ORIGINS OF THE WEIPA SHELL MOUNDS

by

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A thesis submitted for the degree of Master of Science at the Australian National University.

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Except where otherwise acknowledged, all the work presented here is my own. The research undertaken here has not been presented as part of the requirements for any other degree.

T. Stone
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ABSTRACT

The shell mounds at Weipa on the west coast of Cape York Peninsula are thought by archaeologists to be among the world's largest prehistoric middens. The mounds appear to be composed almost entirely of whole and fragmented shell valves of the cockle *Anadara granosa* and artefacts have been recovered from them. Stone (1989), however, proposed that the tall, steep-sided shell mounds were not built by shellfishing Aborigines but by generations of mound-building Scrubfowl *Megapodius reinwardt*. This thesis aims to determine the tenability of the Scrubfowl hypothesis by first testing the hypothesis of human origin. It then aims to establish a geographical and chronological context in which to interpret the origins of the shell mounds.

From the literature it is evident that physical and biological processes of mound formation are far more certain and universal than cultural processes. Cheniers and barriers are common features of the world's coastlines and may form mounds through quirks of sediment supply or erosion. Mound-building organisms include megapodes, termites and ants, alligators and crocodiles, and fossorial rodents. Human occupation mounds are distinguishable by architectural features and related cultural remains. Mounds of doubtful human origin include the shell mounds of the Americas, Europe and southeast Asia. These mounds have morphostratigraphic features which strongly suggest that they are natural shoreline deposits, not massive shell middens. In the Andaman Islands, New Caledonia and southeastern Australia there are also mounds considered cultural in origin which may have been built by megapodes.

The hypothesis that the Weipa shell mounds are the result of repeated Aboriginal shellfishing and occupation has been tested by dating a sequence of ten shells from the Kwanter mound. The results show that most of the shells in the sequence are roughly the same radiocarbon age. This casts serious doubt on the hypothesis of human origin. An examination of the interior surfaces of a selection of shell valves was also undertaken to determine if the shells contain any evidence for shellfish death offshore. Although microborings likely to have been produced by endolithic cyanobacteria were recorded, it is possible that these are post-depositional in origin as seven genera of cyanobacteria have been cultured from the shells.

Mapping and auguring of coastal deposits at two locations along the Mission River has revealed the natural origins of some of the Weipa shell mounds. Essentially, the growth of the mounds reflects the development of the local chenier plains. Shell mounds have formed where the sea has concentrated coarse *Anadara granosa* shell whereas mounds composed of sand and gravel are present where these sediments predominate. At Prumanung whole *Anadara* valves have been transported by wave-action to the crest of the modern beach forming a coarse shell berm. At Uningan the prominent shell mounds originated as small, isolated shell cheniers. The hypothesis that Scrubfowl have transformed these natural shell deposits into tall, steep-sided mounds is tenable. Habitats favourable to Scrubfowl are associated with each location.

Stanner's (1961) belief in the natural origins of the Weipa shell mounds is supported by this thesis. Only the mound-building Scrubfowl is needed to explain their unusual shapes and vertical exaggeration. The strong likelihood that these mounds are natural shell deposits raises serious questions about basic principles of shell midden archaeology. It is concluded that new methods for distinguishing between natural and cultural shell deposits are needed.
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CHAPTER 1

INTRODUCTION

This has got to be the residue of the biggest feed in history ("The Bush Tucker Man", Major Les Hiddins, on scrambling up the sides of a large shell mound at Weipa).

Weipa is a bauxite mining township located near Albatross Bay in far north Queensland (Fig. 1.1). Archaeologists have recorded numerous large conical shell mounds near Weipa and presented these as among the world's largest prehistoric middens (e.g. Bailey, 1975). The Weipa shell mounds have since been listed on the Register of the National Estate. Although regarded by archaeologists as solely the product of intensive Aboriginal shellfishing, the precise origins of the shell mounds have remained shrouded in mystery.

Bailey (1977, 1983) has estimated that there are about 500 distinctive shell mounds around Weipa with clusters located mainly along the banks of four tidal rivers which flow into Albatross Bay. These are the Pine, Mission, Embley and Hey Rivers (Fig. 1.2). The Weipa mounds vary widely in size and shape ranging from shell scatters 3m in diameter to steep-sided mounds up to 250m x 50m in base area and 10m high (Bailey, 1983). Of the 304 mounds inspected closely by Bailey (1977) the majority (80%) were less than 2m thick. Bailey (1983) claimed that the mounds were composed almost entirely (95%) of shells of the bivalve \textit{Anadara granosa}. Wright (1963) however, observed varying proportions of shell and earth in them. Bailey's (1977, 1983) excavation of the Kwamter shell mound, excavated previously by Wright (1963, 1971), recovered fish and marsupial remains and some 25 stone and bone artefacts. Thin lenses of ash and fine charcoal were also revealed. A series of radiocarbon dates suggested that the Kwamter mound built up over the last 1200 years.
Figure 1.1 Cape York Peninsula and the study area.
Figure 1.2 Map of the Weipa area showing the general distribution of shell mounds (shell mound distribution after Bailey, 1983:Fig.1).
Similar mounds have been recorded by archaeologists elsewhere in northern Australia (Fig. 1.3). Differences between these mounds and the Weipa mounds are apparent mostly in composition. Near the Love River south of Weipa Cribb (1986) recorded 28 shell mounds of the 'Weipa type' which also seemed to consist almost entirely (99%) of *Anadara granosa*. One exception was a large shell mound on the Ward River which appeared to Cribb *et al* (1988) to contain roughly equal proportions of *Geloina* (mud shell) and *Telescopium telescopium* (mud whelk). Cribb (1986) also described many other mounds in the Aurukun region as consisting of either earth or variable layers of earth, shell and clay. Only on the surface of one of these mounds did Cribb record stone artefacts in any number.

At Princess Charlotte Bay on the east coast of Cape York Peninsula Beaton (1985) recorded 38 shell mounds of which 13 were excavated or sectioned. One of the largest of these, the South Mound, was excavated by backhoe to a depth of 2.4m (Fig. 1.4). Its section revealed contrasting layers of *Anadara granosa*, either rich or poor in dark silty sediment. The remains of turtle and a few fish were also recorded along with a few small lenses of burned wood. No stone or bone artefacts were detected. Beaton obtained a total of 27 radiocarbon dates from the South Mound which ranged between c.1930 years BP (ANU 3038) and c.660 years BP (ANU 3383). Its basal date was around 1700 years BP (Beta 1754). Beaton also obtained dates from the basal layers of nine other shell mounds in the area but details are sketchy. According to Beaton 'the period around 1200-800 years BP saw the production of more numerous (and larger) mounds.' On the basis of five dates from unspecified shell mound surfaces he claimed that large-scale *Anadara* deposition ceased around 500-400 years BP.

In the Northern Territory the large shell mounds of Millingimbi Island have long attracted the curious (e.g. Barrett, 1941:126, Chaseling, 1957:26). In 1927 the anthropologist Warner (1958:455) excavated 'eight feet of shell' from the Macassar Well mound and recorded numerous Aboriginal artefacts throughout the deposit. Because of the association of Tamarind trees with the mound he had hoped to find evidence of early Macassan contact but was unsuccessful. In 1948 McCarthy and Setzler (1960:230-250)
Figure 1.3 Locations of shell and earth mounds recorded by archaeologists in northern Australia.
Figure 1.4 The South Mound, Princess Charlotte Bay, Queensland (from Beaton, 1985:Fig.2).
excavated two more trenches into this mound and produced the first detailed diagrams of a northern Australian mound (Fig. 1.5). In section, they identified four varying stratigraphic units which consisted respectively of topsoil, ashes and shells; loose cockle shells; a dense mass of shells and ash; and consolidated soil and shells. They also identified human bone fragments beneath the mound surface.

Two other shell mounds on Millingimbi Island were excavated by McCarthy and Setzler (1960:244) but details are scarce. One of these, the Wallaby mound, contained 'millions of whole and burned cockle shells' but no artefacts while the other, much larger, shell mound produced only four artefacts. This larger mound had been quarried for airstrip construction. Its original height was estimated to have been about 7m. In 1965 Mulvaney (1975:248, 1981) collected charcoal from the base of the Wallaby mound and from the base of the much larger Garrki shell mound located nearby. This returned ages of around 1200 years BP (ANU 1265) and 1300 years BP (V-61) respectively. The Garrki shell mound may have been the same disturbed large mound excavated earlier by McCarthy and Setzler.

Shell mounds up to 5m in height have also been investigated on the mainland south of Millingimbi Island. Near the mouth of the Glyde River Peterson (1973) recorded four shell mounds which appeared, like most others, to be dominated by Anadara shell. However, surface samples taken by Meehan (1982:168) from two shell mounds in the Blyth River region showed one to be dominated by Dosinia juvenilis (91%) and another by Coecella horsfieldi (83%), both bivalves. Aboriginal beliefs about how shell mounds form are a feature of these two studies (Peterson, 1973; Meehan, 1982).

Earth mounds are another type of deposit commonly found in northern Australia which archaeologists have attributed to the subsistence activities of Aborigines. These mounds are often similar in morphology to the shell mounds and have been reported mostly from coastal parts of the Northern Territory. Peterson (1973) surveyed a cluster of 17 earth mounds on the edge of the Arafura Swamp south of Millingimbi Island and
Figure 1.5 The Macassar Well shell mound, Millingimbi, Northern Territory (from McCarthy and Setzler, 1960).
inspected six other mound clusters in the area. He described these mounds as being 'usually less than 40 ft. in diameter and 4 ft. in height' and 'composed almost exclusively of earth.' On the surface of two of these he recorded the recent remains of Aboriginal camping and cooking activity. This included stone artefacts, shell, animal bone and termite nodules. Meehan (1988) has investigated similar earth mounds around the wetlands of the neighbouring Blyth River area. These also contain artefacts, termite mound nodules and organic material. Preliminary results indicate that construction of the Blyth River earth mounds began about 1500 years ago (Meehan, 1988).

On the edge of the Adelaide River floodplain near Humpty Doo White (1968) excavated a 1.5m high earth mound, the largest of three, and recovered 'numerous fragments of charcoal, animal and human bones, shells and stone and bone tools'. Smith (1981) located a further nine earth mounds in the Humpty Doo area and at Kapalga on the edge of the South Alligator River floodplain he located five more. Smith (1981) noted that the Kapalga mounds are 'considerably larger than those recorded by Peterson (1973) for Arnhem Land'. Also near the South Alligator River Meehan et al (1985) excavated the 0.7m high Ki'na mound and recorded clusters of low earth mounds at three other locations in the area. The Ki'na mound, consisting largely of dark silt and clay, also contained some freshwater mussel shell. Excavation produced a total of 614 stone artefacts. Charcoal and shell from this mound was dated to around 280 years BP (ANU 3212) but Meehan et al (1985) considered it more likely that the mound formed between 500-1000 years ago.

In summary, the Weipa mounds are but one group among many investigated by archaeologists and anthropologists in northern Australia. Their descriptions give the impression that there are basically three types of mound:

1. Shell mounds dominated by a single species of bivalve (Weipa, Love River, Princess Charlotte Bay, Millingimbi, Glyde River, Blyth River)

2. Mounds containing a mixture of shell and earth (Weipa, Aurukun, Millingimbi)
3. Earth mounds (Aurukun, Arafura Swamp, Blyth River, Adelaide River, South Alligator River)

These mounds often contain Aboriginal stone or bone artefacts, and from two mounds, fragments of human bone have been identified. Other mound features interpreted by archaeologists as 'cultural' include shell, charcoal and ash lenses, animal bone and nodules of termite mound. Radiocarbon dates have been obtained for four shell mounds and one earth mound. These suggest that shell mound construction began between 1700 and 1100 years ago. Earth mounds would appear to be of a more recent age.

1.1 Archaeological Theories of Mound Formation

The widely held belief that Aborigines had somehow built the large shell and earth mounds of northern Australia can be traced back to the earliest days of European settlement in the region. On a visit to the Cobourg Peninsula in 1840 the naturalist John Gilbert noted that local settlers referred to the mounds as the 'tumuli of the aborigines' (Gould, 1865:168).

The earliest account of the shell mounds of western Cape York may be that of Queensland government geologist Robert Logan-Jack (1921:534). While exploring along the Archer River in 1879 he described 'enormous heaps of mussel-shells accumulated by the natives'. Some twenty years later the Weipa shell mounds were visited by the ethnographer W.E. Roth (1901) who used the term 'middens' to describe them. The geologist C.F.V. Jackson (1902) also visited Weipa and described the mounds as 'remarkable midden heaps'. Roth's (1901) interpretation of how the shell mounds formed differs little from the explanations offered by present-day archaeologists:

On the tops of certain of them may be seen remains of fires and huts, the shells, after cooking, having been thrown down the sides. Considering the total number of tons of shell comprising these mounds must be reckoned in hundreds, probably thousands, and that the local population is comparatively scarce, the progress of their formation has evidently been going on for several generations.
past. In view of the fact that these middens can be scaled only with difficulty, and that an aboriginal will not exert himself physically any more than is absolutely necessary, it seems feasible that the natives have purposely cooked and camped on the summits to avoid mosquitoes and sand-flies, and so have unconsciously been continually increasing, year by year, the height up which they have had to climb.

Roth's (1901) early ideas about how the Weipa shell mounds formed were first tested by Wright (1963) whose limited excavations lent archaeological credibility to Roth's interpretation. Wright concluded that the Weipa shell mounds were indeed cultural in origin because:

1. they were entirely superficial,

2. there were artefacts throughout the two mounds he excavated,

3. there were bands of charcoal and beds of ash, and

4. selectivity was apparent in the shellfish species represented.

Bailey (1977) later remarked that these attributes were the 'classic distinguishing marks of midden deposits' while Mulvaney (1975:246) wrote that the presence of charcoal concentrations, faunal remains and artefacts 'prove' that the mounds are human in origin. Roth's reference to huts and fireplaces was described by Wright (1964) as 'tantalising' and he later wrote that it must have been 'culturally desirable to dispose of shells in heaps' (Wright, 1971).

Roth's basic idea was developed further by Bailey on the understanding that the Weipa shell mounds met the criteria necessary for them to be considered Aboriginal midden deposits. As Roth had observed huts and fireplaces on mound-tops it appeared that there had to be a connection. Bailey (1977) proposed that the basic unit of mound habitation, and thus mound formation, was a small Aboriginal family living in a hut. Shells accumulated in a process of upward growth as Aboriginal families returned to camp on their domestic residue. Bailey believed that the size and shape of the mounds reflected the frequency of habitation events in a preferred location.
At the base of the Kwanter mound Bailey (1977) detected an extensive layer of shells that were lighter and more brittle than the shells above it. This suggested to him that the mound originated as a shell scatter or low deposit and later grew upwards as the shells became confined to a more restricted area. Ethnographic observations of Aboriginal shellfishing appeared to be relevant (Peterson, 1973). In the belief that shellfishing led to mound growth Peterson (1973) described a low scatter of shell on a beach in Arnhem Land as an 'incipient shell mound'. As Aborigines were camping on this low scatter at the time Peterson concluded that this represented the essential process of mound formation. That is, families would camp on the shell scatter in various locations, and gradually, enough shells would accumulate to form a steep-sided conical mound, until finally, there would be room at the top for only one hut.

A very similar hypothetical scenario was depicted in a series of drawings by Cribb (1986) who needed only a few trees for Roth's idea to make sense to him (Fig.1.6). As Aborigines often seek shade to have their meals under Cribb proposed that shell mound growth was initiated and sustained by trees growing on the mound. He considered that the platforms and foothills of some mounds may represent the migration of shade patterns across a mound as individual trees died and were replaced by others. Beaton's (1985) explanation of the South Mound was more simple. He regarded this mound as basically an *Anadara* dump formed by the repeated dumping of numerous small loads of shell over the mound area. It appeared to Beaton that these dumping events had come with such frequency that they obscured the mound's stratigraphy making it impossible to identify archaeologically separable lenses.

Earth mounds are also believed by archaeologists to be the result of Aboriginal domestic activity. In this case they attribute them not to the dumping or gradual build-up of shell but to the break-up of termite mound pieces used as heat retainers in cooking. Peterson (1973) wrote that 'mounds represent a deliberate construction later added to by the making of ovens'. To show how Aborigines used these mounds Peterson (1973) had one family build a hut on top of an earth mound and then took a photograph of them living in it.
An hypothetical sequence in the evolution of a shell mound:
a) initial use; b) initial accumulation and vegetation
growth; c) continued siltation and accumulation, formation of
salt pan and mangrove; d) further accumulation following
shade patterns, erosion of silt plains and mangrove develop-
ment.

Figure 1.6 The view widely held by archaeologists of how shell mounds form
(from Cribb, 1986).
Meehan et al (1985) claimed that the dark silty earth of the Ki'na mound probably derived from lumps of termite mound brought in by Aborigines to use in their earth ovens. They calculated that the weight of the Ki'na mound could be accounted for by only 40 such ovens a year. Ethnographic observations are again used to reinforce these beliefs. Near the Blyth River Meehan (1988) saw an Aborigine take two dead wallabies to the edge of an earth mound and cook them with 50kg of termite nest pieces. She wrote that 'this process was identical to those which, over 1500 years, have caused Djibena mound to rise to two metres above the level of the plain'.

In general, archaeologists have claimed that shell and earth mounds formed largely in response to the seasonal flooding of much of the low-level land on which many of them are located. They believe that mounds were positioned so that Aborigines could be as close as possible to marine or wetland resources, and at the same time, have a dry place to camp on (e.g. Peterson, 1973; Bailey, 1977; Meehan, 1988). Being able to escape insect pests, catch a breeze, and look out for enemies also seemed to them to be important factors in mound construction. Bailey (1983) explained the Weipa shell mounds as being the product of a prolific supply of Anadara, good preservational conditions and a pattern of discard which concentrated shell in particular locations. On a broader scale Beaton (1985) linked the formation of shell mounds to Aboriginal population growth. In summing up the Weipa shell mounds Flood (1990:125) wrote that their formation was consistent 'with archaeological evidence from other parts of Australia for a period of increased activity, population expansion or "intensification" over recent millenia'.

1.2 Aboriginal Beliefs

Many Aboriginal groups across northern Australia have beliefs about how shell and earth mounds were made and it may be significant that no group, on present anthropological evidence, actually believes that their predecessors constructed the mounds. In fact, Peterson (1973) recorded that the people of the Arafura Swamp
recognize the earth mounds there as simply:

isolated patches that remain dry in areas that flood. They do not recognize them as being made by man, assuming them to be natural in this area.

Similarly, Meehan (1982:167) wrote the following with regard to the large shell mounds of the Blyth River area:

These have an obvious human origin, but the Anbarra say that they are not the work of man but of the 'dreaming'.

Regardless of their origins large shell mounds are known to have considerable mythological significance. Peterson (1973) wrote that Aborigines attribute the large Millingimbi Island shell mounds 'to the activities of the local ancestral hero looking for fresh water on the flats, scooping up the mounds in the process'. Meehan (1982:167) recorded that in the Blyth River area this 'ancestral hero' took the form of a dog, scratching up the shell with its paws, or a stingray, making the mounds as it flapped across the land.

One aspect of these accounts which should not be overlooked is that Aborigines in Arnhem Land have classified large shell mounds and much smaller Aboriginal shell midden deposits into completely different categories (Peterson, 1973; Meehan, 1982:167). They believe that large shell mounds do not have a human origin. On the other hand, they recognise shell middens, under a metre in thickness, as the camps of 'dead men' (Meehan, 1982:166). Although archaeologists claim that both types of shell deposit are of human origin it is clear that these Aborigines regard large shell mounds as being in a separate non-human category.

Similarly, Aborigines of the west coast of Cape York attribute large shell mounds to the stirrings of mythological beings and not to the mundane activities of their human predecessors. Of the Love River shell mounds Cribb et al. (1988) wrote that local Aborigines did not regard these as ever being traditional camping sites. Instead they were associated with two mythical carpet snakes whose coils pushed up the shell mounds as

At Weipa Moore (1963) reported a story told by a very old Aboriginal woman to explain the shell mounds along the banks of the Embley River. What makes this story so interesting is that she attributed the mounds to a pair of birds, albeit mythical ones. These birds were also collectors of cockle shells. As Moore recounted it, one was a waterhen called Wong-wong who was the wife of a lazy ibis called Nuanda. As Nuanda would not help his wife after she had gathered all the cockle shells she left him with her son. They ran off along the banks of the Embley River in such a hurry that Wong-wong's cockle shells fell out of her dilly-bag forming the large piles of shell visible today. This story, recorded in 1963, may represent one of the last untainted Aboriginal accounts of the Weipa shell mounds for, since then, the Aborigines of Weipa have played host to teams of archaeologists who have told them a different story.

1.3 Stanner's Dissent

Stanner (1961) foreshadowed the controversy surrounding the Weipa shell mounds when, after a field trip in October 1958, he argued cogently for a natural origin for their formation. Aware of the importance of context Stanner noted that the distribution of shell mounds around Weipa conformed closely to the pattern of the coastline with the long axis of each mound running roughly parallel to the present shoreline. Many of these mounds and connecting shell ridges had been cut by small creeks suggesting that the drainage pattern post-dated the formation of the mounds. For these basic reasons Stanner concluded that the mounds 'resulted from the same processes that shaped the estuary and on much the same broad plan'. 
Stanner felt confident with this assessment because visiting Weipa at the same time was the geomorphologist Hartmut Valentin with whom Stanner was able to swap notes. Valentin told Stanner that 'there was no reason to suppose that the mounds were of human origin, and their appearance suggested a natural origin'. Later however, Valentin (1959) changed his mind and wrote that the mounds were 'most probably' Aboriginal middens. At this Stanner lamented the making of a myth as Valentin went on to write, as if it were established fact, that 'the aborigines were witness of this high stand of the ocean as is shown by their kitchen-middens around the Hey River estuary'.

As Valentin had not examined the mounds as closely as himself Stanner was unmoved but he did acknowledge the difficulty of explaining more precisely the mounds as natural phenomena. Stanner envisaged, not a natural catastrophe as some thought he did to explain the mounds (e.g. Wright, 1971), but a complex series of environmental changes including those associated with fluctuating sea-levels, climatic change and tectonics. According to Stanner the mounds were most probably deposited by wave action, as suggested by their pattern of distribution, while their variable size may be a reflection of environmental change through time.

Although Stanner had difficulty in identifying specific mechanisms which led to shell mound formation he was adamant that they could not have been constructed by Aborigines. His reasons for this were based on close examination of the mounds and some excavation. Stanner claimed that the shells in the mounds showed no traces of human interference or calcination by fire and that the majority of bivalves were laid down whole in conditions that did not un hinge them. In attempting to demonstrate that the presence of whole, unopened shells could be explained in other than natural terms Bailey (1977) cooked 50 bivalves the Aboriginal way and found that four had returned to an unopened state after the meat had been extracted.

Another feature of the Weipa mounds which Stanner considered to be inconsistent with theories of human origin is that the shell is not densely compacted but loose like scree. There is no evidence of a long process of bedding or settling down that
would be expected if the mounds were lived on by Aborigines. One section of a mound showed layers of silt and carbon which Stanner interpreted as the result of discontinuous growth and periodic bushfires. These layers may be similar to the lenses of ash and fine charcoal in the Kwanter mound interpreted by Bailey (1983) as the 'remains of hearths'. Stanner however, an accomplished anthropologist, simply could not link Aboriginal behaviour, present or recent past, to the construction of the mounds. He clearly preferred a geographical approach to solving the problem and sagely wrote:

The difficulty of explaining them as natural phenomena may mean only that we have not enough facts to go on and have not used imaginatively the principles which are understood (Stanner, 1961).

1.4 Stone's Hypothesis

Stone (1989) claimed that archaeologists had created a myth. According to him the large shell and earth mounds of northern Australia were not built by Aborigines at all but by generations of nesting birds. These were of a species of mound building megapode known as Megapodius reinwardt or the Orange-footed Scrubfowl (Plate 1.1). These birds rake up soil and shell debris with their large feet eventually forming large mounds in which to incubate their eggs. Struck by the similarity between Scrubfowl mounds and allegedly Aboriginal mounds Stone believed he had identified the natural process of mound formation which had eluded earlier researchers (see also Stone, 1991a).

Scrubfowl mounds and 'Aboriginal' mounds are similar in size, shape, appearance and distribution which suggested to Stone that ecologists and archaeologists had been writing about basically the same thing. Both groups of mounds may reach heights of up to 10m or more and their shapes can vary from tall, conical mounds to long, steep-sided ridges. Both groups are commonly located in clusters along the edges of tidal rivers, beaches, mangrove swamps and freshwater wetlands and may be composed of almost any sediment including shell. At a broader level mounds recorded by both ecologists and archaeologists tend to cluster around latitude 12 degrees and conform
Plate 1.1 John Gould's illustration of the Orange-footed Scrubfowl *Megapodius reinwardt* (from Gould, 1967). Note the activity on the mound in the background.
closely to the known distribution of the Scrubfowl in Australia (Fig. 1.7).

Like Stanner (1961), Stone was very sceptical about claims that Aborigines were responsible for mound growth. As these mounds were highly variable in composition Stone suspected that multiple processes had been at work. In structure, little could be seen that was consistent with archaeological theories of mound formation. No complete assemblages or 'living floors' had been identified beneath any mound surface and what few stone artefacts there were seemed to be distributed only randomly throughout some mounds. The dates from the South Mound were not really in sequence and rather suggested periodic mixing or reworking. Ethnographic observations purporting to link Aboriginal activity to mound growth appeared to be little more than wishful thinking.

To account for the presence of cultural material in some mounds Stone proposed a connection between the nesting activities of Scrubfowl and the discard behaviour of Aborigines. That is, artefacts and shell were present in some mounds as the result of either Scrubfowl raking up Aboriginal debris from nearby middens or campsites or Aborigines leaving their debris directly on the surface of abandoned Scrubfowl mounds. He contended that large shell and earth mounds were essentially 'source-bordering' features and that their composition reflected the lateral variation in surface material around the mound site. This material included middens which could be easily reworked by the birds. Excluded from this hypothesis were low mounds or scatters of shell which Stone considered to have a better chance of being undisturbed Aboriginal middens. At Weipa Bailey (1977) estimated that 56% of the 304 mounds which he examined were under 1m in thickness.

In the belief that the large shell and earth mounds of northern Australia were primarily Scrubfowl mounds Stone reinterpreted archaeological data on mounds in the context of recent developments in palaeoecological theory. Research by Stocker (1971) and Russell-Smith (1986) had shown that the presence of abandoned Scrubfowl mounds in eucalypt woodland may be used to infer that these areas once supported the bird's monsoon vine forest (MVF) habitat. In comparing Russell-Smith and Dunlop's
Figure 1.7 Distribution of recorded mound sites and Scrubfowl (shaded) in northern Australia (from Stone, 1989:Fig.1). Scrubfowl distribution after Blakers et al (1984:112).
schematic representation of the distribution of MVF habitat types in the landscape (Fig. 1.8) with Bailey's distribution map of shell mounds in the Weipa area (see Fig. 1.2). Stone observed that all the Weipa mounds are located precisely where Russell-Smith and Dunlop's diagram suggests that MVF is most likely to have been. Because the Weipa mounds are now located mostly in woodland or open environments Stone concluded that local MVF communities had contracted significantly.

Finally, Stone placed dated shell and earth mounds from across northern Australia in their geochronological context. This suggested that the scientific value of Scrubfowl mounds may lie in their potential as 'palaeoclimatic indicators' as well as being general indicators of environmental change. From analysis of the regional chenier record Lees and Clements (1987) drew palaeoclimatic inferences and proposed that the period 1600-2800 years BP was a period of reduced wet season rainfall in northern Australia. As many shell mounds are located on chenier plains Stone thought that there may be a connection. He noted that available dates for the commencement of shell mound growth in the region cluster between 1100 and 1800 years BP and proposed that this may be related to the change to possibly wetter conditions around 1600 years BP. These conditions may have encouraged the spread of monsoon vine forest and an expansion in Scrubfowl numbers, hence the growth of most mounds from 1800 years BP onwards.

Stone was in no doubt that the archaeological significance of northern Australian shell and earth mounds needed to be reassessed. He alleged that archaeologists may have been selective in their presentation of field evidence and that the Weipa mounds, if recorded properly, would probably vary as much in composition as other mounds in northern Australia. He further suggested that the bird hypothesis could be extended to parts of southern Australia, such as the Murray River valley and western Victoria, where some clusters of allegedly Aboriginal earth mounds could perhaps be just as easily attributed to another species of mound-building megapode, the Malleefowl (*Leipoa ocellata*).
Figure 1.8 Typical distribution of monsoon vine forest in northern Australia (from Russell-Smith and Dunlop, 1984).
The last word in Stone's paper was left to David Burrumarra, a resident of Elcho Island and one of the most senior traditional Aboriginal men in Arnhem Land. He was also a chief informant to the noted anthropologist R.M. Berndt. When local school teacher Ian Macintosh showed him a photograph of the Garrki shell mound Burrumarra described it as a birds' nest. According to Macintosh he was adamant that Aborigines had nothing to do with mound construction. He said that the Scrubfowl rake up whatever is there. The Yolngu people have no story about their predecessors making the mounds. There are, however, many stories about Scrubfowl, their mounds and eggs which are all sacred and belong to the Yirritja moiety.

1.5 Controversy

Needless to say, archaeologists did not appreciate Stone (1989) turning their data upside down and interpreting it in a fundamentally different light. Stone's hypothesis drew heated criticisms from Bailey (1991) and Cribb (1991), two leading exponents of the belief that Aborigines made the mounds. Their reaction contrasted to some degree and Stone (1991b) replied. While Cribb (1991) wished to dispute 'most vigorously' an imagined claim that all mounded features in northern Australia are the work of Scrubfowl, Bailey (1991) took a more dogmatic view stating:

To assert that these (the Weipa shell mounds) are scrub-fowl mounds is to fly in the face of logic, plausibility, field observations, and what is known of shell middens elsewhere in Australia and in other parts of the world.

Bailey (1991) insisted that the logic of his original argument was water-tight and reiterated much of it. He claimed that Aborigines must have built the mounds because it was clear that they liked to camp on top of them, and that they did so to keep dry during the wet season and gain an economic benefit from being near their resources. This he claimed was 'very well established' and that the distribution of mounds around Weipa was a reflection of this. He considered this to be 'the only serious hypothesis in sight'.
On locational criteria, Bailey could not accept that any of the Weipa shell mounds were built by Scrubfowl. He believed that Scrubfowl mounds should only be associated with sandy ridges or sandy soil and forest edge conditions on the sandstone plateau. None, he claimed, should be found on the low-lying floodplain (meaning chenier plain), and in particular, none should be lying directly on mangrove mudflats or saltpans. As 36% of the Weipa shell mounds are sitting directly on the floodplain surface Bailey considered that the Scrubfowl hypothesis could not be supported without invoking 'quite massive and implausible changes of coastal environment and geomorphology'.

Bailey disputed Stone's (1989) claim that the Weipa shell mounds would vary widely in composition if examined more carefully and insisted that *Anadara* shell is the overwhelmingly dominant constituent of all the Weipa mounds. He stated that they do not exhibit wide variation in shell/soil ratios. Wright's (1963) excavations, however, revealed 'differential' shell/soil ratios. Of northern Australian mounds in general, Bailey did concede that there were those of varying size and composition whose interpretation is more controversial.

One possibility suggested by Stone (1989) to account for the abundance of *Anadara* shell in the Kwamter mound was that earth materials could have been washed or leached out of the mound particularly as removal of the forest cover would have greatly increased the impact of rainfall. Bailey considered this to be a 'hypothesis of extraordinary implausibility' because there was no evidence of any redeposited material and the Kwamter mound section showed a series of intact, ashy lenses, which were undisturbed.

Finally, Bailey thought that Stone (1989) had used low artefact density in the Kwamter mound as further evidence for the Scrubfowl hypothesis. Bailey stated that artefact density in the Kwamter mound was not exceptional by midden standards and contended that the absence of complete assemblages or living floors was a feature common to most open-air shell middens in the world. Furthermore, he claimed that shell
mound formation was entirely consistent with what is known ethnographically of Aboriginal shell gathering behaviour.

Unlike Bailey, Cribb (1991) thought that Stone's hypothesis had some merit and was prepared to accept that some shell and earth mounds he had recorded in the Aurukun region were in fact Scrubfowl mounds partly constructed from midden material. He stated that shallow shell middens on sand are readily converted into mounded middens by Scrubfowl. Cribb however, argued that there were also 'oven mounds' made of earth and 'true shell mounds' both of which were of purely human origin with completely different locational characteristics. Cribb claimed that Scrubfowl mounds are located randomly along dune ridges which support MVF while 'true shell mounds' are heavily concentrated in a very narrow ecotone along the edges of silt (chenier) plains. He did not consider it possible for Scrubfowl to have ever occupied this ecotone. Furthermore, he considered shell mounds on silt to be 'discrete occurrences' and if they were Scrubfowl mounds he could not account for the original source of midden material.

In commenting on mound composition Cribb was apparently in two minds. On the one hand he stated that there are mounded middens built by Scrubfowl partly from Aboriginal debris and partly from loose sand and earth. On the other he stated that there is no continuum from earth mounds to shell mounds. Scrubfowl, he continued, would have logistical difficulties in building mounds out of shell and therefore could not be responsible for shell mound growth. Cribb also claimed that the internal structure of shell mounds is fundamentally different from that of Scrubfowl mounds. He interpreted the South Mound section as showing clear micro-stratigraphy, a regular layer-cake, and claimed that similar features were not as clearly defined in Scrubfowl mounds. According to Cribb the shell mounds could only have been built by Aborigines and the best evidence of this is three low shell mounds on the Love River each with a doughnut shape and a depression thought to be hut foundations.
Cribb concluded his criticisms on a political note by declaring that Stone's hypothesis would have an impact on Aboriginal Land Rights, National Estate listings and other environmental issues and as far as Cape York is concerned it 'could not have come at a worse time'.

In his response Stone (1991b) questioned whether Bailey and Cribb really had provided sensible arguments or proof for their case that Aborigines, not Scrubfowl, had made the mounds. Stone dismissed Bailey's 'water-tight logic' as being essentially circular. It assumed that as there were economic attractions to camping on sodden low-lying ground Aborigines must have built the mounds which proves that it was economically attractive to do so in the first place. This reasoning forms the basis for Bailey's belief that it is 'very well established' that Aborigines prefer living on mounds. Cribb's claim that Aborigines were still responsible for 'true shell mounds' and 'oven mounds' was described by Stone as invention because Cribb had presented no excavated data on which to base such claims.

Stone also cast doubt on Bailey and Cribb's basic grasp of northern Australian landscapes. It did not appear that Bailey and Cribb had any sense of environmental change and regarded the shell mound landscape as essentially static. As Russell-Smith (1986) has demonstrated it is untrue that Scrubfowl are excluded from chenier plains because MVF will not grow there. The narrow ecotone along the edges of chenier plains considered by Cribb to have never been occupied by Scrubfowl is also a part of the landscape which is highly favoured by MVF (see Fig.1.8). Stone did not find it surprising at all that 36% of mound sites at Weipa are located on chenier plains with a silt-substrate. Mounded deposits of shell are commonly found on chenier plains and are called chenier ridges. These may be rapidly invaded by MVF, occupied by Scrubfowl, and later abandoned as MVF retreats. Stone considered that the Weipa shell mounds were more likely to be 'biogenically distorted midden-capped beach deposits' rather than being among the world's largest prehistoric middens.
Bailey's comments on artefact density were dismissed by Stone because they addressed criteria in favour of the Scrubfowl hypothesis which were not proposed. Stone argued only that low artefact densities and absence of living floors in mounds were features inconsistent with archaeologists' particular theories of mound formation. Archaeologists do not explain northern Australian shell mounds in the same way that they explain standard middens but instead see them forming much like 'tells.' Stone argued that if this were the case the mounds should contain evidence of living floors, particularly as habitation would be confined to a relatively small area. As it is, no such evidence has ever been presented. Stone also repudiated Bailey's claim that shell mounds are consistent with behaviour observed ethnographically.

Yet another fallacy Stone identified is Cribb's claim that Scrubfowl are incapable of building mounds entirely from shell. On Channel Island near Darwin Stone had observed four Scrubfowl mounds built almost entirely from shell and it was clear that shell of any origin presents Scrubfowl with no logistical difficulties. Indeed, Scrubfowl have been observed shifting rocks weighing over 6kg (Crome and Brown, 1979). Stone used this to explain the abundant pieces of ant bed and other large objects which may be found in some mounds. Cribb also misinterpreted the South Mound by stating that it showed clear micro-stratigraphy. Beaton (1985) actually wrote that its fine structure is vague in the extreme. This, along with the South Mound's erratic dating sequence, are features which Stone considered to be more consistent with Scrubfowl processes (see Fig.1.4).

As for the alleged political implications of his theory, Stone pointed out that no Aboriginal group had ever claimed that their predecessors had made the mounds and only their archaeological significance would be diminished by it.
1.6 Aims

The origins and environmental significance of shell and earth mounds are a major controversy in northern Australian archaeology. It is clear that while there is no shortage of opinion regarding the formation of these mounds there is a dearth of geographical or contextual data concerning them. At Weipa only one excavation of one square metre of shell mound has been well documented (Bailey, 1975; 1977).

The idea that these mounds were built by Aborigines has been assumed largely on the grounds that some contain artefacts and that the shell in them was gathered by Aborigines for food. This hypothesis has never been subjected to rigorous testing. Stone's (1989) hypothesis presents a departure from orthodox thinking about these mounds and is central to this thesis. It aims to:

1. Determine the tenability of Stone's hypothesis. The key element is that Scrubfowl have played a significant role in shell mound formation.

2. Test the competing or 'null' hypothesis which is that shell mounds form as the result of repeated Aboriginal shellfishing and occupation.

3. Provide detailed stratigraphic and palaeoenvironmental data in which to provide a geographical and chronological context in which to interpret the Weipa shell mounds.
CHAPTER 2

WORLD MOUNDS: A REVIEW

One reason why archaeologists in Australia have rarely questioned their belief that Aborigines built large mounds of shell and earth is that these mounds appear similar to those attributed to prehistoric humans elsewhere around the globe. Bailey (1977, 1983) wrote that the Weipa shell mounds are comparable in size, shape, concentration and location to large shell mounds recorded in Brazil, Peru, Mexico, California, West Africa and the Andaman Islands (e.g. Fairbridge, 1976; Shenkel, 1971; Cipriani, 1955). In world archaeological literature the large conical mounds of northern Australia do not appear to be unusual in terms of human origin and Bailey (1991) drew attention to this.

Similar deposits of shell and other sediment may be formed by natural processes. Along the coasts of many countries mounded deposits of shell are constructed by wave action. On land biological processes may give rise to mounds composed of whatever material is locally available. It is often the case, however, that once artefacts are identified in a mound archaeologists rarely consider that its origins may be natural or even partly natural. Post-depositional disturbance is also ignored by many archaeologists. Concerning shell midden reports Ceci (1984) complained that ‘primary site status is rarely questioned’.

The aim of this review is to outline some of the natural processes which may lead to mound formation and critically examine archaeological accounts of mounds from around the world. Given the variety of mechanisms by which material may accumulate on the surface of the earth it is possible that many mounds attributed to cultural processes could be more simply explained as natural phenomena. It is also necessary to identify which mounds are clearly of human origin in order to see just how comparable the mounds of northern Australia are to them.
2.1 Physical Processes

Since the end of the post-glacial rise in sea level some 6 - 7000 years ago waves, currents and wind have constructed landforms which appear as superficial heaps or 'mounds' in the modern coastal landscape. Cheniers and barriers are two major examples (e.g. Otvos and Price, 1979). While waves, currents and wind are responsible for piling sediments up into prominent depositional landforms it is often erosion which transforms them into discrete mounds of sediment. It is important that these physical processes be understood before drawing any conclusions about the role of organisms, particularly humans, in sediment accumulation.

2.1.1 Cheniers

A chenier or beach ridge is an elongate mound of coarse sediment. Cheniers are normally associated with low-energy wave environments and their distribution ranges from the tropics to the subarctic zone (Augustinus, 1989). Progradation of the coastline may result in a series of cheniers fanning out across a broad plain composed of more poorly sorted sediments (Fig.2.1). As each successive chenier is abandoned by the retreating sea it may be colonised by vegetation and develop soil. The entire feature is known as a 'chenier plain'. Examples of chenier formation are well known from the coasts of Louisiana and Texas (e.g. Gould and McFarlan, 1959). The cheniers of the southern coast of the Gulf of Carpentaria are comparable in extent (Rhodes, 1982).

Cheniers are usually quite distinct topographic features which may reach heights of up to 3m above the level of the coastal plain (Todd, 1968). They may run continuously for up to 50km as in the case of some Louisiana cheniers or discontinuously as in the case of many northern Australian cheniers (e.g. Rhodes, 1982). Widths of individual cheniers may be anything up to 200m and where they coalesce they may form thick composite bodies. (Todd, 1968). Many northern Australian cheniers, however, are only
Figure 2.1. Typical cheniers of a prograding shoreline, Gulf of Mexico (from Otvos and Price, 1979: Fig.4).
small features less than 2m high and no wider than 10 or 20m. These may also be significantly less than 1km in length (e.g. Jennings and Coventry, 1973).

When a chenier first forms it may develop as a small spit or longshore bar and will typically have a straight to gently curving seaward margin and an irregular, landward margin lobed by washovers (Todd, 1968). The chenier may also become recurved as the result of wave refraction at one end and recurved hooks may also form from it (Brouwer, 1953). In cross section cheniers usually have a slightly concave, moderately steep seaward face; a flattish top mainly inclined gently landward; and a short, steep landward face (Jennings and Coventry, 1973). Brouwer (1953), however, reported cheniers having their short, steep slopes facing the sea. Reversals in morphology like this were attributed by Augustinus (1989) to washover fanning which may remove sediment from the foreshore of the chenier to the backshore.

Initially, cheniers were thought to be discrete mounds perched on the surface of underlying deposits of silt and clay (e.g. Russell and Howe, 1935). Stratigraphic investigations have shown this to be illusory and that chenier sediments typically extend for metres below the surface (Fig.2.2). Instead of representing beaches driven over mud flats by storm waves as first thought, cheniers are now seen as winnowed and sorted shoreface sediments laid down as a continuous sheet in advance of the prograding shoreline (Todd, 1968). More recent studies stress that cheniers are highly variable in character. Augustinus (1989) noted reports of cheniers resting on subtidal mud, intertidal muddy sediments, and on supratidal marsh deposits. These reports show that some cheniers are indeed perched on the surface of silt and clay deposits. Augustinus considered this to result from the landward migration of cheniers during spring tides or storms.

While most cheniers are located near sea level and are essentially progradational in nature Aliotta and Farinati (1990) reported chenier-like formations from the Atlantic coast of Argentina which stand 8-10m above mean sea level. These formations are elongate ridges which reach up to 2m in height and are underlain by finer-grained tidal
Figure 2.2 Chenier formation by alternation of progradation and wave reworking. Note chenier sediments extending above and below surface (from Davis, 1983:Fig.12-23).
flat deposits. Aliotta and Farinati attributed the unusually high elevation of these deposits to a Holocene marine transgression which produced a much higher sea level. Although these ridges resemble cheniers Aliotta and Farinati did not consider them as such because these ridges are the result of transgressive-regressive processes rather than progradational processes.

The composition of cheniers is as varied as the sediments in the sea. Sand and gravel supplied by rivers and longshore transport are perhaps the most frequently occurring sediments. Shell produced by biological activity offshore is also very common in cheniers. It may be present as whole valves (shell gravels) or highly fragmented pieces. Typically, cheniers occur as a mixture of sand and shell while others grade laterally from purely sand at one end to purely shell at another (e.g. Brouwer, 1953). Differences in composition may also exist between cheniers separated in time. At Point Stuart in the Northern Territory five seaward cheniers are composed almost entirely of small whole shells while five landward cheniers are composed of clean medium sand with less than 25% shell (Lees, 1987).

Shelly cheniers composed of a high proportion of whole shells are a category of particular interest because, at first glance, these deposits may closely resemble thick prehistoric middens. Natural deposits of shell like these constitute a transported death assemblage or 'thanatocoenosis' (Boucot, 1953). Often there is a greater diversity of shellfish species in a death assemblage than in a living assemblage. This is due to the mixing of different populations through time otherwise known as 'time-averaging' (Staff et al, 1986). Cheniers resulting largely from the mortality of shellfish are well known from warm, sheltered waters such as the Gulf of California and the Persian Gulf (Thompson, 1968; Shinn, 1973). Examples are also known from the cooler coasts of England and New Zealand (Greensmith and Tucker, 1969; Woodroffe et al, 1983).

In the Gulf of California Thompson (1968) recorded shelly cheniers dominated overwhelmingly by two species of bivalve mollusc (*Mulinia coloradoensis* and *Chione fluctifraga*). He described the shell fraction comprising whole valves as 'calcirudite' and
the fragmented shell fraction as 'calcarenite'. During spring tides the swash and backwash of waves breaking on the beach face sort the two fractions apart leaving the whole valves stranded in the uppermost swashline. The whole valves are then transported during higher spring tides or storms to the chenier crest where they may form a coarse shell berm. These berms appear similar to the thick carpets of whole shell located on the crests of cheniers at Princess Charlotte Bay which Chappell and Grindrod (1984) described as human occupation deposits.

Bivalves also dominate the cheniers and related landforms of the North Sea. Some of these deposits have been referred to as 'shell mounds' (Schafer, 1972:487). The cheniers north of the Thames estuary reported by Greensmith and Tucker (1969) contain an average of 60% shell. Some are dominated by a single species of bivalve (Cerastoderma edule). In section these cheniers show alternating layers of whole and broken shell valves (Fig.2.3). On the crest of a shell bank at Foulness Point about 10% of the valves are unworn and about half of these are still articulated. Thick berms of coarse shell are also evident. Similarly, cheniers from the Firth of Thames in New Zealand are capped by whole shell of a single bivalve species (Chione stutchburyi). These shell deposits lie above the level of the high spring tide and are considered to be storm ridges (Woodroffe et al, 1983).

Shell types other than bivalves may also dominate chenier sediments. In the salt-marsh estuaries of Georgia Wiedemann (1972) recorded relatively small, 2m high cheniers where oyster shell is the chief sediment (Fig.2.4). He wrote that the fecundity of oysters enhances rapid accumulation of enormous quantities of shell. These are piled up on the marsh surface by storm surges. The oyster shells are fragmented and waterworn where wave energy is high and often display tight vertical wedging. Local charts term the larger cheniers 'hammocks' (sic). In the Persian Gulf Evans et al (1973) recorded chenier-like beach ridges composed largely of gastropods.

The kind of chenier which receives the most attention from geomorphologists is usually the long, well-developed linear variety which is normally found as one of a set.
Figure 2.3  Shell chenier sections from Essex, north of the Thames River, England (from Greensmith and Tucker, 1969:Fig.2).

Morphology and structure of modern banks and ridges (cheniers). Small mounds on upper surfaces are minor transitory ridges.
Figure 2.4 Oyster shell chenier and associated deposits, Sapelo Sound, Georgia (from Wiedemann, 1972:Fig.4b).
Few studies have attempted to explain why some cheniers appear as small, discontinuous or isolated mounds. Either they have simply formed that way, perhaps because of a deficiency of coarse sediment, or they represent the eroded remnants of what were larger features. Rhodes (1980:165) remarked on the difficulty of distinguishing between the two possibilities.

Discontinuous chains of low shelly islets are commonly encountered closest to the sea and are simply young formations (Chappell and Grindrod, 1984). Rhodes (1980:86) termed these features 'incipient shell ridges'. It is conceivable that these cheniers do not develop any further than this and in time may be left stranded. Older cheniers may appear as eroded relics cut by rivers and scoured by wet season runoff. Rhodes (1980:88) described such remnants as 'isolated shelly mounds perched on the mudflat'. Natural depositional and erosional processes thus provide a sensible explanation for the appearance of discrete mounds in this kind of coastal landscape. Obviously these mounds may be composed of any of the sediment types mentioned above.

2.1.2 Barriers

Barriers are elongate mounds which may reach dimensions far greater than cheniers. Hoyt (1969) described them as the most common type of shoreline feature along the gently shelving coastal plains of the world. Barriers are particularly well known from the Atlantic and Gulf coasts of North America, the North Sea and the coasts of Brazil and southeastern Australia. They are often separated from the continental mass by shallow lagoons and where they are segmented by tidal inlets they are known as barrier islands (Fig.2.5). The conditions most conducive to the formation of barriers and barrier islands are a gentle gradient, abundant sediment and a low to moderate tidal range (Glaeser, 1978). The major processes involved in barrier construction are wave action, longshore currents and wind. Barriers may derive from the emergence of shallow bars by
Figure 2.5 Schematic diagram of a barrier island complex (from Davis, 1983:Fig.12-3).
wave processes, the downdrift growth of spits or the drowning of beach ridges by a rise in sea level (Davis, 1983:403).

Galloway and Hobday's (1983) summary identified three basic types of barrier (Fig. 2.6). Transgressive barriers result from the landward migration of barrier sediments during periods of rising sea level. The main processes involved are washover, inlet-related deposition and wind. Transgression proceeds as washover and windblown sediments accumulate on a platform of flood-tidal delta sediments behind the barrier. Regressive barriers, on the other hand, are accretionary beach ridges usually associated with stable or falling sea levels. Parallel foredune ridges are common while washovers are less so. Aggradational barriers are also accretionary but show a much more pronounced vertical growth including the landward development of extensive tidal flats. In all three cases the barrier sediments adjoin lagoon or estuarine deposits.

Internally, barriers may display a variety of sedimentary structures (Reineck and Singh, 1973; Frey and Howard, 1988). Processes of swash and backwash operating in the foreshore produce characteristic low-angle wedge-shaped sets of evenly laminated sediment. Steeper laminations including antidune cross-bedding are produced where ridge and runnel topography is developed. Backshore sedimentary structures are far more irregular. In the backshore storm tide washovers and wind may redistribute sediment in all directions. Washovers may either add new sediment or plane off pre-existing structures. Wind can produce such features as wind ripples, blowouts and cross-stratified dunes. These foreshore and backshore sediments often perch on shoal and tidal inlet deposits. Shoals are characterised by such structures as sand waves, megaripples and small-scale wave and current ripples. Tidal inlet migration may rework much of the barrier sequence and leave in its place a series of steeply dipping lateral accretion surfaces and tidal channel cross-beds (Elliott, 1978).

Barrier sediments may be either terrigenous or biogenic in origin. Quartz sand is the dominant terrigenous sediment while the biogenic component is dominated by molluscan shell (Davis, 1983:425). Coarse shell berms resembling middens may occur
Figure 2.6 Contrasting sections of three basic types of barrier (from Galloway and Hobday, 1983:Fig.6-10).
on barrier beaches and are similar to those found on shelly cheniers (e.g. Albertzart and Wilkinson, 1990). Shell concentrations are also common in the backshore due to storm washover. Some Texan barriers are capped by 'shell ramps' over 1m thick which McGowen and Scott (1975) attributed to the passing of hurricanes. In the foreshore shell concentrations commonly form the wrackline and are also deposited on the landward edge of runnels (Dorjes et al, 1986). In each case large shells may be left concentrated due to the winnowing effects of wave action or wind. The amount of shell breakage is often minimal particularly when the distances involved in transport are small (Albertzart and Wilkinson, 1990).

Like cheniers, barriers are subject to erosion which may leave them appearing as discontinuous or isolated mounds of sediment. Guilcher (1959) described numerous 'sand mounds' from the barrier coast of Dahomey which he interpreted as the remnants of truncated bars. Some he thought might be original islets constructed in former coastal lagoons. These mounds are circular or ellipsoidal in shape and may reach heights of up to 4m. They are located in marshland where they support palm trees and a thick grassy cover. Also present are many formations transitional between mounds and beach ridges. These include elongate mounds, strings of nuclei connected by narrow necks, and bars ending in rounded promontories. Guilcher argued that shifting floodwater courses and rain-wash were responsible for eroding the old beach ridges into mounds.

Similar mound forming processes are operative in the nearby Niger delta. Allen (1965) showed that as barrier islands and mangrove swamps advance seaward along the delta front older barriers are fragmented by the encroachment of dendritic swamp channels which 'sap' away the barrier sand (Fig.2.7). This leaves a series of isolated barrier remnants which become smaller and further removed from each other in the landward direction. These remnants are commonly parallel and elongate in form because the direction of sapping is controlled by the original alignment of the barrier ridges. Tertiary sand and clay deposits bordering the Niger delta have also been eroded and dissected leaving isolated remnants surrounded by swamp (Fig.2.8). Erosion by large
Figure 2.7 Mound formation in the Niger delta by erosion of barrier ridges (from Allen, 1965:Fig.21).

Figure 2.8 Mounds of remnant Tertiary deposits in the swamplands of the Niger delta (from Allen, 1965:Fig. 27).
meandering channels was considered by Allen to be of secondary importance in transforming the Niger deposits into distinct mounds.

Among the most difficult mounds to explain are the 'pimple mounds' of the barrier coasts of Texas and Louisiana. Numbering in the tens of thousands, these mounds range in height from 15cm to over 1.5m, are circular to elliptical in plan, and vary in diameter from 2m to over 60m (Aten and Bollich, 1981). Many theories have been advanced to explain these mounds but it is generally agreed that most result from the erosion of Pleistocene meander and barrier island ridges (e.g. Bernard and Leblanc, 1965). This view was challenged by Aten and Bollich who claimed that the presence of ceramic artefacts in some mounds demonstrated that some are in fact aggradational features. They made it clear, however, that this did not mean that artefact-bearing mounds are the result of cultural processes. Instead they claimed that storm surges and wind had periodically eroded the sediments lying between the mounds and redeposited them on the mounds thus stratifying the ceramics. The mounds retain their distinctive shapes because storm surges inhibit lateral spreading by maintaining nick points at their bases.

2.2 Biological Processes

Living organisms may also produce large mounds but few of their constructions reach the dimensions of cheniers or barriers. Among the most impressive mound-building organisms are the megapode birds of the Indo-Pacific region. One species of megapode may be responsible for building mounds up to 10m high (Stone, 1989). It would appear that termites are the only other organism capable of building mounds on such a scale. Alligators and crocodiles are also known to build mounds but these are much less substantial features. Mammalian mound-builders include fossorial rodents and the tiny pebble-mound mouse. Mounds may also arise following the death of an organism. Fallen trees have been known to trap sediments forming a patchwork of soil mounds. Biological processes such as these may explain many mounds of uncertain origin.
2.2.1 Megapodes

One species of megapode has been mentioned in the previous chapter and its mound-building proclivities are indeed central to this thesis. Jones (1989) recorded that there are six genera of megapodes in the world today comprising 19 species. Figure 2.9 shows that megapodes are distributed throughout island southeast Asia and Melanesia with notable exceptions being Java, Sumatra and most of Borneo. Fiji and New Caledonia are also devoid of megapodes. Australia is home to three megapode species. Fossils of extinct megapodes show that they were much more widely distributed in the past (Jones, 1989). A small late Eocene megapode is known from France, a very large Pleistocene megapode is known from southeastern Australia, and bones of a large megapode have been recovered from Holocene cave deposits in New Caledonia (see Olson, 1985; Van Tets, 1985; Balout and Olson, 1989).

Megapode reproductive behaviour is extraordinary and extremely variable. Megapodes are among the few bird species in the world known to bury their eggs (Seymour and Ackerman, 1980). The heat needed to incubate them is procured from a variety of external sources. In active volcanic regions megapodes deposit their eggs in pits beside craters or hot springs and use geothermal heat to hatch them (e.g. Pockley, 1937). Others simply dig into beach sand heated by the sun. Black sand is often preferred presumably because black absorbs more sunlight and is warmer (Diamond, 1983). Heat released by rotting vegetation is also used by megapodes to hatch eggs. It is the use of this heat source which entails the construction and maintenance of elaborate incubation mounds. Seymour and Ackerman (1980) wrote that the size of the mound is related to the degree of reliance on organic decomposition as a heat source. Frith (1962:18), however, noted mounds in the tropics which consisted almost entirely of pure soil. These needed only a small amount of organic matter because the surrounding warm air supplied most of the heat.

The species of megapode which live in Australia are mound-builders. Unfortunately only two are well understood. They are the Australian Brush-turkey
Figure 2.9 The distribution of the megapodes (from Jones, 1989:Fig.1).
*Alectura lathami* and the Malleefowl *Leipoa ocellata*. The Brush-turkey is widely distributed in eastern Australia where it inhabits environments ranging from rainforest to open woodland (Blakers *et al.*, 1984). An introduced population is also thriving on Kangaroo Island. Brush-turkey mounds are constructed by the male bird from soil and leaf litter and average 3-5m in diameter and about 1m in height (Jones, 1988). Individual mounds are abandoned at the end of each breeding season and new sites chosen for mound construction the following year. In subsequent years the earthen remnant of the mound abandoned initially may again be used as a nesting site (Jones, 1988). In this way sediments may accumulate to form small earth mounds.

The Malleefowl inhabits the drier parts of southern Australia and was once more widely distributed than its name implies. Today the Malleefowl is largely restricted to remnants of mallee and other types of eucalypt woodland with a significant population surviving in the Goonoo and Pilliga forests of central New South Wales (Priddel, 1990). Prior to 1950 the Malleefowl's range included central Victoria and the forests of the South-West region of Western Australia (Blakers *et al.*, 1984). Malleefowl were also once numerous throughout the mulga lands of the arid interior (Noble, in press). Their overall numbers have declined primarily because much of their habitat has been cleared for wheat and sheep (Priddel, 1990). Competition for food from introduced grazers and predation upon eggs and chicks are also known to seriously impact upon Malleefowl numbers.

Frith (1956, 1959, 1962) gave a detailed account of how Malleefowl build mounds (Fig.2.10). In May when the ground is moist the male bird digs a hole 3-5m in diameter and about 1m deep. It then fills the hole in with leaf litter from a radius of 10-15m. In August it covers the entire nest with up to 1.5m of loose dry sand or soil. The moist organic matter inside the mound begins to decompose and mound temperature rises. Egg-laying starts in mid-September and lasts until early March. The eggs are deposited in the centre of the mound, usually one every 4-8 days. Mound temperature is mostly regulated by the male. If it gets too hot he opens the mound in the early morning and scatters the soil. When the soil has cooled he restores it to the mound. In Autumn, when temperatures fall, the mound is opened to the sun and the soil reheated. Reuse the
Figure 2.10 Frith's (1959) classic sketch of a Malleefowl mound.
following breeding season leads to an increase in mound size. The level at which the organic matter is placed also rises. A mound in its first year of use may have its organic layer 1m below the soil surface but in a very old mound it may be up to 1m above the soil surface.

At Lake Mere station in northwestern New South Wales Noble (in press) recorded 48 circular 'pebble mounds' which he interpreted as abandoned Malleefowl mounds. These symmetrical features, some with well-defined central depressions, are around 10m in diameter and characterised by a high density of surface pebbles. Presumably older mounds are nearly flat from erosion yet still distinct. Most are located along the ecotones flanking mulga groves either singly or in clusters. Chemical analysis revealed that soil fertility is much higher in the mounds than in the surrounding subsoil with particularly high levels of nitrogen and organic carbon in the central depressions. Because of this increased fertility these abandoned mounds function as forage production sites for native herbivores and act as foci for subsequent seed dispersal (Noble, in press).

The third megapode living in Australia is the Orange-footed Scrubfowl *Megapodius reinwardt*, often referred to as *M. freycinet*. Although only about the size of a chicken this bird builds the largest of all megapode mounds (Clark, 1964). These are located mostly in northern Australia (see Fig.1.7) but populations of *Megapodius reinwardt* are also known from southern New Guinea and the islands of eastern Indonesia (Jones, 1989). Northern Australian megapode mounds have provoked astonishment since John Gilbert first identified them as such in 1840 (Gould, 1865:168). Local European settlers had mistakenly thought that the mounds had been constructed by Aborigines. Accounts of Scrubfowl mounds since then have been scattered but many pertinent facts about them are available.

Scrubfowl mounds are typically 3-5m in height and 10-12m in diameter (Cayley, 1984:101). So prominent are they that Gilbert likened them to 'a bank thrown up by a constant heavy surf' (in Gould, 1865:172). Most are relatively symmetrical, conical features but some may be elongate or irregular in shape. Long, narrow ridges are
produced by Scrubfowl heaping fresh organic material on one side of the mound only. In this way the mound 'creeps' lengthwise (Frith, 1956). One examined by Frith on Humpty Doo Station was over 3m high and 20m long. This was generating heat only at one end. Small subsidiary mounds less than 1m high and 2m in diameter have also been found in association with active Scrubfowl mounds (Crome and Brown, 1979). Their function is unclear because eggs are not found in them. Either they are the result of displacement activity by birds occupying the larger mounds, the practice mounds of young birds or 'larders' containing arthropods which the birds feed on.

In northern Australia many early observers remarked on the closeness of Scrubfowl mounds to the sea. Gilbert (in Gould, 1865:169), Lucas and LeSouef (1911) and Banfield (1913) all described Scrubfowl mounds located on the beach just above the high-water mark. Deignan (1964) wrote that in Arnhem Land the bird only left the coast along some of the tidal rivers. Consequently Scrubfowl mounds are most numerous along the coast and are frequently located on Holocene landforms (Russell-Smith, 1986). Mounds of sand and shell are common while others are made from black soil and rotting vegetation (Mathews and Iredale, 1921:219). Gilbert described one 'composed entirely of pebbly iron-stone, resembling a confused heap of sifted gravel'. In non-coastal areas Scrubfowl mounds are most numerous on the Atherton Tableland (Frith, 1956). Isolated Scrubfowl mounds have also been recorded on a mountain plateau near Yeppoon in southern Queensland and in the sandstone terrain of the Arnhem Land escarpment (Chisolm, 1925; Russell-Smith, 1986).

Scrubfowl in northern Australia normally inhabit patches of seasonal or evergreen monsoon vine-forest (Russell-Smith, 1986). This vegetation type is highly vagile and very partial to recently formed coastal landforms (Wightman and Andrews, 1989:8). Litter produced by monsoon vine-forest and other closed communities is the chief source of organic material used by the birds to generate heat. However, Frith (1956) noted seaweed in some mounds. Scrubfowl are also known to inhabit mangroves. Bell (1969) described two active mounds constructed in mangroves on a coral cay near Port Moresby. These contained no decaying organic material and Bell assumed that the sand in
them was heated only by the sun. On the Cobourg Peninsula Macgillivray (cited in Gould, 1865:176) described two instances where Scrubfowl and their mounds had been encountered among mangroves and Deignan (1964) also noted the occurrence of Scrubfowl in the mangroves of Arnhem Land.

Crome and Brown (1979) surveyed 28 Scrubfowl mounds located in monsoon vine-forest north of Cairns and spent almost five years closely observing one active mound. Unlike most other megapodes Scrubfowl are social in their breeding habits and more than one pair may use the same mound at any one time. Crome and Brown saw four different pairs use the same mound in the period 1970-74 but only two of these shared the mound in a single breeding season. Work on the mound is divided between the male and female and goes on all year. However, the male does twice as much collecting. Near the beach the material collected was sand mixed with leaf litter. On heavier clay soils further inland the mounds consisted mostly of litter with only a small amount of soil. This material was raked up from a radius of 25m and if not scraped immediately to the top of the mound it was left in piles at the base or half way up. Both sexes repeatedly dug holes in the top of the mound to accommodate the new material and loosen the mound if made compact by rain.

During the breeding season which lasts from September to March the Scrubfowl dig numerous 1-2m deep test holes presumably to find a suitable place to deposit their eggs (Crome and Brown, 1979). This is generally a joint activity involving one bird digging the hole and the other pushing the excavated material aside. When a suitable hole is made the female lays the egg and fills in the hole with the assistance of the male. They then rework the surrounding material and pile it over the egg. More material is added the next day. In Crome and Brown's study the period between successive eggs ranged from 9-20 days. Overall mound temperatures fluctuated between 29-38 degrees Celsius. The temperature around the eggs was always warmer than the rest of the mound. Although Crome and Brown were unable to demonstrate that Scrubfowl control the mound temperature the way Malleefowl do they did suggest that Scrubfowl can at least detect the appropriate temperature.
Figure 2.11 shows how a Scrubfowl mound can grow and change in morphology year by year. Similar observations were made by Frith (1956) at Iron Range. In November 1944 he found a small Scrubfowl mound '8 ft. in diameter and 3 ft. high' which contained three eggs. In August of the following year the same mound had grown to be '12 ft. in diameter and 5 ft. high'. These observations show that some Scrubfowl mounds are subject to very rapid growth. Lucas and LeSouef (1911) felt that the mounds were not abandoned until they had become so filled with tree roots that the Scrubfowl could no longer work them. The use of abandoned Scrubfowl mounds in palaeoecological reconstruction in northern Australia has been mentioned in the previous chapter.

2.2.2 Insects

Large conical mounds resembling those built by Scrubfowl are also produced by some termite species. For example, three species of the African termite genus *Macrotermes* are known to build mounds which may be anything up to 5m high and 20m in diameter (Hesse, 1955). These are built entirely from subsoil collected from a depth of 60-150cm. Watson (1967) described one built by *Macrotermes goliath* in an Iron Age burial ground in Zimbabwe (Fig.2.12). This was 2.7m high and 15m in diameter. Interestingly, human skeletal material was preserved in the alkaline environment of the termite mound but not in the graves dug into the surrounding acid soils. A large dome-shaped mound built by *Macrotermes goliath* was also depicted by Harris (1955: Fig.9). He noted that once abandoned by the termites these mounds weather to a more rounded form and provide a fertile habitat for distinctive trees and shrubs. Similar termite mounds are also found in many parts of Asia. Pendleton (cited in Harris, 1955) described some in Thailand which were being planted with crops unable to grow in the surrounding paddy fields.
Figure 2.11 Change in a Scrubfowl mound at Sweet Creek near Cairns over two seasons. Stars = trees, solid circle = known site of an egg, circle = suspected site of an egg (from Crome and Brown, 1979:Fig.4).
Figure 2.12 Sections of a *Macrotermes* mound in a Zimbabwe grassland (from Watson, 1967:Fig.2).
Many of the African termite mounds are known for having high concentrations of calcium carbonate even when there is very little calcium in the surrounding soil (Watson, 1974). Visible nodules of carbonate are common in the centre of these mounds while hard concretionary masses of impure limestone are often found beneath them (Milne, 1947; Hesse, 1955). The various methods proposed to explain these calcium accumulations have been summarised by Watson (1974). A possible biological method is the formation of calcium carbonate from the mineralised residues of food collected by termites. The physical methods all involve the evaporation of water containing calcium bicarbonate. This may be introduced into the mounds through capillary action, seasonal flooding or saturation from groundwater. Precipitation of calcium is enhanced by the large evaporating surface of the mounds and an internal ventilation system which results in the accumulation of salts near the mound base (Wood and Sands, 1978). Evidently calcium can accumulate in mounds quite rapidly (Watson, 1974).

Some ant species also build large mounds of earth. These are most common in cool, temperate climates (Sudd, 1982). The largest ant mounds are built by the wood ants (Formica) such as Formica exsectoides which in the eastern United States builds a conical mound up to 1m high and over 2m in diameter (Borror et al., 1976:676). These mounds normally consist of soil or small pebbles but Wheeler (1910:Fig.110) recorded a mound of F. rufa in Belgium which consisted of a mass of sticks and pine needles resting on a large crater-shaped base of earth. This mound was 2.15m high and 9.8m in diameter. In Australia conspicuous ant mounds are built by the meat ant Iridomyrmex purpureus (Ettershank, 1968). Most meat ant mounds are 15cm high and 1.5-2m long but on poorly drained soils or in cooler localities they may be up to 70cm high. Ettershank noted one which was 60cm high and over 10m in diameter. These mounds are usually made of silt or sand and are commonly 'decorated' with round pebbles or ironstone nodules.
2.2.3 Reptiles

Large ferocious reptiles such as alligators and crocodiles are also mound-builders. Their behaviour in this regard is similar to that of the megapodes for they also build mounds to incubate their eggs. The American alligator *Alligator mississippiensis* inhabits rivers, lakes and swamps of the southern United States where it builds dome-shaped incubation mounds up to 1m high and over 2m in diameter (Neill, 1971; Goodwin and Marion, 1978). Mounds are usually located in the shade 3-5m from the water's edge and consist of a mixture of soil and vegetation. The female alligator builds the mound with lateral body and tail movements. A hind foot is also used to scrape material together. Neill (1971:Fig.9) depicted a captive female building a mound entirely from sand because no other building material was available. Clusters of nesting mounds may form in areas where there is a shortage of building space. Neill (1971:210) felt that there may have been more communal nesting in the past when alligators were more abundant.

Similar incubation mounds are built in northern Australia by the crocodile *Crocodylus porosus* (Webb *et al*., 1977). These are about 30-80cm high and 1-2.5m in diameter. In some locations grasses and sedges are the main building material while in others earth, vines and leaf litter are used. Soil forms a considerable part of most of these mounds. Common mound-building sites are the tops of concave riverbanks, floodplains behind mangroves and adjacent freshwater swamps. Some nests are made in which no eggs are deposited. Webb *et al* wrote that the effect of flooding on *C. porosus* nests is catastrophic. Presumably these mounds are not long-lasting.

2.2.4 Mammals

In the west of North America conspicuous mounds of earth are built by fossorial rodents. Known as Mima-mounds these are thought to have been built by pocket gophers (Cox, 1984). The mounds are nearly circular in outline and range from a few centimetres to 2m in height. In diameter they range from a few metres to 50m. In California they are
located on the edge of coastal salt marshes, coastal marine terraces, foothill slopes, mountain valleys and the margins of desert-edge marshes. Cox wrote that the mounds lack internal stratification and are almost invariably composed of textural materials less than 5cm in diameter. They appear to be formed by pocket gophers tunnelling outwards from centres of territorial activity which causes soil displacement towards these centres. Similar Mima-mounds have been recorded in the highlands of Kenya (Cox and Gakahu, 1983). These have been attributed to the root rat *Tachyoryctes splendens*. Small mounds of the termite *Cubitermes sp.* are often found superimposed on them. Possible Mima-mounds have also been found in the Peruvian altiplano where fossorial animals now seem to be absent (Cox and Gakahu, 1983).

In Australia the only mound-building mammal of any note is the Pebble-mound Mouse *Pseudomys chapmani* (Dunlop and Pound, 1981). It appears to be confined to the arid Pilbara region of Western Australia but the distribution of its abandoned pebble mounds suggests that it once ranged more widely. Davies (1986) described its mounds as 'a series of public works that must have taken years to build and been used by generations of mice'. They can be 1m high and 2m across. However, those recorded by Dunlop and Pound stood only 25cm above the ground surface. In their study the length of the pebbles in the mounds ranged from 15-40mm. What purpose pebble mounds serve is unclear. Davies surmised that they act as 'dew ponds' into which moisture condenses, so that the mice can obtain water without having to dig deeply for it.

2.2.5 Dead Trees

Mulga log mounds are a type of mound which form following the death of an organism, in this case a tree (Tongway *et al.*, 1989). These mounds form in the semi-arid woodland of eastern Australia through the accumulation of sediment around fallen logs. Although quite distinct these mounds do not appear to stand more than 15cm above the ground surface. They are usually around 3-4m long and 1-1.5m wide. Tongway *et al* stated that mound sediment probably derives from aeolian and fluvial activity in the local
landscape and from rainwash depositing material brought to the surface by termites living in the fallen logs. Apparently, mulga log mounds persist for many years. Tongway et al considered them to be 'fertile patches' because they are high in nitrogen and organic carbon and water infiltrates rapidly through them. Mulga log mounds may provide a refugium for some plants and animals during times of environmental stress (Tongway et al, 1989).

2.3 Human Occupation Mounds

Around the world there are innumerable sites which archaeologists have claimed are mounds resulting from human activity. Examples of mounds with strong claims to human origin are found in the Middle East, West Africa, North America, Peru and Japan. Architectural features and other cultural remains associated with these mounds serve to distinguish them clearly from mounds built by natural processes. Other kinds of human occupation mound are recognised as being natural deposits which people occupied after their formation. These include some of the shell middens of Scotland and a large earth mound in Thailand. European 'barrows' and the earthen ceremonial mounds of North and South America are not included here because these were built for ritual purposes rather than as a consequence of repeated human occupation.

Archaeological perceptions of how human occupation mounds form appear to derive from the 'tell' concept. A tell is a cultural deposit produced largely from the residue of collapsed mudbrick structures (Rosen, 1986:9). These form as cities and towns are constructed upon the ruins of previous settlements leading to the growth of mounds with a succession of occupational layers. Clark (1977:64) wrote of northern Iraq as a classical area for tells. Rosen's (1986) investigation of tells in Israel showed how complex their statigraphy can be. She identified mudbrick, stone, ceramics, lime plaster and organic refuse as the primary building blocks of a tell. The tell is composed either of structural features such as houses, walls and ramparts or the reworked fragments of these. Natural processes such as floods or wind may also contribute sediment to the tell. Erosion has a
more significant effect on final tell form. This smooths the tell surface and modifies the configuration of its slopes.

In the Lake Chad region of Nigeria Connah (1976) investigated a number of large earth mounds which he later dubbed the 'African equivalent of the south-west Asian tell' (Connah, 1981:52). The Nigerian mounds consist predominately of clay. Connah (1981:52) stated that 'they result from the gradual accumulation of structural remains and domestic rubbish from successive human settlements that have been located for long periods of time on the same site'. The smallest examples are 1.5m high with a diameter of 75m while the Daima mound which is one of the largest, is over 10m high, 250m long and 170m wide. Connah's excavation of the Daima mound revealed a series of horizontally-banded occupation material containing the fragmentary remains of walls, floors and hearths. Artefacts are abundant and in sequence. Connah (1976) called the Daima mound 'the only site in Nigeria that clearly spans the transition from a stone and bone using technology to one using iron'. His claim that the mound accumulated gradually is supported by eight radiocarbon dates which span a period of 1700 years.

Similar earth mounds are found in the Parowan Valley of southwestern Utah (Dodd, 1982). Like the tells of the Old World these also formed from the collapse of mudbrick or 'adobe' structures. One of the most prominent is the Evans Mound site. This mound is 2.1m high and covers an area of around 90m by 50m. Excavations uncovered 33 structures consisting of 25 pit dwellings and eight granaries. Dodd identified five basic occupational strata into which many of the structural features had intruded. Features associated with these structures include adobe walls, floors with postholes and firepits. Thousands of stone, bone and ceramic artefacts were also recovered, as well as 25 burials and numerous plant macrofossils. Despite a number of incongruities in the dates for the site Dodd concluded that Evans Mound was inhabited from A.D. 1050 to 1150. If this were so it would appear that the Evans Mound grew at a much faster rate than its counterpart in Nigeria.
The Huaca Prieta of northern Peru is perhaps the largest human occupation mound to have ever been found in a coastal setting (Bird, 1985). It is located on a base of conglomerate rock 122m from the Pacific Ocean. The mound is 125m long, 50m wide and rises 12m above the level of the bedrock (Fig.2.13). It may have been more extensive prior to attack by waves on its seaward face. Bird described the Huaca Prieta as a 'preceramic midden' because no pottery was associated with its formation. His use of the word 'midden' in this sense may be misleading. It is not a shell midden because shell actually contributes very little to the deposit. Instead the mound consists of layers of compact ash and dirt laden with hearths, food remains, textile fragments, stone and bone artefacts and burials. These layers surround structural features such as cobblestone retaining walls and pit dwellings. Bird attributed the accumulation of ash and dirt partly to the dumping of refuse over the walls. Radiocarbon dating suggests that the mound formed from c.5000-3200 BP. Bird claimed that a tidal wave washed over the mound about a thousand years ago leaving a thick cobblestone layer on its lee side.

The shell mounds of Honshu in Japan are perhaps the only sites in the world referred to as 'shell mounds' that are unequivocally human in origin. Known from the period c.6500-3000 BP these shell mounds are most numerous around Tokyo Bay where they are located on plateaus or terraces some 25-40m a.s.l (Groot and Sinoto, 1952; Koike, 1986). The cultural deposits vary from thin scatters of molluscan shell to mounds containing layers of shell and black earth up to 2m thick. In shape the mounds are typically irregular in all three dimensions (Suzuki, 1986). Koike recognised 'horseshoe-shaped shell accumulations' while Groot and Sinoto described the shell mound of Ubayama as 'almost round' with a diameter of roughly 130m. Besides their location what serves to distinguish these shell mounds as genuine human occupation mounds are the structural features and other cultural remains associated with them. These include pit dwellings and postholes often sunk into the underlying volcanic soil. Firepits, ceramics, stone and bone artefacts and burials are also numerous. The mounds appear to form as pit dwellings and their surrounds fill with shelly cultural refuse (Groot and Sinoto, 1952:6).
Figure 2.13 The Huaca Prieta of northern Peru (from Bird, 1985:Fig.4).
Large conical mounds on the island of Oronsay off the west coast of Scotland have been referred to as 'shell mounds' but it is clear that aeolian sand makes up the bulk of these deposits (Fig.2.14). Shell midden material consisting mostly of densely packed limpet shell normally forms only a capping on the summit of these dunefield deposits (Mellars, 1987). Shell thicknesses are typically 0.5-1m but the midden on the top of the conspicuous Caisteal nan Gillean mound was estimated to have reached a thickness of 2.4m before it was excavated last century. The shell middens of Oronsay are very likely to be human in origin. Among the poorly stratified layers of shell refuse are the burnt remains of discrete hearths, heat fractured stones, mammalian remains and stone and bone artefacts. Radiocarbon dating shows that the Oronsay sand mounds were occupied by shell gatherers from c.6200-5400 BP. The local maximum Holocene marine transgression was placed at around 7200-6600 BP.

A final example of a prominent mound with a significant occupational component is the Khok Phanom Di mound in Thailand (Suchitta, 1980). This mound is located in a clayey floodplain some 20km from the Gulf of Thailand. It is circular in shape with a diameter of 235m and rises 12m above the level of the floodplain. The core of the mound appears to have formed in situ from the decomposition of granite which produced a deposit of clayey sandy loam. Occupational debris reached depths of over 4m in a road cutting through the top of the mound. This consisted mostly of a mixture of potsherds and whole *Anadara* shell dispersed throughout a series of clayey soil layers. Human bones and stone and shell artefacts were also recorded. Suchitta claimed that when the people who left these remains occupied the mound it was surrounded by a brackish mangrove swamp environment. The occupants he said were 'people who exploited the marine shellfish and used earthen pots'.
Figure 2.14 Sketch and section of the Caisteal nan Gillean I 'shell mound', west of Scotland (from Mellars, 1987: Figs.8.1 and 11.21).
2.4 Mounds of Doubtful Human Origin

There is an idea among prehistorians that at one time in prehistory coastal people subsisted almost entirely on shellfish. These people came to be known colloquially as 'strandloopers' and their intensive shell gathering economies were thought to have led to the growth of large shell mounds in many parts of the world (e.g. Evans, 1969). However, shell mound cultures were not highly regarded. Meehan (1982:7) showed that subsisting on shellfish was often unfairly perceived as 'a low form of human existence' and her ethnographic work did much to dispel this notion. But did 'shell mound cultures' really exist in the first place? In the critique that follows it is reasoned that there is no connection between human shell gathering behaviour and the growth of most large shell mounds. Strandlooping on the scale that has been envisaged by many prehistorians may not have been a form of human existence at all.

2.4.1 The Americas

The largest shell mounds in the world thought by archaeologists to be of human origin are the 'sambaquis' of the southern coast of Brazil. Hurt (1974) and Fairbridge (1976) described sambaquis up to 25m in height and over 300m long. Much smaller sambaquis are also known to exist. Martin et al (1986) noted small circular sambaquis no higher than 1.5m with a diameter of only 10m. Hurt (1974) believed that the large dome or loaf-shaped sambaquis were built by 'preceramic cultures' while horizontally stratified sheet-type mounds were built by ceramic-making people. This latter group also liked to camp on top of the large mounds apparently vacated by their preceramic predecessors. Unfortunately the accounts of sambaquis in English are not at all clear about the provenance of the artefacts recovered from them. Most would appear to be intrusive although some sambaquis appear to have stone artefacts at all depths and occasionally burials in their lower levels (e.g. Hurt, 1964).
In terms of composition sambaquis do not appear to be as complex as the human occupation mounds discussed in the previous section. Most consist predominately of one or two species of mollusc (Schmitz, 1987). Some sambaquis consist almost entirely of *Anomalocardia brasiliana* while others show a mixed composition (Martin *et al.*, 1986). Hurt (1964) described the 8m thick Sambaqui do Macedo as consisting of layers of *Anomalocardia* alternating with bands of fragmented *Modiolus brasiliensis*. Sambaquis consisting of mixed sand and crushed *Mytilus perna* shells have also been reported as well as some containing a high proportion of oyster shell. (Hurt, 1974). *Anomalocardia* forms the bulk of the largest sambaquis. This species is a bivalve only 1-2cm in length and because of its small size it is difficult to accept Hurt's claim (1974) that it was much sought after for food. The fragmentary condition of the other shells is also suspicious. Deposits of whole and fragmented shell like these are commonly constructed by wave action.

The idea that many sambaquis may in fact be natural in origin was not lost on Serrano (1963). Prior to the arrival of Hurt and Fairbridge on the Brazilian landscape, archaeologists were divided between those who believed that sambaquis were human constructions and those who believed that sambaquis were natural littoral deposits occupied by people after their formation. Mindful of their enormous size, bedding and the fact that many of the shells in them were unopened Serrano (1963) proposed that most sambaquis were essentially water-lain deposits. He claimed that the contribution made by people to the size of the mounds was negligible. However, Willey (1971:442) wrote that Serrano's ideas could now be 'set aside' thanks to twenty years of artefact-revealing research.

Photographs of the 24m high Sambaqui da Carnica presented by Hurt (1974: Figs.5, 6 and 7) reveal morphological and structural features commonly associated with wave-built barrier deposits (Plate 2.1). Although its overall shape and appearance have been modified by quarrying it was clearly elongate and perhaps one of a series of parallel barrier ridges. Internally it displays features diagnostic of a barrier deposit. These include
Plate 2.1 Two views of the Sambaqui da Carnica, Brazil (from Hurt, 1974:Figs.6 and 7). Evident in the bedding are wedge-shaped sets of shelly sediment and a megaripple.
a vertical series of low-angle wedge-shaped sets of evenly laminated shelly sediment overlying what appears to be a megaripple. It would seem that washover processes are responsible for this sambaqui and there is no reason why cultural material could not be buried or stratified during washover episodes. It is therefore difficult to reconcile such a massive shell deposit with human agencies even though artefactual material may be encountered occasionally at some depth.

The dating of the sambaquis is also inconsistent with human agencies. Ages from even the most long-lived sites seldom span more than 300 years (Schmitz, 1987). This includes the Sambaqui da Carnica for which there is a difference of only 300 years between shell dates from the top (3040±50 years BP) and base (3310±150 years BP) of this mound (Hurt, 1974). Similarly, there is a difference of only some 200 years between the highest and lowest dated levels of the Sambaqui do Macedo (Hurt, 1964). The six other dates from the middle levels of this mound are virtually the same age i.e. c.3300 years BP. Other sambaqui dates are simply in reverse stratigraphic order. These include dates from the Sambaqui do Porto Mauricio excavated by Rauth and those from the Sambaqui de Ponta das Almas excavated by Piazza (in Hurt, 1974). These sambaqui sequences do not support the claim that the shells accumulated gradually as a result of human agencies.

The likelihood of most Brazilian sambaquis being essentially wave-built deposits is borne out by the descriptions of the environments in which they occur. The southern Brazilian coast is characterised by sandy barriers interrupted by steep promontories of crystalline rock, coastal plains with beach ridges, mangrove swamps and elongate sandy beach barriers backed by coastal lagoons (Martins and Willwock, 1987). Its outer shelf is covered by molluscan sand and gravel. Hurt (1974) wrote that most sambaquis are located on beach ridges or ancient shorelines that alternate above and below present mean sea level. Usually they are located along the sides of estuaries and lagoons but some have formed on the lee side of inselbergs protruding near the shoreline. Given that most sambaquis are deposits of shell associated with transgressive or progradational coastal landforms it is probable that most were piled up by wave-action. Abundant molluscan
remains offshore are a likely source for the bulk of the sambaqui shell. Serrano's (1963) interpretation of the Brazilian sambaquis as natural features seems more reasonable than claims that they accumulated entirely through human agencies.

Elsewhere in South America mounds of questionable human origin are located along the southern coast of Peru. Craig and Psuty (1971) recorded 31 shell mounds around a raised embayment at Otuma which they interpreted as shell middens abandoned by 'non-ceramic' people after a period of tectonic uplift. These mounds consist of uncompacted scallop valves loosely held in a matrix of sand and wind-blown silt. Most are located along the crest of a low, wave-cut cliff and run parallel to the former shoreline typically for a distance of 30m. The average thickness of the mounds is 'four to five feet'. Craig and Psuty's test excavations into 14 of the shell mounds revealed very little stratification and they were puzzled by the absence of stone artefacts despite an abundance of suitable raw material nearby. Rather than question the human origin of these deposits they concluded that the mounds were of 'an uncommonly austere and impoverished culture almost exclusively concerned with the gathering and consumption of scallops'. It seems more likely that these elongate shell deposits are the eroded remnants of raised beach ridges.

The shell mounds investigated by Shenkel (1971) on the west coast of Mexico in the Marismas Nacionales region are also considered by archaeologists to be of human origin. Along the shorelines of the Teacapan estuary are linear mounds of oyster shell the largest of which was 3.6km long and 100m wide with peaks reaching heights of 10m or more (Scott, 1985). Despite excavation and survey these linear mounds yielded no artefacts. Circular to ovoid mounds of Tivela shell are also present in the estuary. These range up to 16m in diameter and 4m in height. Prehistoric artefacts have been recovered from them. Scott wrote that both types of shell mound tend to be located along beach ridges. Curray et al (1969) have shown that these ridges are part of a strand plain barrier coast. As such it is possible that the linear mounds could easily be natural shell ridges while it is possible that the nonlinear mounds are eroded remnants of these.
Many North American shell mounds purportedly human in origin are also likely to be natural shoreline deposits. This is strongly suggested by their morphostratigraphy and composition which indicate that they have more in common with eroded barrier deposits or cheniers than with human occupation mounds. Two examples are the well-known Emeryville and Ellis Landing shell mounds both located on the coastal plains of San Francisco Bay. These were excavated early this century but have now been largely destroyed. The Emeryville mound was one of the largest measuring some 300m by 100m and before it was levelled it reached a height of 9.8m (Moratto, 1984:227). It is likely that this mound was the eroded remnant of a barrier island because its size and shape were typical of such a deposit as was its stratigraphic position which showed that it rested on littoral clay with its base 75cm below the present high tide line. Its composition was also consistent with a wave-built deposit. Uhle (1907) wrote that it was composed mostly of shells crumbled into small fragments mixed with sand.

Similarly, records of the nearby Ellis Landing shell mound present a perfect example of a shelly barrier island. This mound was originally an elongate deposit some 150m long and 80m wide (Nelson, 1910). It was set in a marshy plain of fine silt where it extended above and below the silt plain for over 4m each way. Sections and photographs of this mound produced by Nelson show that its morphostratigraphy is almost identical to some of the barrier islands recorded by Otvos and Price (1979) in marshland Mississippi (Fig.2.15). Figure 2.15 also bears a striking resemblance to the sections of shelly cheniers produced by Greensmith and Tucker (see Fig.2.3). Both sets of sections show alternating layers of whole and fragmented shell interspersed with occasional rocks or pebbles and both reports arrived at a figure of around 60% for the proportion of shell in each deposit. These aspects aside, perhaps the best evidence for a natural origin for the Ellis Landing shell mound is Nelson's photograph (Plate 39) of a section of the mound. This close-up shows a series of evenly-layered disarticulated whole shells most of which are resting convex upward. This arrangement is normally attributed to deposition by water (e.g. Cann et al, 1991).
Figure 2.15 The Ellis Landing shell mound, San Francisco Bay, California (from Nelson, 1910). Note the resemblance of this section to Greensmith and Tucker's (1969) sections of shell cheniers (see Figure 2.3).
The excavations of shell mounds conducted by Uhle (1907) and Nelson (1910) revealed prehistoric artefacts and burials at all levels but this is hardly proof that the deposits accumulated through human agencies. The cultural material could have been incorporated into the deposits during washover episodes or through post-depositional processes. The latter is equally plausible because Uhle observed what he thought were holes made by burrowing animals which disturbed the stratigraphy. Similarly, the presence of ash and charcoal layers throughout the mounds are not necessarily indicative of human origin either. Uhle described some "no thicker than a sheet of heavy paper" and only in the upper levels was there a sizeable bed of ash. Nelson recorded ashes that occurred in thin streaks or lumps but admitted difficulty in being able to distinguish between ashen material and very finely divided shell and earth. Neither recorded definite fireplaces and most of the burials appear to be simply intrusive. The evidence really suggests that these Californian shell mounds are water-lain deposits. Many of the stone 'manuports' examined by Nelson were encrusted with barnacles.

In the northeastern United States the shell mounds of the Damariscotta estuary were proclaimed 'the world's largest known aboriginal accumulation of oyster shells' (Snow, 1972). The largest was 115m long, 41m wide and over 5m high. Snow reported that there were very few artefacts relative to the volume of oyster shell in the mounds and the largest contained only six intrusive burials. However, prehistoric village refuse had been found on high ground behind the mounds which suggested to Snow that while people had formed the mounds they did not live on them. Perhaps a more sensible explanation is that the oyster mounds are water-lain deposits similar to the oyster mounds of the salt-marsh estuaries of Georgia (see Wiedemann, 1972). Chadbourne (1859), one of the first scholars to examine the Damariscotta mounds, rejected this conclusion because the shells in them were opened and not mixed with broken shells or sand. The geologist Charles Jackson, however, thought that the 'regular stratiform position' of the shells suggested a natural origin (in Chadbourne, 1859).

Along the Gulf Coast of the southern United States there are also numerous shell mounds which archaeologists appear to have mistaken for middens. This is
surprising given the amount of geomorphological research done in this region. White's (1987, 1991) survey of the lower Apalachicola Valley delta in northwest Florida located a dozen elongate shell mounds one of which she described as shaped like a banana. These rise 1-4m above the surrounding swampy plain and average over 100m long and 50m wide. They are usually composed of *Rangia* clams with some oyster shell but the amount of sandy matrix and artefacts in them varies widely. Test excavations revealed no distinct strata and all the artefacts came from the uppermost levels. A core taken from the edge of one mound showed that crushed shell extended for 2m below the surrounding clay surface. This suggests that these mounds are in fact barrier island remnants or cheniers. Most are linear and run roughly parallel to the present barrier island coastline. They may have been isolated in the back-swamps of the Apalachicola delta by processes similar to those which isolated the barrier remnants of the Niger delta (see Allen, 1965).

Similar *Rangia* clam mounds have been recorded by archaeologists along the coasts of Texas and Louisiana. Aten's (1983:Fig.11.32) photograph of a *Rangia* mound in the marshlands of the Trinity River delta in Texas is almost identical to Otvos and Price's (1979) photograph of a barrier island in marshland Mississippi. Like most shell mound archaeologists Aten (1983:204) attributed the extension of shell beneath the water table to subsidence of the midden rather than to a simple subsurface expression of a typical barrier island. Big Oak Island in Louisiana interpreted by Shenkel (1984) as a cultural deposit would appear to be similar. It reached a depth of 4m. Above the clay it rested on Shenkel identified a 'thick noncultural zone of shell beach deposit' but then pronounced the overlying deposit of *Rangia* shell cultural in origin because of its high artefact content. The difference between these two shell units, however, may reflect sorting processes which separate coarse and fine shell rather than deposition by two completely different agencies (see Thompson, 1968).
2.4.2 Europe

On the other side of the Atlantic the shell mounds of the Baltic coastline inspired the Danish Kitchen Midden Committee of 1851 to develop criteria which they thought would permit distinction between natural and cultural shell deposits. Coastal archaeologists have used these criteria ever since. Lubbock (1869:216) wrote that the shell mounds of the Baltic coastline could be distinguished from beach deposits because beaches are composed of a variety of shell species with individuals of different ages and are invariably mixed with sand and gravel. The shell mounds, on the other hand, comprise shells of mostly fully grown individuals represented by four species which do not share the same habitat and contain very little gravel. Needless to say the association of artefacts with these mounds was interpreted as proof that they were middens and the 'Ertebolle culture' of northern Europe was born.

Ertebolle culture 'middens' are usually linear mounds of shell 1-3m thick (Lubbock, 1869:217; Clark, 1975:193). Most are located only a metre or so above sea level. The four most abundant species in the mounds are Ostrea edulis, Cardium edule, Mytilus edulis and Littorina littorea. Slides taken by Wilfred Shawcross (pers. comm.) at Roskilde Fjord show a typical Ertebolle mound. It consists of a linear ridge of shell on the crest of a sandy beach ridge adjacent to the present shoreline. Although it contained numerous Ertebolle-style artefacts its form and composition rather suggest a natural storm ridge similar to the linear shell ridges which cap the cheniers of Essex in England and the Firth of Thames in New Zealand (Greensmith and Tucker, 1969; Woodroffe et al, 1983). It is evident that most of the archaeological criteria invented in Denmark for middens are met by these natural shell deposits and therefore are not useful criteria at all. The presence in the Ertebolle mounds of shellfish species seemingly from divergent habitats may reflect time-averaging rather than selection by people from a range of environments. Again the artefacts in them may simply be post-depositional in origin.

The Ertebolle midden itself is the 'classic type site' (Andersen and Johansen, 1986). This is not a mound in the usual sense but a series of shell 'heaps' located in a
marshy grassland below a small coastal cliff. Flint, bone and ceramic artefacts are found throughout the deposits. The grassland sediments are a raised seabed. Andersen and Johansen wrote that the Ertebolle midden displays many traces of marine activity and was always in the intertidal zone exposed to wave action, high tides and storms. Despite the obvious influence of marine processes they claimed that the main body of the midden was in situ. Plate 2.2 shows two shell heaps which they believe are undisturbed middens. The depression between the two heaps was interpreted by them as a hearth or firepit because it contained charcoal, burnt shell and clay. However, the shells in the heaps appear to be layered largely convex-side upward in the manner normally associated with wave-deposited shell. In fact the undulating surface of the shell heaps rather suggests ridge and runnel topography. The 'hearth' in the middle may simply be a runnel between two wave forms.

2.4.3 Southeast Asia

Danish thinking, which strongly influenced North American shell mound archaeologists, was also exported to southeast Asia by the British and Dutch. Shell mounds on the Malaysian coast northeast of Penang were first investigated by G.W. Earl in 1861 and his interpretation of them as man-made differed from that of the local Malays who considered them to be natural in origin (in Callenfels, 1936). Earl claimed that a shell mound at Guak Kepah rose nearly 7m above the surrounding paddy fields but by the time Callenfels excavated there in 1934 quarrying had reduced it to 1-2m in height. Callenfels' work demonstrated that the Guak Kepah mounds consisted of broken and unbroken shell dominated by the bivalve *Meretrix meretrix*. Artefacts were numerous throughout the mounds but given the disturbance wrought by lime-burners in the 1860's their original provenance is uncertain. Perhaps more illuminating are Callenfels' aerial photos which show that the mounds are part of a prograding beach ridge plain. In this context these mounds could easily have been natural shell deposits.
Plate 2.2 A section through the Ertebolle 'midden', Denmark (from Andersen and Johansen, 1986:Fig.9). Note the layering of the shells and the undulating surface of the shell heaps suggestive of ridge and runnel topography.
Across the Straits of Malacca in northeastern Sumatra similar shell mounds were known to exist but these too have been heavily disturbed. Van Heekeren (1972:87) recounted that these mounds reached heights of 4.5m. Initially they had been attributed to 'a plague raging among the shellfish' i.e. mass mortality but the discovery of artefacts in them convinced archaeologists that the mounds were middens. Most appear to have been located on a prograding coastal plain and like cheniers most extended for more than a metre beneath the surface or rested on marine clay. In this context the mass mortality theory seems to make more sense than accumulation through human agencies. Glover's photograph of a shell mound north of Medan presents an unlikely image of a cultural deposit (in Ceci, 1984). Glover dated a feature which he claimed was a hearth at the base of this massive deposit and it returned an age of c.7500 BP. Appearances suggest that this deposit really formed a natural part of a barrier sequence.

Archaeologists in north Vietnam have also investigated large shell mounds thought to be human in origin and these were reported by Boriskovskii (1968-71) a visiting Russian. In his account the pattern again emerges of shell mounds with characteristics consistent with wave-built deposits. The 5m high Quynh Van mound and the 4m high Da-but mound both appear to be located directly on coastal floodplains while the Bau Tro mound appears to be a 3m thick deposit of shell and other sediment located along the crest of a 23m long beach ridge also set in a low-lying coastal plain. Boriskovskii's photograph of a section of the Quynh Van mound indicates that the evenly-layered shells were probably deposited by water. 'Prospect holes' sunk through the Da-but mound showed that it continued for up to 1.5m below the surface of the floodplain. Again a barrier remnant or chenier is suggested. Numerous stone and ceramic artefacts were associated with these mounds but their provenance went unreported. Only the Da-but mound burials were said to reach depths of over 3m. Twelve burials in the Quynh Van mound were all 1-1.5m below the surface and are likely to be intrusive.

In the Andaman Islands Cipriani (1955, 1966) recorded numerous shell mounds which he believed had formed from the accumulation of waste beneath the communal huts of the indigenous Onge people. None of the islanders, however, had any personal
knowledge of the mounds and could not explain them (Cipriani, 1966:68). Cipriani wrote that the mounds were all regular in shape each with a circular base rising 45 degrees to form a truncated cone. Mound diameter was variable and heights ranged from 2-10m. The 5m high Golpahar mound which Cipriani excavated appears to have been located in mangrove swamp 200m from the sea. At least 90% of its contents were bivalve shells mainly *Cyrena* interspersed with 'sterile layers of black mud'. Five intrusive burials were present along with numerous obsidian, bone and ceramic artefacts. The top 4m of shell was very loose and well preserved but the bottom metre was hard and cemented. Cipriani (1955) claimed that the shells at this level had been calcinated by fire.

Although reinterpretation is difficult because Cipriani's accounts contain no maps or drawings, these mounds seem very similar in morphology and composition to some of the Scrubfowl mounds of northern Australia. It is noteworthy that the Nicobar Islands which are adjacent to the Andaman Islands are home to the Nicobar Scrubfowl *Megapodius nicobariensis* (Dekker, 1989). This bird is a mound-builder and its distribution may have been more extensive in the past. Dekker noted that earlier observers had thought it present on Little Andaman and on Coco Island to the north. Dekker argued that Scrubfowl were now absent from the Andaman Islands because of the presence of the predatory palm civet. He concluded that the Nicobar Scrubfowl may have ranged more widely in the past but become a relic on the arrival of predators in its former range. The mounds investigated by Cipriani may be evidence of this former distribution.

### 2.4.4 Australasia

South Pacific archaeologists are coming to grips with the idea that the earth mounds which they believed had been constructed by people were more likely to have been built by megapodes (Green, 1988). Most of these mounds are located on the interior plateau of the Ile des Pins south of New Caledonia. Comparatively few are known from the New Caledonian mainland. Green and Mitchell (1983) noted that mounds on the Ile des Pins were constructed from ferruginous gravel or coral while some on the mainland
comprised silica. The size of these mounds varies but one was 2m high with a diameter of 30m. Artefacts are very seldom found in the mounds although burials are encountered occasionally. Green and Mitchell thought that many of these mounds could be representative of an 'aceramic cultural complex' but since the discovery of bones of *Sylviornis neocaledoniae* on the Ile des Pins Green (1988) has acceded to the view put forward by Mourer-Chauvire and Poplin (1985) that this extinct galliform was probably the mound-builder. Balout and Olson (1989), however, have questioned the inclusion of this species in the Megapodiidae. Their discovery of the extinct *Megapodus molistructor* in a cave on the west coast of New Caledonia offers an alternative mound-building species.

One particular feature of the New Caledonian mounds which intrigued archaeologists was the presence of 'concrete cylinders' in the middle of the mounds (Green and Mitchell, 1983). Many of these cylinders are 2m high but one mound contained a flat bed of concrete 2m in diameter and 30cm thick a metre below its surface. Analysis revealed that the material was a calcite cementing haematite ironstone. Archaeologists believed that this material was mortar or cement produced by people and considered the cylinders an important indicator of cultural origin. Poplin and Mourer-Chauvire, however, claimed that the calcite globules in the material were formed in the soil by the action of micro-organisms (cited in Green, 1988). They argued that these micro-organisms were introduced into the mounds by megapodes whose nesting activities somehow influenced the growth of the central cylinders. Perhaps a simpler answer lies in comparison with the *Macrotermes* mounds of central Africa (Watson, 1974). These appear to have very similar calcareous features suggesting that universal physical processes such as groundwater flow and evaporation may have more to do with concrete formation than localised biological conditions.

A final example of mounds which have very little real claim to being human in origin comes from southeastern Australia. These are the earth mounds of central and western Victoria, the Murray valley and the Riverina region of New South Wales. These were deemed 'cultural' following excavations conducted by Coutts *et al* (1976). Williams
(1988) provided a detailed summary of the mounds. Typically they consist of dark earth and are circular to oval in shape (Fig.2.16). Most are 5-15m in diameter and can be anything from 0.2-1.2m in height. Some were apparently larger prior to European disturbance. Coutts et al's (1976, 1979) discovery of charcoal layers, burnt clay, faunal remains, stone artefacts and burials in some of the mounds was taken as proof that they were constructed by Aborigines. Archaeologists still debate whether the mounds were deliberately built as hut foundations or resulted from repeated earth oven cooking (e.g. Bird and Frankel, 1991).

The proposition that these earth mounds are human in origin was fuelled by the uncertain observations of early explorers who found the land and its people very unfamiliar. While their ramblings provide some evidence that Aborigines used mounds, none recorded Aborigines actually building them (see Coutts et al, 1976; Williams, 1988). In fact the link between these observations and the theories proposed by archaeologists to explain the growth of the mounds is tenuous. For example, G.A. Robinson's Aboriginal guides told him that one 1.2m high mound they passed was 'a black man's house, a large one like white man's house' (cited in Williams, 1988:9). In this case it is unclear whether the Aborigines were referring to the mound itself or a possible hut on top which had been burnt down. Other observations are simply mounds noted in passing, some clearly with huts on top of them, and recollections or assumptions that some were used as ovens for cooking. None of this ethnography presents any evidence for claims that the mounds were deliberately constructed by Aborigines or resulted from repeated cooking events.

Evidently the bond between archaeology and ethnography in this case is circular. Ethnographers remark on the mounds they encounter as Aboriginal in origin. Archaeologists recover cultural material from the mounds which 'confirms' the veracity of the ethnographic accounts. The ethnography is then used to support the archaeologists' interpretations of the mounds. Could this circle be broken with a natural explanation for these mounds? Sullivan and Buchan (1980) attempted this by drawing attention to naturally formed mounds which included discontinuous or eroded levees, gilgai mounds,
Figure 2.16 A typical western Victorian earth mound (from Coutts et al, 1976:Fig.7).
aeolian sand hummocks and mounds formed by fluvial deposition around trees which may then burn. They correctly stated that the presence of burnt clay and charcoal in any earth mound cannot be taken as evidence of human origin because these products commonly result from natural processes. Unfortunately they succumbed to the idea that the presence of artefacts in a mound was proof of human origin and proposed that this was the major difference between natural and 'Aboriginal mounds'.

Sullivan and Buchan (1980) wrongly concluded that the only natural mounds which closely resembled 'archaeological' mounds were fluvial mounds over which burnt trees had stood or fallen. In fact Malleefowl mounds also bear a striking resemblance to many of these earth mounds. Noted for their radial symmetry the dimensions of abandoned Malleefowl mounds recorded by Noble (in press) are very similar to those recorded by archaeologists for 'Aboriginal' mounds. Chemical analyses have shown that both types of mound comprise earth which is more fertile than the surrounding soil. Both types are also commonly distributed in clusters near water courses. As the Malleefowl is known to have ranged more widely than it does today it is conceivable that it built many of the earth mounds which archaeologists have recorded. Aborigines may have simply camped on abandoned Malleefowl mounds or used them as burial sites. Malleefowl may have also raked artefacts into their mounds from nearby Aboriginal campsites. It should also be remembered that meat ants could also be responsible for mounding the soil in which many artefacts are found (see Ettershank, 1968).

2.4.5 Summary

In summary there is good reason to suspect that many of the mounds investigated by archaeologists are natural in origin. Claims that shell mounds show how dependent some prehistoric people must have been on shellfish may give a very misleading impression of coastal life in the past. The presence of artefacts in a coastal shell deposit is no more proof that the shell was piled up by people than the presence of artefacts in a river terrace is proof that river sediments were piled up by people. In both
cases what probably happens is that artefacts are buried during natural depositional events or enter the deposits through post-depositional processes such as bioturbation. In none of the examples mentioned in this section is there anything to suggest that artefact-bearing shell deposits are demonstrably human in origin. In fact most of these deposits share a number of characteristics which strongly suggest that they were built by wave-action. The most salient are:

1. they are usually linear or elongate in form and shore-parallel,

2. they are usually located close to sea level either along the crest of a beach ridge or as part of a wider barrier system,

3. they are mostly composed of crushed shell or large whole shell which could have been sorted by surf action, and

4. they often extend beneath fine-grained coastal plain sediments in the same way that prograding shoreline deposits do.

Biological processes are likely to account for many of the remaining mounds of doubtful human origin. While the possibility that the shell mounds of the Andaman Islands are megapode mounds is highly speculative because adequate data is lacking, there is every reason to believe that many of the earth mounds of the South Pacific and southeastern Australia were built by these birds. It should be further noted that some of the 'Indian' earth mounds of California resemble Mima-mounds built by fossorial rodents (e.g. Treganza and Cook, 1948). Artefacts may enter these mounds in the same way that they enter any deposit and in some cases with the active assistance of the organism in question.

Ceci's (1984) criticism of shell midden archaeology stressed how little is known about specific behaviours and processes responsible for shell midden formation. She wrote that 'it scarcely seems possible to extrapolate the processes responsible for the world's truly huge shell middens' and suggested that ethnographic studies of shellfishing societies more sedentary than the shell gatherers studied by Meehan (1982) were needed
to explain the formation of these large shell deposits. Instead of better ethnographic analogues it would be far more productive to develop new methods for distinguishing between cultural and natural shell deposits.
CHAPTER 3

WEIPA

Scientific interest in the Weipa landscape was aroused by the geology of the area and its unusual shell mounds (Roth, 1901; Jackson, 1902). Economical deposits of bauxite were recognised in 1955 and the first shipment of bauxite left Weipa in 1963 (Evans, 1975). The landforms around Weipa were described briefly by Valentin (1959). His claim that the shell mounds were Aboriginal 'kitchen-middens' was disputed by Stanner (1961). This sparked the first shell mound controversy. Since then the Weipa area has been the focus of a number of studies involving geology, geomorphology, botany and archaeology. This chapter summarises the relevant information so that the Weipa shell mounds can be interpreted in their proper context.

3.1 Geology

Doutch (1976), Smart (1977a) and Smart et al (1980) have detailed the geology of the Weipa region. Schaap (1990) proposed a simplified version which is shown in Figure 3.1. The oldest rocks in the region are Proterozoic metamorphic rocks and middle to late Palaeozoic granites and volcanics. These outcrop on the east side of Cape York forming the Coen inlier. West of the Coen inlier these rocks are overlain by 250m of Jurassic and Cretaceous sandstones of the fluvial Garraway beds and the marine Gilbert River formation. Overlying these are 600m of early Cretaceous sediments of the Rolling Downs Group. These consist of shallow marine mudstone, siltstone and sandstone. The sediments at the top of the sequence in the Weipa area are known as the Weipa beds. These are fluvial or deltaic in origin and consist of coarse quartz sandstone overlain by interbedded kaolinite clays and quartz sands. At the surface there is a laterite zone comprising 0.5m of soil, 1-5m metres of bauxite and 1-2m of ironstone. Grubb (1971)
Figure 3.1 Simplified geology of Cape York Peninsula (from Schaap, 1990:Fig.1).
wrote that the most striking feature of the Weipa bauxite deposits is their characteristic loose pisolithic texture. The pisoliths range in size from less than 1mm to 20mm and are set in a red brown sandy matrix (Evans, 1975).

3.2 Climate

Weipa has a tropical savannah climate characterised by a short wet season between December and March and a long dry season between April and November (Bass et al, 1988, Gutteridge et al, 1990). Mean minimum and maximum daily temperatures range between 18 and 35 degrees Celsius throughout the year. During the dry season easterly and southeasterly trade winds prevail and humidity is relatively low. During the wet season Weipa receives most of its average annual rainfall of around 1700mm. Northwesterly winds are dominant at this time and tropical cyclones may develop. Holland (1984) noted that the Gulf of Carpentaria experiences the highest frequency of tropical storms in the northern Australian region.

3.3 Coastal Geomorphology

Albatross Bay is a fully marine coastal embayment with a depth of water generally less than 10m (Blaber et al, 1990). The Pine, Mission, Embley and Hey Rivers empty into the bay forming estuaries which extend for more than 30km inland. The coastline is mesotidal. Blaber et al reported a maximum tidal range for Weipa of 2.6m. The salinity of Albatross Bay varies little with season except in the river mouths (Blaber et al, 1989; Wang and Heron, 1990). Figure 3.2 shows how surface salinity, temperature and turbidity change each season in the Embley River. Salinity is dramatically lowered during the wet season. Evaporation during the dry season produces an `inverse estuary' which is more saline in its upper reaches than at its mouth (Wang and Heron, 1990).

The landforms of Albatross Bay were first described by Valentin (1959). He considered the estuaries to be `the finest examples of drowned river valleys on the west
Figure 3.2: Seasonal changes in salinity, temperature and turbidity in the Embley estuary (from Blaber et al., 1989: Figs. 1 and 2).

Map showing Embley estuary and Albarross Bay, with sampling sites in Embley estuary. (U = upper reaches, M = middle reaches, L = lower reaches.)

Seasonal changes in salinity (‰) (S), temperature (°C) (T) and turbidity (nephelometric turbidity units) (Tu) in the (a) lower, (b) middle and (c) upper reaches of the Embley estuary.
coast of Cape York Peninsula.' He recognised Duyfken Point, which forms the northern entrance to Albatross Bay, as a core of lateritised plateau fringed by dunes from which a 'compound recurved spit' had grown nearly barring the mouth of the Pine River. Alluvial land comprising mangroves, salt flats and marshes had formed in the shelter of the spit.

Valentin similarly described the Mission and Embley Rivers noting the presence of a 'barring ebb delta' as the only obstacle to shipping in the bay. He identified 'islands and banks of young alluvia' in the higher reaches of these rivers and 'a fantastic maze of mangroves, salt flats and marshes' at the southern end of the Hey River.

Valentin took a particular interest in the shell mounds of the Hey River. His observations from the air were among the first made of the shell mound environment. The mounds he saw were mostly long and narrow and appeared to rise around 6-13m above their surrounds. They ran roughly parallel to the shore and usually presented a steep slope on their seaward side. Two or three mounds were frequently found close together separated only by small streams draining the hinterland. The longer axes of these mounds formed a single line which was continued to a more distant mound by a low ridge similarly breached by small streams. The mounds and the low ridges connecting them appeared to follow the contours of the estuary. Most were located close to the boundary between the 'alluvial belt' and the forested hinterland.

Valentin interpreted the low ridges as natural beach ridges 'formed during the maximum of the submergence which drowned the Hey River'. The shell mounds, however, were puzzling. Valentin decided that they could not be isolated remnants of beach ridges because the waves of a narrow estuary could never build features 10-13m high. Instead he concluded that they were 'most probably artificial kitchen-middens which were piled up by an aboriginal population along the old shoreline indicated by the low ridge'. He further thought that the 'Aboriginal' shell mounds could be used to date the high stand of sea level which formed the old shoreline. His reasoning was that as Aborigines appeared to have arrived no earlier than the end of the last glaciation this shoreline must have formed in the mid-Holocene rather than the last interglacial period.
This model is flawed for it assumes that Aborigines avoided camping on landforms older than the period of their occupation.

Geomorphological investigations of coastal deposits near Weipa began in earnest with Smart (1976, 1977b). At Cape Keerweer south of Weipa Smart (1976) distinguished a barrier island sequence thought to be of late Pleistocene age from a sequence of mid-late Holocene chenier and barrier island ridges. The Pleistocene sequence lay inland on a basement of older alluvial fan material and comprised four sets of poorly preserved quartzose sand ridges. Smart claimed that these had formed during a regression from a high sea level some 120,000 years ago. The Holocene sequence was also represented by four sets of ridges. In the younger ridges shelly sand and whole shells were abundant but in the older ridges much carbonate appeared to have been removed by leaching. Smart's interpretation of these ridges as a progradational sequence post-dating the Holocene transgression 6-7000 years ago was supported by 25 uncorrected radiocarbon dates.

Smart (1977b) described the sediments lying offshore from Weipa (Fig.3.3). A nearshore sequence off Duyfken Point consisted of marine sandy shelly mud overlying sandy calcareous clay. Further offshore in water deeper than 60m these two units were separated by a carbonaceous sandy mud containing brackish-water foraminifera. Smart believed that the older calcareous clay unit had been exposed to subaerial weathering between 37,000 and 11,000 years ago when sea levels in the Gulf of Carpentaria were below -53m. The presence of brackish-water foraminifera in sediments below -60m suggested that the Gulf was a closed lake for most of this time. A minor marine transgression may have occurred between 30,000 and 20,000 years ago. Smart claimed that the youngest unit began forming less than 11,000 years ago in response to a rise in sea level which flooded the Gulf. He showed that this transgressive unit underlies many of the more recent progradational deposits in the region. Smart (1976) stated that the sand and shell in the beach ridges he examined derived from the winnowing of the transgressive unit by wave action.
Figure 3.3 A sequence of coastal and offshore sediments near Weipa (from Smart, 1977b:Figs.2 and 3).
Recent palaeoenvironmental investigations have detailed the sea level history of the Gulf of Carpentaria and confirmed the former existence of 'Lake Carpentaria' (e.g. Torgersen et al, 1988). Near Weipa the dunefields of the Pennefather Peninsula may be a local manifestation of regional sea level change (Fig.3.4). Lees et al (in press) have dated dune emplacement at 11,200 years BP; 8200 years BP and 5200 years BP and suggested that each of these events relates to a disturbance of the shoreline caused by rising sea levels. They argued that there has been at least one cycle of transgression - minor regression - transgression in recent times rather than a uniform sea level rise.

Late Holocene environmental change in Albatross Bay has been demonstrated by Hayne (1992). He investigated a beach ridge plain at Botchet, 9km northwest of Weipa, and obtained a sequence of 16 radiocarbon dates on shell from the ridge sediments (Fig.3.5). The shells ranged in age from around 2500 years BP at the rear of the sequence to 200 years BP near the modern beach face. Hayne argued that the formation of the beach ridges was associated with high energy events of the wet season. In sediments deposited between 2500 and 1300 years BP Anadara granosa was abundant. Around 1300 years BP there was a dramatic change in sediment type with Anadara shell replaced by much finer sediments. Hayne attributed this change to the longshore movement of sediments from the Pennefather Peninsula around Duyfken Point. This probably destroyed the Anadara beds and established a new source of sediment for ridge building.

3.4 Vegetation

The plant communities of Weipa have been documented by Specht et al (1977) and Gunness et al (1987). The vegetation map of Specht et al is presented in Figure 3.6. The lateritized plateau supports mostly Eucalyptus tetrodonta open-forest. Patches of closed forest (monsoon vine forest) grow around the edges of the plateau and on adjacent beach ridges and dunes. Many shell mounds around Weipa also support MVF species. Specht et al believed that MVF was more continuous in the past when there had been
Figure 3.4 Chronostratigraphy of the Pennefather Peninsula dunefield (from Lees et al, in press).
Figure 3.5 The Botchet beach ridge sequence (from Hayne, 1992:Fig.4.7).
Figure 3.6 Map of the vegetation around Weipa (from Specht et al., 1977:Fig.6).
more rainfall and attributed the contraction of MVF boundaries to climatic change rather than to fire or cyclone damage.

3.5 Archaeological Investigations

Since Roth (1901) and Jackson (1902) archaeological interest in the Weipa landscape has centred on the shell mounds of the Embley and Hey Rivers. Stanner (1961) set the example for future scientific inquiry by excavating a shell mound on the east bank of the Hey. His reasons for attributing the mounds to natural processes have already been discussed. Wright (1963) and Bailey (1975) concentrated on the shell mounds of the Embley and Hey Rivers. Guided by their archaeological training they dismissed Stanner's ideas and proposed that the shell mounds were of human origin. In 1984 Beaton excavated shell mounds from all around the Weipa landscape. He submitted shell samples for radiocarbon dating but did not publish the results. The archaeological research undertaken around Weipa from 1963 onwards is a good example of what Murray and White (1981) called 'Cambridge in the bush'. The following is a more detailed account.

3.5.1 Wright's Reconnaissance

Wright's (1963) aim was to establish either a natural or human origin for the shell mounds. To do this he chose a mound for excavation which already had a trench bulldozed through it. This was the Artesian Bore Midden later to be known as the Kwamter site (Fig.3.7). Three test pits were excavated along the eastern side of this mound and the section exposed by the bulldozer was examined. Wright found that the mound comprised mainly cockle shells and soil. The stratigraphy was unclear because of the 'differential charcoal content and soil/shell ratios'. In the bulldozer cutting bands of charcoal could be traced indicating discontinuous stratification. Wright (1971) obtained two radiocarbon dates on charcoal samples from the cutting. These returned ages of 810±105 BP (I-1738) near the base and 235±110 BP (I-1737) near the top.
Figure 3.7 Plan of the Kwarnter shell mound (from Bailey, 1975:Fig.VII.3).
'Deep borings' placed alongside the mound showed that it rested on sand and marine mud. Wright claimed that this demonstrated that the mound was entirely superficial. However, the precise locations of the holes went unreported. Surface examination of the mounds initially disappointed Wright for he found only 'three undiagnostic flakes' and no traces of the huts and fireplaces mentioned by Roth. His excavations, however, showed that although stone artefacts were 'exceedingly rare' bone points called muduk were 'liberally present'. He stated that muduks were recovered in situ from the lowest levels of the bulldozed section. Broken wallaby bones, stingray barbs and crocodile teeth were also recovered from the Kwanter mound. Wright's excavation of a shell mound on the Hey River showed that its structure and contents were indistinguishable from the Kwanter mound.

Wright was unable to accept any natural explanation for the mounds. He objected to the suggestion that they were eroded residues of previously more extensive shell deposits because there were no traces of gulling and the irregularities in mound form had not been removed. He also ruled out storm action as a cause of shell accumulation because of the occurrence of fragile artefacts and bands of charcoal throughout the mounds. The only reasonable natural explanation he could think of was a higher sea level but discounted this because it would need to be about 10m higher than present and he could find no evidence of tectonic or eustatic change. He therefore proposed that the mounds were human in origin. The reasons why he thought this have been outlined in the first chapter. These are the usual reasons invoked by archaeologists to justify calling a shell deposit a midden. In this case it seems that Wright was particularly persuaded by the presence of artefacts, faunal remains and charcoal layers.

3.5.2 Bailey's Research

Despite Wright's efforts, the possibility that the shell mounds were natural in origin 'remained a live issue locally' (Bailey, 1975:VII:2). In 1972 Bailey conducted a programme of survey and excavation which persuaded many archaeologists that the
Weipa shell mounds were middens after all. The cornerstone of his evidence was a one square metre excavation of the section bulldozed through the Kwamter mound (Fig.3.7). This revealed the same features which he and Wright considered to be the classic distinguishing marks of midden deposits. Bailey's (1975, 1977, 1983) analysis, however, was more detailed. From his excavation of 3m of deposit he counted eight polished bone points (muduk), fifteen small quartz flakes, a quartz core, a quartz pebble and a large flaked volcanic piece. He also considered as artefactual five broken stingray barbs and several split wallaby incisors. The bones which he recovered were small and fragmented. He counted 264 pieces of mammalian bone, 125 fish vertebrae and 21 crab claws. These he interpreted as the food remains of Aborigines. The presence of charcoal was also seen by Bailey (1975:Appendix B) as a sure sign that the deposit was a midden.

Bailey demonstrated that *Anadara granosa* accounted for 95% by weight of all shell in the Kwamter mound. A typical sample contained 54% by weight of intact single valves, 24% of small fragments and 22% of single valves with damaged edges. Bailey explained the condition of the shell in the mound entirely in terms of human impact on the site i.e. cooking and trampling. Other calculations were made by Bailey to show how much he thought shellfish contributed to the Aboriginal diet each year.

Bailey dated three samples of charcoal (SUA) from his excavation of the Kwamter mound and compared these to the two dates (I) obtained previously by Wright (Fig.3.8). However, he was unable to establish the precise stratigraphic relationship between the two sets of dates. Bailey (1977) claimed that the dates showed 'that shells began to be collected about 1200 years ago and accumulated more or less continuously until quite recently'.

Bailey believed that the way to remove all doubt about the human origin of the Weipa shell mounds was to compare them to shell deposits he was able to recognise as natural features. He chose for comparison the Kokato Island shell bank located in the middle of the Embley River opposite Kwamter and a shelly beach ridge at Edward River 250km away. He believed that what distinguished the Kwamter mound fundamentally
Radiocarbon Dates from the Kwamter Shell Mound

<table>
<thead>
<tr>
<th>Lab. no.</th>
<th>Provenance cm*</th>
<th>Date BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-1737</td>
<td>Near the top</td>
<td>235 ± 110</td>
</tr>
<tr>
<td>SUA-147</td>
<td>265</td>
<td>710 ± 100</td>
</tr>
<tr>
<td>SUA-149</td>
<td>150</td>
<td>835 ± 80</td>
</tr>
<tr>
<td>I-1738</td>
<td>At the base</td>
<td>810 ± 65</td>
</tr>
<tr>
<td>SUA-149</td>
<td>5</td>
<td>1180 ± 80</td>
</tr>
</tbody>
</table>

* The total depth of deposit is 3 m. Provenance is expressed in terms of height above the base of the deposit.

Figure 3.8 Charcoal ages from the Kwamter shell mound (from Bailey, 1977:Table 1).

Comparison of Molluscan Species in Artificial and Natural Shell Deposits
(dotted line divides species in common from those unique to each site)

<table>
<thead>
<tr>
<th>Kwamter (artificial)</th>
<th>Kokato Island (natural)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zeuxis dorsatus</td>
<td>Clémentia papyracea</td>
</tr>
<tr>
<td>Placmen sp.</td>
<td>Mactra sp.</td>
</tr>
<tr>
<td>Telecopium telescopium</td>
<td>Placuna placenta</td>
</tr>
<tr>
<td>Volegea wardiana</td>
<td>Turritella sp.</td>
</tr>
<tr>
<td>Batissa cf. violacea</td>
<td>Paphia semirugata</td>
</tr>
<tr>
<td>Tapes sp.</td>
<td>Tellina sp.</td>
</tr>
<tr>
<td>Crassostrea sp.</td>
<td>Regocara flava</td>
</tr>
<tr>
<td>Anadara granosa</td>
<td>Terebralia sulcata</td>
</tr>
<tr>
<td>Zeuxis cf. aurisjudae</td>
<td>Patro australis</td>
</tr>
<tr>
<td>Trigonostoma scalarina</td>
<td>Periglypta tesselcuta</td>
</tr>
<tr>
<td>Melo sp.</td>
<td>Gari venta</td>
</tr>
<tr>
<td>Corbults sp.</td>
<td>Venerid sp.</td>
</tr>
<tr>
<td>Cassidula cf. angulifera</td>
<td>Saccostrea cucullata</td>
</tr>
<tr>
<td>Cerithium sp.</td>
<td>Trisidos semitoria</td>
</tr>
<tr>
<td>Nerita linea</td>
<td>Anadara jurata</td>
</tr>
<tr>
<td>Ellohiuni cf. aurisjudae</td>
<td>Modiolus penellesans</td>
</tr>
</tbody>
</table>

Figure 3.9 Shellfish species represented in the Kwamter mound and nearby Kokato Island (from Bailey, 1977:Table 2).
from Kokato Island was the difference in the number of shellfish species present in the two deposits. These differences are shown in Figure 3.9. The most abundant species in both deposits was *Anadara granosa* but the Kwamter mound had only another seven species in common with Kokato Island. Bailey (1975:Appendix B, 1977) claimed that if the same process was responsible for shell deposition at both sites they would share a similar species list. Because they do not he declared that the shells in the Kwamter mound had been humanly selected. He believed that the presence of a large baler shell in the Kwamter mound was confirmation that cultural processes were responsible for this site.

These two deposits also differed in other ways which Bailey thought was relevant. The shells on Kokato Island were broken into small fragments, water-worn or bored by marine organisms while their counterparts in the Kwamter mound were apparently not. The shells on Kokato Island were also graded and Bailey considered the predominance of heavier shells on the lower surfaces to be typical of water lain deposits. The beach ridge he examined at Edward River was nothing like the Kwamter mound either. A section through the beach ridge revealed horizontal layering, a wide range in shell size and a complete absence of organic matter. These observations convinced Bailey that the Weipa shell mounds were not natural shell deposits.

Bailey spent the remainder of his time in the field measuring the Weipa shell mounds with a tape and clinometer. From this he was able to estimate the heights and volumes of 304 mounds. These were located on the east bank of the Hey River, both banks of the Embley River and the north bank of the Mission River. The shell mounds in the remaining areas were surveyed from the air or located on aerial photos. The largest mounds were on the East Hey where Bailey recorded four over 10m in height. However, the vast majority (94%) were less than 5m high. Bailey's impression was that *Anadara granosa* was the predominant molluscan species in all the Weipa mounds. He wrote that as 'far as can be judged from superficial examination, all the middens appear to be quite uniform in terms of species composition' (Bailey, 1975:VII:14). The Kwamter mound was considered to be representative of them all and this became the 'type-site'.
Bailey interpreted the prehistory of the Weipa landscape using 'site catchment analysis'. This approach was developed in Europe by Higgs and Vita-Finzi (1972) and at its heart is the belief that the distribution of archaeological sites is determined by economic considerations such as the proximity of resource zones and time-distance factors. Bailey drew circles around a major group of mound clusters to show just how 'optimally placed' they were in relation to marine and terrestrial resources. He attributed the clustering pattern to seasonal changes which compelled people to switch campsites. For example, in the wet season people would live on mounds under the shelter of trees and when mosquitos made life insufferable at the end of the wet the people would shift to mounds on open ground exposed to light breezes. Bailey's prehistory is underpinned by the belief that the coastal environment of Weipa has not changed since the formation of the shell mounds. He wrote:

Some sediment has probably accumulated in the mangroves and on the salt pans since the middens were first occupied. But there is no basis for inferring from the distribution of middens any substantial changes in the morphology of the river channels, the width of the mangrove barrier, or change in local relative mean sea level, during the past 1000 years (Bailey, 1983).

3.5.3 The Forgotten Work of John Beaton

Beaton (1985) is known for his work on the shell mounds of Princess Charlotte Bay but few researchers are aware of his fieldwork in the Weipa area conducted in 1984. Evidence of this was found in files held by the ANU Radiocarbon Dating Laboratory where Beaton had submitted a large number of shell samples for dating. These were analysed by John Head but final calculations were not made because Beaton apparently lost interest in them. John Head has now made the final results available. These include measurements of the $^{13}$C in the shells. A total of 34 samples were analysed (Table 3.1).

Fortunately the samples submitted by Beaton for dating were also accompanied by notes and sketches detailing where he had collected the shells. Figure 3.10 is a map based on Beaton's notes showing the general locations of the shell samples that were
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Table 3.1 Radiocarbon dates obtained on *Anadara granosa* shells collected by John Beaton from the Weipa shell mounds.

dated. Also shown are the heights of some of the shell mounds he recorded. Many of the shells which were dated simply came from shell mound surfaces but others were from sections he excavated. It would appear that at least seven shell mounds were excavated, all on the north and south banks of the Mission River. However, no detail is available about the precise stratigraphic provenance of the excavated shells. Beaton only refers to samples coming from the 'base', 'middle levels' or 'top' of a shell mound. Nevertheless,
Figure 3.10 Locations of shell mounds investigated by J. Beaton in the Weipa area and dates obtained on Anadara granosa samples collected from them. Figures in metres (m) represent shell mound heights. Radiocarbon dates are Conventional Radiocarbon Ages.
there is sufficient information available to locate which particular mound sites the samples came from. This is significant because it allows an overview of shell mound ages from all around the Weipa landscape.

The general picture which emerges is that the shells furthest from the sea tend to be older than the shells nearer to the sea. Six of the seven dates on the landward side of a chenier ridge east of Luang Creek are significantly older than two dates from the seaward side of this ridge. On the south side of the Mission River there are ten dates which also tend to decrease in age in the seaward direction. This pattern is again repeated in the southeastern corner of the Hey River. The overall trend of the shell ages around Weipa to become progressively younger in the seaward direction is consistent with a prograding shoreline sequence.
CHAPTER 4

RESEARCH PLAN

The first chapter presented current thought on mounds in northern Australia and stated the basic aims of this thesis. The second chapter showed that mound formation is possible from a range of natural and cultural processes. It also introduced an element of doubt about many archaeological accounts of mounds. The third chapter set the environmental backdrop to Weipa and detailed the previous work undertaken on shell mounds in the area.

The rest of this thesis is divided into two parts. The first tests the hypothesis that the Weipa shell mounds are human in origin by dating a sequence of shells from the Kwamter mound. This is augmented by an examination of the shells under a light binocular and scanning electron microscope. The second part is a geomorphological analysis of the shell mound environment. Two locations on either side of the Mission River have been selected for investigation of this kind.

4.1 Radiocarbon Dating

The hypothesis that the Weipa shell mounds are human in origin is eminently testable. Bailey (1975, 1977) has explicitly stated that the mounds are shell middens. The evidence in favour of this hypothesis derives entirely from excavation of the Kwamter mound. This is the 'type-site' for all the Weipa shell mounds. The hypothesis that the shells accumulated gradually through human agencies rests entirely upon five radiocarbon dates obtained on charcoal samples from the Kwamter mound. Bailey (1977) wrote:

The Kwamter radiocarbon dates indicate that shells began to be collected about 1200 years ago and accumulated more or less continuously until quite recently.
This hypothesis will be tested by dating a sequence of shells from the Kwamter mound and comparing the results to those obtained previously on charcoal. If, as Bailey maintains, the shells really had ‘accumulated in a process of upward growth’ the shell dates should get progressively younger from the bottom of the mound to the top. If they do not, the hypothesis of human origin must be questioned. In this event a natural explanation should be sought for the mounds.

4.2 Microscopy

A further test of the hypothesis of human origin can be made by examining the shells under a light binocular and scanning electron microscope. Surface textures imprinted on the shells may reveal the post-mortem history of the shell and show if the organism died onshore or offshore. The part of the shell to be examined will be the interior surface of the valve inside the pallial line. Cutler (1987) chose this surface for his SEM work to:

- ensure that the features observed were truly post-mortem, since these surfaces are not exposed during life. Interior surfaces have the added advantage of being relatively smooth and uncomplicated, serving as an easily interpretable “blank slate” for borings, scratches, and the like.

Cutler's SEM investigation was aimed at identifying traces left by various biological, physical and chemical agents on shells in a present-day intertidal environment. These traces included encrustation by epibionts, boring by sponges, algae and other organisms, rasping by gastropods and chitons, abrasion by waves and currents, and dissolution. Cutler believed that the identification of such traces in fossil shells could be used to reconstruct past sedimentary environments.

Examination of the interior surfaces of shell valves also has potential to resolve archaeological problems such as the origins of shell mounds. If the shells in the Weipa shell mounds were taken from their intertidal habitat and brought to dry land by Aborigines for consumption then their interior surfaces should show no signs of encrustation, boring or any other activity associated exclusively with sea water. If these
signs are present it will prove that the shellfish died in the sea and could not possibly have been collected by Aborigines for food.

The shells selected for examination are from the Kwanter sequence and the surface of a mound at Prumanung on the north bank of the Mission River. To ensure that the traces observed on the shells are not due to organisms still living in the mounds a sample of shells will be placed in a medium to see if any trace-producing organisms can be cultured from them.

4.3 Geomorphology

The geomorphology and environmental history of the coastal landscape encompassing the Weipa shell mounds will be investigated by mapping and augering two contrasting shell mound environments. The first is at Prumanung on the north bank of the Mission River. The shell mound here is Bailey's (1975) Site 304. The age of this mound is known from radiocarbon dates obtained on three shell samples collected from it by Beaton (see Fig.3.10). Three transects will be surveyed across the coastal deposits at Prumanung including one across the shell mound. The deposits will be described in the field and sediment samples retained for grain-size analysis (whole samples). A contour map will also be constructed to detail a mound cluster not recorded previously. Shells from the various depositional units will be dated to provide a geochronological framework in which to interpret the Prumanung shell mound.

The second environment to be investigated is on the south bank of the Mission River in the Uningan Nature Reserve. This is a broad coastal plain containing five conspicuous shell mounds. Four of these mounds will be included in two transects across the coastal plain. Two smaller transects will supplement this information. The sediments along the transects will be augured and analysed in the same way as those from Prumanung. Ten radiocarbon dates obtained on shell samples collected by Beaton from
the Uningan shell mounds will facilitate a geochronological interpretation of the coastal plain (see Fig.3.10).

Geomorphological analysis will determine if the coastal environment of Weipa has changed substantially since the formation of the shell mounds. Subsurface investigation of sediments surrounding the mounds will test the claim that the mounds are superficially located on the surface of deposits older than them. Detailed mapping of the shell mound environment will show if the mounds are composed largely of *Anadara granosa* or contain a diversity of sediment types. Whatever the results it should be possible to draw conclusions about the origins of the Weipa shell mounds.
CHAPTER 5

RESULTS

The results of the various analyses undertaken are described in this chapter. A sequence of ten shells from the Kwanter mound has been dated and this shows that most of the shells in the mound are roughly the same age. Under the microscope the shells reveal a range of features imprinted on the interior surfaces of the valves. These may have been produced by cyanobacteria still living in the shells as seven genera have been cultured from them.

Geomorphological investigation at Prumanung and Uningan has revealed the stratigraphy of the shell mound environment. Eight shell samples from a ridge sequence at Prumanung have been dated. The sediments in these two environments are diverse and this is reflected in the composition of the mounds. The morphology of a selection of these is detailed with contour maps and block diagrams.

5.1 The Kwanter Sequence

The Kwanter shell mound is located on the north bank of the Embley River some 10km southeast of Weipa (see Fig.1.2). Bailey (1977) described it as a mound 110m by 45m with a maximum thickness of 3m and an estimated volume of 2250 cubic metres (see Fig.3.7). Its long axis runs roughly parallel to the shoreline. The trench which had been bulldozed through the mound prior to Wright's excavation in 1963 still exists today. An indentation observed in the east wall of this trench is probably the remains of Bailey's excavation. The floor of the trench is partly filled with shell which has collapsed into it from the sides. The rest of the mound is relatively undisturbed and supports a cover of monsoon vine forest species.

On the east wall of the bulldozed section about 1.5m south of the indentation thought to be the site of Bailey's excavation a face was cleaned back with a shovel to
expose an undisturbed section of shell (Plate 5.1). This revealed a sequence of randomly-oriented *Anadara granosa* valves interspersed with thin layers of ash and fine charcoal. The shells in the top metre of the deposit are mixed with a high proportion of sand and shell grit. In the bottom two metres the deposit consists almost entirely of tightly-packed whole valves. The ash and charcoal layers which occur throughout the sequence are similar to those recorded by Wright and Bailey. These are no thicker than 5cm (Plate 5.2).

Samples of *Anadara granosa* shell were taken from the section at intervals of 30-40cm. Ten shell valves were submitted to the ANU Radiocarbon Dating Laboratory for analysis. Following pretreatment and conversion to benzene the samples were placed in a liquid scintillation spectrometer where the beta emmissions were measured. The abundance of $^{13}$C in the carbon dioxide removed from each sample was determined by stable isotope mass spectroscopy. Two living mud whelk shells (*Telescopium telescopium*) were also analysed. One came from the floor of the mangrove forest opposite Kwamter (ANU 8020) while the other came from the floor of the mangrove forest opposite Uningan (ANU 8019). Table 5.1 lists the results of these analyses.

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Table 5.1 Radiocarbon dates obtained on shells from the Kwamter mound and on two living specimens. $^{13}$C values for each sample are included. Depths are from the surface of the mound to the base.
Plate 5.1 Three metre face exposed in the bulldozed section of the KwaMter mound. Shells were collected from this face at 30-40cm intervals and dated.

Plate 5.2 A close-up of the exposed face showing randomly-oriented *Anadara granosa* valves and two thin layers of ash and fine charcoal.
These results demonstrate that most of the shells in the Kwamter mound are roughly the same age. The top two dates have an average conventional age of around 650 years. The remaining eight dates are significantly older and average around 930 years. Analysis of the modern samples shows that the carbon isotopes of living shell are in equilibrium with the atmosphere. Their $^{13}\text{C}$ values are far more negative than the $^{13}\text{C}$ values for the old shell. Figure 5.1 compares these results to the ages obtained on charcoal by Wright and Bailey. Except for the charcoal age at the top of the sequence, the shell and charcoal dates are comparable.

5.2 Shell Valve Microscopy

5.2.1 Surface Textures

Ten *Anadara granosa* valves were taken for microscope examination from the same levels of the Kwamter mound as the shells which have been dated. Three *Anadara granosa* valves from the surface of the Prumanung shell mound were also examined. A control sample came from *Anadara granosa* shells received alive from Arnhem Land. In order to scan the interior surfaces of these shells the umbo of each sample was removed with a rock saw and the sample cut in two. This left half a valve with one abductor muscle scar. These pieces, usually about 2cm wide, were sputter-coated with gold and placed inside a Jeol 6400 Scanning Electron Microscope. A light binocular microscope was used on only one sample because of the relatively high magnification needed to see most features.

Plate 5.3 shows a selection of the range of microscopic features found on the interior surfaces of the shells. All are located inside the pallial line. The undisturbed abductor muscle scar surface of the control sample is shown in Plate 5.3/1. It displays an arrangement of flat hexagonal tablets. Outside the area of the muscle scar the interior surface of the control sample has a grainy appearance (Plate 5.3/2). These two surfaces provide the 'blank slate' on which the post-mortem history of the shell may be written.
Figure 5.1 Schematic section through the Kwamter mound showing the Conventional Radiocarbon Ages of the shells in relation to the charcoal dates obtained previously by Wright (1971) and Bailey (1977). Also shown are the $^{13}$C values for the shells.
Plate 5.3  1. Undisturbed abductor muscle scar surface of *Anadara granosa*. 2. Undisturbed surface of *A. granosa* outside the muscle scar (inside the pallial line). 3-4. Two kinds of boring on the interior surface of a shell from 20cm below the surface of the Kwarmer mound. 5. Bundle of needles on the interior surface of a shell from 50cm below the surface of the Kwarmer mound. 6. Borings and shallow pits on the interior surface of a shell from the Prumanung shell mound.
The features imprinted on a sample from 20cm below the surface of the Kwamter mound include two different types of borings. The first is represented by a group of long, continuous furrows (Plate 5.3/3). These occur on the surface of the muscle scar and are about 10 microns wide. The second type are discontinuous grooves which sometimes show a branching pattern (Plate 5.3/4). These are found mostly outside the muscle scar and are between 4 and 10 microns wide.

The samples from depths of more than 50cm below the surface of the Kwamter mound consistently show needle-like objects scattered randomly about the shell surface. The individual needles are only 1 micron wide but vary considerably in length (Plate 5.3/5). Some give the appearance of being hollow tubes. Others appear to have fused together. On one sample these needles have coalesced to form a thick microscopic mat. Often the shell surface is so completely covered in needles that it is impossible to locate any other features.

Samples from the surface of the Prumanung shell mound also display a range of microscopic features imprinted on the shell. These include borings which are present on surfaces both inside and outside the muscle scar (Plate 5.3/6). These borings are around 4-10 microns wide and are usually continuous. They appear to have been overprinted by numerous circular pits around 5-10 microns in diameter.

One sample from 80cm below the surface of the Kwamter mound has three macroscopic features on the abductor muscle scar which appear to be encrustations (Plates 5.4 and 5.5). The muscle scar is around 1cm in diameter and has the encrustations distributed evenly across it. The shell surface surrounding the muscle scar appears to be unmarked.

5.2.2 Living Micro-organisms

Three shells from 40cm, 80cm and 100cm below the surface of the Kwamter shell mound and one shell from the surface of the Prumanung shell mound were placed
Plate 5.4 Encrustations on the abductor muscle scar of an *Anadara granosa* shell from the Kwamter mound.

Plate 5.5 Close-up of one of the encrustations.
in beakers of full strength Allen and Arnon medium plus 1mM of ammonia and left in continuous light at 26 degrees C for 3 months. The medium was changed after one month. At this point a shell from the surface of the Kwanter mound was also placed in a beaker of medium. After 2 months in the medium all the shells had sprouted growths of bright green organic matter. These growths have been identified as blooms of blue-green algae, now known as cyanobacteria.

Nola de Chazal of the ANU Biochemistry Department has identified seven genera of cyanobacteria in the cultured specimens. The shells from the Kwanter mound support filamentous non-heterocystous LPP (Lyngbya, Plectonema, Phormidium) cyanobacteria and heterocystous Nostoc. Also present are unicellular Chlorogloeopsis, Myxosarcina, Xenococcus and Dermocarpa. These genera, with the exception of Nostoc, have also been identified in the sample from the Prumanung shell mound. An additional genera in the Prumanung sample is the heterocystous Scytonema.

5.3 Geomorphology

The two areas which have been investigated using geomorphological methods are located along the banks of the Mission River where it widens into a funnel-shaped estuary (Fig.5.2). The Prumanung deposits consist of a sequence of linear ridges partly fringed by mangroves. Mound clusters are located at opposite ends of these ridges. The Uningan environment is largely a broad, flat coastal plain thick with mangroves on its seaward side. Mounds are scattered across the plain and along an isolated linear ridge.

5.3.1 Prumanung

The Prumanung sequence fronts the Mission River west of Andoom Creek (Plate 5.6). It consists of a series of shore-parallel sandy ridges which converge on a point approximately 800m southwest of the mouth of Andoom Creek. These ridges form a thick composite body with only one ridge clearly diverging from the rest. The Prumanung
Figure 5.2 Location of Prumanung and the Uningan coastal plain.
Plate 5.6 Aerial view of Prumanung. Scale is approximately 1:5000.
shell mound is located at the point where the ridges converge. It is the largest of a cluster of three elongate shell mounds. These are strung out along the crest of the most seaward ridge for a distance of nearly 200m. The main shell mound is 42m long and 15m wide (Plate 5.7). Exposed sections show that the mounds are composed almost entirely of coarse *Anadara granosa* shell. These shells are also scattered widely over the surface of the adjacent deposits. A distinguishing feature of the Prumanung shell mounds is their almost complete cover of monsoon vine forest species.

The three transects surveyed across the Prumanung deposits are shown on Plate 5.6. A total of 33 holes have been augured along these transects. Figure 5.3 is a stratigraphic section showing the position of the main Prumanung shell mound (Transect A-B). This mound is located immediately behind the modern shell-capped beach. Its seaward side presents a very steep slope rising 3m above the crest of the modern beach. Its landward slope is shorter rising only 1.5m above the adjacent deposits. The entire depositional complex has been built on a sandy tidal flat. The lowermost unit consists of shelly sand with pisoliths and medium to fine shell fragments. Beachrock has developed within this unit. The uppermost units abut the base of the shell mound and are composed of sand with variable quantities of pisoliths. These units are devoid of shell material except for a veneer of coarse *Anadara granosa* shell.

The Prumanung sequence widens significantly in the direction of Transect C-D (Figure 5.4). Along this transect the stratigraphy again shows a sandy tidal flat overlain by a unit of shelly sand, pisoliths and medium to fine shell fragments. Beachrock recurs in this unit. At the seaward end of the transect the deposits contain a high proportion of coarse *Anadara granosa* shell. The sediments on the crest of the modern beach and the slope of the ridge behind it are mainly fine sands. The ridge is capped by a thick unit of shell hash and pisoliths. Towards the rear of the sequence the shelly units are covered by deposits of sand and pisoliths. The sands at the surface tend to be finer than those underneath. Swales at the foot of the highest ridge and at the rear of the sequence have filled with silt and clay. Overall, this section shows some pronouncement of the ridges and the beginnings of ridge divergence.
Plate 5.7  The main Prumanung shell mound. Note the cover of monsoon vine forest species.

Plate 5.8  Mounds of shelly sand and pisoliths under a patch of monsoon vine forest near the mouth of Andoom Creek (see also Fig.5.6).
Figure 5.3 Stratigraphic section along Prumanung Transect A-B. Note the relationship of the shell mound to the beach capped by similar material. Also shown are the shellfish species represented in the sediments.
Figure 5.4 Stratigraphic section along Prumaning Transect C-D showing grain size data representative of the stratigraphic units. Also shown are the shellfish species represented in the sediments.
Figure 5.5 Stratigraphic section along Prumanung Transect E-F showing grain size data representative of the stratigraphic units. Also shown are the shellfish species represented in the sediments. Radiocarbon dates were obtained on shells and are Conventional Radiocarbon Ages only (see Table 5.2).

A = Anadara granosa
M = ? Marcia hiantina
C = cf Circe lentiformis
S = Saccostrea sp.
P = Protholotia suturalis
Ce = Cerithiopsilla cf cingulata
N = Nerita plicata
Ar = Arca imbricata
Transect E-F shows the Prumanung deposits diverging into four distinct ridges (Fig.5.5). The sandy tidal flat which underlies the deposits elsewhere in the Prumanung sequence is replaced by silt and clay. The most seaward ridge is in the mangrove zone. It consists of shelly sand, pisoliths and coarse *Anadara granosa* shell. These sediments extend beneath the mangrove mud for 2m. Behind this ridge are three closely-spaced ridges separated by two swales. Most of the sediments in these ridges are shelly sands, pisoliths and medium to fine shell fragments. The first extends for 2m beneath the mangrove mud and contains coarse *Anadara* shell in its lowermost unit. At the surface this shell is mixed with a deposit of fine shelly sand and pisoliths. Shell hash and pisoliths cap the next ridge while the most landward has only sand and pisoliths in its upper units. The swales are filled with deposits of silt and clay overlain by fine sand and pisoliths.

Radiocarbon dates were obtained on eight shell samples augured from the four ridges along Transect E-F (Figure 5.5). Two living shells from the floor of the mangrove forest near the mouth of Andoom Creek were also analysed. The conventional ages of the shell in the ridge sequence range from 800±40 years BP (ANU 8032) at the seaward end to 4530±80 years BP (ANU 8038) at the landward end. The date of 790±220 years BP (ANU 8033) has a large error band because the sample size was small. Analysis of the two modern samples shows that the carbon isotopes of living shell are in equilibrium with the atmosphere. Both give $^{13}$C values similar to those obtained on living shell from Kwaamter and Uningan. Again they are far more negative than the $^{13}$C values for the old shells. These results are listed in Table 5.2.

Identification of the shellfish species represented in the Prumanung deposits confirms that they are estuarine in origin. These were sieved from samples taken from a range of depositional units and identified by Phil Colman of the Australian Museum. A total of ten species were identified all of which inhabit an estuarine environment. Figures 5.3, 5.4 and 5.5 show how these species are distributed across the deposits. The most frequently occurring species are *Anadara granosa*, *Marcia hiantina*, cf *Circe lentiformis*, *Saccostrea sp.*, *Prothalotia suturalis* and *Cerithidiopsilla* cf *cingulata*. The remaining four
species occur only sporadically. These are *Trigonostoma scalarina*, *Nerita plicata*, *Arca imbricata* and *Telescopium telescopium*.

Figure 5.6 is a block diagram, contour map and section of a mound cluster near the mouth of Andoom Creek. It shows one large mound and two smaller mounds aligned along the top of a sandy ridge fringed by mangroves (Plate 5.8). Part of the smallest mound has been cut away by Andoom Creek. The rest are under a cover of monsoon vine forest. The large mound is conical to elongate in form with a very steep seaward slope. From its landward side it rises nearly 2m above the level of the ridge. The smaller mound nearby rises only 80cm above this level. These mounds are similar in many ways to the shell mounds at the opposite end of the sequence. However, these mounds contain only minor amounts of coarse *Anadara granosa* shell. Figure 5.6 shows that the large mound is composed mostly of shelly sand and pisoliths. The smaller mounds are composed of similar material.

<table>
<thead>
<tr>
<th>ANU No</th>
<th>Sample Material</th>
<th>$^{13}$C</th>
<th>Conventional Age yBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>8031</td>
<td>Estuarine shell</td>
<td>-2.0±0.1</td>
<td>1090±50</td>
</tr>
<tr>
<td>8032</td>
<td>Estuarine shell</td>
<td>-1.7±0.1</td>
<td>800±40</td>
</tr>
<tr>
<td>8033</td>
<td>Estuarine shell</td>
<td>-2.1±0.1</td>
<td>790±220</td>
</tr>
<tr>
<td>8034</td>
<td>Estuarine shell</td>
<td>-1.7±0.1</td>
<td>1490±80</td>
</tr>
<tr>
<td>8035</td>
<td>Estuarine shell</td>
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<td>3820±60</td>
</tr>
<tr>
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<td>Estuarine shell</td>
<td>-0.4±0.1</td>
<td>2790±80</td>
</tr>
<tr>
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<td>Estuarine shell</td>
<td>-1.4±0.1</td>
<td>2850±70</td>
</tr>
<tr>
<td>8038</td>
<td>Estuarine shell</td>
<td>-0.7±0.1</td>
<td>4530±80</td>
</tr>
<tr>
<td>8017</td>
<td>Live <em>Polymesoda coaxans</em></td>
<td>-8.6±0.1</td>
<td>121.0±1.0% M</td>
</tr>
<tr>
<td>8018</td>
<td>Live <em>Telescopium</em></td>
<td>-7.9±0.1</td>
<td>120.0±1.0% M</td>
</tr>
</tbody>
</table>

Table 5.2 Radiocarbon dates obtained on shell samples from Transect E-F of the Prumanung ridge sequence including $^{13}$C values for each sample.
Figure 5.6 Block diagram, contour map and section of the shelly sand and pisolith mounds near the mouth of Andoom Creek (see also Plate 5.8).
5.3.2 Uningan

The Uningan coastal plain is a broad expanse of silt and clay which fans out into the Mission River from Oxmurra Point (Plate 5.9). Along its inner edge there is a discontinuous sandy ridge running parallel to the bauxitic laterite plateau. Mounds and monsoon vine forest species are found along the length of this ridge. Towards the Mission River the silt and clay plain forms a belt of grassland and salt pan up to 500m wide. Five conspicuous shell mounds are found in this belt and all support a light cover of monsoon vine forest species. At its southern end the plain is cut by the meandering tidal channel of Uningan Creek. Mangroves grow along this channel and along the muddy shore of the Mission River.

The locations of the four transects surveyed at Uningan are shown on Plate 5.9. A total of 71 holes have been augured. Two shell mounds located along Transect G-H have been made the subject of a fence diagram (Fig.5.7). This was constructed from holes augured alongside the edges of the mounds. Both appear to be composed mainly of coarse Anadara granosa shell. The shell mound closest to the sea is the tallest of the two. It rises 3.7m above the level of the plain (Plate 5.10). The basement rock beneath this mound is no more than 90cm below the surface of the plain. On the seaward side of the mound fragments of Anadara shell extend beneath the plain to the rock below. On the landward side the mound is underlain mostly by silt and clay.

Figure 5.8 depicts this mound in more detail. The mound is 38m long and 20m wide with its long axis running roughly parallel to the shoreline. The landward face of the mound is distinctly lobed along the base. About half way up there is a break in slope which separates the more subdued lower half of the mound from the much steeper upper half. This gives the deposit the appearance of being a steep-sided conical mound supplanted on an elongate ridge.

The other shell mound located along Transect G-H rises 1.8m above the level of the plain. On its seaward side fragments of Anadara shell extend for 30cm into the
Figure 5.7 Fence diagram showing the stratigraphy of the deposits located along Transect G-H at Uningan. Note the extension of coarse sediments beneath the shell mounds to the rock below.
Plate 5.10 Shell mound located along Transect G-H at Uningan. The line of trees in the background are mangroves. Monsoon vine forest species grow on the mound (see also Fig. 5.8).

Plate 5.11 Two of the three composite shell mounds located along Transect K-L at Uningan.
Figure 5.8 Block diagram, contour map and section of 3.7m high shell mound located along Transect G-H at Uningan (see also Plate 5.10).
underlying deposits. Near the surface these deposits consist of silt and clay. Beneath these sediments the shell passes into sand mixed with silt and clay. The sandy deposits rest on basement rock on the seaward side of the mound. They run parallel to the shoreline for 70m and reach a maximum thickness of 1m directly under the mound. Towards the landward side of the mound the sandy deposits taper out into silt and clay. Between the mound and the sandy ridge behind it the basement rock is covered by a sandy sheet 20-30cm thick. This is overlain by more silt and clay which continues beneath the sandy ridge at the rear of the transect. This ridge consists of coarse sand and gravel overlain by gravelly medium sand. A deposit of almost pure silt mantles the foot of the ridge.

The two shell mounds located along Transect I-J are shown in Figure 5.9. The largest of these is actually a composite feature consisting of three steep-sided conical mounds superimposed on two linear shell ridges (Plates 5.11 and 5.12). Transect K-L shows that the three mounds stand between 3 and 4.5m above the level of the plain (Fig.5.9). All appear to be composed of coarse *Anadara granosa* shell. The two linear ridges are also composed of this shell. In both this extends beneath the underlying silt and clay for 60cm. The ridge on the seaward side forms an arc around the foot of the three mounds (Plate 5.13). The seaward face of this ridge is relatively gentle and lines of mangrove debris are found along it. However, its landward face dips steeply where it protrudes from under the mounds (Plate 5.14). The slopes of the ridge behind it are more subdued and rise steadily to merge with the tallest mound. Mangroves encircle the entire feature.

The second shell mound located along Transect I-J is a much less substantial feature (Plate 5.15). It measures only 20m X 10m in area and rises only 1m above the level of the plain. The long axis of this mound runs roughly parallel to the shoreline. Coarse *Anadara granosa* shell appears to be the main component. However, this shell does not rise to a conical peak as it does in all the other mounds. Nor does it extend
Figure 5.9 Stratigraphic section along Transect I-J at Uningan. The shell mounds along Transect K-L are projected to show that they are superimposed on two low shell ridges. Grain size data is shown for the sandy ridge at the rear of the sequence.
Plate 5.12 One of the two linear shell ridges which protrude from under the shell mounds along Transect K-L. This is the most seaward ridge located along Transect I-J.

Plate 5.13 The most seaward ridge along Transect I-J arcs around the foot of the most seaward mound along Transect K-L.
Plate 5.14 The steeply-dipping landward face of the seaward ridge along Transect I-J at its distal end. Mangroves protrude from the ridge.

Plate 5.15 The isolated low shell mound located along Transect I-J. Deposits of silt and clay are exposed in the foreground. A few monsoon vine forest species grow on the mound.
beneath the surface. The sediments underlying the edge of this mound are entirely silt and clay.

Towards the rear of Transect I-J the basement rock rises steadily. The overlying silt and clay deposits rise with it. The elevated sandy ridge at the rear of the transect rests mostly on silt and clay. It consists of a deposit of very gravelly sand overlain by a deposit of gravelly medium sand. Deposits of almost pure silt mantle the foot of the ridge on both sides. The base of the sandy ridge is 1.2m higher than the base of the most seaward shell ridge.

Figure 5.10 presents a stratigraphic section through a mound built on the sandy ridge (Transect M-N). This mound is a conical feature which rises some 1.2m above the surface of the ridge. The mound sediments consist of a deposit of very gravelly sand mixed with shell hash overlain by very gravelly sand. Only a small amount of coarse *Anadara granosa* shell is present. Most of the ridge sediments rest on basement rock but those on the landward side have been deposited over silt and clay. These include a deposit of very gravelly sand similar to the sediments at the top of the mound. The ridge sediments immediately beneath the mound are similar to the sediments at the core of the mound.

Mounds which appear to be composed mainly of coarse *Anadara granosa* shell also occur along the top of the sandy ridge. Figure 5.11 is a block diagram, contour map and section of a shell mound located on the sandy ridge just south of Transect G-H. Examination of the surface of this mound suggests that sand is also a major component. This mound is a discrete conical feature 20m long and 14m wide. It rises 1m above the surface of the sandy ridge. Beyond a radius of about 30m from the mound the surface of the ridge is scattered with coarse *Anadara granosa* shell.
Figure 5.10 Stratigraphic section along Transect M-N at Uningan showing grain size data for a mound of mixed composition and the sedimentary units underlying it. Also shown are the shellfish species represented in the sediments. Note the coarseness of the mound sediments.
Figure 5.11 Block diagram, contour map and section of 1m high shell mound located on the sandy ridge near Transect G-H at Uningan.
CHAPTER 6

DISCUSSION

One hypothesis that has remained in tact, however, is the hypothesis that the Weipa shell mounds were accumulated by generations of human occupants. This remains the only serious hypothesis in sight, and I expect it to retain that position in the face of future challenge, conjecture and field observation (Bailey, 1991).

The results of this investigation suggest that archaeologists have erred in interpreting the Weipa shell mounds as cultural deposits. The hypothesis that the shells in the Kwamter mound accumulated as a result of repeated Aboriginal shellfishing and occupation is not supported by the sequence of radiocarbon dates obtained on shells from the mound. From a geographical perspective the coastal environment of Weipa emerges as a natural rather than cultural landscape. The shell deposits were initially formed by wave action and each is best seen as a transported death assemblage or 'thanatocoenosis'. The hypothesis that Scrubfowl have played a significant role in transforming many of these deposits into tall, steep-sided shell mounds is clearly tenable. No other hypothesis adequately explains the available data.

6.1 The Hypothesis of Human Origin

The hypothesis that the Weipa shell mounds are human in origin has been tested by radiocarbon dating a sequence of shells from the Kwamter mound and examining the interior surfaces of a selection of shell valves. The results of the dating do not support archaeological theories of mound formation. The shell valve examination was experimental and was pursued because of its potential to provide a simple method for distinguishing between cultural and natural shell deposits. It met with only limited success because most of the features that were observed could have been produced \textit{in situ} rather than in a prior depositional environment.
6.1.1 The Kwamter Mound

Ever since Roth (1901) first speculated about the processes which might have led to the formation of the Weipa shell mounds archaeologists have maintained that the shells accumulated 'through regular human exploitation of the local shellfood supply' (Bailey, 1977). On the basis of five charcoal dates from the Kwamter mound Bailey (1983) claimed 'a total span of ca.1000 years for the bulk of the shell accumulation'. Gradual accumulation is the fundamental tenet of the hypothesis of human origin. Each shell mound is thought to have formed by a process of upward growth involving generations of human occupants. Archaeologists have proposed no other process by which the shell mounds could have formed.

Bailey (1977) proposed that the shells in the Kwamter mound 'began to be collected about 1200 years ago and accumulated more or less continuously until quite recently'. This hypothesis has been tested by dating a sequence of shells from the Kwamter mound. The results do not show gradual accumulation of the shells and lend no support to the hypothesis of human origin. It can also be argued that the charcoal dates do not demonstrate gradual accumulation of the shells either. The contrast between these two sets of dates and Bailey's hypothesis is shown in Figure 6.1. Ages of the shells are very similar throughout most of the mound sequence and evince little conformity to Bailey's hypothesis. Three of the oldest shell dates are actually near the top of the mound. This makes it appear that the sequence is slightly inverted. If the mound was of human origin it is highly unlikely that such a sequence would emerge.

Absolute dating of the shells in the Kwamter mound is complicated by the fact that they are estuarine in origin. This is indicated by the $^{13}$C values accompanying each radiocarbon age (see Fig.5.1). Marine shells typically have $^{13}$C values which range between +4.2 and -1.7 while freshwater shells range between -2.1 and -15.2 (Keith et al, 1964). The $^{13}$C values for the Kwamter shells range between -0.8 and -2.3 suggesting that the shellfish lived in conditions transitional between the two environments. If the shells from the Kwamter sequence were fully marine it would simply be a matter of
Figure 6.1 Shell (ANU dates) and charcoal (SUA and I dates) ages obtained from the Kwanter mound contrasted with Bailey's (1977) hypothesis. Note that at 2SD there is no sign of gradual accumulation.
applying the Australian Marine Shell Correction Factor of 450±35 years to calculate the actual age of each sample. In this case it is uncertain whether a correction factor should be applied or not because the amount of marine water present in the estuary when the shellfish were alive is unknown. Woodroffe et al. (1986) experienced a similar problem in dating shells from the deposits of the South Alligator River.

As a consequence of this uncertainty the shell dates are reported as Conventional Radiocarbon Ages only. Although these may not indicate the actual age of each shell they do provide an accurate measure of relative age. This is enough to falsify Bailey's hypothesis as it shows that most of the shells in the Kwamter sequence are roughly the same age. Comparison with the charcoal dates suggests that a correction factor is not necessary. ANU 8022 pairs comfortably with SUA 147, ANU 8025 with SUA 148 and ANU 8030 with I-1738. If the marine shell correction factor was applied only ANU 8021 and I-1737 would pair. The significance of this possible pairing is limited because these dates are from the top of the mound and I-1737 could easily represent younger charcoal which had intruded.

The charcoal dates below I-1737 presumably came from the intermittent lenses of ash and fine charcoal. These lenses suggest that the growth of the Kwamter mound was periodically interrupted by fire. If the correction factor was applied to the shell dates below ANU 8021 it would show that most of the shells are younger than the fires which swept over them. This would make little stratigraphic sense. In all likelihood the conventional ages of the shells are a good reflection of their actual age. These suggest that the formation of the Kwamter mound involved two episodes of rapid shell accumulation. In the first episode shell aged around 930 years was rapidly piled to produce most of the shell mound. In the second episode shell aged around 650 years was added to the top. The two events appear to have been separated by a hiatus of around 200 years. A similar hiatus is evident near the top of the South Mound sequence (see Fig.1.4).
6.1.2 Shell Valve Microscopy

Textures imprinted on the interior surfaces of shell valves from the Kwanter and Prumanung shell mounds include microborings, needles and encrustations. None, however, are unambiguous indicators of the specific environment in which the shellfish died. The microborings which are probably algal in origin could have been produced either offshore or onshore. The latter possibility is suggested by the fact that the shells host up to seven genera of living cyanobacteria including two which are known borers of carbonates. This imposes serious limitations on the use of this kind of evidence to determine shell mound origins. The needles are a type of carbonate cement which only reflect the vadose diagenetic environment. The encrustations were probably produced internally by *Anadara granosa* while the shell sample was still alive.

The best explanation for the microborings shown in Plates 5.3/3, 5.3/4 and 5.3/5 is that they are the trace fossils of boring cyanobacteria. These micro-organisms are termed 'endoliths' because of their ability to penetrate carbonate rocks and shell (Golubic *et al*, 1975). The microborings in the shells from the Kwanter and Prumanung shell mounds could indicate shellfish death offshore because most endolithic cyanobacteria inhabit the photic zone of the sea. However, seven genera of cyanobacteria have been cultured from the shells showing that the supratidal zone also supports these micro-organisms. Two of the genera cultured are *Plectonema* and *Scytonema*. Both have filaments which are similar in outline to the microborings and both are known to be endolithic (e.g. Perkins and Tsentas, 1976). In all probability these extant cyanobacteria produced the microborings and could have done so at any stage during the post-mortem history of the shell. As such the microborings cannot be used to infer the environment in which the shellfish died.

In the field of ichnology it is generally held that microborings produced by cyanobacteria usually indicate a marine environment. Golubic *et al* (1975) have taken this further and suggested that microborings may be used as 'paleobathymetric indicators'. If
indeed there was a simple relationship between microborings and marine environments the task of determining whether a shellfish died onshore or offshore would be relatively easy. The results of this investigation, however, suggest that no such simple relationship exists. Shells deposited on land beyond the present-day intertidal zone were found to contain both microborings and living genera of cyanobacteria. Although a link between the two has not been established with any certainty, such a co-occurrence casts doubt on Cutler’s (1987) claim that microborings present in shells from beach ridges are inherited from earlier taphonomic episodes.

The needles which are abundant on most of the shells relate only to the post-depositional history of the mounds (Plate 5.3/6). These are a product of the vadose diagenetic environment and are similar to the fungally-precipitated needles termed ‘needle fibre calcite’ common in South Australian calcrete profiles (Phillips and Self, 1987). The encrustations shown in Plates 5.5 and 5.6 have the appearance of being produced by organisms normally associated with the intertidal zone such as barnacles but their very simple morphology and microstructure suggests an alternative origin. Geologist Ken Campbell (pers. comm.) has suggested that the encrustations were produced by the cockle itself in response to an invasion of its body by parasites.

Although examination of the interior surfaces of shell valves from the Weipa mounds did not produce any strong evidence for shellfish death offshore the method still has considerable potential for resolving shell mound origins. A case in point is the Glidden site, an oyster shell mound on the Damariscotta estuary in Maine (Sanger and Sanger, 1986). This was visited in August, 1992 and a 1m deep sequence of tightly-packed oyster shells examined. These were arranged, as Charles Jackson had observed, in a ‘regular stratiform position’ (in Chadbourne, 1859). Examination of the interior surfaces of the oyster shells showed that many had been perforated by dozens of round holes less than 2mm in diameter. Very similar holes are known to be caused by boring sponges (e.g. Boekschoten, 1966). This evidence along with the layering of the shells indicates that these mounds are more likely to have been formed by currents than by prehistoric Indians.
6.2 The Natural Origins of the Shell Mounds

Mapping and augering of coastal deposits at Prumanung and Uningan provides evidence of a natural origin for the Weipa shell mounds. In a geomorphological context the shell mounds are not anomalous and human agencies need not be invoked to explain them. Both Prumanung and Uningan are chenier plains and in these dynamic environments mounds composed of a variety of sediment types have formed. Tall, steep-sided shell mounds are closely associated with wave-built deposits of coarse Anadara granosa shell while mounds composed of shelly sand and gravel are present where these sediments predominate. The most likely agent of mound formation is the Orange-footed Scrubfowl Megapodius reinwardt.

6.2.1 Prumanung

The Prumanung shell mound environment is the result of Holocene coastline progradation at the mouth of Andoom Creek (Plate 5.6). This process has led to the development of a small-scale chenier plain comprising a bundle of ridges which have accreted seaward into the Mission River. Subsurface investigation shows that where the ridges converge away from Andoom Creek they rest on a sandy shoreface (Figs.5.3 and 5.4). Towards the mouth of Andoom Creek the ridges fan out onto much finer shoreface sediments where they become recognisable as cheniers (Fig.5.5). An understanding of the depositional history of these cheniers is necessary to interpret the origins of the mounds located on them.

The model proposed by Rhodes (1980, 1982) to explain chenier plain formation in the Gulf of Carpentaria is applicable to Prumanung. Silt and clay transported in suspension by Andoom Creek during periods of high fluvial discharge entered the Mission River where it was deposited in the nearshore zone as low-tide and subtidal mud. As mangroves became established intertidal organic mud was added. Sand and pisoliths
contained in the overlying cheniers probably derived from ebb-tidal delta deposits formed at the mouth of Andoom Creek. These coarse sediments were mixed with shells and redistributed in the shallow subtidal and intertidal zones away from the creek mouth. During periods of reduced mud input the coarse sediments were winnowed from the shoreface by waves and transported onshore to form the Prumanung cheniers.

Ages obtained on shells from the Prumanung cheniers indicate when each ridge formed (Fig. 5.5 and Table 5.2). These results must be interpreted with caution because the accompanying $^{13}$C values show that the shells are estuarine. As a consequence it is uncertain whether the marine shell correction factor should be applied. Further uncertainty arises with the possibility that the shells have been reworked from older deposits and do not date the actual period of chenier formation. It is usual to assume that the youngest date from each chenier is closest to the time of its emplacement (Lees, 1992a).

Despite these uncertainties it is clear that the two landward cheniers are significantly older than the two closest to the sea. Shells from the landward cheniers range in age from 2790±80 years BP (ANU 8036) to 4530±80 years BP (ANU 8038). These cheniers are more subdued than the seaward cheniers and the oldest is devoid of shell in its upper layers. This may reflect prolonged leaching. Shells from the seaward cheniers range in age from 790±220 years BP (ANU 8033) to 1490±80 years BP (ANU 8034). These cheniers are distinguished by an intervening mudflat and the presence of large quantities of coarse *Anadara granosa* shell.

The two seaward cheniers are probably less than 800 years old. The date of 790±220 years BP (ANU 8033) provides a maximum age for them. The appearance of large quantities of *A. granosa* shell in these cheniers is probably due to environmental change. Unfortunately little is known about environmental conditions which favour the proliferation of *A. granosa* in Australia but the species has received considerable attention in Malaysia where it is a commercial crop (e.g. Pathansali, 1966; Broom, 1982). On the west coast of the Malayan Peninsula the natural habitat of *A. granosa* is intertidal estuarine mudflat. The densest populations are found in fine, soft brackish mud seaward
of mangroves. Similar conditions are present near the mouth of Andoom Creek where formation of the locally extensive mangrove mudflat probably triggered an increase in the *A. granosa* population.

The highest concentration of coarse *Anadara* shell on the Prumanung chenier plain is at the point where the cheniers converge. Most of this shell is contained in the three mounds located immediately behind the modern beach (Fig. 5.3). Closer to the mouth of Andoom Creek coarse *Anadara* shell is much less concentrated and the cheniers are sandier. Present are mounds of shelly sand and pisoliths in place of coarse shell mounds (Fig. 5.6). This kind of change in predominant sediment type over the length of a chenier is common in northern Australia. For example, Rhodes (1980:88) mentions sandy cheniers which grade laterally into shell away from tidal inlets and Lees (1992b) notes a similar lateral gradation for the Princess Charlotte Bay cheniers.

The coarsest sediments on the Prumanung chenier plain are whole *Anadara* valves. These are concentrated at the point where the cheniers converge because the terrigenous sediment normally mixed with them diminishes with increasing distance from its source at the mouth of Andoom Creek. Another reason for the concentration of whole *Anadara* valves at this end is the steeper offshore profile. Todd (1968) explains that without the impediment of mud in the local nearshore zone wave energy is higher. This enhances winnowing and coarse sediment is concentrated. More effective wave-action also results in better sorting. The crest of the beach adjoining the shell mounds has been capped by numerous whole *Anadara* valves (Fig. 5.3). This well-sorted deposit is a coarse shell berm (see Thompson, 1968).

Localisation of so much coarse *Anadara* shell at one end of the Prumanung chenier plain is a geomorphological phenomenon. There is no evidence to suggest that any of this shell was collected by Aborigines for food. The emergence of distinctive mounds from these sediments and from wave-deposited sediments elsewhere on the chenier plain is also a natural phenomenon. Section 6.2.3 discusses the process most likely to have given rise to these mounds.
6.2.2 Uningan

The Uningan shell mound environment is also an example of a chenier plain (Plate 5.9). It formed along a sheltered part of the Mission River which usually experiences low wave energy. Consequently development of the chenier plain has been dominated by silt and clay deposition. Seaward accretion of mangrove mud has added to its size. Across this broad progradational plain coarse sediments are relatively sparse. Sand and pisoliths are concentrated in the one linear ridge at the rear of the sequence (Figs.5.7 and 5.9). This wave-built deposit is a chenier. Towards the sea there is a change in predominant coarse sediment type with the appearance of five isolated mounds of coarse *Anadara granosa* shell. The origins of these mounds are revealed by their morphostratigraphy and geochronology.

Surface morphology strongly suggests that the Uningan shell mounds originated as cheniers. All are elongate and run roughly parallel to the modern shoreline. At their base each has a gently curving seaward margin with at least one having an irregular landward margin probably lobed by washover (Fig.5.8). The two linear ridges which protrude from under the composite shell mound are even more obvious as cheniers (Plate 5.13). These have been recurved by wave refraction around the main body of the shell mound (Plate 5.9). The most seaward is still active as shown by the mangroves it has buried on its steep landward side (Plate 5.14).

Subsurface investigation shows that contrary to archaeological belief the shell mounds do not `sit on' the surface of older landforms. The two mounds shown in the fence diagram are composed of coarse *Anadara* shell which extends beneath the chenier plain surface (Fig.5.7). This shell continues to basement rock on the seaward side of the taller mound and on the seaward side of the other it grades into sand. The two ridges at the foot of the composite shell mound are also composed of shell which extends beneath the chenier plain surface (Fig.5.9). This kind of subsurface expression is further evidence
that the mounds originated as cheniers. Each marks the position of a former shoreline rather than the location of a human habitation site (see Fig.2.2).

The ten radiocarbon dates on *Anadara* shell from the Uningan mounds are also consistent with a chenier sequence (Fig.6.2). Again the shells have estuarine $^{13}$C values so the marine shell correction factor has not been applied (see Table 3.1). The oldest dates are on shells from the surface of the sandy chenier at the rear of the sequence. These range between 1210±60 years BP (ANU 4415) and 1460±60 years BP (ANU 4419). It is likely that these shells were transported to the chenier crest by wave-action before the shoreline had prograded far. The only 'anomolously young' shell age from the sandy chenier is the date of 710±60 (ANU 4420). This could be a shell from an Aboriginal midden but its proximity to a 5-700 year old time-line (see below) suggests that it could also have been deposited by wave-action.

Some time after 1400 years BP sand and pisoliths ceased to become available for chenier construction. Either the Mission River no longer supplied terrigenous material or the sea had lost its capacity to transport relict bay sediments shoreward. This environmental change was followed by significant mudflat accretion. Conditions for the proliferation of *Anadara granosa* were enhanced and its shell valves became the predominant coarse sediment type. The first shells winnowed from the mud and redeposited to form an isolated shell mound have an age of 1250±80 years BP (ANU 4414). The sandy sediments beneath this mound may be a vestige of the terrigenous phase of chenier construction (see Fig.5.7).

Subsequent shoreline progradation is shown by two time-lines (Fig.6.2). These are inferred on the basis of topography and similarity between shell ages. The first connects two shell mounds located along the boundary between the belt of grassland and the salt pan. The three shell ages from these mounds suggest that this was the position of the shoreline some 5-700 years ago. The second time-line runs along the boundary between the salt pan and mangrove forest. A date of less than 200 years from the surface of the composite shell mound shows how recently the sea was in this position.
Figure 6.2 The Uningan chenier plain showing progradation of the shoreline over the past 1400 years.
Interestingly the youngest mounds on the chenier plain are the largest. This is the reverse of what might be expected if the mounds were habitually lived on by people.

Geomorphological investigation shows that the Uningan shell mound environment has changed considerably over the past 1000 years. This is contrary to the claim made by Bailey (1983) that the coastal environment of Weipa has not changed during this period. The most obvious indicators of environmental change are the shell mounds out on the silt and clay plain. These deposits originated as cheniers and were constructed largely from the remains of one species of shellfish. They are not evidence of a static environment camped on frequently by Aborigines. Each shell mound marks the changing position of the shoreline and implicates mass mortality of *Anadara* as a cause of shell accumulation. The most likely reason why so many of these mounds are unusually shaped and tall is discussed below.

6.2.3 The Scrubfowl Hypothesis

The nesting behaviour of the Orange-footed Scrubfowl *Megapodius reinwardt* provides the only reasonable explanation for the transformation of many of these natural shell deposits into tall, steep-sided mounds. As discussed in Chapters 1 and 2 this bird builds mounds of a variety of shapes and sizes for the purpose of egg incubation. It draws on shell, sand or any kind of loose sediment for building material and may shift objects weighing over 6kg. It thrives in the monsoon vine forests of northern Australia and is also known to inhabit mangrove swamps. These habitat types are an intrinsic part of the Weipa environment.

Stone's (1989) hypothesis predicted that the Weipa mounds would vary widely in composition thus rendering it unlikely that human agencies were responsible for mound growth. The presence of mounds composed of a variety of sediment types at both Prumanung and Uningan confirms this prediction. The strength of the Scrubfowl hypothesis is that it can explain the growth of shell mounds and mounds composed
predominately of sand and gravel. The composition of each clearly reflects the lithology of the adjacent or underlying sediments. It is unnecessary to think that shell mounds might be a separate category of mound more likely to have been built by people.

The main Prumanung shell mound has all the attributes of a Scrubfowl mound (Plate 5.7, Fig.5.3). It is located very close to the beach and is 3m tall on its steep, seaward side. Monsoon vine forest species grow along the mound and are patchy elsewhere in the vicinity. The mound appears to have grown lengthwise by Scrubfowl heaping shell from the adjoining berm composed of whole *Anadara* valves. At the opposite end of the chenier plain there are mounds composed of shelly sand and pisoliths which also support a cover of MVF species (Fig.5.6, Plate 5.8). It is likely that these mounds were constructed by Scrubfowl from adjoining sandy chenier sediments.

Ages obtained on shells collected by Beaton from the Prumanung shell mound also support the Scrubfowl hypothesis (Table 3.1, Fig.3.10). Shells he excavated from the base and middle of this mound returned ages of 760±75 years BP (ANU 4409) and 790±60 years BP (ANU 4408) respectively. A surface age of 360±100 years BP was also obtained. The two older dates show that most of the shell in the mound is probably around 800 years old. The two seaward cheniers beneath the mound are also likely to be around this age (Fig.5.5). The close fit between the shell mound ages and the ages obtained from the seaward cheniers is consistent with Scrubfowl having reworked the shells from adjoining shoreline deposits.

In a sense the Prumanung chenier plain is a microcosm of much larger chenier plains elsewhere in northern Australia. One example is Princess Charlotte Bay (Chappell and Grindrod, 1984). In the northeastern corner of PCB shell is the major component of the cheniers but westward they fan out into cheniers composed of coarse sand and gravel (Lees, 1992b). Present on the surface of the shell cheniers are numerous conical shell mounds which Beaton (1985) thought were Aboriginal middens. However, recent inspection of the sand and gravel cheniers at Harry's Hole in the Annie River area of PCB revealed similarly shaped mounds composed of these sediments. In both cases mound
composition is a reflection of the sediments in the underlying cheniers. Scrubfowl are again more likely than humans to be the agent of mound formation.

The fact that mound composition will change in accordance with changes in chenier composition is repeated at Uningan. Along the sandy chenier at the rear of the Uningan sequence there are relatively small, conical shell mounds (Fig.5.11) as well as shelly sand and gravel mounds with very similar dimensions (Fig.5.10). At Oxmurra Point where wave energy is higher coarse *Anadara* shell is more concentrated and consequently the shell mounds are larger and more clustered (Fig.6.2). Active Scrubfowl mounds are also present at Oxmurra Point indicating that mound-building processes are ongoing. The birds' MVF habitat is present along the length of this chenier.

Most of the shell cheniers out on the silt and clay plain at Uningan also appear to have been reworked by Scrubfowl into mounds. The best example of this is the composite shell mound located near the inner edge of the mangrove fringe (Fig.5.9; Plates 5.11 and 5.12). This incorporates three steep-sided conical shell mounds up to 4.5m in height. These near radial features have all the morphological attributes of Scrubfowl mounds. The two linear cheniers beneath these mounds are an obvious source of shell for mound construction. Although MVF species grow on the mounds today it is possible that the Scrubfowl first utilised the encircling mangrove habitat.

Scrubfowl also appear to have reworked the tall seaward chenier shown in the fence diagram (Fig.5.7). This is indicated by the accompanying contour map which shows a steep-sided conical mound supplanted on an elongate ridge (Fig.5.8). The feature may have been encircled by mangroves when it was first occupied by Scrubfowl and been invaded by MVF species only after the shoreward migration of the mangrove fringe. Of the remaining shell mounds out on the silt and clay plain the role of Scrubfowl is less evident. In fact the isolated mound shown in Figure 5.9 is simply a small shell chenier with no suggestions of Scrubfowl reworking (see also Plate 5.15).

Geomorphological analysis of the Weipa shell mound environment has shown that the key element of Stone's (1989) hypothesis is tenable. This is especially so in lieu
of any other hypothesis which might reasonably explain the available data. Although it is likely that Scrubfowl have played a significant role in shell mound formation it is clear that Stone was wrong in one important respect. He unwisely accepted archaeological claims that the *Anadara* shells had been initially deposited by people and proposed that the Weipa shell mounds might be an extreme example of the interplay between Aborigines and Scrubfowl. It is now clear that the shells are far more likely to have been initially deposited by wave-action. Rather than being the result of interaction between cultural and natural processes as Stone proposed the Weipa shell mounds must now be seen as entirely natural in origin.
CHAPTER 7

CONCLUSION

Let me insist that as far as I am aware there is no fragment of positive evidence that the mounds are man-made (Stanner, 1961).

More than three decades ago Stanner (1961) wrote of his conviction that the Weipa shell mounds were natural in origin. His reasons are outlined in Section 1.3 and are just as pertinent today as then. To these can be added the results of this investigation which demonstrate that:

1. The shells in the `type-site' at Kwamter did not accumulate gradually in the manner proposed by archaeologists. In fact most of the shells in the Kwamter sequence are of a similar radiocarbon age.

2. Shell ages from mounds elsewhere around Weipa are consistent with a prograding shoreline sequence. It is likely that these trace the natural development of the local chenier plains rather than the shifting focus of Aboriginal occupation.

3. The distribution of shell mounds coincides with the distribution of natural deposits of coarse Anadara shell. Some, such as the large mounds on the silt and clay plain at Uningan, clearly originated as small shell cheniers.

4. Mounds composed of a variety of sediment types are also present at Weipa including many composed of shelly sand and pisoliths. There are enough similarities between each type of mound to suggest a single cause of mound formation.

Clearly archaeologists should not have dismissed Stanner's ideas so lightly. His belief in the natural origins of the shell mounds has been supported by this thesis and all his argument lacked was a mechanism capable of explaining their unusual shapes and vertical exaggeration. That mechanism is most likely to have been the mound-building
Scrubfowl *Megapodius reinwardt*. This bird is common to the coastal landforms of northern Australia where it inhabits monsoon vine forests and mangroves. These habitat types are closely associated with each of the mounds investigated at Weipa or were likely to have been so in the past.

Stone's (1989) hypothesis that nesting Scrubfowl are primarily responsible for shell mound growth is highly tenable but it is clear that he overstated the possible connection between Aboriginal discard behaviour and Scrubfowl. It is now fairly certain that most of the shells in the mounds were initially deposited by wave-action and are not the remains of Aboriginal meals. The low mounds (<1m thick) which Stone thought had a better chance of being undisturbed Aboriginal middens now seem more likely to be small shell cheniers or coarse shell berms undisturbed by Scrubfowl. In the case of coarse shell scatters these may be little more than washover features.

Bioturbation of chenier sediments, soil and occasional archaeological remains by Scrubfowl appears widespread in northern Australia. Some other likely examples of Scrubfowl mounds in the archaeological literature include the shell mounds of Princess Charlotte Bay (Beaton, 1985); many of the shell and earth mounds of the Aurukun region (in particular Cribb, 1986; Figs. 7 and 11 and Cribb *et al*, 1988; Figs. 2 and 3); and many of the shell and earth mounds of Arnhem Land (in particular Peterson, 1973: Plates 1 and 2; Meehan, 1982: Plate 40 and Meehan *et al*, 1985: Figs. 7.26-27). In other examples the role of Scrubfowl is less evident and the mounds seem more like isolated cheniers or natural shell banks (e.g. Cribb, 1986: Fig. 6; McCarthy and Setzler, 1960: Plates 3 and 4; and Peterson, 1973: Fig. 6).

In a global context the Weipa shell mounds clearly belong in the 'mounds of doubtful human origin' category (see Section 2.4). There are very few points of similarity between these mounds and genuine human occupation mounds. The occasional presence of artefacts and faunal remains is not proof of a human origin for the Weipa mounds as this material could easily have been raked in by nesting Scrubfowl or been incorporated by some other post-depositional process. Furthermore, few thinking archaeologists
would necessarily attribute thin layers of ash and fine charcoal to human campfires (e.g. Attenbrow, 1992). The weight of evidence points solidly to a natural origin for the Weipa shell mounds. An apt term for them would be `pseudo shell middens' (see Bindon et al., 1978).

7.1 Implications

Archaeologists willingly believed that the Weipa shell mounds were human in origin because of their faith in criteria for distinguishing between cultural and natural shell deposits laid down by the Danish Kitchen Midden Committee of 1851. One of the key criteria asserts that shell middens will contain shells predominately large in size showing that people had collected them for food whereas natural shell deposits will invariably contain shells of many sizes including species too small to eat (see also Gill, 1954; Coutts, 1966 and Bowdler, 1983). Other criteria include the absence of water-worn shell and clear stratification in shell middens compared to the presence of these features in natural shell deposits. If indeed these criteria were reliable indicators of origin the Weipa shell mounds may well have been middens.

The strong likelihood that the Weipa shell mounds are natural shell deposits suggests that these criteria are fundamentally flawed. Geomorphologists have long recognised that size sorting of shell is possible by wave-action with concentrations of whole shell valves often resulting from the winnowing and removal of finer sediments (e.g. Thompson, 1968; Greensmith and Tucker, 1969, Woodroffe et al., 1983). These shells are commonly transported by waves to the crests of beach ridges where they may easily be mistaken for middens. In the geomorphological literature deposits of whole shell valves are variously referred to as `shell gravels', `coarse shell' or `calcirudite'.

The lack of wear on shells also indicates little about the natural or cultural origins of shell deposits. In northern Australia whole, unabraded shells are common in beach ridge sediments and their `fresh' condition simply indicates that they have not been transported far (e.g. Rhodes, 1982; Lees, 1992a). Abrasion may also be minimal because
of the soft, muddy character of the sediments over which the shells have been transported (Rhodes, 1980:305). Similarly, absence of clear stratification does not necessarily mean that a shell deposit is a midden either. Sections through shell cheniers, for example, frequently show poorly layered shells without any imbricate structure (e.g. Greensmith and Tucker, 1969; Rhodes, 1980:89).

Given that key criteria for the identification of shell middens can be met by natural shell deposits it would appear that coastal archaeologists have been misled. Consequently open shell midden sites from the smallest shell scatters to the largest shell mounds must be regarded with some scepticism. This is especially so if they are located at or near past or present sea level where natural processes of shell deposition are likely to have had far more impact on the landscape than human shell-gatherers. While it cannot be denied that people have lived on shellfish in the past, the challenge which remains for archaeologists is to find new ways of distinguishing between shells collected by people and shells deposited by nature.

7.2 Concluding Remark

In one of the most comprehensive reviews of shell midden archaeology Waselkov (1987) devoted less than two pages to explaining how shell middens could be distinguished from natural shell deposits. The idea that a certain type of shell deposit must be a shell midden is so entrenched in the archaeological literature that its assumptions are rarely ever questioned. From Waselkov's account it is interesting to note that prior to the 1840's most scientists believed that 'shell heaps' were natural formations. The results of this investigation suggest that these scientists were right and that the belief in shell mounds as middens is simply an artefact of the search for human origins.
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