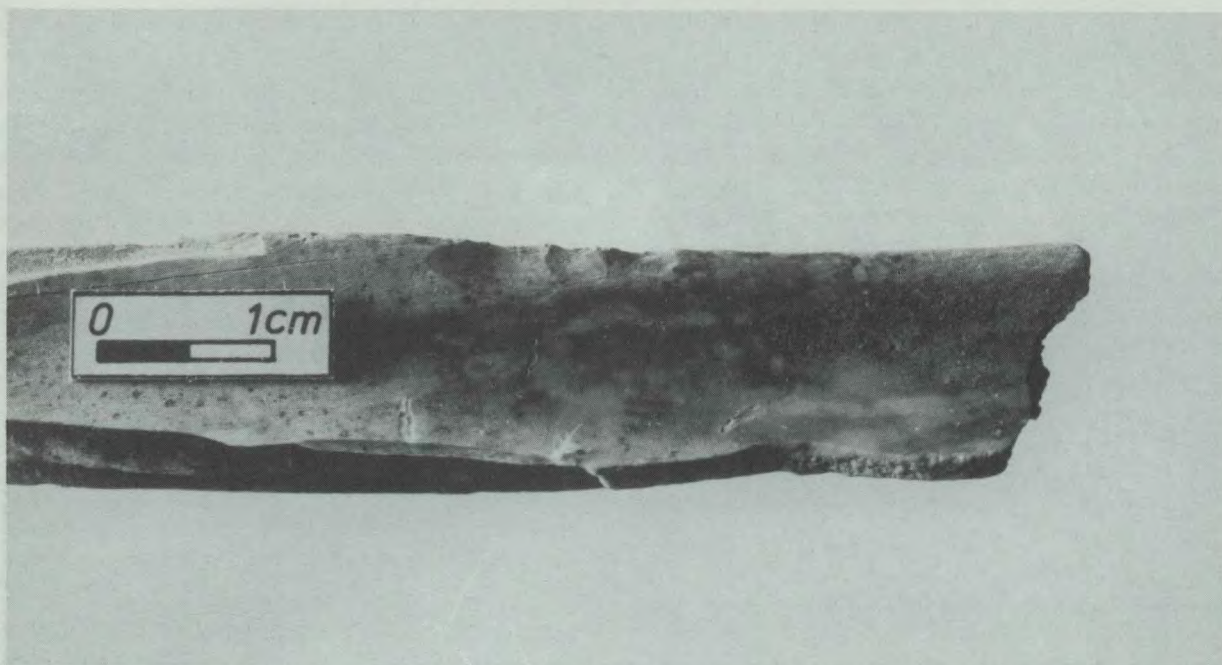


Plate 3 Impact flaking on the crest of a Bennett's wallaby tibia resulting from marrow extraction process (Bone Cave – post-glacial maximum levels).

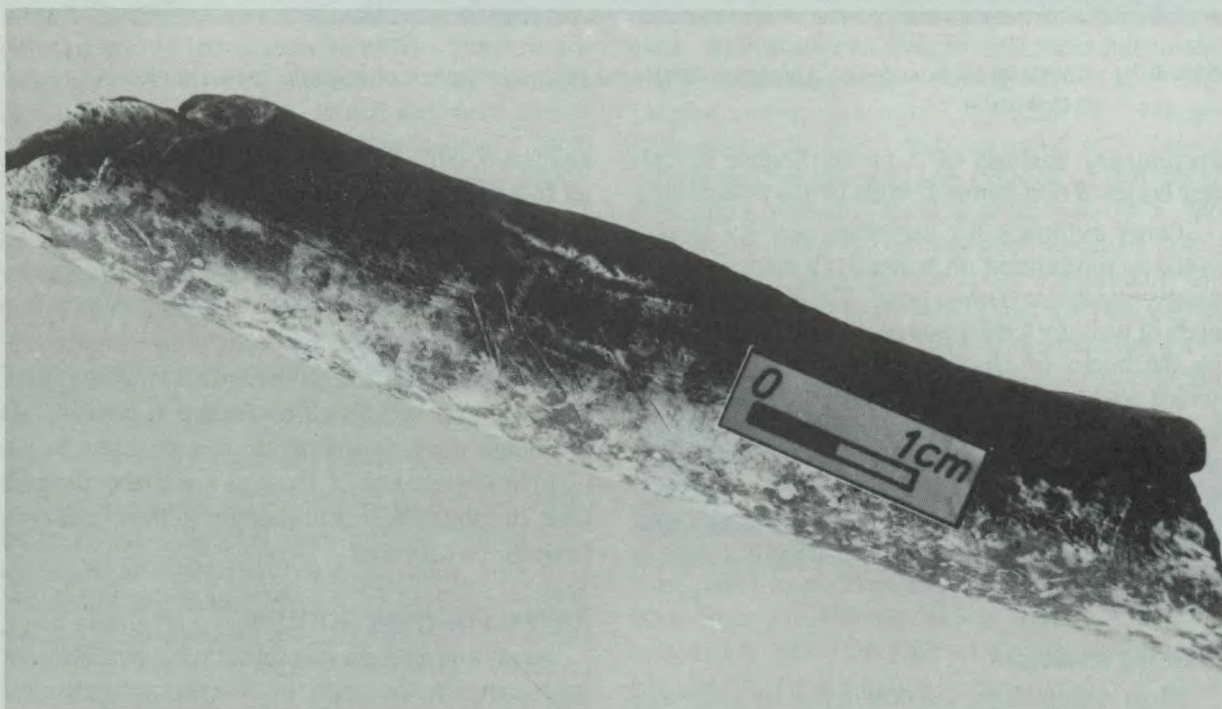


Plate 4 Cutmarks adjacent to muscle attachment on Bennett's wallaby femur shaft fragment (Warreen Cave – post-glacial maximum period).

plications have been discussed previously (Cosgrove *et al.* 1990).

Although relatively infrequent, cutmarks are another distinctive feature of these assemblages (Plate 4). They occur mostly on longbones adjacent to muscle attachments and are represented by single or multiple striations. These marks clearly indicate that bones were being defleshed at some stage during processing. Cutmarks seem to be most

common at Warreen Cave where they are associated with a range of other surface alterations, many of which are natural in origin.

CONCLUSION

This paper has provided a broad overview of the SFAP, together with preliminary results of research on the stone artefact and faunal assemblages. The

richness of assemblages combined with their high degree of integrity contrasts with late Pleistocene records elsewhere in Australia. The faunal remains in particular allow for more detailed reconstructions of late Pleistocene hunting and processing of animals than is presently possible for many other regions of the continent. However, as the SFAP moves into its synthesis and explanatory phase, we have been confronted directly by higher order theoretical problems of scale and resolution in the archaeological record (cf. Cosgrove 1991:302; Frankel, this volume). For example, how does one compare the 50 cm deep sequences at Mackintosh 90/1 and Nunamira Caves when the temporal resolution of the former may be up to ten times that observed at the latter? In short, problems of conflation of activities both within and between sites moves us beyond the 'illusion of riches' (cf. Cosgrove 1991:316, 357) to the difficult task of generating explicitly archaeological models of past human behaviour which may have no ethnographic comparison in terms of their chrono-spatial dimensions. We believe that resolution of these problems is critical for furthering our understanding not only of southwestern Tasmania, but for all of Pleistocene Sahul.

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PHOTOGRAMMETRIC RECORDING OF PLEISTOCENE CAVE PAINTINGS IN SOUTHWEST TASMANIA

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People first moved into Tasmania 36,000 or more years ago, when low sea levels exposed a land bridge across the Bass Strait (Blom 1988:96; McNiven et al., this volume). By 35,000 years ago they had occupied southern Tasmania where their campsites, preserved in caves, now provide rich evidence of lifestyle and economy. Over 50 occupied caves are known in the limestone and dolomite valleys of southwest Tasmania (Allen 1989; Brown et al. 1991:27-8; Cosgrove 1989; Cosgrove et al. 1990; Department of Parks Wildlife and Heritage 1991:66; Murray et al. 1980; Pocock 1991:188; see also Freslov, McNiven et al., Pocock, this volume). Those that have been excavated show occupation ranging between 35,000 BP and 10,250 BP.

Ochre nodules have been found in several of the occupation deposits, suggesting that painting took place at these camp sites. At Kutikina Cave, in the Franklin River Valley, ochre nodules were found in deposits dated between ca. 17,000 BP and ca. 15,000 BP, suggesting that decoration and painting took place there at that time (Kiernan et al. 1983:31). Ochre nodules have also now been found in the occupation deposits of two other Pleistocene sites in southwest Tasmania: at Warreen Cave in the Maxwell River Valley and at Lake Mackintosh (Allen et al. 1989; Allen 1990; Stern 1991). At the Lake Mackintosh site, there is an abundance of small lumps of ochre in the occupation deposit which dates to 17,000-15,000 BP (see McNiven et al., this volume). At Warreen Cave ochre, including some faceted lumps and stained pieces of limestone, occurred throughout deposits which have recently been dated between 35,000 BP and 16,000 BP (Allen 1990; McNiven et al., this volume).

Cave paintings in the form of hand stencils and ochre smears have now been found at three caves: Ballawinne Cave in the Maxwell Valley (Harris et al. 1988), Wargata Mina (Judds Cavern) in the Cracroft Valley (Cosgrove and Jones 1989; Jones et al. 1988) and Keyhole Cavern in the Weld Valley

(Allen et al. 1988:85). Human and mammal blood in pigment from Wargata Mina has been dated by accelerator mass spectrometry, giving a minimum age of 10,000 BP (Loy et al. 1990). Pigment in Wargata Mina and Keyhole Cavern is covered by a thin layer of calcite, demonstrating that paintings in those caves must have been created before the calcite formed. A major phase of calcite building has been noted in caves throughout south and west Tasmania, and is thought to have occurred during a humid period at the very end of the Pleistocene (Jones et al. 1988). There is no reason to doubt that the other cave paintings are also coeval with the dated cave sites in southwest Tasmania. None of the painted cave sites contain any material that has been dated to the Holocene and all the other dated cave sites in southwest Tasmania are older than 10,250 BP.

These cave paintings provide positive proof that Tasmanian Aborigines used the interior of caves beyond the daylight zone. They provide direct evidence of the non-utilitarian side of Tasmanian culture in the late Pleistocene, complementing our knowledge of the economy and settlement from excavated sites elsewhere in southwest Tasmania. All the known cave paintings are located deep inside limestone caves either in darkness or in very dim light. Despite intensive searching no occupation material has been found in the painted caves. In any event the paintings are located beyond the habitable regions of the caves. It is hard to interpret these as anything other than ceremonial sites.

The cave paintings in southwest Tasmania are early by world standards. Few other late Pleistocene painted sites are known, except for example those in southwest Europe, southern Africa, South America and northern Australia (see Rosenfeld, this volume). They provide evidence for the development of creative expression and perhaps also ceremonial activities. The location of the three known Tasmanian sites in different river valleys (Fig. 1) suggests that these paintings may have

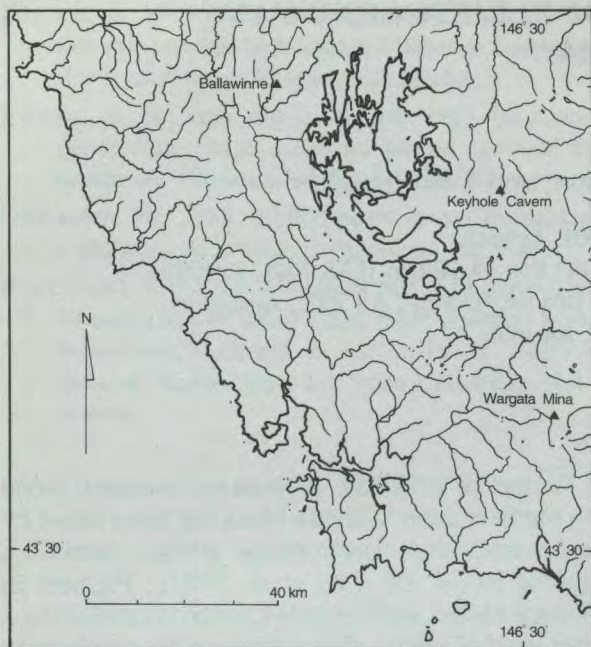


Figure 1 Sites with Pleistocene handstencils in southwest Tasmania.

been symbols of an emerging group identity. Placing their hands on the cave walls and creating stencils may have enabled particular groups of people to identify their association with particular caves or perhaps larger tracts of land such as whole river valleys. If so, the distribution of the same painting style over a wide area in southwest Tasmania suggests that common symbols and ideas may have been shared by groups of people occupying a large geographical range. Their function in society may have been to identify particular social groups with particular places (cf. Rosenfeld, this volume).

They now provide lasting personal and tangible links between their creators and the land they once occupied. Although today's Aboriginal community feel that all Aboriginal sites are important, places such as the painted sites are held in special regard as providing a source of pride in Aboriginal culture.

SITE PROTECTION AND MANAGEMENT

Because of the outstanding importance of these cave paintings in Tasmania, the Parks and Wildlife Service has sought to ensure that they are adequately recorded and managed. Therefore a long term program of management and interpretation has been initiated in co-operation with the Tasmanian Aboriginal community. Through a consultation process which has been ongoing since 1988, appropriate site protection measures have been identified and are now being implemented. The main bushwalking track across the Cracroft Valley

to Federation Peak has been re-routed and now by-passes Wargata Mina to relieve casual visitor pressure at that site. A program of long-term monitoring of the cave micro-environment at Wargata Mina is being implemented and baseline data on the presence of microbiota and microbial activity was collected in July 1991 (Brown 1991). This study found that there is low microbial activity in the cave and the site is currently below the threshold for acute biodeterioration. A walkway with interpretation panels was installed at Wargata Mina in February 1992.

As part of this program, the hand stencils discovered in 1987 in Wargata Mina were recorded in March 1988 (Brolsma and McGowan 1988; Brolsma et al. 1988). The hand stencils discovered in 1986 and 1989 in Ballawinne Cave were recorded in 1989 (McGowan et al. 1990). Those discovered in 1988 in Keyhole Cavern were recorded in April 1991 (McGowan et al. 1992).

The recording method used was standard terrestrial photogrammetry, a technique which had already been successfully applied to recording Aboriginal rock art in rockshelters in Kakadu National Park (Rivett 1983). This method was chosen because it is comprehensive, accurate and time-efficient. The use of photogrammetry at Wargata Mina in 1988 was the first application in Australia of this technique to rock art inside a cave. All three caves are situated in remote locations in southwest Tasmania. We used helicopters to transport recording and camping gear to the expedition base camps, as backpacking this gear in would have been impractical. Technical details of the photogrammetric cave survey methods and photogrammetric plotting are summarised below and further details are provided in McGowan et al. (1991).

Photogrammetric cave survey methods

Photogrammetry is a way of making scale maps and drawings from photographs. To do this stereo pairs of photographs are needed. These are viewed through a stereo-viewer to give a three-dimensional image from which contours and features can be traced, using a stereo-plotter. Cameras, lighting equipment and techniques used at each cave site were selected according to its particular shape, dimensions and circumstances. At Wargata Mina we used a Wild C.40 stereometric camera with Agfa AVIPAN 100 black and white glass plates and incandescent floodlights. At Ballawinne and Keyhole Cavern we used a Hasselblad camera with 50 mm lens, Kodak Vericolour colour negative film and electronic flashes. Photography for the individual hand stencils used normal close range techniques. Because the narrow confines of the passage in Ballawinne Cave made the use of scale bars

impossible, we began using 12 mm green stick-on labels. We found these stick-on labels very successful as they adhered to the rock faces quite adequately without affecting the wall surfaces and we were able to measure the distance between them to the nearest 0.5 mm.

The Wargata Mina and Ballawinne expeditions included surveyors whose role was to provide co-ordinated control points for photogrammetric plotting. At Keyhole Cavern, the photogrammetrists set up their own control. The equipment used was a Wild T2 theodolite, a standardised 30 metre tape, 'forced centring' Sokkisha and Wild targets and electronic distance measuring (EDM) equipment for the longer lines.

Photogrammetric plotting

Plotting the wall panels containing the paintings and the individual stencils was carried out on a Zeiss C120 analytical plotter using Digmap data acquisition mapping software. Using colour negatives, the stereo models of the wall panels were set up in the general case, not as true terrestrial models. Major features such as stalactites, the location of the painted panels and a vertical profile through the paintings from ceiling to floor were captured, then plotted on a Wild TA10 automatic plotter.

The close-up photography of the individual hand stencils was set up in a similar way. Final plots of the wall panels and the stencils were presented at 1:1 scale as four colour biro on paper. Figure 2 gives an example of the hand stencil plots, reproduced here at a reduced scale to fit the page size and in black and white only.

Plotting the floor plans and main cave profiles in Wargata Mina was carried out using a Wild A7 stereoplotter and normal terrestrial plotting techniques.

Results of the photogrammetric surveys

The following results have been produced from the three site recording expeditions:

1. A complete set of stereo photographs of the hand stencils and wall panels at all three sites,
2. photogrammetric plots of the wall panels and floor to ceiling profiles at Keyhole Cavern at scale 1:10,
3. photogrammetric plots of the wall panels and floor to ceiling profiles at Ballawinne Cave and Wargata Mina at scale 1:25,
4. photogrammetric plots of the hand stencils at 1:1, including contour overlays of the rock surfaces, at all three sites.

These plots are unsuitable for reproduction in the format of this publication, as they are presented on A1 or larger size paper and the pen lines are too

thin to reduce successfully. Figure 2 is a black and white copy of a reduction of one of the 1:1 plots, illustrating the type of plots obtained.

At Keyhole Cavern we undertook a tape and compass survey of the entrance chamber and the adjacent Weld Arch. A cave plan is currently in preparation. At Ballawinne a 1:100 plan of the cave (at ASF grade 55) which shows the location of the stencil panels already existed, so we considered it unnecessary to re-survey the cave. This is published at a reduced scale in Harris et al. (1988). At Wargata Mina, a speleologist's plan of the known extent of Judds Cavern has been published at a scale approximating 1:500 (Clark 1987:33). We produced a 1:100 plan and cross-sections of the entrance chamber and a detailed 1:25 plan of the gallery containing the painted panels in the entrance chamber, as the basis for designing proposed site protection installations. A plan and profile of the entrance chamber based on the 1:100 plan has been published in Cosgrove and Jones (1989).

SITE DESCRIPTIONS

Wargata Mina

Wargata Mina, which has been known to cavers as Judds Cavern since the early 1970s, is a large cave with at least 4.3 km of passages. The main passage is occupied by a substantial outflow stream, Judds Creek, which drains a vast subterranean hydrological system (Kiernan 1989). This entrance is an imposing horizontal tunnel into the hillside with a diameter of approximately 10 to 16 m. There are at least 11 other known entrances to the system, all vertical shafts. At least one blocked horizontal side passage terminates very close to the surface and was probably an open horizontal entrance at times in the past. Progress along the main stream passage is blocked by a low wide water-filled tube, which intrepid cave divers negotiate to further their explorations. The cave system is noteworthy not only for its sporting challenges, but also for a variety of scientific values. It contains several deposits of small mammal remains, including a roost of fossil bat remains comprising several bat species, none of which are normally found in caves in Tasmania. The cave is one of few where the speleothems are suitable for uranium series dating (Clarke 1987; Eberhard 1990; Gillieson and Taylor 1980; Goede and Harmon 1983).

Twenty-three stencils have now been identified on the walls of the entrance chamber at Wargata Mina. The stencil gallery, known as Dregena Lewnana (meaning 'Hand Den'), is located on a deep ledge about 8 m above the main stream pas-

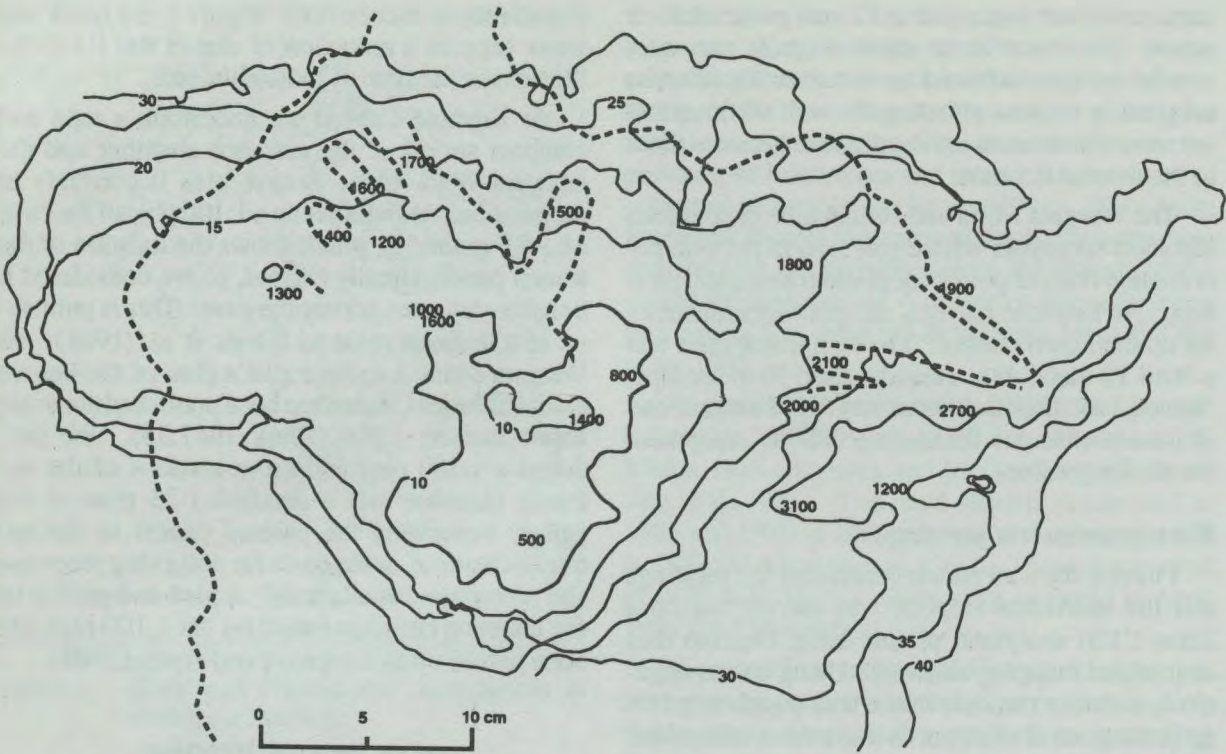


Figure 2 Copy of photogrammetric plot of stencils 2 and 3 in Keyhole Cavern.



Plate 1 Stencils 2 and 3 in Keyhole Cavern.

sage, some 35 m from the cave entrance. The gallery is in virtual darkness, although in the mid-afternoon there is enough daylight filtering in from

the cave mouth to move around carefully without a torch. The gallery is highly decorated with calcium carbonate formations. In some places this calcite

extends over the ochre, indicating that the paintings were created before the formation of the calcite. Samples of pigment collected in 1987 have been analysed and found to contain human blood. This has been radiocarbon dated using accelerator mass spectrometry to give dates of $10,730 \pm 810$ BP (RIDDL 1268) and 9240 ± 820 BP (RIDDL 1269) (Loy et al. 1990).

Jones et al. (1988) reported the discovery of 15 hand stencils in 1987. These plus an additional three found during the survey exercise were recorded and plotted up in 1988. During the plotting up two more hand stencils were identified from the stereo photography of the wall panels and subsequently confirmed with a site inspection. Since then an additional three hand stencils have been identified on the walls of Dregena Lewnana. These five more recently discovered stencils have not yet been recorded or plotted.

Dregena Lewnana comprises two main panels of stencils and ochre smears, plus several isolated stencils and patches of ochre. All these paintings are located on the south and west walls of the ledge. All the ochre in Wargata Mina is red.

Panel A – the lintel

Panel A consists of five stencils located on a rock lintel between 2 and 2.4 m above the floor, on the west side of the ledge. This panel comprises four apparent left hands and one apparent right hand.

Panel B – south wall

Panel B consists of large smears of red ochre on the south wall of the ledge, containing at least 14 identified stencils. The cover of ochre is discontinuous with stencils and smears occurring within an area approximately 3 m high by 8 m wide. Many of the stencils are faint or indistinct and at least two appear to overlap each other. Some of the smears may be the end result of repeated overlapping stencilling, creating a wall of pigment in which individual outlines have become obscured. Of the identifiable stencils, two are apparent right hands, two are apparent left hands (including one child) and ten are indeterminate.

Isolated stencils

Four stencils and several small patches of ochre occur on the walls and low ceiling along the west side of the ledge. These comprise one apparent left hand and three indeterminate hands.

Bibliography for Wargata Mina

Brolsma and McGowan (1988); Brolsma et al. (1988); Brown (1991); Cane (1976); Clark (1987); Cosgrove and Jones (1989); Eberhard (1990); Gil-

lieson and Taylor (1980); Goede (1974); Goede (1977); Goede and Harmon (1983); Jones and Cosgrove (1987); Jones et al. (1988); Judd (1896); Kiernan (1989); Loy et al. (1990); McGowan et al. (1991)

Ballawinne Cave

A total of 23 hand stencils have now been identified in Ballawinne Cave, occurring in two panels located between 15 and 25 m inside the cave. A plan of the cave showing the location of the painted panels has been published in Harris et al. (1988). There are two entrances to Ballawinne which are open today. Both of these are low, narrow winding passages leading into a chamber about 7 m high and 8 m across. The floor of this chamber is at present partially covered with a pool of water. This chamber is in total darkness, although a third entrance which is now blocked with debris may have provided both access and light into the main chamber at times in the past. The easiest of the currently open entrance passages is some 15 m long and requires some crawling to negotiate. A number of other low passages, some with wet floors, lead away from the entrance passage and main chamber for a few metres.

Ballawinne Cave is also noteworthy as the only known location of several newly discovered species of cave fauna, including a new genus and species of crustacean in the Koonungidae family (Eberhard et al. 1991).

Sixteen stencils and some ochre smears were discovered in Ballawinne in 1986 (Harris et al. 1988). During the 1989 recording expedition an additional seven hand stencils were identified, located in and between the two panels previously reported.

To date, 16 ochre smears have been identified. These include five prominent blazes of red ochre on rock protuberances at the narrow cave entrance, four patches of ochre on the wall and ceiling of the narrow, winding entrance passage, a large diffuse patch of ochre on the ceiling of the main chamber opposite panel XY, three patches on the floor and low ceiling opposite panel Z and three patches between panels Z and XY. All the ochre in Ballawinne Cave is red.

Panel XY

Panel XY consists of 19 stencils and several patches of ochre located along the northeastern wall of the narrow entrance passage where it leads into the main chamber. One stencil is on the flat bevel between the two panels. The panel comprises four apparent left hands, six apparent right hands and nine indeterminate hands.

Panel Z

Panel Z consists of four stencils and several patches of ochre located along the eastern wall of the main chamber. The panel comprises one apparent left hand and three indeterminate hands.

Bibliography for Ballawinne Cave

Eberhard et al. (1991); Harris et al. (1988); McGowan et al. (1990); McGowan et al. (1991).

Keyhole Cavern

Three stencils were found at Keyhole Cavern in 1988 (Allen et al. 1988) and an additional three ochre smears were identified during the recording exercise in 1991. At Keyhole Cavern a wide but low cave mouth opens out into a large chamber. The entrance is about 10 m wide and 1 m high. About 20 m into the cave, the cave opens out into a chamber about 25 m wide by 2 m high. Beyond the main chamber, a deep cave passage extends for at least another 50 m, but a deep pool of water has so far proved a barrier to further exploration. The cave entrance and interior is heavily decorated with calcium carbonate. Today the entrance is filled with a maze of calcite speleothems which substantially hinder a passage through and filter out much natural daylight. Before this phase of speleothem formation, it is likely that access to the main chamber would have been much easier. Brown excavated a small test pit in the entrance in 1988 but no cultural material was found.

The stencils and ochre smears are grouped in two panels located along the eastern wall of the cave, approximately 50 m from the entrance. All the ochre in Keyhole Cavern is red.

Panel A

Panel A consists of one stencil and three smears on a low sloping ceiling. This is the most deeply located panel in Keyhole Cavern and is the deepest place reached by daylight in the middle of the day.

Stencil 1 is an apparent right hand, positioned horizontally on the rock wall and orientated north. It consists of a palm, thumb, part of a wrist, and parts of the forefinger, second, third and little fingers.

Smear 1 lies between 15 and 35 cm north (left) of stencil 1. It is in the form of ring of ochre blobs which could be a remnant stencil about 15 to 20 cm across. Smear 2 located about 1.5 m away consists of numerous spots of ochre in an area 20 x 50 cm. Smear 3 is located about two metres from the main group on a low ceiling and wall. It consists of spots of maroon-coloured ochre in cracks and hollows in the rock wall. It is heavily encrusted with calcite.

Panel B

Panel B consists of two stencils and an ochre smear, located at about head height along the eastern wall of the entrance passage. During the course of the day a shaft of sunlight passes along the wall, lighting the panels for a short while.

Stencils 2 and 3 (Fig. 2 and Plate 1) are located in a dome-shaped recess in the ceiling and are partially encrusted with a skin of calcite. Stencil 2 is an apparent left hand, positioned on the flattish ceiling of the dome and possibly oriented south. The thumb and part of the forefinger are clearly visible. Parts of the second, third and little finger are also faintly identifiable.

Stencil 3 is located adjacent to stencil 1 inside the flattish dome. It consists of part of a finger, oriented east/west. More spots of ochre occur lower down the side of the dome.

Smear 2 is located about 2 m away from the dome on a low curved ceiling. It consists of numerous spots of ochre in an area 20 x 25 cm.

Bibliography for Keyhole Cavern

Allen et al. (1988); McGowan et al. (1991); McGowan et al. (1992).

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THE ROLE OF OPEN SITES IN THE INVESTIGATION OF PLEISTOCENE PHENOMENA IN THE INLAND SOUTHWEST OF TASMANIA

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While the aim of this volume is to review the terminal Pleistocene as a spatial entity within the confines of Greater Australia, the prehistory of inland southwest Tasmania can be investigated more effectively as a seamless entity in terms of both time and space. The usefulness of the late Holocene record in providing a broader analytical and conceptual baseline for Pleistocene archaeological phenomena and their interpretation is explored in this paper.

BACKGROUND

Archaeological research in the inland southwest of Tasmania has been carried out since the late 1970s and has focused upon a series of very rich archaeological deposits in cave sites spanning the period 35,000-12,000 BP. Current work being conducted in this area by the Southern Forests Archaeological Project is concerned with gaining a detailed knowledge of the late Pleistocene (Cosgrove et al. 1990:60; McNiven et al., this volume). This paper looks at two other facets of the archaeological record of inland southwest Tasmania, open or surface sites and the recent past.

Numerous open sites have been recorded throughout the region (see Fig. 1), particularly in the King and Queen valleys where conditions of archaeological visibility are exceptional. These sites mainly consist of stone artefact scatters, although some bone refuse has been found on sites in the Queen valley (Corbett 1980). Artefact occurrences range from single finds to sites covering many hundreds of square metres (see Corbett 1980; Kiernan et al. 1983). On the whole, the density of stone artefacts on these sites is low.

The chronology of the open sites is poorly understood. Radiocarbon dates exist for only four open sites; the Denison-Gordon confluence site (NR5), dated to 300 ± 150 BP (ANU 2787) (Kiernan et al. 1983:28), the Flying Fox site on the Franklin River (FFS), dated to $17,100 \pm 1350$ BP (ANU 3562) (Jones 1989:285), an open site on the Nelson River karst (SK1), dated to 1580 ± 130 BP

(WK 2090) (Pocock 1991:205) and a site in the northern King valley (KRV3), dated to 460 ± 60 BP (Beta 46486). Thirty surface sites on glacial moraines in the Queen River valley are thought to fall in the time period between the penultimate glaciation, before 100,000 BP, and the Holocene expansion of the rainforests, at approximately 9500 BP (Corbett 1980; Kiernan 1982). Although Corbett (1980) argues that Holocene occupation of the area was unlikely due to the impenetrability of the rainforest, it is possible that patchy distribution of the vegetation may have allowed easier access to the area than previously thought (Kiernan 1982). A lithic scatter found on the Tyndall Range is thought to postdate the last glacial maximum advance at 19,000 BP (Cosgrove and Hughes 1983).

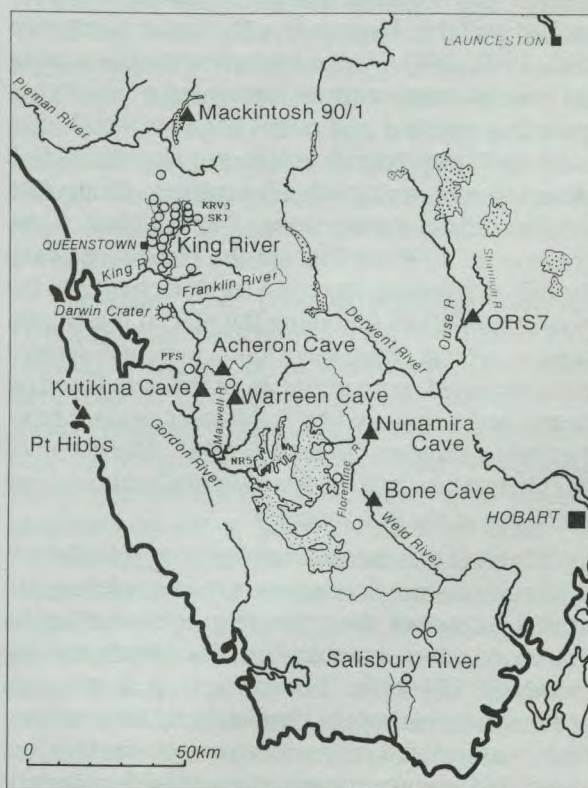


Figure 1 Archaeological sites in southwest Tasmania. Solid triangles show cave sites; open circles show open sites.

HOLOCENE SITES AND PLEISTOCENE ARCHAEOLOGY

The potential of open sites to illuminate some aspects of the Pleistocene record lies in the following three areas. First, to investigate whether or not the archaeological signature found in the Pleistocene cave sites is characteristic of that time period and site type. Secondly, to use data from both Holocene open sites and Pleistocene cave sites to compare settlement and landuse patterns during the major climatic and vegetative changes of the Holocene and Pleistocene. Thirdly, the behavioural inferences drawn from the spatial differentiation of raw material use and technology in lithic assemblages in the open sites may be used both comparatively and heuristically to examine the behavioural implications derived from the Pleistocene lithic assemblages. The open sites provide data from a greater area, broader time frame, a greater range of site types and a more varied series of landforms than the Pleistocene cave sites. Each of these three issues is discussed in detail below.

A distinctive archaeological signature?

Sequences from the Pleistocene cave sites show a consistent archaeological signature with occupation terminating at around 12,000 BP and rich bone assemblages predominantly of one or two prey species (e.g. wombat, *Vombatus ursinus*, and red-necked wallaby, *Macropus rufogriseus*) (Cosgrove et al. 1990:66-7). Stone tool assemblages contain not only the usual range of Tasmanian artefact types including notched and nosed scrapers, small disc cores and steep-edge scrapers, but also distinctive elements such as thumbnail scrapers, denticulate flaking and an exotic stone: Darwin glass (Cosgrove et al. 1990:69-71). In the Pleistocene cave deposit at Kutikina there is a sudden change in the stone assemblage following the glacial maximum, from a typical Tasmanian core tool and scraper industry based on quartzite, to an industry based on quartz and dominated by a different artefact type: thumbnail scrapers (Jones 1987:36). The extent of this change has yet to be tested spatially (though see McNiven et al., this volume).

It is clear that the distinctiveness of this Pleistocene suite cannot be assessed without reference to a greater range of site types, (e.g. open sites) and a more extensive chronological framework that includes the Holocene. For example, it is unknown at this time whether the characteristic suite of artefacts is associated only with caves, or whether it is also found in some form in open sites. Similarly, it is not known whether it is purely a late Pleistocene phenomenon, or if such elements are found in the Holocene, or in different environments. Put sim-

ply, the distinctiveness of the polythetic set regarded as typical of Pleistocene southwest Tasmania should be tested.

Even within the Pleistocene period, the low quantities of excavated material that have been analysed mean that the apparent homogeneity of this signature may break down as further analysis of materials takes place. A more extensive time frame may further weaken it. The present cohesiveness, or tightness of the signature may also be an artefact of the conflation of a broad time frame.

Holocene use of the region

The inland southwest of Tasmania was once thought to have been unoccupied in the past, an inference based primarily on information derived from the journals of G.A. Robinson written during the period 1829-1834 (Jones 1982). After the discoveries in the Franklin-Gordon River system in the 1970s and 1980s, this view of a *terra incognita* changed to one of intense occupation during the late Pleistocene and marginal use during the Holocene (Kiernan et al. 1983). Documentary evidence does in fact exist for some Aboriginal use of the area during the contact period, particularly in the northern and eastern parts of the area (Burn 1842:19; Goodwin 1828 and Sharland 1832, quoted in Binks 1980:23). It is unknown at present whether this represents a response to the dislocation caused by the European invasion of neighbouring regions, or a traditional pattern of landuse. Ethnohistorical information about landuse and occupation of the region is extremely sparse and consequently any reconstruction must be entirely derived from the archaeological record.

At present descriptions of occupation and landuse are almost entirely based on cave sequences, with the consequence that a prehistory of the region effectively ceases at 12,000 BP. Work on open sites is hindered by their low archaeological visibility and poor chronological control, while evidence of the Holocene occupation of caves and shelters in this region is meagre and unlikely at present to provide information about the prehistory of the area. Only two shelter deposits have been found in the inland southwest which may possibly date to the Holocene. Overhang Cave, in the Nelson Valley, 5 km east of the King River has a basal date of 340 ± 105 BP (WK 2088) although the deposit may be older as there are indications that it may have been reworked (Pocock 1991:215, see also Pocock, this volume). An unexcavated rock shelter site on the Tyndall Range to the north of the King Valley may contain a shallow and probably sparse deposit likely to postdate the last glacial period (Cosgrove and Hughes 1983). The use of cave sites in the region seems limited to the Pleistocene, while open

sites appear to span both time periods. Ultimately, dated open sites may provide an alternative data base for the investigation of the duration of occupation of the region and differences in landuse between the two periods and under a variety of different environmental conditions.

One of the perennial problems in the detection of open sites and landuse patterns in the inland southwest of Tasmania is ground visibility. On the whole, archaeological visibility is poor and the relationship between visibility and relative density is an unknown factor in determining the current patterning of sites. At present it is difficult to know whether the dense distribution of sites in the Queen and King valleys is real, in a behavioural sense, or a product of good visibility. Conversely, it remains unknown if the lower densities of recorded sites in other southwestern valleys are a function of either sparse occupation or poor visibility. Therefore, the question remains of whether Pleistocene sites may be more visible due to their location in caves and Holocene sites less visible because they were generally located in the open.

The number of open sites so far located in inland southwest Tasmania raises a number of important questions, not only about possible contrasting patterns of occupation and landuse between the Holocene and Pleistocene, but also about alternative expressions of landuse to that so far documented by cave records. Consequently, the analytical integration of open sites with cave sites may allow more detailed insights into chrono-spatial continuities and discontinuities in the occupation of the area.

Lithic differentiation

The third role that open sites may play in providing a broader context for the Pleistocene, is in developing a fuller understanding of the spatial patterning of raw material use and lithic technology and settlement or logistic arrangements between open sites and cave sites and their effects upon inter- and intra-assemblage form.

Analyses of lithic assemblages in southwest Tasmanian caves show that there is some raw material differentiation, with quartz and quartzite dominant in the west and other materials such as chert, crystal quartz, hornfels and silcrete dominant in the east (Cosgrove et al. 1990:70). As these authors point out, such patterning probably reflects the use of local materials (1990:70).

Darwin glass is found in small, but variable quantities in most cave sites. While there is some evidence that the amount of glass declines with distance from Darwin Crater, the pattern is not consistent. Some sites close to the source have very small amounts and others further from the source

have larger amounts of this material (Jim Allen pers. comm.). During the Pleistocene, transport of Darwin glass appears to have been small scale and intermittent (Cosgrove et al. 1990:71). Darwin glass has not been found in a securely dated Holocene context. One piece of Darwin glass was found in the deposit in Overhang Cave, which, as noted earlier, may be reworked (Pocock 1991:215). The only surface sites to contain Darwin glass are the Queenstown sites, which could be of any age. Clearly this pattern is not entirely dependent upon distance from source, or time period. Perhaps it also reflects the operation of interaction spheres or particular patterns of landuse.

The key role that open sites may play with respect to understanding lithic differentiation is in providing a range of ecological, logistic and behavioural circumstances not represented by cave sites.

THE KING RIVER VALLEY: A CASE STUDY

With the above research problems in mind, I commenced a project in the King River valley. The specific aims of the project were to obtain detailed information from dated open sites within a small region and to compare them to both cave sites and to open sites elsewhere in inland southwest Tasmania.

The study area is 30 km inland from the coast. The King River valley consists of 60-70 km² of topographically varied country, 200-240 m asl, with high ranges to the north, west and east of the valley. The King River drains a number of these ranges before turning east through the West Coast Range. The valley is now Lake Burberry, having been dammed as part of the King River Power Development scheme in 1991.

The valley floor contains both Holocene and Pleistocene landforms, which allow a coarse form of relative dating. Most landforms in the valley have resulted from the penultimate glaciation and earlier Quaternary glaciations (Colhoun 1985; Colhoun and Fitzsimons 1990:207-12; Fitzsimons 1988; Kiernan 1980). Landforms from the last glaciation consist of outwash fans from small valley and cirque glaciers, scree and some river terraces. Landforms from the Holocene are made up of the lower two river terraces, the present flood plain, some levee banks, back swamps, peats and the podzols (Colhoun et al. 1988:12; Fitzsimons 1988:55, 197). The vegetation was dominated by large areas of poorly drained buttongrass moorland and sedgeland, with some *Eucalyptus delegatensis* woodlands in the north of the valley and rain-forest on some valley sides, in gullies and in patches along the river (Kirkpatrick 1977a).

Archaeological visibility was patchy. Extensive erosion and exposure of sites has occurred in the middle section of the valley as a result of 100 years of bushfires, and acid rain at the turn of the century from the Queenstown copper smelters (Kirkpatrick 1977b). More recently there has been some subsurface exposure in the north of the valley due to dam construction.

Sites

In 1990 I carried out survey work in the valley and located 47 open sites of varying size, some with hundreds of stone artefacts made from a variety of local materials including quartz, quartzite, chert, sandstone and silcrete. These results augment previous environmental impact studies in the valley which located 97 archaeological sites (see Cosgrove 1986; Macfarlane and Coates 1990; Pocock 1991 and this volume). The distribution of artefacts within sites was mapped and 4000 artefacts collected. Fourteen sites were excavated, resulting in the recovery of artefacts and charcoal within a number of distinct soil horizons. Most artefacts in the northern part of the valley were found within a widespread and distinctive grey, ashy silt likely to date to the late Holocene. In the middle section of the valley, artefacts were found mainly in a stratigraphically older, orange podzol, likely to postdate the last glacial maximum. Although excavations on sites were small, the areal extent of sites was tested further by employing shovel test pits. Shovel test pits were also dug in a number of landforms to investigate subsurface stratigraphy. Several artefacts were recovered incidentally from these test pits.

Preliminary results

Preliminary results from the survey and excavations are useful with respect to all three issues discussed. Due to poor preservation conditions, bone refuse was not found in any site. Therefore, no comment can be made about the chronological distinctiveness of the Pleistocene bone signature. But initial comparisons of King River stone artefact assemblages with those from the caves show a number of points of similarity and difference with other aspects of the Pleistocene signature.

In contrast to the Pleistocene assemblages, Darwin glass was not found in any of the King River sites, even though the Darwin Crater is located only a few kilometres to the south and small nodules are available at the southern end of the valley. Its absence may be due to a number of factors, discussed below, but the lack of this material in the King River sites, particularly from the excavated sites, tends to confirm that it has a distinctive chronological distribution. Its occasional presence

in Overhang Cave and the Queenstown sites does not seriously undermine this pattern, as these are not securely dated to the Holocene.

On the other hand, the King River sites demonstrate a number of similarities with the Pleistocene cave signature. A similar suite of artefacts including thumbnail scrapers persists into the late Holocene. A distinctive lithic manufacturing technique, denticulate flaking, is also found in the King River lithic repertoire. This technique is an unusual one in Tasmanian assemblages. More detailed analyses of both the Pleistocene cave assemblages and those from the King River may allow more extensive comparisons in the future (see McNiven et al., this volume).

Other similarities with the Pleistocene signature include raw material selection and procurement. The heavy reliance upon local procurement strategies during both periods has been argued to be characteristic of southwest assemblages in general (Macfarlane and Coates 1990:49). Like the upper layers of Kutikina, in some sites in the King River valley quartz is used preferentially over other readily available raw materials. The chronological and behavioural significance of this pattern has yet to be examined.

One of the frequently cited features of the Pleistocene cave signature is their 'richness' of deposit in terms of both stone and bone (Kiernan et al. 1983; Cosgrove et al. 1990:74). It is difficult to compare the density of artefacts between different site types, given the constraints placed by cave boundaries and their role as traps for sediments and artefacts. The relative 'richness' of these deposits is not directly comparable to sites having more extensive but less focused occupation. The entire archaeological deposit of several sites in the King River valley could comfortably fit into an excavation unit in Nunamira cave. The apparent discrepancy between poverty and riches may be dispelled when one considers that the two types of deposit may in fact span similar lengths of time (see Table 4.3 in Cosgrove 1991:71). Excavation of some open sites in the King River valley has revealed a much greater density of subsurface artefacts than was indicated by surface materials. For example, at one site with only 144 surface artefacts exposed over 200 m², 105 artefacts were removed from a 5 cm excavation unit in a 50 cm diameter shovel test pit. Although artefact density is comparatively low in the King River surface sites, they are relatively larger and denser than most exposed lithic scatters in the inland west of Tasmania (Macfarlane and Coates 1990:54). Ultimately, it may be more useful to compare behavioural inferences drawn from both types of sites, the Pleistocene cave de-

posits and the open sites, than to compare the density or 'richness' of archaeological deposits.

A preliminary analysis of the data from the King River sites demonstrates a number of contrasts in occupation and landuse of inland southwest Tasmania to the Pleistocene cave sites. Only one radiocarbon date has been processed so far, a date of 460 ± 60 BP (Beta 46486) for charcoal in the grey, ashy horizon. On stratigraphic grounds, this site and others with artefacts in a similar grey layer are most likely to date to the late Holocene and those in the orange podzol are likely to be older, but to postdate the glacial maximum. If future dating confirms this Holocene chronology, the valley represents a more extensive and intensive use of a part of the inland southwest, than was indicated by the Gordon-Denison open site (Kiernan et al. 1983). In contrast to earlier assessments of Holocene landuse, fleeting visits using the rivers as highways, the evidence from the King River sites suggests more regular use, by people who were familiar with local lithic resources and who appear to have used the sedgeland rather than the rivers as highways.

The King River valley although underlain by limestone has no karst formations as such and therefore lacks the cave systems found in many southwest river valleys. Although occupation of this valley during the Pleistocene cannot be ruled out, no evidence for its use at this time can be found on degrading Pleistocene landforms, even though the valley forms a natural access route to the Franklin-Gordon river system. A valley without the welcome shelter of caves in bad weather may have been less attractive during the more severe climatic conditions of the glacial advance. Contrasting patterns of landuse may therefore have resulted from the lack of facilities such as caves.

Although the use of Darwin glass appears to have been on a small scale and intermittent during the Pleistocene, its absence from the King River sites may have one, or several causes. These may include different land use patterns, functional requirements of tool kits and activities, differing interaction spheres, or demographic arrangements. The fact that very few sites are found in the southern part of the King valley indicates less active landuse in the south with consequently fewer opportunities to locate and exploit Darwin glass sources. The concentration of sites in the middle and northern sections of the valley has also been argued to indicate contrasting patterns of movement within the region, with a north-south movement into the Franklin region through the King and Andrew valleys during the Pleistocene and an east-west movement during the Holocene (Cosgrove 1986; Macfarlane and Coates 1990:49).

During the Pleistocene, raw material differentiation within the region was generally determined by the availability of local raw materials, and movement of exotic raw materials, other than Darwin glass, appears to have been limited (Cosgrove et al. 1990:70). In the King River valley, the use of different raw materials is spatially differentiated on a finer scale. Initial observations of the assemblages indicate that within the valley there is evidence of diminishing abundance, or distance decay, occurring over as little as 3-4 km. As a whole, sites in the valley contain a wider range of materials than exhibited by the southwestern Pleistocene sites. But individual sites usually show a narrow range dominated by one or two materials. The distribution of raw materials in the King River sites resembles the pattern observed in the Pleistocene sites, where raw material movement is on a small scale, the movement of Darwin glass being a significant exception. This long term pattern of local exploitation contrasts with patterns elsewhere in Tasmania where there is evidence of far greater use of exotic raw materials in sites (Jones 1987:33; Sutherland 1972:21).

CONCLUSION

Future work will continue to focus on the King River valley as a source of comparison to both the cave sites and open sites elsewhere in the region. This work will involve further dating of the sites, site location analysis and technological and typological characterisations of sites so that a detailed understanding of past Aboriginal landuse patterns may be formulated in at least one valley in the inland southwest. These results can then be used as a heuristic device for interpreting other southwestern open sites and to explore spatial and chronological continuities and discontinuities with cave sites in the inland southwest karst systems.

Initial results from the King River valley demonstrate significant continuities between Pleistocene and Holocene lithic assemblages. Similar artefact types, manufacturing processes, procurement strategies and raw material selections are found in both periods. The sites also demonstrate a number of contrasts including the procurement and transport of Darwin glass, the use of valleys with caves, landuse patterns and settlement and occupation of different areas at differing times.

We now need to ask whether this signature is an inland southwestern Tasmanian signature, rather than a Pleistocene signature, and what long-term cultural and behavioural continuities and discontinuities its presence and absence may indicate?

To summarise, I have suggested that as well as the late Pleistocene caves in southwestern Tasmania, there is an extensive alternative and largely unexplored archaeological record, consisting of open sites. Investigations of this record should prove useful in expanding the present site database both spatially and chronologically, leading to a better understanding of the prehistory of the southwest region as a whole.

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EXCAVATION OF LIMESTONE CAVES IN THE NELSON RIVER VALLEY, CENTRAL WESTERN TASMANIA

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In early 1991, the Centre for Prehistory, University of Western Australia, was engaged by the Hydro-Electric Commission of Tasmania (HEC) to carry out a program of salvage recording, collection and excavation in the King River valley. This was undertaken because of plans by the Hydro-Electric Commission to flood the river valley as part of a new power scheme. The work carried out by the Centre for Prehistory was undertaken with the full cooperation of the Tasmanian Aboriginal Land Council, and Aboriginal Consultants were employed in all phases of the project.

The flooding of the King River valley is now complete. The King River originates about 35 kilometres inland in southwestern Tasmania and flows into Macquarie Harbour (Fig. 1). The area which has been flooded lies to the east of Queenstown. Prior to inundation the King River flowed along a broad, level glaciated valley to the east of the West

Coast Range. Within the inundated area several major tributaries, one of which is the Nelson River, have also been flooded.

Two previous archaeological surveys had been carried out in the King valley and one of the recommendations arising from this work was that the rockshelters and caves in the limestone karst of the Nelson River should be investigated (Cosgrove 1986; Macfarlane and Coates 1990). Ten caves and shelters without surface indications of human occupation were recommended for test excavation. Excavation of two other caves recorded as having evidence of occupation was also recommended.

OVERHANG CAVE (TAS 4676)

A total of 13 caves/shelters without surface evidence of human activity were test excavated. Of these only one was found to contain any evidence

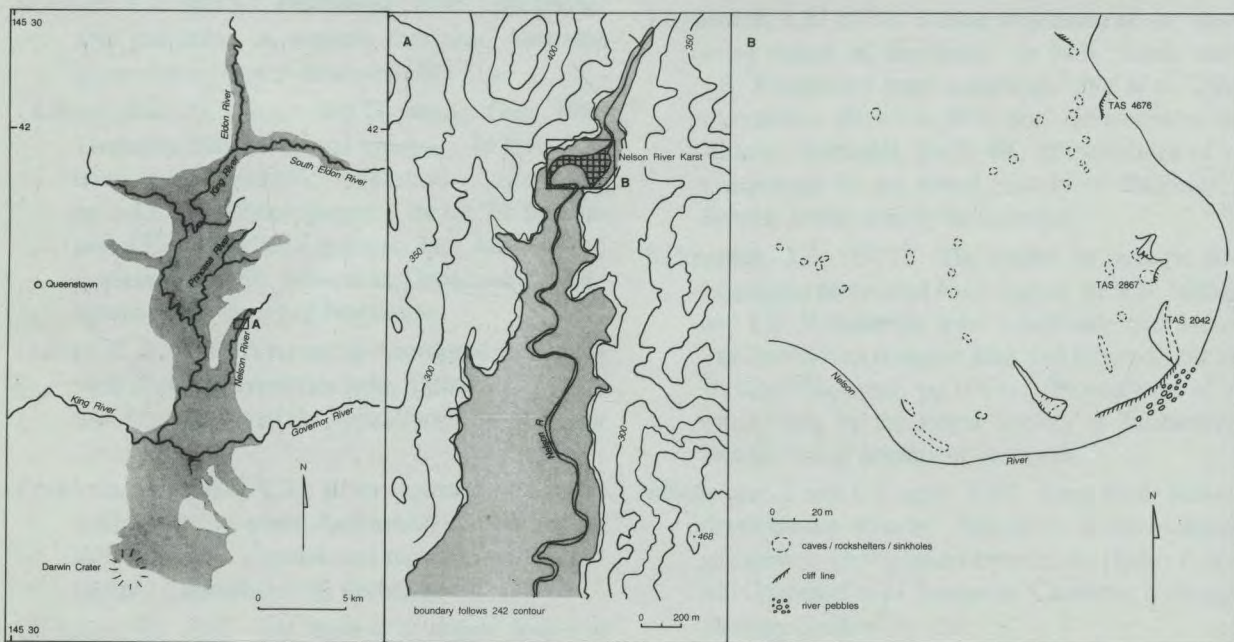


Figure 1 Location of the King River valley showing the area now inundated (shaded). Inset A shows the extent and location of the Nelson River karst. Inset B shows the location of Overhang Cave (TAS4676), Nelson River Cave 1 (TAS2042) and Maneena Langatick Tattana Emita (TAS2867).

of human occupation. Most of these shelters and caves were low lying, damp and dark. By contrast, Overhang Cave (TAS 4676) had a more elevated position and was dry and light with a good, relatively open aspect. A small shelf of deposit around the wall of the cave appeared to be riverine in origin (Fig. 2) and no archaeological material was recovered from it. The deposit on the floor of this shelter was, however, loose, friable and partly cultural in origin. It seems likely that the deposit in this shelter is very disturbed as parts of the floor had collapsed and several large pieces of limestone roof fall were present on the floor.

The existing deposit was found to be very rubbly and shallow. Two test pits, each 50 cm x 50 cm, were positioned on the existing floor of the cave (Fig. 2). One reached a maximum depth of 15 cm and the other a depth of 25 cm. Twelve artefacts

were recovered from these two squares. The dominant raw materials are quartz and quartzite and only single pieces of chert and Darwin glass were recovered. The small amount of bone (38.95 g) from the site is mostly unidentifiable though wombat, macropod and murid are present. The larger mammals are believed to have been part of human diet at the site.

The lowest charcoal sample from each test pit was submitted for dating. These have been dated to 340 ± 105 BP (Wk2088) and 330 ± 105 BP (Wk2089). The recent date from this site has to be considered as possibly the result of an intrusive sample as none of the floor of this cave was intact at the time of excavation.

NELSON RIVER CAVE 1 (TAS 2042)

Of the two caves which were recorded as having evidence of human occupation, only one was found to contain positive evidence of such activity. Kiernan (1982) recorded the presence of burnt bone and one possible stone artefact in Nelson River Cave 1 (TAS 2042). The stone later proved to be non-artefactual (Kiernan 1982:88). When Cosgrove visited the site in 1985, he could find no evidence of human occupation at the site and the bone that was present appeared to be stained rather than burnt (Cosgrove 1986:14).

Excavations conducted at this site revealed no evidence of human occupation (Pocock 1991a: 119-25).

MANEENA LANGATICK TATTANA EMITA (TAS 2867)

Maneena Langatick Tattana Emita (TAS 2867), previously known as Manfern Cave and Nelson River Cave 2, was first recorded by Cosgrove (1986). The cave is situated in the face of a limestone cliff, about 3.5 m above the ground, 30 m northwest of Nelson River Cave 1 (TAS 2042). It has a northeasterly aspect and overlooks the flood plain of the Nelson River. It is about 6 m long, 5 m wide and 3 m high. It is relatively dry, has good natural light and appears to have once had a flat floor. The deposit in the cave has, however, undergone considerable slumping and most of it is likely to be disturbed. The centre of the cave floor is dominated by a hole of more than a metre in diameter which drops 3.5 m to the ground below. The present floor and associated deposit slopes steeply towards the centre, apart from a narrow remnant shelf of deposit which clings to the cave walls (Fig. 3).

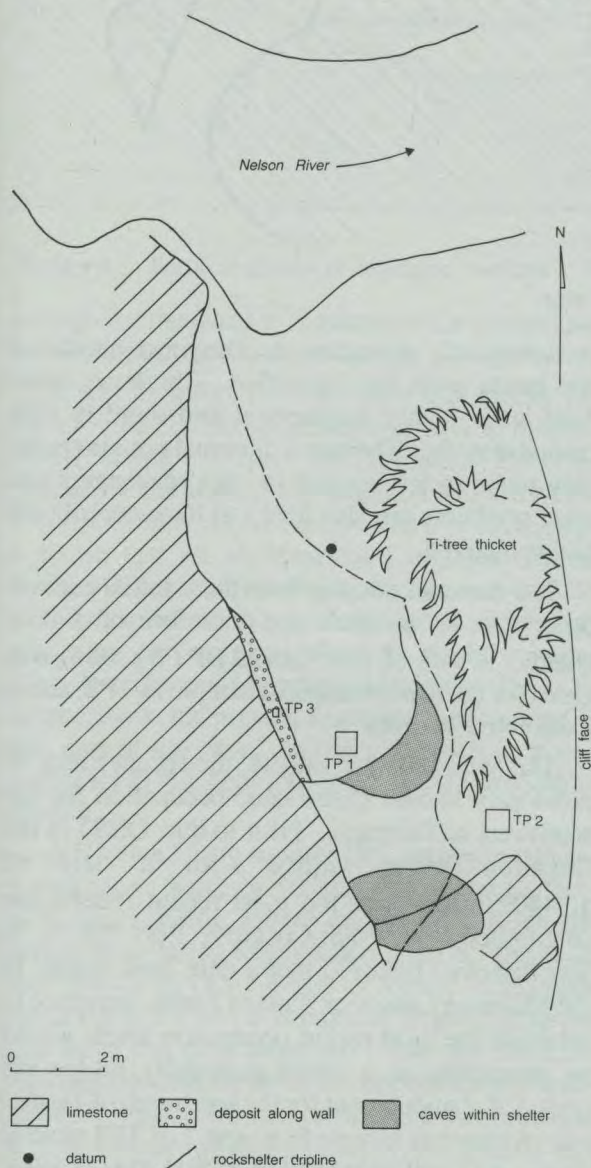


Figure 2 Plan of Overhang Cave.

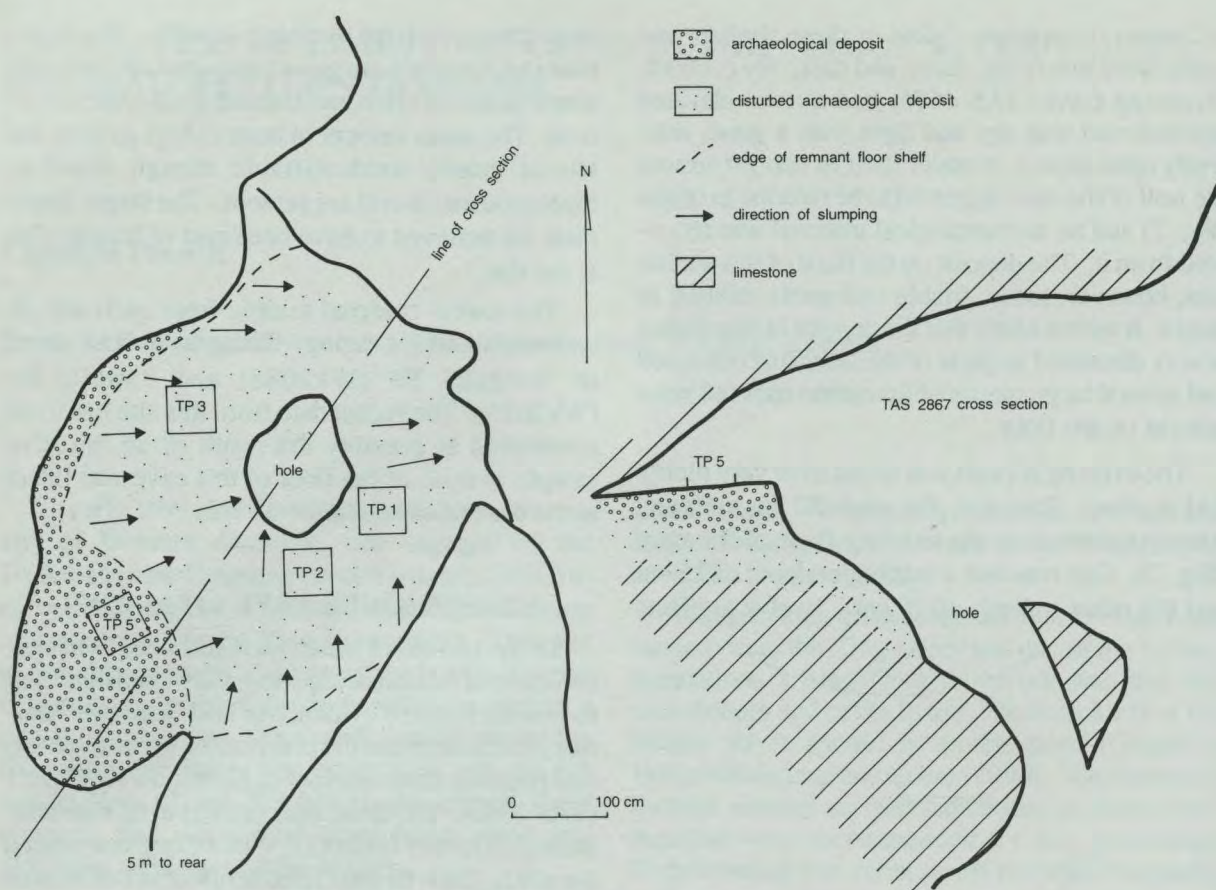


Figure 3 Plan and profile of Maneena Langatick Tattana Emita.

Initially three 50 cm x 50 cm squares were excavated in the loose deposit which surrounds the hole at the centre of the cave. The broad aims were to establish the nature and antiquity of occupation at this site.

The deposit in this area appeared to be characterised by two different sediments. There was cultural material in the loose friable deposit observable on the surface and throughout the excavation squares. Mixed with this material and often dominating much of the squares was a more compact sterile limestone clay. These two components can be seen in the south and west sections of TP2 (Fig. 4). Bedrock was reached at a maximum depth of 48 cm below the surface, in square TP3.

Two hundred and eight stone artefacts were recovered from these squares. Quartz was the most common raw material, making up almost 80% of the assemblage. Darwin glass was the next most frequently occurring material with a total of 20 pieces being recovered. Most of the stone was debitage (predominantly flake fragments and debris, but including flakes and broken flakes) with cores and scrapers only making up 3.85% of the assemblage.

Faunal remains from the initial three excavation squares at Maneena Langatick Tattana Emita are

predominantly of macropod. Dasyurid, bandicoot and murid were also identified. The bone, some 1365 g, is highly fragmented and there is little cranial material. The larger mammal remains probably relate to human activity, but scavengers and other predators are also likely to have contributed to this material.

The charcoal samples from these initial excavations were quite small and therefore of a poor quality. A date of $10,250 \pm 420$ BP (Wk2086) was given for the lowest charcoal sample in TP2, about 7 cm above bedrock.

This date falls just outside the recent limits of previously known Pleistocene occupation for the southwest of Tasmania. Prior to this, ORS7 in the Shannon River valley with a date of $10,440 \pm 160$ BP was the most recent Pleistocene date (Allen et al. 1988; Cosgrove 1989:706-7). It was therefore believed that a date from higher in the Maneena Langatick Tattana Emita sequence to establish the most recent occupation levels would be interesting as it could potentially bridge the period of abandonment for the southwest of Tasmania. A charcoal sample from spit 2 of TP3 yielded a date of $11,250 \pm 390$ BP (Wk2126). This is, however, likely to be too old as the sample was not large

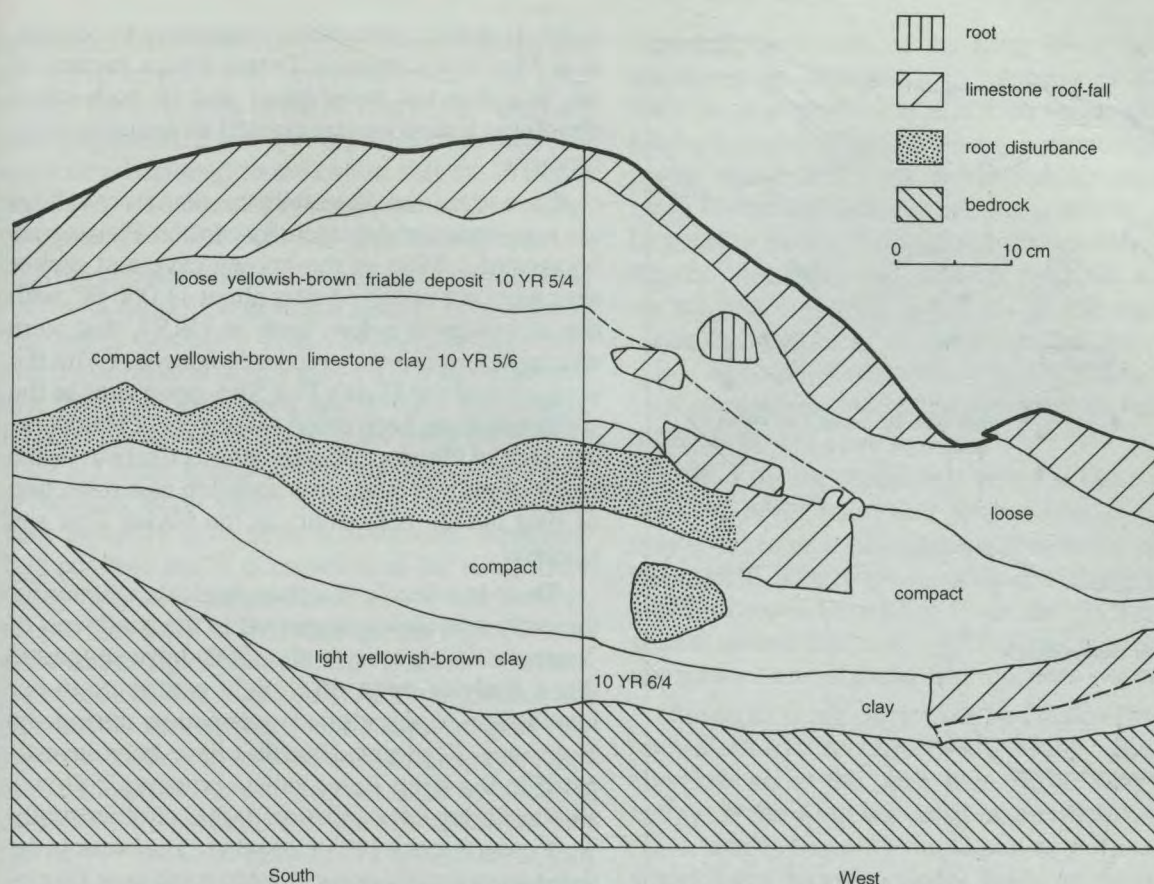


Figure 4 South and west stratigraphic sections in TP2, Maneena Langatick Tattana Emita.

enough for the usual pretreatments for contamination by limestone to be carried out.

It was therefore recommended that further excavation be carried out at this site prior to inundation (Pocock 1991a). In September 1991 the Centre for Prehistory was engaged by the Hydro-Electric Commission to carry out the excavation of a fourth test pit in Maneena Langatick Tattana Emita. This test pit was excavated towards the rear of the cave where the shelf of deposit which may represent the original floor is slightly wider (Fig. 3). The shelf is barely accessible due to its height above the present floor and the low roof in this part of the cave. In order to reach it, it was necessary to dig steps into some of the surrounding deposit.

A 50 cm x 50 cm square, TP5, was excavated to a maximum depth of 108 cm below the surface. TP4 was a sterile square excavated beneath the central hole during the first field season. The basic stratigraphy in TP5 appears to consist of an upper cultural and a lower non-cultural layer. Unlike the first three test pits, these two levels are distinctly separate from each other. The upper unit is characterised by dark yellowish brown rubbly deposit. As well as containing many limestone fragments this level was rich in artefacts, bone and charcoal. Beneath this is a rich yellowish brown clay which

contained very little archaeological material. This division can be seen clearly in the west section of TP5 (Fig. 5). Towards the base of the square, fine silt and gravel appeared which suggest a riverine origin for this part of the deposit. At this level no cultural material was recovered and it was also impossible to excavate further. The underlying clay level and associated silt correspond with the stratigraphy of the previous excavations. Because of these similarities and the fact that the previous squares were excavated to bedrock it seems unlikely that cultural layers are present below this level.

Analysis of material from the fourth test pit is still in progress. Three charcoal samples from this excavation have been submitted for dating, and it is hoped that these will provide a much finer chronology for the site, pinpointing the age of the most recent, the earliest and intermediate periods of occupation at Maneena Langatick Tattana Emita (Pocock 1991b).

DISCUSSION

The cave sites that have been found in the Nelson River valley are poorly preserved. Most of the caves within the limestone karst, as they appear now, are not suitable for human habitation. They

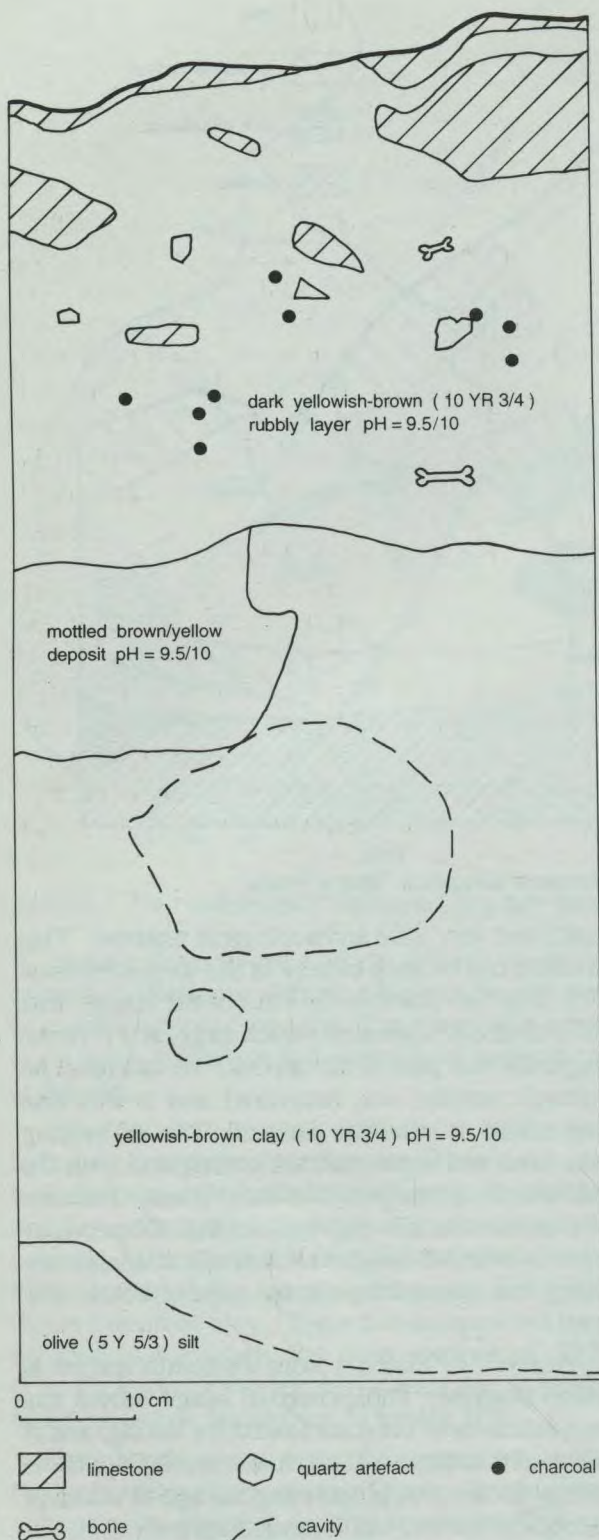


Figure 5 West section of TP5, Maneena Langatick Tattana Emita.

are low lying, wet, dark and small and only two were found to contain evidence of human occupation. Overhang Cave and Maneena Langatick Tattana Emita are elevated above the Nelson River flood plain, both sites are sheltered but have plenty of natural light. The present condition of the sites

is not, however, particularly conducive to occupation. Maneena Langatick Tattana Emita, in particular, is somewhat treacherous and in both caves dissolving limestone has created an unstable environment.

Cave sites in southwest Tasmanian river valleys are renowned for the intensity of their Pleistocene occupation. Most of the known cave and shelter sites were not occupied after about 11,000 BP, with the exception of a few, such as ORS7, that were reoccupied in the very recent Holocene. With the exception of the Flying Fox Site, open sites in the southwest have been dated to the recent Holocene. The lack of Pleistocene open sites is likely to be the result of poor preservation as much as a reflection of past human behaviour, as the Flying Fox site suggests.

There is a dearth of archaeological evidence for the early-mid Holocene period in the southwest of Tasmania. Cosgrove et al. (1990) have suggested that a study of open sites might contribute to our knowledge of Aboriginal occupation during the Holocene. The open sites that have been investigated in the King River valley, however, follow a similar timing of occupation to that of other southwest sites (Pocock 1991a:204-14). The break in the dated sequence for occupation in southwest Tasmania has often been attributed to the advance of dense rainforest during the Holocene (Bowdler 1983:62-3; Jones 1982:101). Cosgrove et al. (1990) have argued that rainforest would not necessarily restrict access to an area. On the other hand, the temperate rainforest of Tasmania is very unproductive and if this vegetation was as dense as has been suggested, it is quite possible that this change in vegetation caused people to abandon the region.

The predominant raw materials present in both open and cave sites in the King valley are all available within the valley itself. Although both open and cave sites contain local raw materials, the materials found in each site type within the King River valley differ markedly from each other. Quartz is the dominant raw material in both Overhang Cave and Maneena Langatick Tattana Emita even though the timing of occupation may be different. Open sites in the King River valley, on the other hand, appear to favour quartzite as the dominant raw material. Some quartzite is present in Overhang Cave, and there is a higher proportion of it in this site than in Maneena Langatick Tattana Emita. However, the sample size from this site is extremely small and this difference is not statistically significant. The emphasis on local raw materials may be due to a lack of contact with neighbouring areas or simply to the fact that these materials are of a good quality and imports were unnecessary. The presence of discrete knapping

episodes on the open sites in the valley suggests that use of these sites may represent a series of brief visits. The cave sites of the Nelson River valley are poorly preserved, and it is uncertain whether they were ever occupied to the extent that the Franklin and Florentine River cave sites were, or whether occupation in these sites was also intermittent.

The emphasis on locally available raw materials follows a pattern observed in all sites of southwest Tasmania. Cosgrove et al. (1990) have suggested that the exception to this may be Darwin glass and that this may have been deliberately exchanged. Darwin glass, an impactite glass from the nearby Darwin Crater, appears in both occupied cave sites in the King River valley and other sites of Pleistocene antiquity elsewhere in Southwest Tasmania. It is possible that if occupation of the King River valley was only intermittent, one of the reasons people may have moved through the valley was to procure this raw material. One problem with this suggestion is that most open sites in the valley are situated in the northern area, furthest from the Darwin Crater. An explanation of this may be that the exchange of Darwin glass was strictly a feature of the late Pleistocene and that the differences in use of raw material between cave sites and open sites could possibly reflect a difference in antiquity (Pocock 1991a:36).

Twenty pieces of Darwin glass were recovered from the initial excavations at Maneena Langatick Tattana Emita and many more have been recovered from the fourth test pit. Only one piece was found in Overhang Cave. No Darwin glass was found in open sites of the King River valley which date to the recent Holocene.

The date of 340 ± 105 BP from Overhang Cave would appear to indicate that there is no necessary correlation between Pleistocene occupation and the use of Darwin glass. However, the recent date from this site may be the result of an intrusive sample as none of the floor of this cave was intact at the time of excavation.

The nature of occupation in the different site types could offer an alternative explanation for a focus on different raw materials. Faunal remains can be helpful in terms of determining exploited resources and seasonality. Unfortunately the sediment matrix of open sites in the King valley is very acidic and organic materials do not survive well. It is therefore impossible to draw a direct comparison between elements of resource exploitation at cave and open sites.

Artefacts provide another means of addressing questions about different site use (cf. Freslov, this volume). Macfarlane and Coates (1990) have speculated that the difference between the large and

the small open sites of the King River valley is paralleled by differences in intensity of flaking. They suggest that the artefacts on larger sites exhibit a greater degree of working, with smaller sites being characterised by fewer flaking products, more cortex and less retouch on artefacts. If the larger sites are the result of favoured location rather than different activities, reuse of materials already on the site is more than likely. In this case, the observed differences on these sites are not necessarily the result of intermittent versus more permanent occupation, but rather the result of repeated occupation.

The different occupation patterns observed in the King River valley and other southwest valleys may relate to their environmental contexts. It may be possible, with future modelling, to make a comparison between the King River and the environmental models proposed by Cosgrove et al. (1990) to explain some of these differences.

Research being carried out by Freslov (this volume) is aimed at specifically answering some of the questions about the open sites of the King River valley. If the King was used on an intermittent or opportunistic basis we might ask why it was, and where were people actually going to or coming from? The answers to these questions may not be the same at different times during the past.

There is not yet any evidence for early-mid Holocene occupation of the southwest of Tasmania. If the area was abandoned during this period, people must have moved elsewhere. The answers to some of the questions about the nature of prehistoric occupation in the King River valley may therefore lie in the areas surrounding the King.

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DIVING FOR DINNER: SOME IMPLICATIONS FROM HOLOCENE MIDDENS FOR THE ROLE OF COASTS IN THE LATE PLEISTOCENE OF TASMANIA

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There are no Pleistocene sites in Tasmania which contain direct evidence of the exploitation of coastal resources. There is, however, an immense amount of archaeological material relating to the Holocene occupation of Tasmanian coasts (e.g. Bowdler 1979; Jones 1971; Lourandos 1970; Neal 1981; Reber 1965, 1967; Stockton 1982, Vanderwal and Horton 1984). The archaeological record of Tasmanian coasts is highly patterned, both in geographical and chronological terms. This paper discusses some aspects of that patterning and then asks whether these bear any relevance to the potential roles of coastal resources and regions in earlier, archaeologically invisible, periods.

The discussion will focus on the marine invertebrate component of the coastal economies. The marine invertebrates of interest here include several species of relatively large molluscs, and a crustacean, the crayfish *Jasus lalandei*. There are a number of reasons why it is useful to concentrate upon the marine invertebrate component of coastal subsistence. They are the most common faunal remains in coastal sites throughout the Holocene, as a result of their excellent preservation and the large numbers in which they were available and consumed. Analysis of the comparative contribution of marine invertebrates to the total diet (Coleman 1966; Newland 1984), and inferences drawn from the ethnohistoric literature, suggest that in Tasmania these resources were a particularly significant food source. The species which are prominent in archaeological sites are common to the entire Tasmanian coastline, with the relative abundance of individual species more a matter of microenvironmental features rather than regional variation. As a result they form a very useful standard for comparison between different coastal regions and temporal periods.

There are two central questions to ask of the Holocene archaeological record. First, is there any reason to believe that Holocene geographic patterns may have applied equally in earlier periods? Sec-

ondly, can any of the economic trajectories we detect in the archaeology of Holocene coasts be extended back to origins in Pleistocene subsistence systems?

SOUTHEAST TASMANIA

I will begin in the southeastern corner of Tasmania, around the sheltered waters of the D'Entrecasteaux Channel and Bruny Island. Coastal middens are the most prominent sites around the low energy coastlines which abound in the region (Fig. 1). The feature which distinguishes the lower southeast is the way in which the landscape is

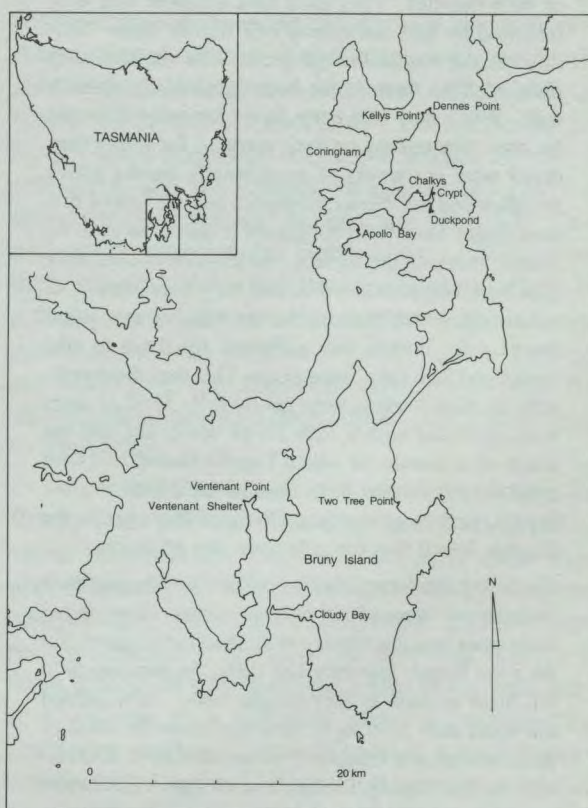


Figure 1 Southeast Tasmania showing archaeological sites mentioned in the text.

dominated by a complex array of convoluted waterways. The adjacent coasts to the north are similar, although generally less sheltered. To the southwest are exposed, high energy coastal landforms.

The lower southeast has a high quality ethnohistoric record, which includes the accounts of the maritime explorers Tasman, du Fresne, Cook, Bligh, Furneaux, Flinders, Labillardière, Baudin and Peron, and the journals of George Augustus Robinson. From these comes a consistent impression of an economic system which relied heavily upon marine invertebrates, especially two species, a mollusc, the abalone *Haliotis rubra*, and a crustacean, the crayfish *Jasus lalandei*. The reliance upon these species, and the high proportion of the diet that they apparently contributed, appears to be at the upper limit, or even in excess, of what might be anticipated from the predominant models of the human ecology of coasts (Meehan 1982). The following extract from Labillardière (1800) is probably the most detailed reference to the procurement of marine foods. The group which is described consisted of 48 people, with 14 women, 10 men and 24 children. The location is on the western shore of the D'Entrecasteaux Channel.

About noon we saw them prepare their repast. Hitherto we had but a faint idea of the pains the women take to procure the food requisite for the subsistence of their families. They each took a basket, and were followed by their daughters, who did the same. Getting on the rocks, that projected into the sea, they plunged from them to the bottom in search of shellfish. When they had been down for some time, we became very uneasy on their account; for where they dived were sea-weeds of great length, among which we observed the *Fucus pyrifera*, and we feared that they might have been entangled in these, so as to be unable to regain the surface. At length however, they appeared, and convinced us that they were capable of remaining under water twice as long as our ablest divers. An instant was sufficient for them to take breath and then they dived again. This they did repeatedly till their baskets were nearly full. Most of them were provided with a little bit of wood, cut into the shape of a spatula, of which I spoke above; and with these they separated from beneath the rocks, at great depths, very large sea-ears. Perhaps they choose the biggest, for all they brought were of a great size.

On seeing the large lobsters, which they had in their baskets, we were afraid that they must of wounded these poor women terribly with their large claws; but we soon found, that they had taken the precaution to kill them as soon as they caught them. They quitted the water only to bring to their husbands the fruits of their labour; and frequently returned almost immediately to their diving, till they had procured a sufficient meal for their families. (Labillardière 1971:309-10)

There are some distinctive characteristics of *Haliotis* and *Jasus*. Individuals of each species are

by far the largest of the invertebrate intertidal organisms available around Tasmania. I specify invertebrate fauna to exclude fish, which need to be treated as a distinct economic issue in Tasmania (Jones 1978). They are also the only two species present in significant numbers in the archaeological record which are purely sublittoral in habitat. They are not found in abundance in the upper or middle parts of the littoral zone. They can only be obtained in any quantity by actively entering the water and diving for them.

The interesting point following from these ethnohistoric sources is that *Haliotis* and *Jasus* are in fact rare in the middens of the region. Only two sites from the lower southeast have been analysed which contain more than a trace of either species. Both are recent. One, Ventenant Shelter, has a basal date of 230 ± 70 BP (ANU 6944). The other, Coningham, has a basal date of 1090 ± 90 BP (ANU 6939). The younger of the two has large quantities of both species, very much in accord with what we might imagine as the archaeological signature of the ethnohistory. These two sites are located inside the D'Entrecasteaux Channel, one on Bruny Island, the other on the Tasmanian mainland (Fig. 1).

In contrast, older sites in the region reflect a focus on molluscan species from the middle and upper littoral zones. At Two Tree Point, on the exposed eastern shore of Bruny, the collection of a range of large intertidal gastropods such as *Turbo undulatus*, *Dicathais baileyana* and *Cabestana splengerii* began some 4000 years ago. The sheltered embayments of Bruny Island's west coast preserve a number of open middens dominated by the extremely abundant mud oyster *Ostrea angasi* and the mussel *Mytilus edulis*. These sites provide basal dates of up to 7500 BP. To them can be added several sites along the Derwent River, and the embayments at its mouth, which also contain these upper littoral, low energy shore species, and which consistently date to between 4000 and 6000 BP (Gaffney 1978; Neal 1981; Stockton and Wallace 1979; Vanderwal 1977) (Table 1).

Some of the sites containing little or no *Haliotis* or *Jasus* are located on shores which would not have supported those species. This does not mean that the pattern can be attributed to sampling bias, since *Haliotis* and *Jasus* are common near at least two of these sites, Ventenant Point and Two Tree Point. Nor is it the case that sites relating to the exploitation of *Haliotis* and *Jasus* are necessarily more liable to site destruction. Both species are present, and in some areas common, within the sheltered waters of the D'Entrecasteaux Channel.

There are clear changes in the invertebrate species which were exploited through time. In the last

Site	Basal Date	Dominant Species	Maximum % of <i>Haliotis</i>	<i>Jasus</i>
Ventenant Shelter	230±70 (ANU 6944)	<i>Haliotis rubra</i> , <i>Mytilus edulis</i> , <i>Cellana solida</i>	92.9	Present
Chalky's	880±60 (ANU 6945) 430±69 (corrected)	<i>Ostrea angasi</i>	Absent	Absent
Coningham	1090±90 (ANU 6934)	<i>Mytilus edulis</i> , <i>Cellana solida</i>	14.7	Present
Cloudy Bay	1100±60 (ANU 6946)	<i>Mytilus edulis</i>	Absent	Absent
Ventenant Point (midden units)	2530±60 (ANU 6947) 2080±69 (corrected)	<i>Mytilus edulis</i>	1.31	Absent
Jordan River	3620±260 (SUA 1113)	<i>Xenopulex securis</i> , <i>Mytilus edulis</i>	Absent	Absent
Two Tree Point	3980±70 (ANU 6941) 3530±78 (corrected)	<i>Mytilus edulis</i> , <i>Turbo undulatus</i> , <i>Dicathais baileyana</i>	0.04	Absent
Duckpond	4520±80 (ANU 6943) 4070±87 (corrected)	<i>Ostrea angasi</i>	Absent	Absent
Royal Botanic Gardens	5210±110 (Beta 5099)	<i>Mytilus edulis</i>	Absent	Absent
Crypt	5410±70 (ANU 6937) 4960±78 (corrected)	<i>Mytilus edulis</i> , <i>Ostrea angasi</i>	Absent	Absent
Porter Bay	5410±220 (ANU 6938)	<i>Xenopulex securis</i> , <i>Mytilus edulis</i> , <i>Ostrea angasi</i>	Absent	Absent
Carlton Bluff (midden units)	5760±130 (Beta 2854)	<i>Mytilus edulis</i> , <i>Ostrea angasi</i>	Absent	Absent
Apollo Bay	7550±90 (ANU 6940) 7110±97 (corrected)	<i>Mytilus edulis</i> , <i>Ostrea angasi</i>	Absent	Absent

Table 1 Southeastern Tasmanian sites with species data. References: Carlton Bluff (Neal 1981); Jordan River (Gaffney 1978).

thousand years, as suggested by the archaeology and the ethnohistory, coastal subsistence included the procurement of the large sublittoral species *Haliotis* and *Jasus*, whereas in sites of the preceding 6000 years these species are absent, and the highly abundant upper and mid littoral species were the focus of collecting activity. The fundamental shift is from a procurement strategy which consists of foraging around an exposed shoreline, to one which requires its participants actively to dive underwater.

NORTHWEST TASMANIA

Bowdler (1988) has argued that a similar shift in littoral collection practice took place in the northwest of Tasmania, as has Sim for the main Bass Strait islands (Sim 1991). The evidence from the coasts of the northwest of the island is significant because of both the similarities and dissimilarities to the southeast, especially in regard to the timing of the change.

On Hunter Island the shift from upper and mid littoral to sublittoral species seems to occur during the hiatus in the Cave Bay Cave deposits, at roughly 4000 to 2000 BP. Bowdler pointed out that the best place to explore the dynamics and precise timing of such a transformation in collection practice is at Rocky Cape (Bowdler 1988:50).

I have analysed bulk shell samples from the Rocky Cape sites with this intention. There are some limitations in using the Rocky Cape material. A continuous column of shell samples is not available. Instead, there is a sequence of samples selected from the pit sections. Additionally, the Rocky Cape sequence is compiled from two separate sites, and the change in emphasis occurs at about the time deposition ceases at the South Cave and commences at the North Cave. This means there is a possibility that the change may simply be a function of different abundances of *Haliotis* and *Jasus* at the two locations. This is not a strong possibility, given the similarities between the shorelines adjacent to each site and their proximity to each other.

Accepting these problems with interpreting the Rocky Cape shell samples, there are striking differences between the species in deposits older than approximately 3500 BP, distinguished by the presence of large quantities of fish bone, and the more recent deposits (Fig. 2). The essential change is from a suite of the intertidal gastropods with very few *Haliotis*, to a situation where it becomes the dominant mollusc. The change is actually more marked than appears – the small quantities of abalone in the older samples are from very small, immature individuals, which are sometimes found higher in the littoral than adults. Only two crayfish

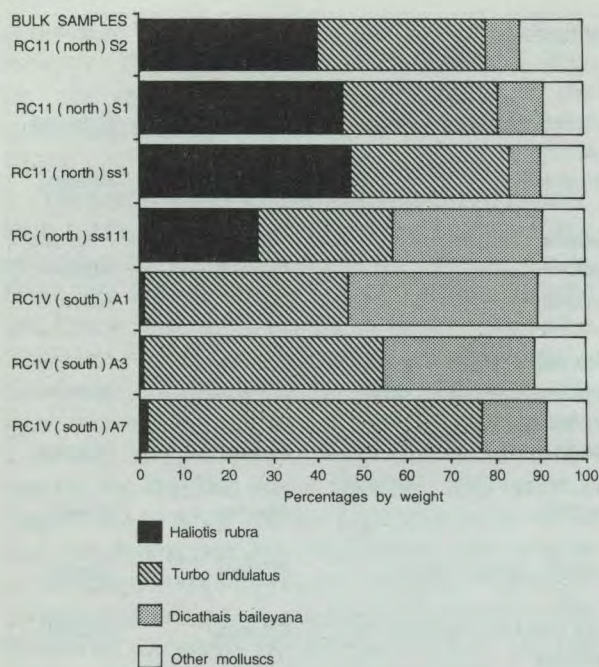


Figure 2 Changes over time in the proportion of mollusc species at Rocky Cape.

were noted in the bulk samples but these came from younger samples.

The Rocky Cape sequence confirms that a change took place in northwest Tasmania at about 3500 BP. There was an initial emphasis on the large intertidal gastropods *Turbo undulatus* and *Dicathais baileyana* prior to this time. Afterwards *Haliotis rubra* became the most abundant species, and *Jasus lalandei* appears for the first time. Although similar to the change proposed for the lower southeast, it occurs some 2500 years earlier in the northwest.

There is no evidence that this economic transformation occurs with the sort of Pan-Tasmanian synchronicity which has been suggested for the dropping of fish from the diet (Jones 1978). This might be taken to imply that there is a problem with the archaeological data base, and that the 'pattern' is purely a function of the sample currently at hand. This is a possibility, and one easily addressed by further dating, but it is not the most likely explanation. Whereas a prohibition might be put into place at a rate which in archaeological terms is instantaneous, the same does not necessarily apply to the inverse situation, the incorporation of an entirely new procurement strategy into the well established economic systems operating around Tasmania. Variations in the rates at which a new strategy was adopted might be anticipated where either new skills not present in the earlier subsistence strategy were required, or where significant alterations to the structure of established subsistence activity

were involved. Both these possibilities need some attention.

The first question regards the level of skill involved in procuring sublittoral resources. There is little doubt swimming was practiced around Tasmanian coasts from at least the establishment of current sea levels. People were present on Bruny Island from 8000 BP onwards (Table 1). This would have required regular crossings, as it is highly unlikely that people could exist in isolation on such a small island (Jones 1976). It is a reasonable assumption that this sort of water transport would be associated with a degree of swimming capability on the part of some members of the groups engaged in such crossings. The critical issue is whether diving represents a separate body of skills to swimming. The ethnographic account presented above entails a much higher degree of skill. Apart from advanced swimming abilities, the capacity to stay underwater for long periods and skill required for the deceptively difficult task of locating relatively small items without the benefit of goggles should not be underestimated. Robinson's Aboriginal companions regarded such skills as a basic component of coastal subsistence:

Today my companions wished me to inform them whether my wife swam in the salt water and got crawfish and muttonfish when she was in England. The native women of the coast think themselves superior to the inland natives because they can dive and get fish. The inland women on the contrary think themselves superior to the maritime tribes because they can climb trees for Opossums. This has been the conversation with the natives today. (Robinson, 1 July 1832, in Plomley 1966:625)

The point is that competence around water does not necessarily translate into the skills necessary to obtain sublittoral species. It is entirely plausible that people could spend part of their time actively exploiting coastal resources without necessarily having the skills required to obtain *Haliotis* and *Jasus*.

The other issue relates to whether the inclusion of *Haliotis* and *Jasus* would occasion significant changes to the structure of subsistence systems. It has been argued for other Australian coastal prehistoric sequences that changes to the mix of marine species may involve major alterations to the allocation of time and effort in subsistence systems, sometimes reflecting changes in the division of labour (Bowdler 1976). The combination of factors such as the time and effort which needs to be invested in the acquisition of sublittoral species, the high food yields of *Haliotis* and *Jasus* compared to the other molluscs, the new skills associated with a sublittoral procurement strategy, and the coincidence with other economic transformations occurring at Rocky Cape, all lead to the conclusion that

it is a change which would have had a substantial impact on the structure of the coastal subsistence strategy.

It is not a change that could be adopted, or for that matter dropped, without major adjustments throughout the economy. It is not surprising then that the incorporation of a sublittoral procurement strategy into the broader economy would not necessarily proceed at the same rate in the southeastern and northwestern corners of the island.

WEST COAST

There is a third sector of Tasmania to consider, the west coast. Despite investigations at sites from a range of depositional contexts, none from the northern part of the western coastline date to older than 4000 BP, or from the south and southwest to older than 3000 BP. There have been a variety of unconvincing explanations brought forward for the relatively recent appearance of sites, including; the late availability of watercraft (Vanderwal 1978); a change in rainforest distribution to a form more amenable to modification by fire (Bowdler 1988; Lourandos 1983); and even mass demographic shifts from the southeast due to a resource crash (Stockton 1983). None of these bear the scrutiny of subsequent archaeological or environmental research very well.

Although the west coast is a particularly productive region in biological terms it is also one which presents acute problems for any human inhabitants. The climate is severe, especially during the winter months. This limits mobility and access to distant resource zones for considerable periods of time. Resources such as seal and seabird are available in enormous quantities, but they are highly seasonal and are by no means a continuous food source (Dunnett 1992). Consequently, there are real problems in ensuring constant and adequate supplies of food. The number of problems associated with constructing a viable subsistence strategy on the west coast, and their interaction, mean that it is unlikely that any single strategy can be credited with permitting the colonisation of that coast. Instead a constellation of different factors were probably involved, including effective scheduling of activities around seasonal resources, transport technology, and specific resource extraction techniques.

Nonetheless, this does not mean that individual strategies were not important in facilitating the process of moving into the west coast region. One approach to identifying these is to ask whether there is anything distinctive about subsistence strategies in this region which is not part of the economic

baggage of earlier periods in other parts of Tasmania. The collection of sublittoral species falls into this category.

This raises the problem of what role these species played on the west coast. There are some suggestions in the ethnohistory that *Haliotis* and *Jasus* were a mainstay of west coast subsistence (Plomley 1991:58), although the observations they are based on are of a very limited duration. An analysis of the West Point midden showed that shellfish, of which *Haliotis* was the dominant component, rivalled seals in terms of meat weight (Coleman 1966). Immense amounts of *Haliotis* were being consumed, but the real issue is whether the sublittoral species fulfilled a function not covered by other resources. The archaeology of the region certainly shows that a much wider range of resources were used (Dunnett 1992; Prince 1990). One group with which we can directly compare the sublittoral species are the other molluscs. It is reasonable to presume that, as with coastal regions generally, molluscs as a group would have been an important resource on the west coast. In terms of the comparison between *Haliotis* and other molluscs several points stand out. One of these relates to obtaining shellfish on high energy coasts. Contrary to the intuitive response, on rough shores it is much safer to be actually in the water, rather than perched on the rockplatforms. The mid littoral is the place where wave action is most intense, and consequently the most dangerous. During inclement weather it may have been safer to obtain sublittoral resources.

Another advantage of *Haliotis* and *Jasus* relative to other molluscs derives from the logistics of foraging activity on the west coast. Individual molluscs contain a relatively small amount of meat compared to their shell weight, which makes transportation costs very high. The general tendency around Tasmania is for middens to occur within a very short distance of the shellbeds. It has been suggested that a much more sedentary occupation pattern was characteristic of the west coast (Kemp 1963; Lourandos 1968). In this circumstance, where resources are being brought to a camp rather than moving the camp to the shellbeds, the fact that *Haliotis* and *Jasus* contain much higher ratios of edible food to shell weight than other molluscs should increase their comparative value in this situation. The value of *Haliotis* and *Jasus* is not restricted to their comparative advantages relative to other molluscs, but also needs to be assessed in combination with other resources. One advantage of having access to sublittoral species in situations where mobility is limited is that it expands the resource base which is available along individual

sections of coasts, thus reducing the need for wider range foraging.

The case for a critical role for sublittoral species in the west is by no means proven. This will await further analysis of sites from the region. Nonetheless, there is some suggestive evidence, and the coincidence between the appearance of an effective strategy for obtaining sublittoral species in the northwest and the commencement of an archaeologically visible occupation of the adjacent west coast is highly suggestive. The archaeological evidence for the exploitation of coastal resources in the period before 4000 BP relates entirely to species which can be collected without the necessity of diving. This raises doubts about whether, in the prevailing environmental conditions of the west coast, intertidal foraging, as distinguished from sublittoral diving, provided an adequate basis for the establishment of viable subsistence strategies.

THE HOLOCENE PATTERN

A quick summary of this 'invertebrate-centric' view of Tasmanian coasts: the use of marine invertebrates is a feature of Tasmanian economies as soon as the current coastline appears some 7000 years ago, although one large segment of Tasmanian coastline, the west, was not used with sufficient intensity to leave archaeological traces until after 4000 BP. At around 4000 BP there is a change in collection practice in the northwest of Tasmania when sublittoral species of marine invertebrates begin to be collected in quantity. Unlike those species previously obtained, these require diving. This change roughly coincides with the initial occupation of the west coast, where sublittoral resources were particularly important. Such a change is not evident in the southeast until much later. An exclusive emphasis upon upper and mid littoral species persists in that region until perhaps the last thousand years.

There are two basic approaches to explaining the late adoption of a strategy for exploiting the large sublittoral species in Tasmania. One is that populations of *Haliotis* and *Jasus* were not present in Tasmanian waters until quite late in the Holocene. The alternative is that people initially chose not to exploit these exclusively sublittoral resources, whether because of prohibition, preference, scheduling conflicts or an absence of the skills required to obtain them. I have argued earlier that the capacity for coastal groups to acquire sublittoral species is not an inevitable consequence of coastal habitation.

The first problem is whether a biological option is credible. The main environmental factors which

might have affected these species during the development of the modern coastline are temperature and turbidity. Contemporary studies of the latter in regard to *Haliotis* suggest that while sediment regimes may determine whether optimum growth conditions are present, it is unlikely to render local populations unviable (W. Nash, Sea Fisheries Research, pers. comm.). The influence of temperature is harder to assess. *Haliotis* and *Jasus* currently maintain healthy populations in the coldest of Tasmanian waters, including the southwest of the state. Indeed, high temperatures are thought to be one of the major inhibitors on the production of *Haliotis* (W. Nash, pers. comm.). If, as implied by the large scale models of sea surface temperatures through the Quaternary (e.g. Bradley 1985:186), sea temperatures in Tasmania were within a couple of degrees of current levels by the commencement of the Holocene, there is no reason why *Haliotis* and *Jasus* would not flourish in Tasmanian waters.

Another problem with the biological alternative is why, of all the molluscs found in Tasmanian middens, it is the two species which require a distinct procurement strategy on the part of human gatherers which are the only ones unable to establish exploitable population levels until some thousands of years after sea levels stabilise.

Despite the above, the biological explanation cannot be completely dismissed. It is possible that the local Tasmanian populations of *Haliotis* became extinct under the much lower temperatures of the glacial maximum. If this happened, then re-establishment of *Haliotis* may have taken some time, as it has a very short pelagic spat phase and does not recolonise depleted areas readily (W. Nash, pers. comm.). In this scenario it might be envisaged that recolonisation from the mainland only occurred in the north around 3500 BP, and in the southeast some 2500 years later. The problem with this scenario is that the species was present at Rocky Cape South from the earliest deposits onwards, although only small individuals were collected. Consequently, even if *Haliotis* had disappeared from Tasmanian waters at 18,000 BP, it had recolonised the island by 6000 BP.

The rare occurrence of *Haliotis* and *Jasus* in Tasmanian sites older than about 3500 BP is therefore evidence against the absence of these species from Tasmanian coasts. A cultural explanation seems the more likely option in the case of this distinctive pattern in Tasmanian prehistory. I am not going to try to define the reasons behind that pattern, beyond noting that the immediate means of effecting such a change in subsistence behaviour, the adoption of diving, requires new skills beyond

those involved in the procurement of other littoral resources.

How is any of this of relevance to our understanding of Pleistocene economies? The way in which Holocene coasts were exploited varies geographically and temporally through the Holocene, so how can models derived from them be applied to periods where there is no coastal archaeology? This problem is made more acute by the rarity of Tasmanian sites which date to the boundary between the Holocene and Pleistocene. There are very few sites dated between about 11,000 BP and 8000 BP. The older end of that age range represents the cut-off for deposition in the shelter sites of the inland valleys. It is not until the first middens appear that site traps of comparable quality or quantity become available. Although the shift in site types and locations probably owes as much to the preservation characteristics of these two groups of sites as it does to the nature of prehistoric settlement, it means that entirely different archaeological signatures are expressed on either side of a gap of several thousand years.

Despite the diverse ways in which Tasmanian coasts were used through the Holocene, one consistent trend across the island was that sublittoral species only become exploited in the second half of the Holocene. Is there any basis for assuming that this trend can be extended into the terminal Pleistocene?

If the underlying reason for the initial absence of sublittoral species in archaeological deposits is that they were not present in Tasmanian waters until after about 4000 BP, then their absence can almost certainly be attributed to the sea conditions of the late Pleistocene. Consequently, they would also have been unavailable in the terminal Pleistocene. If, as suggested here, the reason is cultural, then there is less certainty that they were not exploited in the terminal Pleistocene. However there is some basis for suspecting that the procurement of sublittoral resources was not a feature of Pleistocene economies. The most obvious is the much lower temperature of the water, which is likely to have acted as an inhibition on diving. Alternatively, if diving for sublittoral species persisted throughout the terminal Pleistocene, it is difficult to explain why such a productive strategy should be dropped as sea conditions improve. This problem is particularly acute as molluscan resources are clearly important in coastal economies at 7500 BP, when the first middens appear. In contrast, collection of the mid and upper littoral species does not involve problems with water temperature, nor does it require the skills base of the diving strategy.

The following surmise is dependant on the premise that one aspect of Tasmanian culture history, the initial concentration upon intertidal rather than sublittoral species, has more ancient roots than we can yet verify archaeologically. This allows some speculation on the implications of a concentration upon molluscan resources from the upper and mid parts of the littoral zones for Pleistocene coastal economies.

THE PLEISTOCENE COASTLINE

What would Tasmanian coastlines have been like during the Pleistocene? The rise in sea level has substantially changed the outline of the Tasmanian coastline. One issue is the degree to which changes in coastal landscapes would have affected the basic contrast between the exposed, high energy coastlines of the west coast and the relatively sheltered, lower energy shores of the southeast. There are three main reasons why the west is a harsher environment than the southeast: it is more exposed to the vigorous weather from the west; it is less sheltered; and it has a more abrupt offshore profile. The bathymetric data is not detailed enough to establish whether the southeast would have been as sheltered as it is at present, although it is reasonable to suppose that the major rivers, the Huon and the Derwent, would have maintained incised valley systems. In regard to the other two factors, the west coast would still have been more subject to the westerly airstream and the weather which accompanies it, unless the earth's rotation was reversed during the Pleistocene. In combination with the more abrupt coastal profile, this ensures that western coasts would remain a much higher energy environment than those of the southeast. The basic distinction between the characters of the west and southeast coasts is therefore likely to have been present in the Pleistocene. The coasts of Bass Strait are much more difficult to model for the terminal Pleistocene. The encroachment of the sea onto the Bassian Plain effectively created a new coast at that time. It is probably safe to assume that, as at present, the Bassian coasts were more sheltered than those to the west.

Lower sea temperatures would support a different assemblage of intertidal organisms. Although it is difficult to model which individual species would be present, there is little doubt that the shores of Pleistocene Tasmania would contain a range of edible molluscs. A useful analogue for conditions during the Pleistocene on Tasmanian shores is Macquarie Island (lat. 55°S long. 160°E). Sea temperatures around the island are relatively steady throughout the year at around 6°C (Selkirk et al. 1990:212). The island supports a complex array of

littoral and sublittoral molluscs, the full extent of which is still being investigated (Selkirk et al. 1990:207; Simpson 1987). These include limpets and chitons. It is important to note that as an isolated island, Macquarie contains a much more restricted range of species than would be expected for a continental landmass. The subantarctic islands do, however, demonstrate that molluscan communities persist in conditions much closer to those of the glacial maximum than are currently found in Tasmanian waters.

The productivity of encroaching coastlines is a matter of some dispute (Beaton 1985). It is worth distinguishing between the soft shore environments favoured by many of the economically important northern molluscs, especially bivalves such as *Anadara*, *Katelysia* and *Tapes*, and the rocky shore habitats favoured by the species utilised in Tasmania. The sedimentary regimes which create soft shore coastal formations are an ongoing process, and it may have taken some time to establish these habitats. Rocky shore coasts are created as the sea level rises, providing new habitat for intertidal communities very quickly. It is also important to note that colder conditions do not necessarily reduce the productivity of coastlines. Some groups, especially the marine mammals and marine birds which favour colder water, are likely to expand their range under such conditions.

COASTAL SUBSISTENCE IN THE PLEISTOCENE

If the effective exploitation of sublittoral species was not a feature of Pleistocene economies, then like the economies of the early Holocene coastal phase, the capacity of Pleistocene economies to operate effectively on the coasts of western Tasmania can be called into question. The same does not apply to the southeastern coasts. The intertidal resources of the highly productive low energy environments in that region should have been equally available in the Pleistocene. Once the Bass Strait coast was established, it provided also accessible habitat. Consequently, if there was a coastal component to Pleistocene economies, it is more likely to have been focused around the shorelines of eastern Tasmania, and perhaps the northwest, rather than the coasts of the west.

The concept of a sharp dichotomy between east and west has been a feature of Tasmanian prehistoric research since the 1960s (Kemp 1963). To suggest that the coastal evidence points to an east coast which is economically more valuable to the west coast runs counter to the current economic model for Pleistocene Tasmania (Cosgrove et al. 1990). This model is derived from archaeological

and ecological interpretations of the terrestrial habitats of the east and west. Cosgrove et al. argue that the east can be characterised by an uneven and unreliable distribution of resources, whereas the valleys of western Tasmania support much more productive and predictable resources. They make little direct reference to the possible role of the coasts in their model. The potential role of coasts should not however be discounted, particularly as the model operates by way of large scale characterisation and contrast of the east against the west. The coasts would offer a much more temperate environment than the inland valleys, and consequently are likely to have been important on at least a seasonal basis.

Looking beyond the purely terrestrial habitats, the nature of the contrast between east and west must be questioned. The southeast contains two important agents of resource concentration, the eastward flowing rivers, and the coastline itself. It is worth noting that two of the largest rivers on the island, the Derwent and the Huon, both provide a conduit from central Tasmania to the lower south-east coastline. There is no doubt that the valleys of inland southwestern Tasmania offer unprecedented windows into the Pleistocene (McNiven et al., this volume), however some caution needs to be sounded in regard to a rigid polarisation of the economic characteristics of the eastern and western halves of Pleistocene Tasmania that is based purely on the configuration of terrestrial resources. The relative economic utilities of the coastal regions seem to me to be much stronger towards the east and north than the west. This does not have to be at odds with the apparent concentration of Pleistocene occupation in southwestern Tasmania. The distances to the two opposing coastlines are not actually very different, so the utilisation of both areas by the same groups is possible.

The problem with empirically assessing the role of the southeastern coasts is the lack of comparative data. Site traps of equivalent quality to those of the southwest have not been excavated, although the dolomites at the headwaters of some of the rivers of the far south do contain rockshelter deposits which are thought to be of comparable age (R. Jones pers. comm.). Some open sites from the region may also be of Pleistocene age, although the dating of these remains a problem (Sigleo and Colhoun 1975).

It is a striking feature of Tasmanian prehistory that there is very little archaeological data for the period between ca. 11,000 and 8000 BP. One explanation would be that habitation during this period was concentrated around coastlines that were subsequently drowned. It is notable that by far the most common site type to emerge after this time

period are coastal shell middens. Unlike most parts of the Australian coastline, where the large majority of middens are of young age, in Tasmania there are considerable numbers of middens dating to the establishment of current sea levels in Tasmania. This is particularly evident around the lower southeast (Stockton 1983). Unlike these coastal middens, the earliest dates from the inland component of the southeast do not occur until after ca. 4000 BP, at sites such as Crown Lagoon, Coal River Rockshelter, Coal River Sandsheet and Bells Lagoon (Jones and Ferguson 1987; Kee 1991; Lourandos 1970).

If these drowned coasts were used, what sort of economic role might they have played? One feature of the ethnohistory and recent archaeology of the southeast and west is that habitation seems to have been focused around the coastal strips. This is in part attributable to the reliable and high return sublittoral resources that were prominent in the recent period. Groups restricted to other intertidal species have a narrower resource base. In the case of the Holocene west coast, this factor may have been an important limitation on establishing viable economies in the region. One possibility is that the absence of the sublittoral species would allow a lesser degree of concentration on the strictly littoral. Alternatively, groups could avoid the problem of a lower return from individual stretches of coastline by adopting a strategy of higher mobility. The high transportation costs of the abundant upper and mid littoral species such as *Ostrea angasi* and *Mytilus edulis* would require that high mobility took the form of high residential mobility rather than simply bringing resources to camps from a wider catchment. An implication is that sites from the terminal Pleistocene coasts and coastal margins should be relatively widely dispersed and small. Residential sites, even if short-term, require particular circumstances, such as a coincidence of shellbeds with freshwater access and a suitable camping surface of appropriate aspect and slope. Unfortunately, the corollary of all the above is that the consumption of coastal resources is likely to have been confined to the coastal fringe, with little transport of molluscs inland, unlike some Pleistocene cases on the Australian mainland (Morse 1988, this volume). On a more encouraging note, the likelihood of there being archaeological traces from such a subsistence strategy increases as the coastline gets closer to its current configuration. At two of the middens on Bruny Island, Apollo Bay and the Duckpond, there are underlying undated units which contain artefacts made from raw materials which are not found in the midden sites. These may come from a submerged stone source. There seems to be some potential in these situations for

investigating the early Holocene and terminal Pleistocene.

On relatively mild coastlines such as those postulated for the southeast, the collection of upper and mid littoral species is practical at any time of the year. Consequently, these coastlines may have been used on a seasonal basis, particularly during the winter months when occupation of inland areas becomes much more arduous. Whether or not occupation was seasonally structured, these coasts are suited to exploitation on a transitory basis, as the molluscan resources are extremely accessible and easily located. On almost any piece of southeastern coast some molluscs will be available.

A final issue to consider is the collapse of the terminal Pleistocene systems. If there was a link between the inland valleys of southern Tasmania and the coasts, then how would those links have changed as the inland component of the economy faltered? Sites in the near coastal valleys of the southeast may provide an insight into the manner in which the transition from a predominantly inland to a predominantly coastal archaeological record takes place. These sites should also give some indication of whether the collapse took the form of the abrupt collapse of the inland system, followed by replacement by an economy with a coastal emphasis, or alternatively, whether there was a gradual contraction of activity ahead of the southern and western rainforests and towards the coasts.

There can be no certainty that the pattern of resource exploitation which is manifested in the coastal archaeology of the Holocene can be traced to an origin in the Pleistocene, although the weight of evidence does point in that direction. What is certain is that, as with the coasts of the Holocene, the precise manner in which coastal resources were used would have had a profound effect on the form and structure of Tasmanian subsistence strategies. The concept of a general purpose coastal economy, capable of extracting all of the resources present in coastal environments, is at odds with the evidence from Holocene Tasmania. As with terrestrial habitats, there are a wide variety of ways in which coastal environments can be exploited, and these alternatives have different implications for our understanding of Pleistocene subsistence systems. The possibility considered in this paper, that sublittoral species did not form part of coastal subsistence in the Pleistocene, is the one which the archaeological record of the Holocene coasts suggests is the most applicable to earlier phases of Tasmanian prehistory.

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MANNALARGENNA CAVE: A PLEISTOCENE SITE IN BASS STRAIT

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In 1988 a research project to look at the prehistory of the Furneaux Island region was commenced, with three main foci. First, the region represents an outstanding region within which to examine long term human responses to rapid environmental change. Secondly, it was thought to be an area in which evidence of Pleistocene occupation was likely to be found, allowing comparison with that from southern and central Tasmania. Thirdly it presented an opportunity to investigate a range of issues related to human use of islands. A number of other archaeological investigations have also taken place in the Furneaux Island region (Orchiston and Glennie 1978; Sim 1989, 1991a; West 1990).

Tasmania was connected to the Australian mainland between 37,000 and 29,000 years ago and again between 25,000 BP and about 8000 BP (Blom 1988). Human settlement of the region started in the earlier of these periods (Cosgrove 1989). The earliest evidence for the use of the Bassian Plain is at about 23,000 BP (Bowdler 1984:138). The discontinuous occupation sequence from Cave Bay Cave on Hunter Island (Bowdler 1984:51) and the single date from King Island (Sim and Thorne 1990) indicate that Aboriginal use continued until at least 14,000 years ago.

Early Holocene dates of about 10,000 BP to 6500 BP for Flinders Island (Orchiston 1979; Orchiston and Glennie 1978), 9000 BP to 7000 BP for Erith Island (Jones 1987) and about 7500 BP for King Island (Jones 1979) seem to represent final occupation of the central Bass Strait islands by Aboriginal people. Sim has argued that the large islands were abandoned about 8000 years ago and that there is little evidence of relict populations (Sim 1988:114, 1989:50). Some islands close to the Australian and Tasmanian land masses were used intermittently and in different ways from 6600 BP (Bowdler 1974, 1984; Jones and Allen 1979, 1980; Kee 1991) with some still in use at the time of European invasion.

MANNALARGENNA CAVE

In December 1986, Steve Harris and Nigel Brothers reported a small cave and an open artefact scatter on Prime Seal Island (Harris 1988). I decided to follow up on this report and examine these sites. A test excavation was made at the cave, subsequently called Mannalargenna Cave, in April 1988 (Brown 1988). This was followed by a major excavation at the cave in November 1989 (Brown 1991). The open site at South Bay was visited and recorded on both occasions. In 1991 further excavations at Mannalargenna Cave were undertaken by Sim (1991b) and these will be reported elsewhere.

Mannalargenna Cave is situated in a low limestone cliff, on the east side of Prime Seal Island. The cave is 50 m above present high water mark and offers extensive views to the southeast. Vegetation around the cave consists of a sheoak-boobyalla (*Allocasuarina stricta*/*Acacia sophorae*) shrubland. Several large boobyalla shrubs had to be removed from the front of the cave prior to the excavation to allow access. The front part of the cave is a medium sized rock overhang, with a low roof 1.4 m above the floor level (Fig. 1). There is a small chamber behind the overhang, which it is necessary to crawl into but which opens up inside. No evidence of Aboriginal occupation was found on the floor of the cave.

EXCAVATION METHODS

A grid of metre squares covering 3 m by 3 m was laid out on the surface (Fig. 1). Each square was arbitrarily assigned a number, with the 1988 test pit excavation corresponding to square B1. The sandy deposit was sieved through 9 mm and 3 mm mesh sieves. In addition a 1 mm sieve was used on sediment from squares A1 and B2. All bone, stone artefacts, shell, ochre and charcoal were retained.

The 3 m square was excavated to one metre depth over the first 10 days of fieldwork (Plate 1). Each square was excavated separately in spits

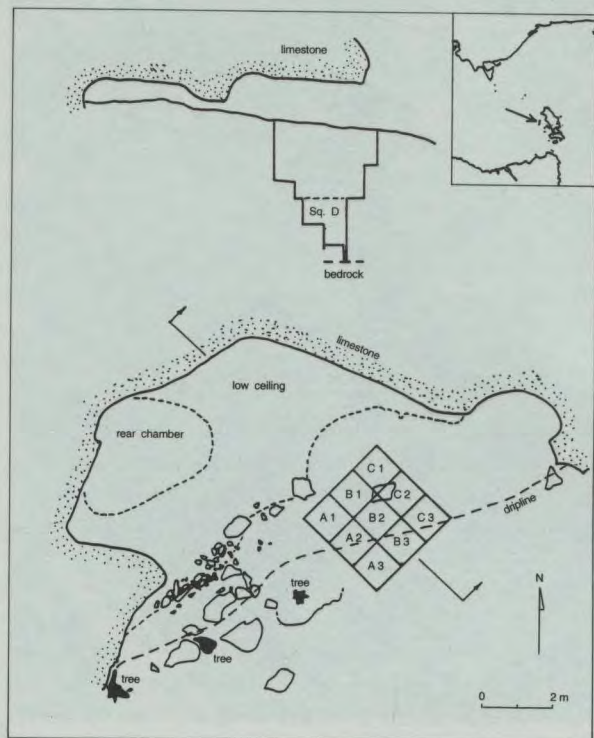


Figure 1 Mannalargenna Cave. Location map and site plan showing layout of the excavation.

which followed the contours of the cave floor surface. The first two spits were 5 cm in depth and all remaining spits were 10 cm deep. The reason for two initial shallow spits was for precision in determining when last use of the site occurred and to collect charcoal with which to establish the date of abandonment. A separate recording sheet was kept for each spit of each square.

Over the second 10 day field period a series of smaller, stepped-in pits were excavated within the 3 m square trench. Initially this was an area 2 m by 1.5 m which was dug to a metre depth (spits 11 to 20) and was shored using pre-fabricated wooden boxes (Plate 2). Within this pit a 120 cm square (called square D) was excavated to a further 80 cm depth (spits 21 to 28) and finally another 60 cm square was excavated to 60 cm deep (spits 29 to 34). Square D was not shored as the sandy deposits at this level were compact. The maximum depth reached was 3.5 m, and the volume of deposit removed was 13.5 m³ weighing 14 tonne. A probe pushed into the base of the excavation indicated that a further 48 cm of deposit exists before bedrock or a large roof-fall slab is encountered.

STRATIGRAPHY

Two major stratigraphic units, or soil layers, were recognised in the floor deposits of Mannalargenna Cave (Fig. 2).

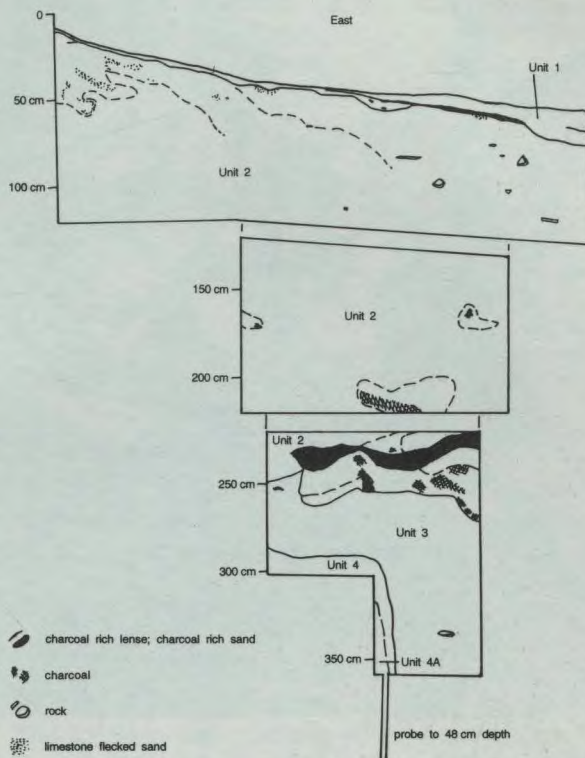


Figure 2 Mannalargenna Cave. East section.

Unit 1: very dark greyish brown (10YR 3/2) clayey sand with charcoal rich lenses. pH 9.5-10.

Unit 2: brownish yellow (10YR 6/6) sand with browner patches. pH 9.

Unit 3: coarse yellow sand (10YR 7/6) pH 8. Becomes slightly browner with depth.

Unit 4: dark yellowish brown (10YR 4/4) cave earth. pH 9.

Unit 4A: brownish yellow (10YR 6/6) coarse sand. pH 9.5.

The uppermost, called Unit 1, is essentially a humic, very dark brown clayey sand. It is very alkaline (pH 9.5). It largely lies outside the dripline, though it appears to have been trampled into the cave (by modern stock, other animals and possibly people) forming a thin layer on the inside surface of the cave floor. There is a dense layer of rock slabs from about 25 cm below the modern floor surface within Unit 1. These rocks probably represent roof-fall and suggest that in the past the cave mouth was further out and the cave was larger than at present. Unit 1 is up to 68 cm deep at the front of the excavation. A notable feature of Unit 1 was the large number of Wolf Spiders (*Lycosa* sp.), a mainland Australian not Tasmanian species (R. Green, pers. comm.). Tunnels constructed by this species were common throughout most of Unit 1.



Plate 1 Excavations at Mannalargenna Cave, beginning of the November 1989 field season.



Plate 2 The completed excavation at Mannalargenna Cave, east section.

Unit 2 is a brownish yellow calcareous sand and is the predominant deposit within the cave floor. It is alkaline (pH 9.0). The boundary between Units 1 and 2 is mostly a diffuse zone of mixed sands about 10 cm wide. Unit 2 contains a low to moderate

percentage of gravel, a few small stones and occasionally larger limestone slabs. The unit is fairly uniform in colour, with some slightly darker brownish yellow patches, to about 1.70 m deep. There is no clear evidence for animal burrows in

this deposit, though the uniform sediment colour made it difficult to distinguish such features.

From about 1.70 m to 2.25 m depth there is a large amount of charcoal stained sand. Several discrete lenses or bands of very charcoal rich sand were recognisable and these appear to represent roasting or cooking pits. Other areas comprised brownish yellow sand in which flecks of charcoal were scattered but common. They probably represent remains of pits or areas where fires were lit and where the remaining charcoal was subsequently trodden into, and distributed around, the sandy cave floor.

Sediments in the lowermost part of the profile (Units 3 and 4) contain only a tiny quantity of charcoal. Here it is a varied sandy deposit with patches of differently coloured and textured sediment, including compact fine sand, loose cave earth and coarse gravelly sand.

The origin of the sediments in Mannalargenna Cave is not clear. Initially I had thought that they probably derived from the cave and limestone cliff itself. Some, if not most, of the humic component of the Unit 1 sediment is likely to be the result of wash material falling over the cliff edge. However, it seems most likely given the dates for the deposit that much of the sand, which contains numerous small fragments of rounded marine shell, represents material transported up the slope and deposited in the cave by strong southeasterly winds during the height of the last ice-age.

DATING

Eleven radiocarbon dates (Table 1) have now been obtained for Mannalargenna Cave. All dates are on charcoal, using conventional dating techniques, supplemented by AMS dating for small samples.

The dates provide an archaeological sequence from at least 20,500 BP. Layers containing large amounts of charcoal stained sand are bracketed by dates of 18,650 and 16,700 BP with most of this deposit dated to around 18,500 BP. The date of 13,930±250 BP (SUA 2896) comes from the base of a cooking pit, but is hard to reconcile with NZA 973 (15,820±220 BP) which comes from 50 cm vertically above SUA 2896. The uppermost dates (SUA 2895 and SUA 2802, from 5-10 cm and 25-27 cm below the cave floor surface respectively) show that the most recent artefacts lie in sands deposited around 8000 years ago. No post-contact artefacts were recovered.

Square	Spit	Lab. Code	Date
C1	2	SUA 2895	7,960±170 BP
B1	4	SUA 2802	8,250±230 BP
B2	8	SUA 2894	14,300±1100 BP -1000 BP
B2	14	NZA 972	14,900±160 BP
C2W	15	NZA 973	15,820±220 BP
B1	17	Beta-28071 ETH-4594	16,690±210 BP
B1S	19	SUA 2893	18,650±350 BP
C2W	20H	SUA 2896	13,930±250 BP
D	23	SUA 2897	18,400±200 BP
D	26	SUA 2898	18,300±600 BP
D	34	NZA 974	20,560±290 BP

Table 1 Mannalargenna Cave. Radiocarbon dates.

BONE

Bone was the most common type of material recovered from the Mannalargenna Cave deposits. It occurs as small and highly fragmented pieces of bones and teeth. Data on the bone recovered from Squares B2/D are presented in Tables 2, 3 and 4. The location and chronology of Mannalargenna Cave and the range and quantity of its faunal remains make it one of the most important subfossil cave deposits in southeastern Australia. Preliminary analysis of the bone and teeth recovered from the 1988 test pit (square B1 spits 1 to 18) and from squares B2/D has been undertaken by Marshall (1991). He was able to identify 27.5% of the 10,470 bone fragments he examined from the 1988 test pit. Examination of the material from Squares B2/D concentrated on the jaws and teeth. In this assemblage, 10 species and 15 genera, all mammals, were identifiable (Table 2). Four species of native rats and mice are represented; Broad Toothed Rat (*Mastacomys fuscus*), Eastern Swamp Rat (*Rattus lutreolus*), Long Tailed Rat (*Pseudomys higginsii*) and New Holland Mouse (*Pseudomys cf. novaehollandiae*). These form the bulk of the identified bone fragments. Dasyurid mice and the small to medium sized marsupials (e.g. bandicoots) are the next most abundant of the identified remains. Most of these are juveniles. Kangaroo and wallaby are represented by at least five species. The largest is the Forester Kangaroo (*Macropus giganteus*). Pademelon (*Thylogale billardieri*) is the most common and widely distributed of the smaller wallabies and there are occasional remains of the Bettong (*Bettongia gaimardi*), Eastern Hare Wallaby (*Lagorchestes leporides*) and Rufous Rat Kangaroo (*Aepyprymnus rufescens*). Bennett's wallaby (*Macropus cf. rufogriseus*) is probably also present. Although mammal bone is the most common, the remains of birds, reptiles and fish are also well represented.

Macropodidae	
<i>Macropus giganteus</i>	Forester/ Eastern Grey Kangaroo
<i>Macropus cf. rufogriseus</i>	Bennett's wallaby
<i>Thylogale billardieri</i>	Red-bellied Pademelon
? <i>Bettongia gaimardi</i>	Eastern Bettong
<i>Lagorchestes leporides</i>	Eastern Hare Wallaby
<i>Aepyprymnus rufescens</i>	Rufous Rat Kangaroo
Petauridae	
<i>Pseudocheirus peregrinus</i>	Ring-tailed Possum
Peramelidae	
<i>Perameles gunnii</i>	Barred Bandicoot
? <i>Isodon</i>	Bandicoot
Vombatidae	
<i>Vombatus ursinus</i>	Common Wombat
Dasyuridae	
? <i>Dasyurus viverrinus</i>	Eastern Native Cat
<i>Antechinus ? minimus</i>	Swamp Antechinus
Muridae	
<i>Mastacomys fuscus</i>	Broad-toothed Rat
? <i>Rattus lutreolus</i>	Swamp Rat
<i>Pseudomys higginsii</i>	Long-tailed Rat
<i>Pseudomys</i> <i>cf. novaehollandiae</i>	New Holland Mouse
Unidentified bird	
Unidentified snake	
Unidentified lizard	
Unidentified fish	

Table 2 Mannalargenna Cave: Cave fauna list (compiled by B. Marshall). Genera or species prefixed with ? require confirmation.

On the basis of his analysis of the bone and teeth, Marshall concludes that:

1. Birds of prey are the main agent responsible for bone deposition, but that this can only account for the more complete bones of small animals, the small reptiles, rats and lizards.
2. The role of marsupial carnivores is not known and further documentation of species representation together with bone fragmentation is required.
3. The presence of charred or burnt bone (31% of the bone in squares B2/D bones) at Mannalargenna Cave is a fairly reliable indicator of human activity. The greatest incidence of burning is recorded from spits 15 to 28 inclusive.
4. Of the identified animals those which most likely represent food remains are the wombat and Forester Kangaroo. Interpretation of the medium to small sized macropods is extremely problematic in this regard. For example, a complete and articulated wallaby skeleton excavated from square A2 spit 3 is indicative of the

natural death of some medium to small sized animals in the cave.

5. The habitat preferences of some of the animals suggest that grassland and semi-arid conditions predominated at the time of human occupation of the cave, or at least that grasslands were being most often utilised for game. This situation occurred at the height of the last glacial maximum about 18,000 BP when the sea was at its greatest distance from the cave and climatic conditions at their driest.
6. The bone assemblage from Mannalargenna Cave is similar to that from the 23,000 to 15,000 BP time period at Cave Bay Cave on Hunter Island, in terms of the species represented and probable origins.

BONE ARTEFACTS

In the analysis to date, one bone artefact has been recognised (Fig. 3) from square B2 spit 28. It is a short (4.50 cm long; 0.54 cm diameter; 1.39 g) piece of long bone (probably fibula) which has a rounded and polished spatula end (0.70 cm wide).

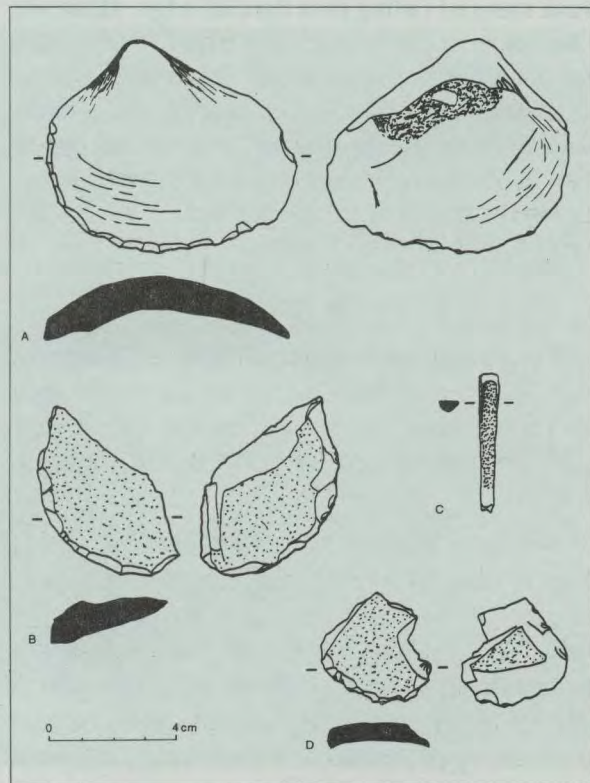


Figure 3 Mannalargenna Cave artefacts. A: fossil shell scraper (square B2 spit 20). Umbo at top. Infilled area is cemented sand. B: Fossil shell scraper (square D spit 22). C: Bone spatula (square D spit 28). Infill is cemented sand. D: Fossil shell scraper (square C1SW spit 20).

Sq.	Spit	Forester Kangaroo	Med/Sm Kangaroo	Wombat	Bandicoot	Possum	Rodent	Marl Mouse	Reptile	Bird	Fish	Not identified
B2	1	-	1	-	-	-	-	-	-	-	-	-
B2	2	-	2	-	3	-	8	-	2	-	1	-
B2	3	-	1	-	-	-	7	1	3	-	1	-
B2	4	-	-	-	-	-	5	1	2	-	-	-
B2	5	-	-	-	2	-	4	-	2	-	1	-
B2	6	-	1	-	2	-	2	-	8	-	-	-
B2	7	-	-	-	3	-	1	-	4	-	-	-
B2	8	-	1	-	-	-	2	-	6	-	-	-
B2	9	-	-	-	3	-	4	-	1	-	-	-
B2	11	-	4	-	-	1	2	2	3	-	-	-
B2	12	-	4	1	-	-	3	-	6	-	-	1
B2	13	-	2	-	4	-	4	-	2	-	-	-
B2	14	-	6	5	11	-	5	1	5	-	-	1
B2	15	?1	6	-	17	-	17	-	13	-	-	2
B2	16	2	16	-	13	-	20	8	26	-	-	-
B2	17	1	13	3	7	-	21	3	36	-	-	2
B2	18	1	12	9	9	-	17	3	11	-	-	-
B2	19	-	10	2	13	-	17	3	33	2	-	2
B2	20	-	16	6	36	-	15	3	31	-	-	3
D	21	1	33	13	8	-	48	12	145	1	-	1
D	22	-	38	9	30	-	60	20	102	1	-	7
D	23	-	19	9	43	-	38	12	48	-	-	13
D	24	-	13	-	17	-	23	12	109	2	-	-
D	25	-	17	4	17	-	35	10	100	-	-	5
D	26	1	10	1	9	-	23	4	128	-	-	1
D	27	-	3	-	9	-	18	6	71	-	-	5
D	28	-	3	-	2	-	23	8	41	1	-	-
DSE	29	-	1	-	1	-	6	-	3	-	-	-
DSE	30	-	-	-	7	-	3	-	4	-	-	-
DSE	31	-	8	-	3	-	3	1	4	-	-	-
DSE	32	-	4	-	7	-	3	-	5	-	-	-
DSE	33	-	2	-	7	-	4	8	48	-	-	1
DSE	34	2	1	1	-	-	10	2	47	-	-	2

Table 3 Mannalargenna Cave. Distribution and relative abundance (NISP) of vertebrate fauna: Squares B2/D (compiled by B. Marshall).

In addition, a fibula recovered from square C2 spit 8 has possibly been polished.

EMU AND OTHER EGG SHELL

Emu egg shell and other egg shell is present throughout most of the deposit in Mannalargenna Cave (Table 5). Emu egg shell fragments were recovered between spits 30 (square D) and 3 (square A2), though most commonly from between spits 28 and 15. A total of 54 emu egg shell fragments weighing over 12 g was recovered from squares B2/D. These fragments range in colour from olive green to black.

Other egg shell comprises mostly thin and small fragments. Some of these may be emu egg shell which has lost its outer and distinguishing rippled surface, but most appear to be from other bird species, possibly the Cape Barren Goose (*Cereopsis novaehollandiae*), a species quite common on Prime Seal Island at present. From squares B2/D a

total of 1920 other egg shell pieces weighing over 50 g was recovered. From Table 5 it can be seen that other egg shell is most commonly found in those spits containing emu egg shell, that is, there is a direct relationship in the distribution of the two types of egg shell. This suggests that the other egg shell also derives from human activities.

STONE ARTEFACTS

Some 1005 stone artefacts were recovered during the 1989 excavation at Mannalargenna Cave. Additionally 202 stone artefacts were recovered from square B1 spits 1 to 18 during the 1988 field season. At this stage, analysis of the stone artefacts has concentrated on those from squares B2/D (Tables 6, 7 and 8). The following comments derive mainly from this part of the excavated assemblage.

A total of 632 stone artefacts was recovered from squares B2/D, 89% of which come from spits 26 to 14. The assemblage is predominantly

Square	Spit	Wt. of Sed. (kg)	Wt. of Bone (g)	Wt. Bone (g) per kg Sed.	No. of Bones	Wt/no. Ratio
B2	1	69.5	10.14	0.146	59	0.172
B2	2	102.0	30.23	0.296	290	0.104
B2	3	153.5	24.75	0.161	365	0.068
B2	4	174.5	27.02	0.155	298	0.091
B2	5	141.0	9.15	0.065	152	0.060
B2	6	197.5	15.72	0.080	233	0.067
B2	7	147.5	11.90	0.081	254	0.047
B2	8	199.0	15.62	0.078	326	0.048
B2	9	180.0	15.03	0.084	170	0.088
B2	11	188.5	18.55	0.098	292	0.064
B2	12	169.0	21.96	0.130	304	0.072
B2	13	165.0	23.49	0.142	463	0.051
B2	14	192.0	60.83	0.317	874	0.070
B2	15	183.0	116.13	0.635	1734	0.067
B2	16	203.0	168.24	0.829	4136	0.041
B2	17	170.5	143.71	0.843	5126	0.028
B2	18	141.5	122.52	0.866	2472	0.050
B2	19	155.0	114.34	0.738	3150	0.036
B2	20	170.5	183.85	1.078	4847	0.038
D	21	215.0	513.01	2.386	13205	0.039
D	22	258.5	540.54	2.091	14039	0.039
D	23	226.5	441.77	1.950	13529	0.033
D	24	225.0	232.55	1.034	7237	0.032
D	25	227.0	236.56	1.042	6185	0.038
D	26	249.5	159.82	0.641	4607	0.035
D	27	183.0	79.81	0.436	2803	0.028
D	28	224.0	68.68	0.307	2246	0.031
DSE	29	63.0	14.45	0.229	407	0.036
DSE	30	58.0	12.91	0.223	340	0.038
DSE	31	54.0	52.61	0.974	515	0.102
DSE	32	58.0	42.44	0.732	441	0.096
DSE	33	56.0	43.42	0.776	1807	0.024
DSE	34	52.0	48.91	0.941	2074	0.024
TOTAL	-	3887.5	3620.66	0.931	94980	0.038

Table 4 Mannalargenna Cave. Bone data: Squares B2/D.

quartz and topaz (98%), with some quartzite, limestone and silcrete. The quartz artefacts include crystal quartz, translucent milky white and grey smoky quartz and opaque white quartz. Topaz is included in the quartz category as it is not easily distinguishable from quartz on the basis of simple inspection. The quartz is derived from water worn beach or river pebbles and from quartz veins which occur naturally in the granites of the Furneaux group. Topaz occurs in the island group as rounded beach/river pebbles and these are widely known as 'Kilacranky diamonds'. All of the stone artefact types represented in the Mannalargenna assemblage, with the possible exception of silcrete, are available within the Furneaux Island group region.

The artefacts are grouped into the following categories:

Fragment: Fragment, chunk or lump of stone which shows no signs of flaking but is out of geological context and must have been transported to the site by people. These make up 30% of artefacts from squares B2/D (Table 8).

Flake: Stone piece showing evidence (a striking platform and bulb of percussion) of having been produced by percussion. Flakes make up 23% of artefacts from squares B2/D.

Flaked Piece: Stone piece with flaked surfaces but which cannot be classified as a flake or a core. They make up 44% of the artefacts from squares B2/D.

Core: Stone piece from which flakes have been removed. Six cores were recovered from squares B2/D. One quartzite multi-platform core and one limestone multi-platform core (both from spit 22) are amongst the largest stone artefacts recovered from the excavation (Table 7).

Bipolar Piece: Stone piece, which may be a flake or core, which is a result of a stone working technique which involves smashing stone between a hammerstone and an anvilstone. Crushing at opposite ends is taken to be evidence of a bipolar core, and at one end only evidence of a bipolar flake/flaked piece. Eight such pieces were recog-

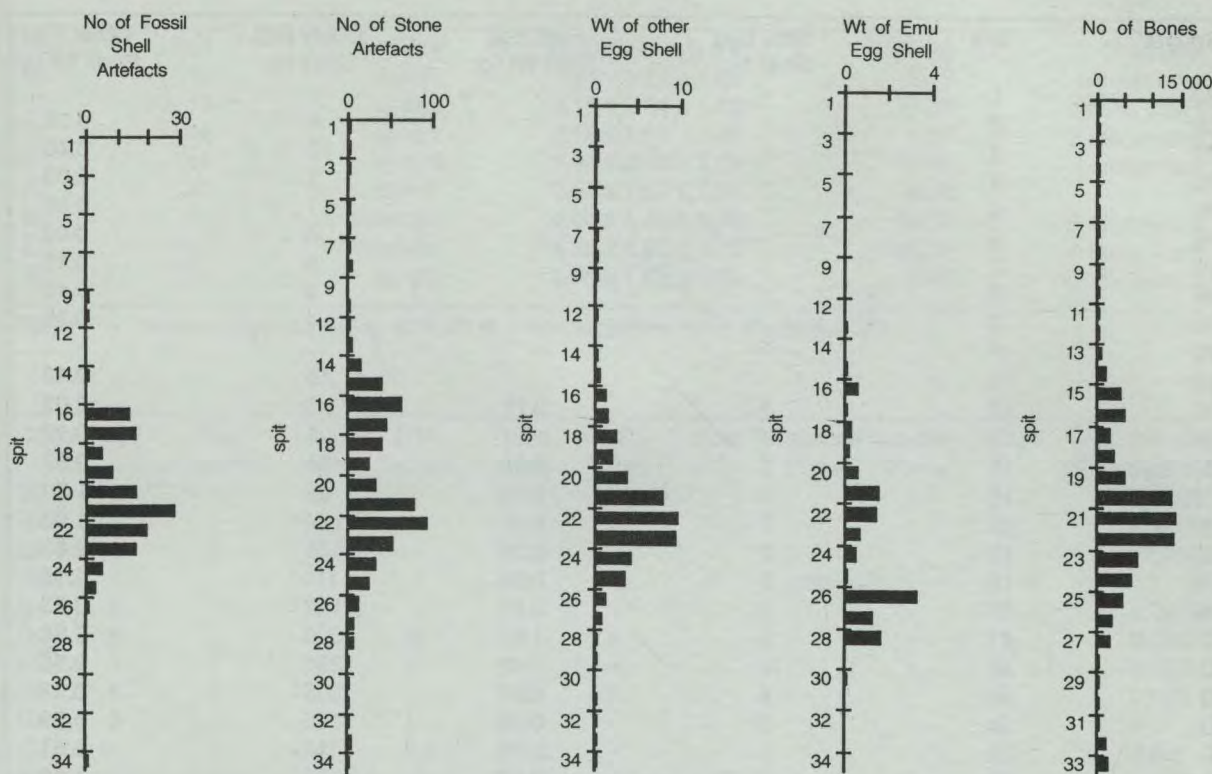


Figure 4 Mannalargenna Cave. Comparative data: squares B2/D.

nised from squares B2/D, though many of the other fragments, flakes and flaked pieces could be the result of the bipolar stone working technique. This technique was used on quartz and limestone at Mannalargenna Cave.

Retouched/Utilised Piece: A fragment, flake, flaked piece, core or bipolar piece which has irregular small flake scarring along one or more margins. This usually indicates use of the artefact as a tool for cutting/scraping tasks. Six retouched/utilised pieces were recognised from squares B2/D; two are retouched/utilised flakes, two retouched/utilised flaked pieces, one a notched (and possibly nosed) quartz scraper and one a quartz thumbnail scraper (1.92 x 0.94 x 0.63 cm; 1.04 g; slightly convex steep scraper margin; from spit 22).

Activities represented by the stone artefacts include stone working, the production and rejuvenation of stone tools, and a low level of wood or skin scraping. A few of the quartz artefacts also have a red staining on their surfaces. This appears to be ochre, but detailed examination is required before a definite identification can be made.

FOSSIL SHELL

Fossil shell was recovered from throughout the floor deposit at Mannalargenna Cave (spits 1 to 34). The use of fossil shell as a stone source is previously unknown in the Tasmanian region, and

the two round-edge scrapers made on fossil cockle shells (see below) appear to be unique.

The original source of these fossil shells would have been Mid-Pliocene to Recent marine beds which occur throughout the Furneaux Island region, though not on Prime Seal Island. The shells clearly represent a wide range of species. The most common varieties are; the large bivalve *Eucrassatella* spp.; Scallop (*Pecten* spp.); mud oyster (*Ostrea* spp.); a ribbed cockle and a mussel. One complete volute (8.50 cm long, maximum diameter 3.45 cm) and one volute spiral-core fragment (3.92 cm long) were recovered from square D spit 22. In addition, occasional fragments of non-fossil *Austrocochlea* spp., and one *Turbo* spp. operculum fragment, were recovered. These pieces would most likely have been brought to the site by seabirds and do not represent food consumption.

Almost all of the remains of *Eucrassatella* spp. found within the Mannalargenna Cave deposits have been flaked or otherwise worked. Data on the fossil shell artefacts is provided in Tables 9 and 10 and some are illustrated in Figure 3. The only non-*Eucrassatella* spp. which shows evidence of working (a retouched fossil shell fragment from square D - spit 23) is a fragment of ribbed cockle (2.08 x 1.01 x 0.46 cm; 1.00 g). Other shell species (scallop, oyster, mussel) may have been flaked or used as tools also, though this could not be determined from the remaining fragments.

Square	Spit	Emu Egg Shell No.	Emu Egg Shell Wt (g)	Other Egg Shell No.	Other Egg Shell Wt (g)
B2	1	-	-	-	-
B2	2	-	-	4	0.06
B2	3	-	-	12	0.40
B2	4	-	-	1	0.03
B2	5	-	-	1	0.03
B2	6	-	-	4	0.09
B2	7	-	-	8	0.15
B2	8	-	-	9	0.16
B2	9	-	-	4	0.10
B2	11	-	-	-	-
B2	12	-	-	15	0.18
B2	13	1	0.11	3	0.03
B2	14	-	-	1	0.13
B2	15	1	0.06	35	0.57
B2	16	3	0.55	88	1.30
B2	17	1	0.07	124	1.66
B2	18	2	0.30	106	2.63
B2	19	2	0.24	111	2.15
B2	20	3	0.61	132	3.73
D	21	9	1.50	300	7.86
D	22	10	1.48	291	9.55
D	23	5	0.67	305	9.43
D	24	3	0.49	145	4.29
D	25	1	0.06	112	3.51
D	26	5	3.22	35	1.19
D	27	2	1.20	29	0.82
D	28	5	1.60	14	0.28
DSE	29	-	-	7	0.39
DSE	30	1	0.06	1	0.01
DSE	31	-	-	5	0.10
DSE	32	-	-	3	0.22
DSE	33	-	-	3	0.08
DSE	34	-	-	12	0.23
TOTAL		54	12.22	1920	51.36

Table 5 Mannalargenna Cave. Emu and other egg shell data: Squares B2/D.

Square	Spit	Stone Type	Artefact Type	Size (cm) L x B x W	Wt (g)
A2	7	quartzite	flake	1.70 x 1.38 x 0.68	1.21
B2	16	quartzite	flaked piece	0.71	0.05
B2	22	quartzite	core	4.00 x 4.42 x 4.08	79.30
B2	22	quartzite	flake	0.77 x 1.04 x 0.21	0.09
B2	22	quartzite	flaked piece	1.26	0.16
B2	24	quartzite	flake	1.04 x 0.91 x 0.57	0.43
D	34	quartzite	flaked piece	0.77	0.04
B2	15	limestone	bipolar flake	1.11 x 0.98 x 0.34	0.31
B2	21	limestone	flake	1.07 x 1.35 x 0.57	0.74
B2	22	limestone	core	4.25 x 4.55 x 3.70	68.76
B2	25	silcrete	flake	0.52 x 0.83 x 0.17	0.06
B2	26	silcrete	flaked piece	0.97	0.25
B2	27	silcrete	flake	1.06 x 0.69 x 0.28	0.20

Table 6 Mannalargenna Cave. List of non-quartz stone artefacts.

The shell assemblage from squares B2/D comprises 36% fragments, 32% flakes and 28% flaked pieces. There are four retouched pieces and two round-edge scrapers (Table 9), tool types most commonly associated with wood working. The largest of these latter tools (78.19 g) has a rounded

margin and is heavily retouched along 9 cm. Ninety percent of the fossil shell artefacts were recovered from within spits 23 to 16 inclusive.

The presence of what appears to be ochre-rich sand from within the volute spiral-core fragment, suggests the possibility that the fossil shell volutes

Square	Spit	Stone Type	Size (cm) L x B x W	Wt (g)	Comment
B2	12	quartz	1.91 x 1.12 x 1.06	2.73	bipolar core
B2	13	quartz	3.15 x 2.54 x 1.43	13.39	4 flake scars
B2	16	quartz	2.15 x 1.53 x 1.40	4.27	2 flake scars
B2	16	quartz	3.96 x 2.42 x 2.07	13.11	bipolar core
B2	21	quartz	2.38 x 1.27 x 1.25	6.98	-
B2	22	quartzite	4.00 x 4.42 x 4.08	79.30	6 flake scars
B2	22	limestone	4.25 x 4.55 x 3.70	68.76	4 flake scars
B2	28	quartz	2.08 x 1.63 x 1.49	4.42	multiplatform

Table 7 Mannalargenna Cave. Details of cores recovered from Squares B2/D.

Square	Spit	Frag- ment	Flake <1cm	F.P. <1cm	Flake >1cm	F. P. >1cm	Core Retouched Piece	Bipolar Piece	Total	No. Art. per 10 kg Sediment
B2	1	-	1	-	-	-	-	-	1	0.014
B2	2	-	1	1	-	-	-	-	2	0.020
B2	3	1	2	-	-	-	-	-	3	0.020
B2	4	-	-	-	-	-	-	-	-	-
B2	5	1	-	-	-	-	-	-	1	0.007
B2	6	-	-	3	-	1	-	-	4	0.020
B2	7	1	1	2	-	-	-	-	4	0.027
B2	8	1	2	-	-	2	-	-	5	0.025
B2	9	-	-	-	-	-	-	-	-	-
B2	11	-	-	1	-	-	-	-	1	0.005
B2	12	-	1	2	-	-	-	1	4	0.024
B2	13	-	3	1	2	-	1	-	7	0.042
B2	14	3	-	8	4	-	-	-	15	0.078
B2	15	5	10	16	5	4	-	-	40	0.219
B2	16	11	11	25	2	12	1	1	63	0.310
B2	17	9	5	23	5	4	-	1	47	0.275
B2	18	5	4	18	3	9	-	1	40	0.283
B2	19	7	2	13	2	1	-	-	25	0.161
B2	20	14	1	6	2	8	-	1	33	0.194
D	21	30	13	11	8	16	1	-	79	0.367
D	22	34	22	20	10	3	2	3	95	0.360
D	23	32	4	9	3	5	-	1	54	0.238
D	24	8	3	14	2	7	-	-	34	0.151
D	25	12	1	7	1	4	-	1	26	0.115
D	26	2	3	6	-	2	-	1	14	0.056
D	27	5	-	1	2	-	-	-	8	0.044
D	28	3	1	2	1	-	1	-	8	0.036
DSE	29	-	1	2	-	-	-	-	3	0.048
DSE	30	1	-	-	-	1	-	-	2	0.034
DSE	31	-	1	-	-	1	-	1	3	0.056
DSE	32	1	-	2	-	1	-	-	4	0.069
DSE	33	3	-	2	-	1	-	-	6	0.107
DSE	34	-	-	1	-	-	-	-	1	0.019
TOTAL		189	93	196	52	82	6	8	632	-

Table 8 Mannalargenna Cave. Stone artefact data: Squares B2/D.

Square	Spit	Artefact Type	Size (cm) L x B x W	Wt. (g)
B2	17	retouched piece	2.61 x 4.96 x 1.22	9.84
B2	20	scraper	6.95 x 8.06 x 1.94	78.19
D	21	retouched piece	3.14 x 1.29 x 0.71	3.16
D	22	scraper	6.26 x 3.29 x 0.73	26.31
D	22	retouched piece	2.17 x 1.60 x 0.52	1.60
D	23	retouched piece	2.08 x 1.01 x 0.46	1.00

Table 9 Mannalargenna Cave. Data on fossil shell scrapers and retouched pieces.

Square	Spit	Fragment	Flake <1cm	F. P. <1cm	Flake >1cm	F.P. >1cm	Retouched Piece	Scraper	Total	No. Art. per 10kg Sediment
B2	1	-	-	-	-	-	-	-	-	-
B2	2	-	-	-	-	-	-	-	-	-
B2	3	-	-	-	-	-	-	-	-	-
B2	4	-	-	-	-	-	-	-	-	-
B2	5	-	-	-	-	-	-	-	-	-
B2	6	-	-	-	-	-	-	-	-	-
B2	7	-	-	-	-	-	-	-	-	-
B2	8	-	-	-	-	-	-	-	-	-
B2	9	-	1	-	-	-	-	-	1	0.06
B2	11	-	-	1	-	-	-	-	1	0.05
B2	12	-	-	-	-	-	-	-	-	-
B2	13	-	-	-	-	-	-	-	-	-
B2	14	-	-	-	-	1	-	-	1	0.05
B2	15	-	-	-	-	-	-	-	-	-
B2	16	4	4	2	1	3	-	-	14	0.68
B2	17	8	2	1	-	4	1	-	16	0.94
B2	18	5	-	-	-	-	-	-	5	0.35
B2	19	2	4	2	-	-	-	-	8	0.52
B2	20	4	8	1	1	1	-	1	16	0.94
D	21	9	7	6	1	4	1	-	28	1.30
D	22	6	3	2	1	5	1	1	19	0.73
D	23	9	3	2	-	1	1*	-	16	0.71
D	24	1	3	-	-	1	-	-	5	0.22
D	25	-	2	1	-	-	-	-	3	0.13
D	26	-	-	-	1	-	-	-	1	0.04
D	27	-	-	-	-	-	-	-	-	-
D	28	-	-	-	-	-	-	-	-	-
DSE	29	-	-	-	-	-	-	-	-	-
DSE	30	-	-	-	-	-	-	-	-	-
DSE	31	-	-	-	-	-	-	-	-	-
DSE	32	-	-	-	-	-	-	-	-	-
DSE	33	-	-	-	-	-	-	-	-	-
DSE	34	-	-	-	1	-	-	-	1	0.19
TOTAL		48	37	18	6	20	4	2	135	-

Table 10 Mannalargenna Cave. Fossil shell artefact data: Squares B2/D. * = not *Eucrassatella* spp.

were used as carrying containers for ochre. It is possible also that some shells may have had a decorative function as ornaments, though this is not immediately apparent from the archaeological evidence.

OCHRE

Small, irregular, weathered nodules of dark red ochre were recovered from within the cave deposits. Data on such pieces is provided in Table 11. Most fragments (95%) occur between spits 25 and 16. It is likely that this material was brought to the cave by people, probably from within the Furneaux region though no local ochre sources have been recorded. Ochre is usually associated with body, hair or artefact decoration and its presence indicates that artistic pursuits were undertaken by the people visiting Mannalargenna Cave, although no direct evidence for use of the ochre, such as grinding striations on the nodules, has been observed. However, red colouring on two artefacts, a fossil shell

flaked piece from square D spit 21 and a fossil shell round-edge scraper from square D spit 22, suggest deliberate colouring of artefacts may have taken place. The red staining on some stone artefacts, noted earlier, may be ochre.

SUMMARY AND DISCUSSION

Mannalargenna Cave has a deep floor deposit which contains a substantial quantity and wide range of archaeological material and evidence, including stone and fossil-shell artefacts, animal bones and teeth, bone artefacts, egg shell fragments, ochre nodules and remains of hearths. The remains are most concentrated within spits 28 to 15 inclusive, from 280 cm to 150 cm depth below the present floor surface (Figs 2 and 4). These levels date from 18,500 to 15,000 BP, showing that the site was most frequently visited during the last glacial maximum. If one were to make allowance for the movement of some artefacts vertically

Square	Spit	No.	Size (cm)	Wt (g)
B2	12	1	0.44	0.03
A2E	13	1	0.49	0.06
A2E	16	2	0.89; 0.53	0.28
B2	17	1	0.79	0.22
A2E	18	2	1.09; 0.49	0.71
C1SW	18	1	0.50	0.04
B2	19	6	0.58 - 0.48	0.35
B2	20	6	0.64 - 0.40	0.30
C1SW	20	1	0.95	0.34
D	21	16	1.10 - 0.36	2.00
D	22	4	0.68 - 0.37	0.23
D	23	4	0.86 - 0.42	0.45
D	24	7	1.13 - 0.33	1.02
D	25	7	0.98 - 0.27	0.46
DSE	32	1	0.53	0.04
TOTAL		60	-	6.53

Table 11 Mannalargenna Cave. Ochre nodules.

within the sandy floor sediments it is possible that use of the cave was restricted to this time period.

The period around 18,000 BP was the coldest and driest time of the last ice-age. The habitat preferences of some of the animals represented in the Mannalargenna Cave deposits such as Emu, Forester Kangaroo and Eastern Hare Wallaby, suggest that local conditions were semi-arid with grassland vegetation in the vicinity of the cave. The presence of New Holland Mouse, which prefers habitat which is regenerating after fire, may indicate human firing of grassland within the vicinity of the cave. However, virtually no pollen survives within the cave sediments (Ian Thomas, Department of Geography, University of Tasmania, pers. comm.).

A wide range of human activities is indicated by the remains. Small fires were lit, some within small to medium sized pits which may have been used to cook animal or plant foods. Wombat, Forester Kangaroos and Emu and other birds eggs appear to have been eaten at the cave. Stone and bone artefacts were brought to and left in the cave, most notably the large round-edge fossil shell scrapers and the bone spatula. Stone working, predominantly the smashing of quartz nodules, took place in the cave. It is not clear whether the stone tools were actually used at the cave and if so for what purpose. However, given the presence of domestic fires and food remains indicative of camping, it is not unlikely that some woodworking or skin working also took place. The presence of red ochre at the site also indicates the pursuit of decorative activities by the visitors to the cave, though not necessarily within the cave itself.

The quantity and type of archaeological evidence recovered suggest that the cave was not frequently visited or occupied for long periods.

Given the altitude of the cave, the difficulty of access and distance from fresh water, a low level of visitation is not unexpected. The cave has a south-east aspect with extensive views to Flinders Island, which suggests it could have had a valuable lookout function, as well as offering protection from north-westerly weather. The presence of emu egg shell suggests some visits to the site occurred in late winter/early spring.

From an environmental point of view, between 23,000 BP and 14,000 BP, both Mannalargenna Cave and Cave Bay Cave on Hunter Island, would have been situated on hills within the Bassian Plain surrounded by semi-arid grassland vegetation communities. There is broad similarity in the range of species represented by the faunal assemblages at both sites, and in the presence of bone tools, ochre and stone assemblages dominated by quartz. Evidence of bipolar flaking is present at both sites as are thumb-nail scrapers (dated to about 19,000 BP at Cave Bay Cave). However, the presence of fossil shell artefacts on Prime Seal Island suggests use of this locally available stone resource only in the Furneaux Island area. The absence of this material from contemporary levels in Cave Bay Cave suggests an east/west division within the Bassian Plain. The two sites also have different sequences of site use. Cave Bay Cave shows intermittent but intensive use from about 23,000 BP to 21,000 BP and more ephemeral visits after this, ceasing altogether about 15,000 BP. In contrast, the most frequent use of Mannalargenna Cave took place between 18,500 BP and 15,000 BP, although visitation may have continued until about 8000 BP. In addition, Cave Bay Cave was re-occupied in the Holocene, from 6600 BP, while Mannalargenna Cave was not.

In comparison with late Pleistocene cave sites in southern and central Tasmania (Cosgrove et al. 1990; McNiven et al., this volume), Mannalargenna Cave shows similarities in the range of fauna represented and possibly exploited by humans, a predominance of quartz in the stone artefact assemblage reflecting use of local resources, and the presence of thumbnail scrapers and bone tools. Mannalargenna Cave differs in the time span of occupation and in density of archaeological remains, being most similar to the eastern Tasmanian site ORS7 (Cosgrove 1989). However, there is no direct evidence, such as Darwin glass at Mannalargenna Cave or fossil shell artefacts in southern and central Tasmanian sites, to suggest use of both areas by the same people, or direct contact or trade between the different populations.

In brief, the evidence shows Mannalargenna Cave was a site visited during the height of the last ice-age, probably by small numbers of people. These visits appear to have been infrequent over

several thousand years. The site was used for cooking and consumption of food, stone tool manufacture and stone and bone tool use. The location of the cave and the evidence it contains suggest use as a daytime shelter/lookout though this is not conclusive. The range of materials found at the cave, all of which appear to have local sources, suggests that the people visiting Mannalargenna Cave between about 18,500 BP and 15,000 BP were inhabitants of the Furneaux Island area and did not necessarily travel over extensive areas of the Bassian Plain, the then Tasmanian Peninsula or southeastern Australia. This provides a tentative picture of a geographically restricted human population on the Bassian Plain at the height of the last glacial maximum. Questions about late Pleistocene settlement and use of the region on either side of this time period remain to be investigated.

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THE LAST DAYS OF POMPEII?

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It is not yet 30 years ago, at an ANZAAS Congress in Sydney, that John Mulvaney announced radiocarbon dates for the lower levels of Kenniff Cave which demonstrated beyond a shadow of doubt that there was a Pleistocene dimension to the settlement of Sahul (see Mulvaney 1962). Many of our subsequent Pleistocene discoveries have depended, just as much as Mulvaney's original one, on radiocarbon dates. What I want to do is to explore several aspects of this situation. First of all, it is worth considering the implications for our predecessors.

As John Mulvaney has shown us (1958), 19th century scholars here and overseas assumed a great antiquity for the human presence. This was the logic of the social evolutionary theory which saw the Aboriginal Australians as standing on the lowest rungs of the ladder, with material culture and anatomical characteristics indicative of that status. Dubois' discovery of *Pithecanthropus* at Trinil a hundred years ago aroused great interest, and expectations seemed to be fulfilled by the Talgai cranium, exhibited in Sydney in 1914 during the Australian meetings of the British Association for the Advancement of Science. 'Now,' said the great geologist Edgeworth David on that occasion, 'if we are asked, "Is man a geological antiquity in Australia?", we can reply, "Yes, he is"', and he went on to speculate about the Talgai youth living at the same time that the long extinct giant marsupials roamed the Darling Downs in the Pleistocene age, perhaps 25,000 years ago (David and Wilson 1914).

That, however, was precisely the trouble. No direct association of humans or their artefacts with extinct fauna was ever forthcoming. In Europe it had been the discovery of human artefacts or bones with antediluvian faunas, repeated in Italy, Germany, Belgium, France and Britain, which was decisive in demonstrating the antiquity of humankind and overthrowing the biblical chronology. Even in New Zealand, the geologist, von Haast, Director of the Canterbury Museum, had a brief flirtation in the 1870s with the idea of a Kiwi Palaeolithic to be contrasted with the Neolithic Maori with their ground stone tools. The evidence

that he appealed to was a huge moa-processing site at the Rakaia river mouth, littered with flakes and flake tools, where the rare presence of indisputably Maori artefacts was explained away as later intrusions (von Haast 1872).

In Australia, where the history of palaeontological discovery goes back to the 1820s, no authenticated finds of associated human remains were made, and few indeed claimed, a situation that has not been decisively altered by the past 30 years of intensive archaeological research, although independent and overlapping chronologies for people and extinct marsupials have been established (Flannery and Gott 1984; Gillespie et al. 1978; Hope 1978). No wonder, then, that after the interruption of the First World War, the Talgai cranium fell into limbo for want of supporting evidence of any kind and the running came to be made by a group of people based in Victoria and inspired by Baldwin Spencer, who argued for a short and unenterprising residence for human beings in Australia, eked out in utter isolation from the outside world (see discussion in Mulvaney 1957).

The idea of a shallow time depth for Australian prehistory was very persistent. During the period when Mulvaney was publishing his Pleistocene dates for Kenniff Cave, Andrew Abbie of the University of Adelaide was still arguing the case, on human biological grounds, in a book calamitously delayed in its publication, which had to be provided with a hurried and somewhat erroneous addendum to take note of the new discoveries (Abbie 1969:219-29, 281).

For some time before this, however, there were scholars at work who explicitly or implicitly were challenging the prevailing orthodoxy in a number of ways. As a result of overseas visits in the late 1930s, Norman Tindale of the South Australian Museum and Fred McCarthy of The Australian Museum, Sydney, separately made comparisons between Australian archaeological materials and those of southeast Asia (McCarthy 1940; Tindale 1937). Even earlier, Tindale had appealed to worldwide sea level changes associated with gla-

cial advance and retreat to argue that the Kartan industry of Kangaroo Island, which was uninhabited when Matthew Flinders came across it, must have been introduced when the island was an extension of the South Australian mainland during the lowered sea levels of the last glacial period (Tindale and Maegraith 1931).

Following the end of World War II, Edmund Gill, palaeontologist at the National Museum of Victoria, began geomorphological investigations at the locality of the Keilor skull, accidentally uncovered in 1940. He rebutted extravagant claims for its last glacial or early last interglacial antiquity, but, by careful stratigraphic work, during which he pioneered the use of the new technique of radiocarbon dating in Australia, established the possibility of its late Pleistocene age (Gill 1953, 1954, 1966). Subsequently, the ex-Hungarian archaeologist Alexander Gallus, professionally unattached in Australia, worked idiosyncratically at Keilor and also at Koonalda Cave (e.g. Gallus 1964). Meanwhile, the no less eccentric 'Black Mac' Macintosh of the Department of Anatomy, Sydney University, had become impressed by the 'primitive' morphology of the Cohuna cranium, an accidental discovery of the early 1930s (Macintosh 1952a, 1952b, 1953). He began to turn his attention to Talgai (Macintosh 1952c) and by the end of the 1950s was firmly set on the human palaeontological path (Macintosh 1967).

It is apposite to recall these men and their work. It is also appropriate that at the same time we remember the contribution of John Mulvaney who joined them in the 1950s with archaeological training at Cambridge and set about laying the foundations for the period of activity to which I now turn.

The remarkable thing is the speed and completeness with which Pleistocene origins became established for settlement in widely divergent environments throughout Sahul – New Guinea and Tasmania, no less than mainland Australia – as a joint result of the availability of radiocarbon dating and the appearance on the scene of specialist archaeologists who were uninfluenced by and largely unaware of the ideological trammels about the past of the continent which I have described. The contrast with the history of research on the peopling of the Americas is startling and one that I still fail to understand, given the longer history of archaeological research there and the vaster scale of activity.

There are reasons, of course, why much of our Pleistocene evidence has come from the bottom of holes in sites that were dug simply because they were there and looked archaeologically promising. A lot of them have to do with the fact that the study

of Quaternary landscapes in our region is as recent as professional archaeology and has been as dependent on radiocarbon dating as we have. One of the pleasing features of the past 30 years has been the way the two enterprises have been pursued side by side, sometimes hand in hand, each helping and illuminating the other.

This work has resulted in the identification of some remarkable palaeoenvironments for the Pleistocene: amongst them the lunette-bordered lakes of the Willandra system in western New South Wales (Bowler 1971, 1976; Bowler et al. 1970), the periglacial uplands of southwest Tasmania (Galloway et al. 1973; Kiernan et al. 1983; Macphail 1975), the subalpine grasslands of montane New Guinea (Hope 1976; Hope and Hope 1976; Walker and Flenley 1979) and the coastal terraces of the Huon peninsula (Bloom et al. 1974; Groube et al. 1986), rising faster than the level of the postglacial sea. Landscapes like these may not be Pompeii, but they afford excellent opportunities for discovering the structured evidence for systems of human activity and interaction in knowable physical environments. Some of them have proved to have archaeological evidence in the richness and variety necessary for the full and integrated investigation of the patterns of past behaviour, others are just revealing their promise, and yet others have still to be tested. The first of these landscapes to be identified, that of the Willandra Lakes, has special significance because of its association with skeletal remains and burial ritual (Bowler et al. 1970; Bowler et al. 1972). This makes it an area of global significance in a wider region that has produced more Pleistocene individuals than any comparable part of the world. The archaeological study of the Willandra and similar systems of the Riverina presents severe methodological difficulties, while the unique attraction provided by the rich skeletal evidence makes it an area of particular sensitivity from the point of view of future research. In the Australian context, however, it is a place of the highest potential, not Pompeii indeed, but certainly Turkana.

Much of our archaeological work takes place, however, where there are no specifically Pleistocene landscapes to be identified and exploited. In these situations we are often restricted to single sites revealed as Pleistocene only by radiocarbon dating and typically in the form of restricted areas of exposure at the base of rockshelter excavations. We are here faced with extreme examples of the archaeological predicament as characterised by Binford (1981) – the archaeological record as a palimpsest of derivations from many separate episodes – with additional noise from the geomorphic history of deposits and often shattering silence as a

result of the decay and disappearance of economic evidence like bone and shell, to say nothing of plant remains, with whose recovery, identification and interpretation we are only just coming to grips.

As a result of the predominantly accidental recovery of evidence as I have described it, we have not much sense as yet of the character of Pleistocene economic systems, to which, however, integrated enterprises like the Southern Forests Archaeological Project are now contributing in their particular and favourable circumstances (McNiven et al., this volume). This being our situation, interpretation of the archaeological record has tended to go in two different directions:

1. One has been the broad geographical canvas – coastal colonisation, fluctuations in the settlement of the arid zone and the like (Bowdler 1977; Horton 1981; Smith 1987).
2. The other has been trajectories of change over time, to which inevitably the less well understood Pleistocene evidence has served only as a prelude, whether the focus be a regional sequence in Arnhem Land (Jones 1985; Schrire 1982) or the grander scheme of Holocene intensification (Lourandos 1983). As has recently been discussed in the literature (Bird and Frankel 1991; Frankel 1988), there are some basic problems of methodology (let alone theoretical assumptions) in such historical exercises: are we comparing like with like and, even if we are, are we using appropriate units for comparison? All this points to the need for larger samples to be taken at appropriate sites or sets of sites, in order to allow a more thorough understanding of the structure of the archaeological evidence as the basis for valid comparison. For these purposes, as we are all aware, some sites are better than others, from the point of view both of content and resolution.

Despite all the limitations, archaeological work over the past 30 years has given us a rich picture of Pleistocene culture in our region when looked at in the large. I have already referred to the settlement, or at least the utilisation, of every major ecological zone of the Pleistocene continent. In addition, we now have evidence for the Pleistocene colonisation of islands to the north and northeast of New Guinea (Allen et al. 1988; Wickler and Spriggs 1988), with all that implies in general for movement across water and out of sight of land (Fredericksen et al., this volume; Irwin 1991). I have also mentioned the significance of burials and burial ritual at the Willandra Lakes and other Riverina sites. Equally significant amongst other discoveries of the 1960s was the evidence at Koonalda Cave for Pleistocene quarrying and particularly Pleistocene art (Wright 1971). Subsequent work has put the latter on a

firmer basis and in wider context as far as finger markings and engravings are concerned (Rosenfeld et al. 1981). The direct dating of paintings or of the mineral skins on top (Loy et al. 1990; McDonald et al. 1990; Watchman 1987) promises to do the same for them, while there is the occurrence of ochres for whatever colouring purposes in numbers of very early levels (e.g. Roberts et al. 1990). We have evidence for the transport of materials and all that implies for systems of communication and connection – Darwin glass in southwest Tasmania, obsidian in the Bismarck Archipelago, baler shell and pearl shell in Western Australia. In the Bismarck Archipelago, moreover, there are indications of the movement of animals and possibly of plants (Flannery and White 1990; Spriggs, this volume). In the sphere of material culture there are bone points and shell ornaments (Morse, this volume) to add to the stone industries which are gradually achieving better definition. And of course we have the well-known edge-ground axes of northern Australia (White 1967) and New Guinea (Mountain 1983), as well as the question as to why they are unknown in the rest of the continent until well into the Holocene (Morwood and Trezise 1989).

This is, of course, the composite picture. It will be the painstaking work of future generations to take the separate elements, establish their associations and provide their geographical and chronological parameters. As these things become clearer and we learn more about the southeast Asian region from amongst whose Pleistocene populations the colonists of Sahul were drawn, we should arrive at some understanding of what the ancestral cultures were like and what distinctive developments these cultures underwent in the new continent.

The recent evidence from the Bismarck Archipelago and the Solomon Islands (Allen and Gosden 1991) deals something of a blow to the old view of the settlement of Sahul being the end result of slow, haphazard movements by small groups of misadventurers from one staging post to another through the island world of southeast Asia. From the new perspective, Bowdler's thesis of Sahul colonisation (this volume) following quickly on the settlement of Sunda by the parent populations seems quite credible, whatever happens to it in the future as a result of discoveries in southeast Asia or the refinement of dating methods which currently have problems in the critical time range. The same, of course, goes for Allen's complementary thesis (1989) of a Birdsell-type settlement process (Birdsell 1957) within Sahul itself, covering a few millennia around 35,000 radiocarbon years ago. Both propositions are very compatible with what we know of later colonising episodes of virgin territories within our region, though these involved movement across

water. I refer, of course, to the swift expansion of Lapita through the southwest Pacific and beyond (Spriggs 1990), but also to the colonisation of New Zealand, where the archaeological signature is virtually instantaneous across the entire country (Anderson 1991). What I am suggesting is that in new territories colonisation, whether by land or sea, proceeded more quickly than models of population pressure might indicate.

There are all sorts of implications in the new scenarios, which sooner or later the evidence will stack up for or against. There is the matter of a common culture being established over wide areas by the colonising groups, which Bowdler (this volume) has emphasised in the case of southeast Asia and our region. There is also the possibility to which Gosden (this volume) has referred, given the apparent proficiency in sea-going revealed by the Pleistocene evidence, of continuing contacts with and from the outside world, which might make developments in northern Sahul more complex than we have perhaps assumed. Questions like these are ones of culture history, and culture history has not found much favour with any of the schools of archaeology that have developed since I began to be professionally employed.

Indeed, at that time, there were no schools, properly so-called, at all. The archaeology in which I was brought up has only come to be known as the traditional school – or mainstream archaeology as I have seen it described – by contrast with what has happened in the discipline subsequently. In David Clarke's phrase (1973) it lost its innocence. And, in the years of its innocence, archaeology, or at least the European variety, was firmly aligned with history.

We all have our particular reasons for choosing to be archaeologists rather than geographers or sociologists. It was precisely the historical dimension of archaeology that was mine. I was, am and will continue to be enthralled by the range and sweep of the human story as it is revealed by archaeological research and I am perpetually amazed by what is achieved out of our frequently obdurate and unpromising material evidence, thankfully illuminated from time to time by Pompeii and its equivalents. I am aware that the archaeological enterprise is flawed by technical, methodological and theoretical shortcomings, but believe that techniques improve, methodologies are tested and theory is sharpened at the middle range. As for ideological predispositions, conventional historians live very easily with the thought that each generation rewrites history in the light of its own concerns. Even so, I have yet to be convinced that all our conclusions are relative and contingent and that, to use the forbidden word, we have made no

progress in our knowledge, even our understanding, of the past. Having said that, I have no doubt exposed the threadbare state of my theoretical undergarments. Given the theoretical hypersophistication of the age in which the latter years of my professional career have come to be spent, I can only say, like the jazz musician, Eubie Blake, interviewed on his 100th birthday, 'If I'd known I was gonna live this long, I'd have taken better care of myself.'

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APPENDIX

A REVISED BIBLIOGRAPHY OF PLEISTOCENE ARCHAEOLOGICAL SITES IN AUSTRALIA, NEW GUINEA AND ISLAND MELANESIA

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The literature relating to the late Pleistocene archaeology of Sahul is extensive and fragmented. In this bibliography, our aim is to bring together primary source material for those archaeological sites which have a Pleistocene component. These are listed in Smith and Sharp (this volume, Table 1). When using this bibliography it will be helpful to remember that it has a site-focus rather than a period-focus. For each of the sites listed we have attempted to collate all references relating to that site, **irrespective** of whether these deal with Pleistocene or Holocene material. The intention here is to provide as full a picture as possible of the sites – their structure, geomorphology, archaeological contents and chronology, as well as an indication of the extent of research concerning particular sites. Because sites have often been reported in a piecemeal fashion the distinction between primary and secondary sources is not at all clear cut. In this bibliography we have included any references that report basic information about a site. Generally we have excluded review articles, synthetic works and articles that deal with interpretation, except where they also report basic site data. In many cases radiocarbon dates, or other crucial bits of basic information about a site, are tucked away in broad ranging review papers. This should be kept in mind when using the site index, otherwise the reasons for listing some references under a particular site name may be somewhat obscure.

This bibliography is based on an annotated bibliography published by the Australian Heritage Commission in time for the 1991 Australian Archaeological Association Conference (N.D. Sharp and M.A. Smith, 1991 *Late Pleistocene Archaeological Sites in Australia, New Guinea and Island Melanesia*. Australian Heritage Commission Bibliography Series – No. 6). This was extensively revised following that meeting. The updated version presented below includes over 100 additional references, new site and subject indexes, and a list of alternative site names.

The bibliography is in three parts:

- A. An alphabetical listing of references, numbered consecutively.
- B. A subject index dealing primarily with aspects of the Pleistocene evidence.
- C. A site index, consisting of an alphabetical listing of sites together with a list of the works that present primary data, Pleistocene or Holocene, for each of these sites.

ABBREVIATIONS

ACT	Australian Capital Territory
NSW	New South Wales
NT	Northern Territory
PNG	Papua New Guinea
QLD	Queensland
SA	South Australia
TAS	Tasmania
VIC	Victoria
WA	Western Australia

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