SECTION 1

Evidence for environmental change in the Lake Victoria basin
INTRODUCTION TO SECTION 1

Section 1 reviews available information on the long term history of the Lake Victoria basin. This evidence is subsequently drawn on to discuss

(i) the potential of the basin, and in particular the lunette for biostratigraphic dating of in situ fossil animal remains, and human occupation deposits;

(ii) to determine the stratigraphy and locate the paleosols in the lunette, and to compare lunette stratigraphy of the comparatively well watered Murray flood tract with lunette stratigraphy in the Darling and Willandra/Lachlan catchments;

(iii) to determine some of the long term changes in climate and water availability which have affected the area, with particular reference to the landscape before human occupation, and changes in the landscape after human occupation;

(iv) to determine if climatic factors could account for the demise of large browsing and grazing species which went extinct in the area between c 50,000 and 14,000 BP; and

(v) to examine the lunette and other landforms as chemical and physical environments for the preservation of human occupation deposits.

Field investigation was concentrated on the lunette dune to the east of the lake, for here there are sediments documenting the variation in water availability to both humans and animals built up through the period of human occupation.
CHAPTER 1

Regional climatic events, and the mid Pleistocene history of Lake Victoria

1.1 Introduction

This chapter begins by reviewing some of the methods used to characterise and analyse the evidence for paleoclimatic change, which have been used to establish climatic variation in the wider region of semi-arid south eastern Australia. Most data for paleoclimatic change have been obtained for areas of cummulative sediments, because here episodes of sediment instability, stillstand, aridity, and erosion may be recognised. The sedimentary history of the Lake Victoria basin is described and related to records of climatic change, as documented in dunes and lake floors of the wider region of semi-arid south eastern Australia.

Recent improvements in dating mean that it is now possible to produce a time scale for mid to late Pleistocene sediments, which is used in this and subsequent chapters to describe and contrast environments of prehuman and post human occupation of the Lake Victoria area.

1.2 Characterising climatic change

Climatic change in semi-arid south eastern Australia had been inferred from sedimentation and fluvial events which are preserved in sediments of dunes, lake floors, river channel forms, lakes and terraces. Datable intervals of sediment mobilization in dunefields, and in the deposition of evaporated salts (evaporites) in lake basin floors are valuable guides to moisture stress periods (Mabbutt 1971, 1977). Wet periods are documented by the form and position of ancient channels and associated landforms, and also by the development of soil which is promoted by the action of moisture and organic matter in sub
aerial sediment. Wet and dry periods indicated by fossil faunal populations and fossil pollen records.

In this work, the most important geomorphic evidence for paleoclimatic change comes from dune sediments, dune structures, and in particular from the development of soils in lake floors and dunes. For this reason, soils and the inference of climatic change from soils, dune structures and dune sediments in the region are discussed in detail in the following sections, prior to examining the evidence for paleoclimatic change in the Lake Victoria basin.

1.3 Soils as paleoclimatic markers

Soils are described by Corbett as:

Soils represent hiatuses in local sedimentation. But not all hiatuses will be represented by the formation of a soil (Dare Edwards 1979). Soil formation is initiated by a complex of factors, among which local topography, biological activity and available moisture are important. Soils are thus frequently associated with both stable periods and increases in available moisture.

The longer the soil is exposed to sub aerial weathering on the surface, the more definite the effects of soil formation will become. Soils formed during hiatuses in rapidly accreting sediments will reflect a shorter span of the soil forming event. Soils which remain exposed on the surface for long periods will (i) develop fully in response to one single soil forming event, and (ii) possibly show the complex effects of exposure to more than one soil forming event (a polycyclic soil).

Any widespread soil forming event leaves traces which may be detected over large areas. Such soil skins or pedoderms are one important basis of comparative soil stratigraphy. Soil
stratigraphy may be used for (i) the correlation of Quaternary sediments, (ii) the reconstruction of Quaternary environments and (iii) development of the understanding of soil formation (Dare-Edwards 1980:37). In the present context, pedoderms are sought because they serve as both climatic indicators and stratigraphic markers.

In western NSW climates since the end of the Tertiary have been characteristically arid in hinterland areas. Intervals of soil development in these areas may be positively associated with wet episodes where weathering is marked by varying degrees of translocation of fine sediment and soluble sediment. Soluble materials may be removed, or dissolved and reprecipitated as earthy powdery sediment, coating crystalline aggregates, nodular aggregates, layers or massive horizons. In semi-arid south eastern Australia much sediment was initially calcareous, and the translocation of soil carbonate has been a valuable guide to the local intensity of weathering in soils. Carbonate reprecipitates as fine earthy sediment, aggregates, nodules, pans or sheets. Carbonate horizons are valuable guides to the presence of local soils or pedoderms.

Other indications of soil formation are (i) relocation of soluble chlorides and sulphates, (ii) oxidation of traces of iron salts in sediments to produce distinctive brown or red horizons (Dare Edwards 1979; Price 1962; Norris 1969; Bowler and Magee 1978;17), by the development of soil structures with associated loss of original bedding planes. In western NSW the chemistry of the surviving soils suggests strongly that soil development is associated with periods when soil moisture was more freely available than at present.

Identification of soils within sediments is the first step in isolating evidence for regional soil forming events. Once isolated local soils may be compared with sedimentary position and development of profile in other areas. This is the approach adopted here.
1.4 Mid to Late Pleistocene cumulative sediments in southwestern NSW

Tertiary and early Pleistocene sediments

Basal sediments of the Murray basin are marine and estuarine (Ludbrook 1961). A marine recession during the Miocene saw the deposition of a sandy facies called the Parilla sand over a wide area of the basin (Macumber 1980). After the deposition of the Parilla sand, the sea retreated. Relict strandline ridges near Narracorte in South Australia give a terminal date for the marine recession of 2.5 million years. All superimposed basin sediments are Pleistocene or Holocene in age.

Above the strandline ridges, fluvial and lacustrine sediments were deposited, as basal sediments of a vast freshwater lake complex, or as fluvial sediments from channels which discharged over the lake floor at times when the lake was low (Firman 1965; Lawrence 1966; Bowler 1980:26). Freshwater sediments are called the Blanchetown clays, and channel sediments are called the Chowilla Sands. The lake complex is here referred to as Lake Bungunnia. These sediments have been dated by paleomagnetic interpretation at Lake Tyrell from early to mid Pleistocene (Bowler 1980; Yaalon, pers comm). Plate 1.1 shows a cliffed exposure of Blanchetown clays in the vicinity of Lake Victoria, where they are close to their maximum thickness of 55 metres. Blanchetown clays outcrop on the surface in areas to the north of the lake basin. They are further discussed in Chapter 7, which reviews the data relating to fossil faunas and climatic changes which are documented in the prehuman period.

Gill described the landforms which were superimposed on the dry bed of Lake Bungunnia as 'thin surficial ones' (1973a:42). These include the mid to late Pleistocene sediments which are primarily aeolian in origin, and the sediments which were deposited by the Pleistocene Murray in the riverain tract.
Plate 1.1 Lake Bungunia sediments, which underlie the Lake Victoria basin, showing grey lake floor clays, white bands of evaporites and pale clays, overlain by red sediments of the Woorinen formation. A soil with pisolithic carbonates has formed in the upper layers of the Woorinen sediments (arrowed).

Plate 1.3 The Lake Victoria lunette and lake basin. Gill's Gully survey area is shown by the centre arrow. Edge of the ancestral lake basin is shown by the centre arrow. Lower arrow shows reddened sediments of the high level alluvium, were a calcareous red soil has formed.

Plate 1.4 The lunette taken facing west, showing (i) reworked lunette sands (Dunedin Park Sands) overlying exposures of the Rufus pedoderm arrowed. On the extreme right the track which bounds the Gull's Gully survey area may be discerned.
Mid to Late Pleistocene cumulative aeolian sediments

(i) Paleoclimatic data from the Woorinen formation

The Woorinen formation (Lawrence 1966, 1980) directly overlies Lake Bungunnia clays to the east, north and west of Lake Victoria. These sediments, and exposures of Blanchetown clay are the landforms which dominate the hinterland environments.

On the ground the Woorinen formation consists of:
pale to dark reddish brown calcareous sandy clay and clayey sand in which at least five superimposed soils are present... soil development on each aeolian layer leaves only thin zones of unweathered Woorinen formation (Lawrence 1966:542)

The long east west trending teardrop shaped dunes of this system, referred to as east west or longitudinal dunes, may be seen in the Frontispiece.

The deposition of this aeolian calcareous dunefield is evidence for an arid period, with strong dune forming winds. Since the dunes overlie the dry lake sediments, it is believed that they were deposited after 400,000 years ago, possibly as recently as 128,000 years ago. After the Woorinen dunes were in place, soil forming began. Nodules of carbonate (Fig 1.6) or carbonate pans which mark the early soils survived while erodible A horizons were often stripped and reworked into the dunes downwind. Renewed soil formation repeated the process, until the dunes in some cases contained evidence for five horizons of carbonate nodules or pans which implies at least five episodes of stabilization/effective soil moisture - punctuated by five or six episodes of devegetation, wind erosion and sediment movement along dune crests. (Carbonate dates for these fossil BCa horizons are given in Table 1.1, but must be interpreted with extreme caution, since the datable carbonate could easily have been contaminated by younger carbonate derived from superimposed horizons).

There is some evidence that the dune forming winds shifted from westerly to somewhat south of west during the reworking of the
Plate 1.2  Pisolitic carbonate and pan carbonate in the Rufus pedoderm.
1. Wooringen formation dunes, Swan Hill (Churchward 1961)

Upper Dune

Kyalite - 15,550 BP (ANU 183)  A sandy, asymmetric cap, sands, calcareous light sandy clays, probably eroded from downwind sediment, little or no soil formation (Churchward 1963b:103).

Second Dune Unit

Speewa - c 24,000 years (ANU 184)  Largely accessional involving the deposition of calcareous clays in extensive sheets. Covers swales and clay plains. Companion sands are fine, 65 to 90 with associated coarse saltation sand of 200 to 400 locally derived (1963b:115). This layer may be equated with the para of Butler 1956. The Speewa Unit is 4 to 5 metres maximum depth (1963c:244).

There is a soil developed on the Speewa Unit, with sub angular blocky pods on the surface to angular blocky pods at depth. Down profile movement of carbonate to 35 cm as soft amorphous lime, pan lime and concretions (1963c:127).

Third Dune Unit

Bymoe - 29,750 BP (ANU 185)  Less well known, believed similar to Speewa in carbonate content.

Fourth Dune Unit

Tooleybuc - Acidic Ph. Leached of carbonate, following a lengthy period of pedogenesis (1963c:244).


Upper Unit

Aeolian Blanket - Recent, or other Holocene, non calcareous weakly saline white quartz sand, no pedogenesis.

Zanci Unit

Zanci - c 18,000 - 17,000 BP  Deposition continued for up to 2,000 years. Formed from calcineptic pellets, clay flakes, companion sand, primary gypsum, wustenquartz. Thin conformable layers 1 mm to 23 mm graded bedding. Weak pedogenesis involving collapse of calcineptic pellets (Dare Edwards 1979:16, 24, 36, 51 and passim; Bowler 1970:79).
### Mungo Unit

**Mungo** - c 38,000 - 23,000 BP  
Pedogenized aeolian sands and clays.

**Upper Mungo Unit** - c 26,000 - 23,000 BP  
Quartz sand and clay rich sand on which a weak soil formed.

**Lower Mungo Unit** - Sands and clays, pedogenesis in progress c 32,000 BP, high organic staining, some evidence for tree vegetation, strong carbonate mobilization, clay and sesquioxide illuviation (Bowler 1970:81, 144, passim).

### Gol Gol Unit

**Gol Gol** - Older than 38,000 BP. Known from lake floor deposits, ancient lunettes strongly developed red soil, nodular pisolithic carbonate, unknown age.

### Lower Units

Unnamed red calcareous soils, below Gol Gol Unit. 'drilling through the floor of Lake Mungo has revealed three paleosols overlying sands which are regarded as basement' (Bowler 1982:30).

### Lake Tandou basin and associated lunette (Dare Edwards, Hope and MacIntyre in press)

**Upper Sediment**  
No name, c 2,000 BP. Mobile free flowing sand, sands to sandy loam texture, low clay and carbonate content, sedimentary structure well developed. Weak soil development.

**Upper Unit**  
**Bootingee Unit** - 27,000 - 10,000 BP (Hope et al, Hope pers comm). 1 - 8 metres pale brown sandy loams to sandy clay loams, calcareous and occasionally gypsiferous. Three episodes of weak soil formation. Soils are truncated and apedal, 7.5 YR B horizons grading into 10 YR 7/4D BCa horizons. Carbonate fine earth and 2 - 3 mm soft gaebules.

**Second Unit**  
**Tandou Unit** - older than 27,000 BP. 1 - 3 metres of original sediments, all strongly altered by pedogenesis. In the Centre of the dune a shallow soil 2.5 YR 5/6 grading into 7.5 YR 6/6 BCa horizon. Carbonate fine earth carbonate and soft gaebules.

**Third Unit**  
**Packer Unit** - older than Tandou Unit. 1 - 4 metres of calcareous sand 2.5 YR 7/4D. Grey clays interbedded with sandy clay loam and sandy loam layers 7.5 YR 7/6D. Several weak soils, identified by soil structures and 10 mm thick layers of carbonate gaebules.
Fourth Unit
Kinchega Unit - older than Packer Unit. 1 - 3 metres of red clays, with thin sand layers. All are altered 5 YR 5/6D angular blocky BCa horizon with 10 - 40 mm hard brittle carbonate glaebules.

Fifth Unit
Buntigoola Unit  Complex unit of colluvial material brown and grey clays, pale fine sandy loams and sands. Evidence of pedogenesis in colluvial materials, and in brown clays.
Woorinen formation, because younger sands of the crests are 'draped' off the downwind portions of the dune, with a west south west orientation (Lawrence 1980:62). Bowler found similar skewing in lunette dune orientation. Comparable skewing may be observed in the Lake Victoria lunettes, as will be discussed below.

Woorinen formation dunes are much older landforms than the lunettes associated with present lake basins. They document the flux of climatic events through the mid to late Pleistocene in the hinterlands away from the river tracts.

(ii) Palaeoclimatic data from lunettes

Lunette dunes are:

- low crescentic ridges which occur on the eastern side of lakes. They are of two types - those composed predominantly of sand, and those composed of silt, sand and clay (Campbell 1968:89).

They appear to be late Pleistocene landforms, related to the availability of sediment in lake basins, and presumably, to dune forming wind strengths with winds from the west, and later the west south west. Lunettes have attracted considerable attention from archaeologists, since the earliest known skeletons of H. Sapiens sapiens was recovered from a lunette at Lake Mungo, in south western NSW (Bowler, Jones, Allen and Thorne 1970). It is likely that there were phases of lunette building - but that the evidence of earlier phases has not always survived. In this, it is significant that the earliest lunettes yet identified are clay rich, and not mobile rather than sand rich and erodible (Bowler 1970:110, 126, 143).

Phases are suggested by the presence of 'en echelon' lunettes in many lake basins. There are many examples of 'en echelon' lunettes, with the older lunette downwind. Lake Victoria has some evidence for the sequential formation of lunettes (Frontispiece), but it is not yet known whether the formation of lunettes can be simply correlated with known phases of aeolian sediment mobility elsewhere. It is likely that although conditions suitable for formation of lunettes are specific, the
Time Scale  Regional Soil forming events

<table>
<thead>
<tr>
<th>TIME</th>
<th>Woorinen Swan Hill</th>
<th>Willandra Lachlan</th>
<th>Tandou Darling</th>
<th>Victoria Murray</th>
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<tr>
<td>5000</td>
<td></td>
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<td></td>
<td></td>
</tr>
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<td>30000</td>
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</table>

- Kyalite 15,550
- Zanci 14,000
- Nungo 32,000
- Goolgal
- Packa
- Kinchega
- Buntigood
- Lake Floor?
- Tandou 27,000
- Nulla NULLA
- Sand 17,500
- Talgarry clay/silt layers
- Mobile sand
actual time of formation of lunettes will vary from lake to lake.

It has been widely recognised that lunettes form episodically, but there has been some debate about the specific conditions under which they will form. Hills suggested that lunettes formed when lakes were at least seasonably full - since dunebuilding requires a supply of sediment which only wave and water transport of sediment could satisfactorily explain (Hills 1940). Stephens and Crocker, in contrast, argued that lunettes formed by deflation from dry lake basins (Stephens and Crocker 1946).

Bowler hypothesised, on the basis of evidence from modern clay dunes, that fine sediment facies of dunes could form under certain specific combinations of wind, lake floor temperature, and salinity in the groundwater capillary fringe. He suggested that capillary rises in saline rich groundwater in seasonally dry lake beds could form normally unerodible clays into erodible aggregates, which would move by saltation, until such time as they became wet (Bowler 1970; Price 1963; Price and Korniker 1961; Macumber 1970 and see below Chapter 2.5). This hypothesis was supported by the association of the salt tolerant shell of Coxiella with clay rich beds in lunettes.

Bowler reasoned that sandy facies could, as Hills suggested, only be explained by the continuous constructional wave supply of sand to beaches on the eastern side of lunettes. This argument was supported by the observation that sand rich facies were generally associated with washed clean fine sands, whereas the sediments of the Woorinen formation are fine and red, with a clay coat, which can be removed by water transport. Sand facies were also associated with freshwater shellfish, or terrestrial species adapted to a fresh water littoral.

The importance of lunette sequences for documenting episodes in which the lake was either full, fluctuating and saline, or dry were recognised by Bowler, who investigated a series of lunette
dunes in the Willandra Lakes of western NSW (Fig 1.5) in an attempt to isolate regional trends in lake development, which might be correlated with paleoclimatic data from alternative sources - such as river channels, deep sea cores, pollen records and glacial advances and retreats.

Some of the available paleoclimatic data from lunettes is summarised below.

(i) Sediment accession and soil formation at Lake Mungo lunette

Details of the sediment accession, and those pauses in accession associated with wetter periods are given in Table 1.1. Bowler suggested that an early phase of lunette formation at Lake Mungo (Fig 1.5) occurred in the late mid Pleistocene (1970:81, 144). The present dune began to build up at an estimated 50,000 BP - with the accession of a thin bed of clean quartz sand. The early history of sedimentation is not yet well understood. On top of the dune so formed, soils developed. The earlier soil, the Lower Mungo Pedoderm, was buried by clay rich quartz sands, which were in turn subjected to weak soil formation. The latter soil forming event of between 23,000 and 18,000 BP produced a distinctive red, carbonate rich soil - which may have been polycyclic in nature. It is known as the Upper Mungo Pedoderm (Dare Edwards 1979:16, 34, 51 passim).

Above the Upper Mungo Pedoderm, there was a build up of sediments into the Zanci Unit which documents the final phases of Lake Mungo as a freshwater lake. Deposition of the Zanci Unit continued for 1,500 years, and apparently ceased by 15,000 BP. In contrast with the Mungo Unit, the Zanci Unit developed only a weak soil, despite the fact that it was exposed for nearly 17,000 years. In other lunettes over a wide area, Bowler found well dated evidence for the build up of sediment at this time. He suggested, on this basis, that lunette formation and the accession of sediment at this time was reflecting a region wide event of desiccation, salinity and aeolian mobility.
He designated this period the Zanci Event. It was reassuring to find that the Zanci Event correlated well with the evidence for high glacial conditions in the Australian Alps, and elsewhere and therefore, it is recognised as a manifestation of the conditions of aridity, increased wind strengths and lowered temperatures which typify this time Australia wide. There is certainly evidence for the Zanci Event at Lake Victoria, which will be further discussed below.

Investigations of earlier lunette sedimentation and soil forming episodes are now suggesting the sedimentary history of the Lake Mungo lunette prior to the Zanci Event may have been more complex than the sequence outlined above (Boo 1990).

(ii) Sediment accession and soil formation at Lake Tandou

The Tandou lunette (Fig 1.5) is a large single lunette, which should imply that a deep complete sequence of sediment accession, soil formation and erosion would be preserved. Current research suggests that there is evidence for at least five episodes of sediment accession. Data from Lake Tandou are reproduced, with permission in Table 1.1 (Hope, Dare-Edwards and MacIntyre in press).

Within the units marking phases of accession, Dare Edwards has identified soils, documenting wetter periods than today. Of direct relevance here is the soil developed in the Tandou Unit. The sandy Tandou Unit is deeply reddened, with evidence for carbonate mobilization. The reddened calcareous soil outcrops along the length of the lunette and is therefore an important marker horizon. It has been named the Tandou Pedoderm. Occupation deposits on the surface of this unit have been dated to younger than 27,000 BP, which means that this soil was formed in the same time period as the Lower Mungo pedoderm.

The Tandou Pedoderm, which also documents a wet period, was buried by between one and eight metres of sand, silt and clay, the Bootingee Unit, in which from one to three weakly expressed
soils are found. The access of sediment into this unit continued until at least 14,000 BP, and possibly until 11,000 BP. The Buntigoola Unit spans the Zanci Event, and may be partly correlated with it. Similarly, formations of the Tandou Pedoderm may be related to the same soil forming event which produced the calcareous Upper Mungo Pedoderm.

Regional events

(i) A tentative correlation may be made between the formation of a calcareous pedoderm at Lake Mungo at c. 32,000 BP and the formation of a calcareous pedoderm before 27,000 BP at Lake Tandou. This soil forming episode, the Mungo Lacustral of Bowler, may have seen a region wide sediment stability, and stable riverain and hinterland vegetation, including wide areas of gallery forests. After c. 27,000 BP the evidence suggests that areas of the Lachlan catchment became successively more arid, until final drying of the Willandra Lakes before 14,000 BP. Weak soils formed on sands and clays, and episodes of soil formation may have expressed local dune stability rather than regional stability.

(ii) After c. 18,000 BP there appears to have been regional sediment mobility, indicating failure of hinterland precipitation, and high wind conditions. During this period, the Zanci Event, 24 metres of sediment were deposited on some lunettes, and most lunettes seem to have experienced some build up. The correlations between these wider events is reviewed below.

Paleoclimatic evidence from the landforms of the river tract

The Murray occupied its present tract, meandering over the surface of the Lake Bungunnia sediments, at some time after Lake Bungunnia dried. The width of the flood tract, which at Lake Victoria incised the Bungunnia sediments down to the Parilla sand, implies that the riverain system must have had a lot more energy at some times during the past. Unfortunately,
little is known of the timing of the episodes of Murray cut and fill, although episodes of major discharge may have been associated with higher inputs of moisture in the catchments, they may also have been associated with lowered base levels, during Pleistocene low sea levels. The chronology of cut and fill in the Murray flood plain is much debated (Pels 1971; Bowler 1970), and at the present time it is difficult to confidently indicated a dated sequence for riverain discharge.

1.5 The sedimentary history of the Lake Victoria region, and the Lake Victoria lunette

In the vicinity of Lake Victoria the Pleistocene Murray river scoured the Blanchetown clays down to the marine esturine Parilla Sands (Macumber 1978:51; Boucaut 1972), and infilled the river tract with alluvial sediments, Fig 1.5 (Gutteridge et al 1970:13-21; Twidale et al 1978; Pels 1971; Woolley 1978; Bowler 1979).

The present river is much reduced, and flows in a channel incised into channel fill. Pleistocene sediments formed a series of terraces, which sit above the level of the flood plain associated with the present river. These sediments are called the high level alluvium.

At some time in the late Pleisotocene, a large lake basin was formed in the high level alluvium. This basin extends to the south and east of the present Lake Victoria. Wave cut beaches to the east of the present lunette have been associated with this larger lake. Details of lake and high level alluvium sediments encountered in three bore holes to the south of Lake Victoria are given in Fig 1.6.

The ancient lake 'encroached upon Phase 1 and Phase 2 sediments of the high level alluvium, and deposited newer sediments on the river sediments' (Boucaut, Currey and Pels 1972:12), which indicates that the ancient lake is a comparatively recent feature. The history of the ancient Lake Victoria is not yet
**TRIAL HOLE LOG**  
**LAKE VICTORIA EAST OF BASIN, SOUTH OF LAKE**  
S.A. ENGINEERING AND WATER SUPPLY DPT. 1973

<table>
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<th>Depth in metres</th>
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<th><strong>HOLE 2</strong></th>
<th><strong>HOLE 3</strong></th>
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<td>fine light brown sand</td>
<td>organic rich dark grey clay</td>
<td>light grey clay</td>
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<td></td>
<td>Fine clayey sand, silty clay pockets</td>
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<td>light grey, silty clay</td>
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<td>Fine sand, pockets of gypsum, organic staining</td>
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<td>clayey, rich with gypsum and organic matter</td>
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<td>silty fine grey sand, charcoal present</td>
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<td>numerous root holes</td>
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<td>light grey or brown</td>
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</tr>
<tr>
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*Fig 1.6*
well known. The bore logs indicate that the lake experienced periods of total desiccation, which lasted long enough for trees to grow over the lake floor. Subsequently, the lake refilled, and at some later date, the lake floor was invaded by gypsum rich groundwater. It is thought possible that the landform feature visible in air photographs to the east of the present lunette is actually a lunette which was formed during the history of the ancestral lake (Frontispiece).

The ancestral lake was truncated by the Murray river during a phase of incision (Boucaut et al 1972; Gill 1973a;24), and subsequently drained. The lake basin was partly infilled by river alluvium. This alluvium was subject to soil formation, the soil which formed is marked by a well developed nodular carbonate BCa horizon, and rubefied sand and clays (Gill 1973a;24; personal observation of soil development on the ancient lake floor surface, to the east of the present lake).

The name Rufus Pedoderm is tentatively proposed for the red calcareous soil. Plate 1.1 and 1.2 show surface exposures of this soil, which is a distinctive bright red. Although the Rufus Pedoderm is well expressed in sandy high level alluvium sediments to the north and east of the lunette, no deep calcareous soil with nodular carbonate has been located in the lunette. Deep gullies which intersect the lunette to within a few metres of current lake level show no trace of such a soil. If such a soil was present, reworked nodular gravels might be expected to occur in reworked lunette sediment, or on lake beaches, but none has been observed. It is therefore tentatively concluded that the lunette was deposited after the formation of the Rufus Pedoderm. If the Rufus Pedoderm may be associated with the regional soil forming event which produced carbonate rich soils at Lake Mungo and Lake Tandou before 27,000 BP, this implies that the Lake Victoria lunette, which apparently lies above the Rufus Pedoderm post dates c 27,000 BP.

Some support for the suggestion that the present lunette of Lake Victoria is a comparatively recent feature may be derived from
the orientation of the lunette - which is aligned to face south south westerly resultant winds. In contrast two outer lunettes (Frontispiece) exhibit westerly orientation. This is consistent with observations that the more recent phases of Woorinen sediment reworking were aligned more south of west than older reworked sediment. It is tentatively concluded that the lunette associated with the present lake is younger than 50,000 BP, and possibly younger than 27,000 BP.

If this hypothesis is accepted, the implications are

1. the present inner lunette formed during the same time period as the Buntigoola Unit at Tandou, and the Upper Mungo/Zanci Event at Lake Mungo

2. the fossil faunal material associated with the lunette sediments all survived to post date c 50,000, and possibly 30,000 BP

3. human occupation deposits of extreme antiquity (if present) will not be found in the lunette, but may be found associated with the Rufus Pedoderm, in areas to the north and west of the lunette

Until dates and stratigraphic associations between the Rufus Pedoderm and the lunette are more clearly established, these hypotheses must be treated as speculative.

The following chapter examines in more detail the evidence for the paleoclimatic conditions between c 30,000 and 14,000 BP which formed the lunette, and which affected the environment of Pleistocene human populations, and species of animals which became extinct.