CHAPTER THREE

Engraved on the desert
are the shadows of remembered rivers.

Rivers of Amazonian size
have pulled a sand blanket over their beds,
till a pluvial age scours them loose
or some new wrinkle on Earth's skin
makes them nonsense forever.

THE LAST 60 MILLION YEARS

For as long as it has existed, Australia — the world's flattest continent — has been a land of floodplain rivers. The climate has fluctuated between wet and dry, but for about 60 million years large and small rivers have run west from the Great Dividing Range in search of the sea, as they still do today. Their history can be traced in old river courses, in the sediment that fills the inland basins and in underground aquifers, where long-vanished rivers still flow in subterranean channels.

Australia's birth pangs began soon after the dinosaurs disappeared, 65 million years ago. It was the last landmass to split away from the ancient southern supercontinent Gondwana, which for the previous 100 million years had been slowly breaking up. By 60 million years ago Gondwana had already shed South America, Africa, New Zealand and India. Only Australia and Antarctica still clung to each other. Then they too began to tear apart.

SCULPTING FLOODPLAINS

Some western areas of the modern Darling drainage system probably pre-dated Australia's split from Gondwana, and may be very ancient. But the rise of the dominant watershed of the Murray-Darling Basin, the Great Dividing Range, coincided with, and was probably caused by, the continental schism 60 million years ago. The floor of the present Basin was then a flat Gondwanan plain, a former primeval seabed from which the ocean had finally retreated some 50 million years earlier. As Australia tore away from Antarctica one edge of the plain was progressively uplifted — perhaps shoved up from below as the continent drifted north over a subterranean volcanic 'hot spot'. Over the next 20 million years the vast western floor of the Basin slowly subsided, while the eastern mountains kept rising. As the Basin deepened, large rivers poured west off the new highlands and began filling it with sediment.

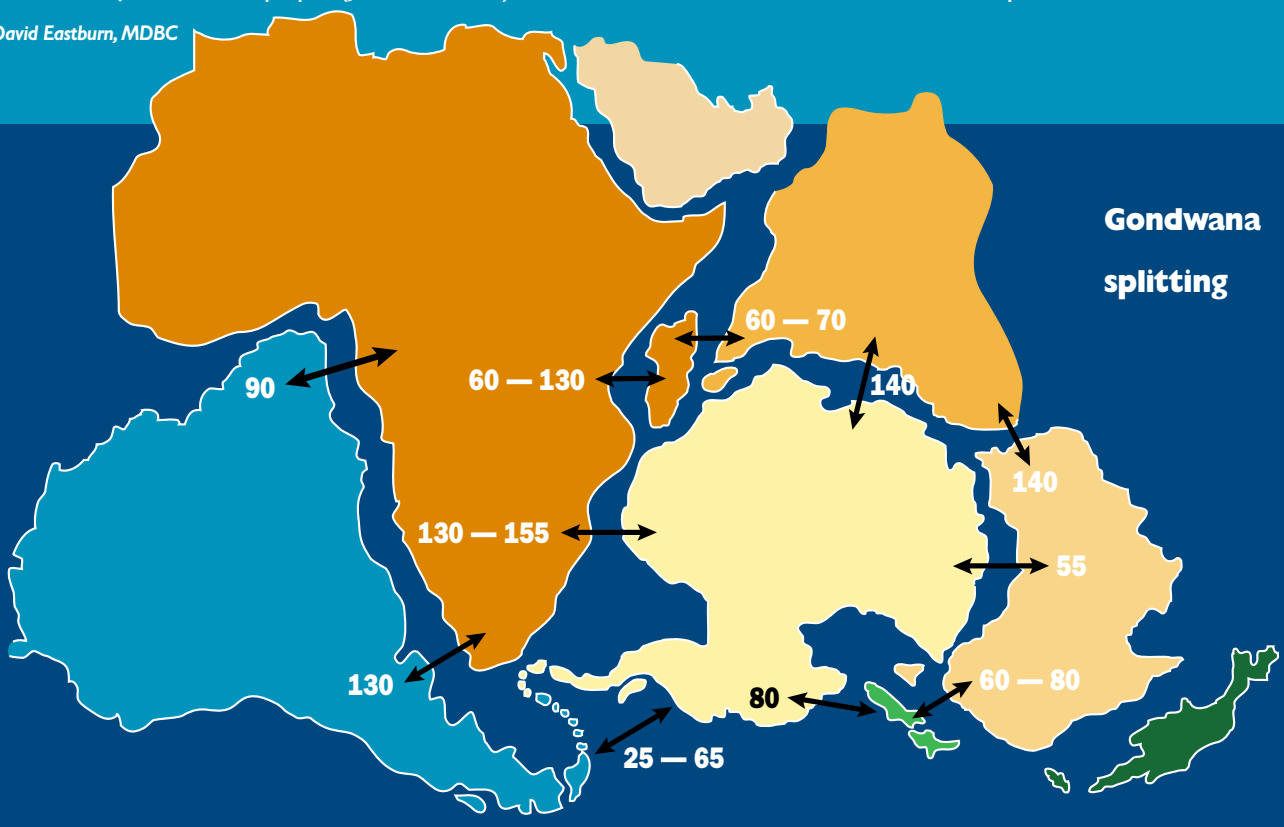
It took many millions of years for Australia and Antarctica to fully separate, with Tasmania caught in a tug of war between. But finally, about 40 million years ago, they parted. Australia dragged Tasmania north, leaving Antarctica alone at the bottom of the world. With Australia out of the way, ocean currents were free to circle the South Pole, as they still do today, greatly influencing the world's climate. Whatever had killed the dinosaurs (most likely a few large chunks of a wayward comet), had also killed perhaps 80 percent of all the other species on Earth. Those that survived were isolated on different continents, drifting away from each other.

After splitting from Gondwana, and while the rest of the world's continents were being churned by mountain-building and shot through with volcanoes, Australia sailed serenely north with hardly a rumble to disturb its flat landscape. It lay protected in the middle of a large tectonic plate, far away from the collisions and upheavals occurring around its edges, in places like New Guinea and New Zealand. Grinding north at an average speed of about one centimetre a year, Australia moved, and is still moving, closer to Asia. About 25 million years ago the gap between Australia and Asia narrowed enough for some new plants, and later some animals, to enter the great southern continent from the north.

For all that time rivers flowed across the mostly undisturbed plains of Australia, depositing sediment and providing homes to plants and animals. The Australian climate fluctuated. Sea levels rose and fell. The ocean invaded, then retreated from, the land. Australia's great inland depressions, such as the Murray and Darling basins, continued to subside slowly and to be gradually filled in — partly by gravel, sand and clay washed down by

'Lake Mungo has come to represent Australia's most sacred place, sacred both to white Australians, as represented by its World Heritage nomination, and to those original Australians who see it as the central embodiment of their ancestral people'. (Jim Bowler 1995) Photo: *David Eastburn, MDBC*

Below: Continental drift produced the modern continents from a single land mass – Gondwana – that existed more than 230 million years ago. This diagram shows the times, in millions of years from the present day, at which the various continents drifted apart.



generations of rivers, and partly by sediment deposited on the beds of inland seas and lakes. At its deepest point the floor of the Murray-Darling Basin has now sunk to about 600 metres. However, it has been filled to the brim with successive layers of sediment so that its surface, where modern rivers flow and flood, remains almost dead flat. At Mildura, for example, the River Murray falls a mere five centimetres in every kilometre. Further downstream the gradient is even less.

The last six million years

Rivers mark the landscape. Like tyre tracks in dried mud, their channels and floodplains remain visible in the landscape long after the rivers themselves have gone. Inland Australia is criss-crossed with many such old river courses. The more recent ones can be easily traced. The older rivers, like old tyre tracks that have been crossed too many times by fresher ones, are more difficult to reconstruct. From these old courses, and from other clues, scientists have worked out some of the history of Murray-Darling rivers. Much of this history remains speculative, and the dates are uncertain. But it is clear that Australia's modern floodplain rivers have been profoundly shaped by their ancestors. Each new river has had to negotiate a maze of older channels and floodplains, shuffling around earlier sediment as it carves its own path to the sea.

Over millions of years southern Australia's climate has fluctuated frequently, but overall it has become drier. Six million years ago plentiful rain meant rivers fanned out into many streams as they ran down the western slopes of the Great Dividing Range, instead of concentrating into just a few as they do now. Sea levels were high, and the ocean reached far inland. In the moist climate, rainforest grew as far west as modern Balranald. The swollen rivers carried large quantities of coarse sand, which they deposited in their channel beds, and fine clay, that settled on wide floodplains to create today's claypans.

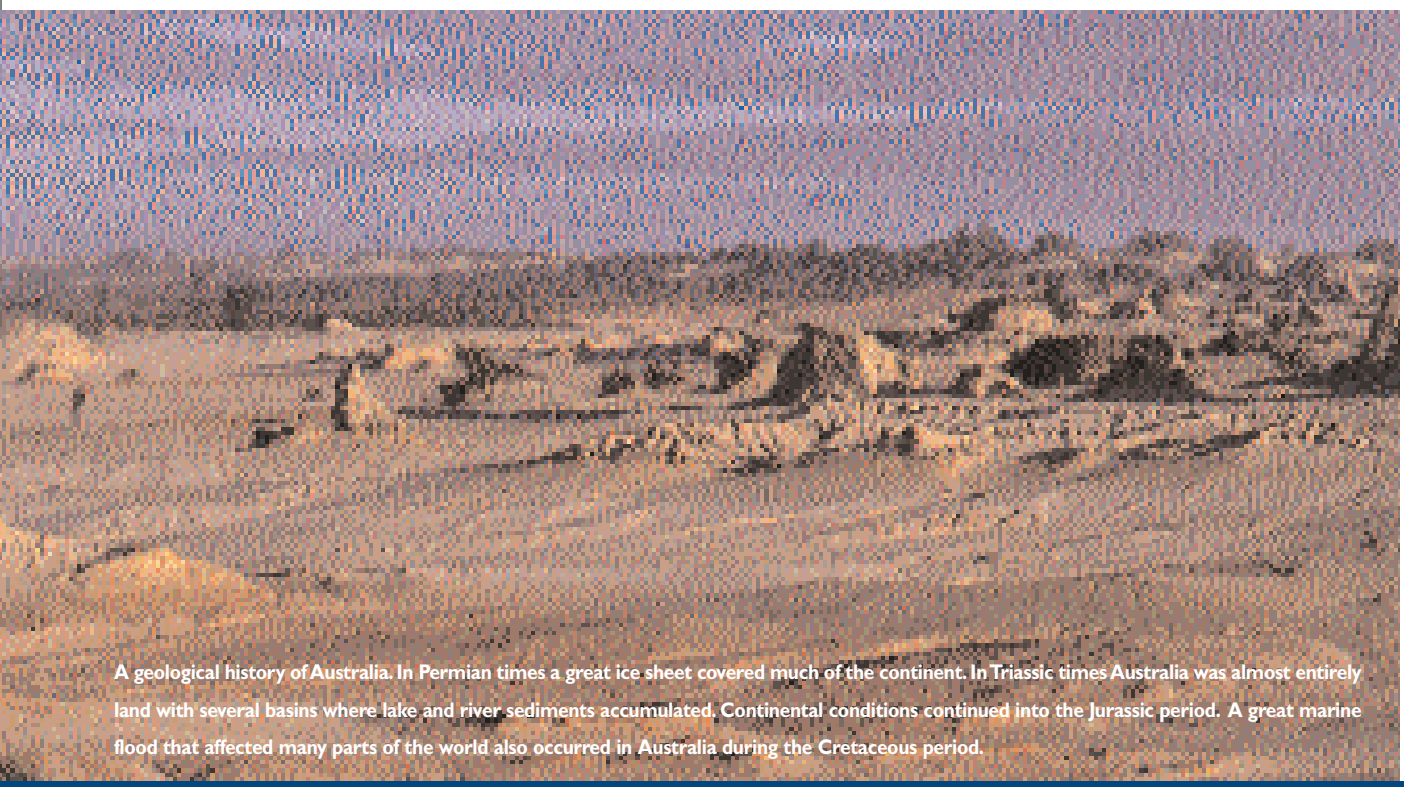
About four million years ago the climate dried. The inland sea retreated west, leaving behind a series of abandoned shorelines — each similar to the modern Coorong — which are still visible as long, north-south sand ridges on satellite images of the Mallee district. The west-flowing rivers followed the retreating shoreline deep into South Australia, until about 2.5 million years ago an uplift near modern Swan Reach dammed their outlet to the sea. A huge lake formed inland of the Swan Reach blockage, reaching north almost to the present-day Menindee Lakes and at its height covering some 33,000 square kilometres. Geologists have dubbed this huge, vanished waterbody 'Lake Bungunnia'.

About two million years ago the Earth's climate cooled, and became locked into its present cycle of long 'ice ages', each lasting hundreds of thousands of years, interrupted by short, warm interglacial episodes — like the present one — of about 10,000 years. For most of the past two million years, Europe and North America have been buried under ice, but such Northern Hemisphere terms as 'ice ages' and 'interglacials' are misnomers for Australia. The southern continent experienced sympathetic climate fluctuations, but they brought little ice and few glaciers. Instead they heralded a drier and more seasonal climate. While the ice sheets covered Europe, the rivers flowing west from Australia's Great Dividing Range shrank in summer, but still flooded in winter, spilling out of their channels to spread sediment over broad floodplains.

Lake Bungunnia survived the drying climate until about 700,000 years ago, when its waters breached the Swan Reach dam and emptied into the sea. The River Murray cut a new channel across the former lake bottom, gouging out the spectacular river gorge which now flows from Overland Corner to Mannum in South Australia. The climate continued to fluctuate.

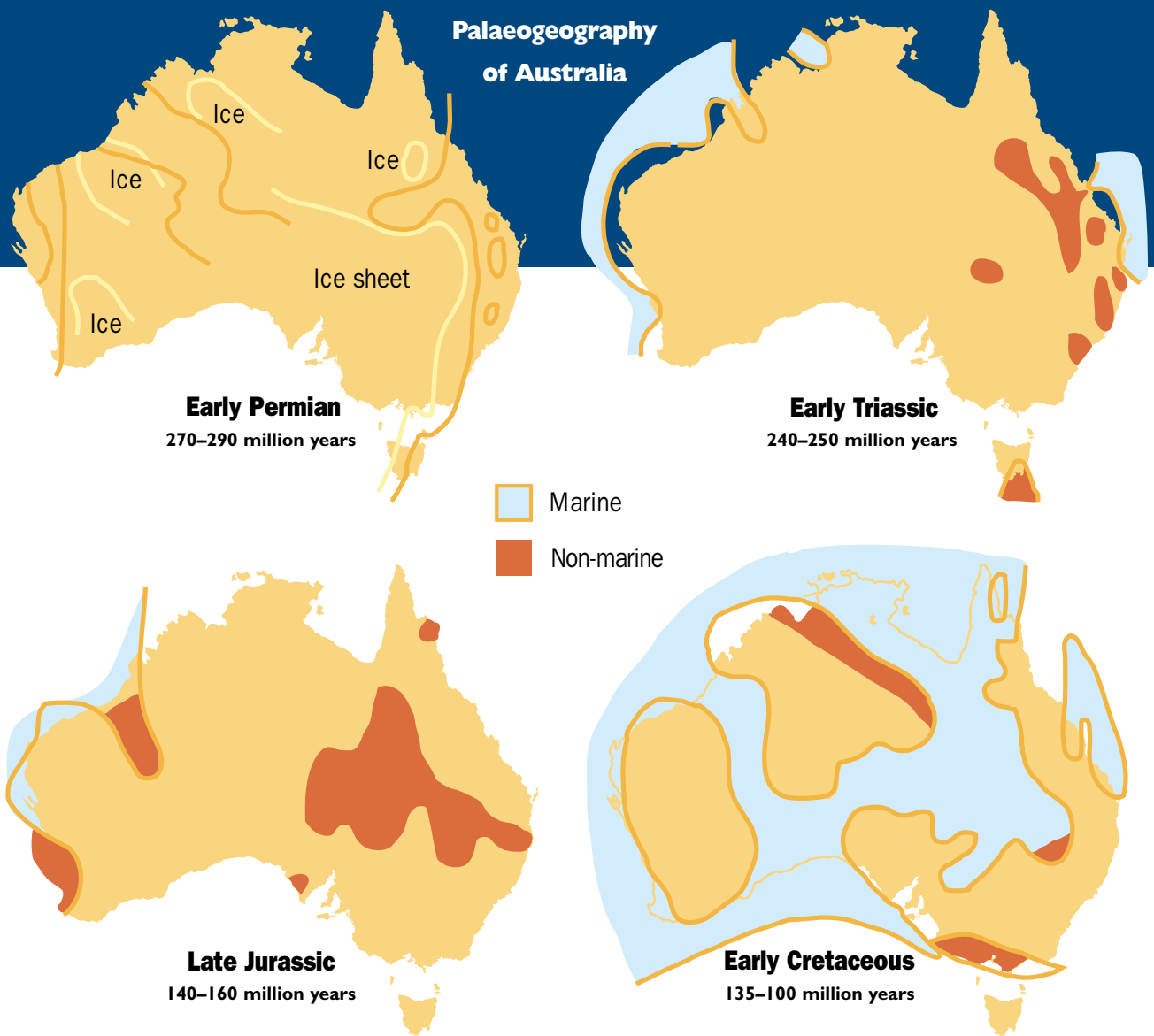
The Coorong, a 2-3km wide coastal lagoon system which stretches southeast for some 100km from the mouth of the River Murray. The Coorong receives freshwater inflow from the River Murray at the junction where the lagoon meets the sea. Photo: *David Eastburn, MDBC*

Mungo National Park, located near Balranald in south-western NSW, is centred on part of the fossil Willandra Lakes system. Photo: *David Eastburn, MDBC*



A geological history of Australia. In Permian times a great ice sheet covered much of the continent. In Triassic times Australia was almost entirely land with several basins where lake and river sediments accumulated. Continental conditions continued into the Jurassic period. A great marine flood that affected many parts of the world also occurred in Australia during the Cretaceous period.

Palaeogeography of Australia



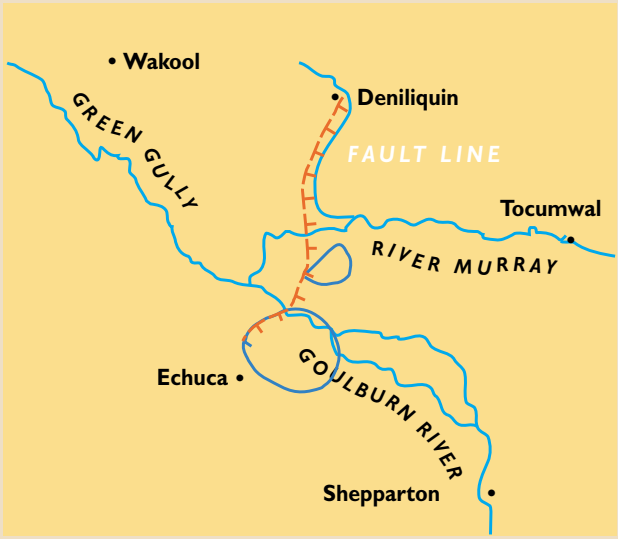
Evolution of the River Murray near Echuca

Before 30 000 years (Before present)

Ancient Murray and Goulburn rivers meet north of Echuca

20 000 years (Before present)

Cadell Fault diverts Murray to the north. Goulburn flows into a lake.



25 000 to 30 000 years (Before present)

Lake drains, channel dimensions reduced by climatic change.

(From Bowler, JM 1986)

About 10 000 years (Before present) to present

Narrow sinuous course develops with climatic change. About 8000 B.P. the Murray breaks to the south to join the Goulburn near Echuca.

The last 50,000 years

Southern Australia's modern inland rivers follow courses laid out perhaps 50,000 years ago, when the rivers resumed flowing after a dry climate oscillation: a sharp arid spell. These new rivers were smaller than their predecessors, but still larger than today's streams. They cut across the earlier drainage pattern, often reworking sediment deposited by previous rivers. But their floodplains followed new courses, roughly mapping the trails of the Murray-Darling rivers today.

The River Murray suffered its last major disruption about 25,000 years ago, when a slab of Basin floor tilted toward the sea, raising a ridge, up to 12 metres high in places, in a long fault line running from Deniliquin to Echuca. Called the Cadell Fault, the ridge dammed the Murray and altered its course, pushing it first north, and later south, to get around the obstacle. The Cadell Fault made a large area of land prone to frequent flooding, creating the wide floodplain on which the great Barmah and Millewa river red gum forests now grow.

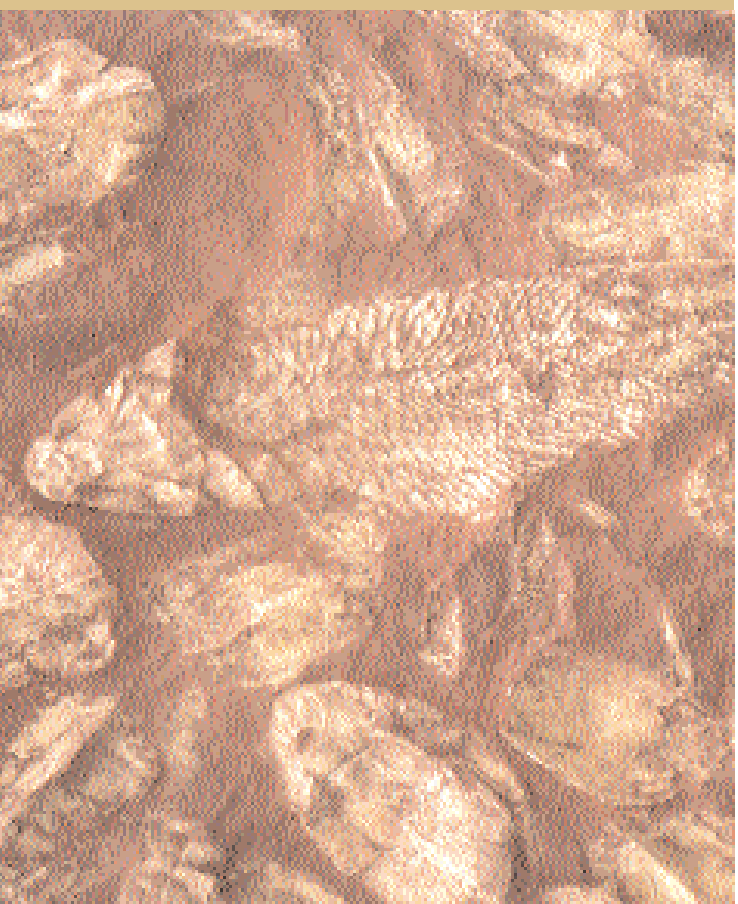
Over the past 10,000 years Australia's climate has become drier. The river channels flowing west from the Great Dividing Range have dwindled. For most of their length Australia's modern inland rivers now meander through old floodplains much bigger than they could create for themselves. Geomorphologists call them 'misfit' or 'underfit' rivers, because they are too small for the floodplains they occupy. Unlike their ancestors, Australia's small, slow-flowing modern rivers carry mostly fine, suspended clay, but, at least until last century, (Chapter 11) little sand or coarse sediment.

Changing channels

Rivers never flow in a straight line. Even when there are no obstacles, flowing water has an inherent tendency to meander. And, over time, the meanders themselves also move. Within the boundaries of their floodplains, river channels shift from side to side, shuffling old sediment and pushing it downstream toward the sea. A river pushes sediment along a floodplain a bit like you might use a running hose to squirt dirt from a concrete path — sweeping from one side to the other, progressively moving the dirt along. Similarly, rivers sweep from side to side within their floodplains. Each meander moves the sediment along a little, then leaves it behind for the next. As a floodplain river moves, it leaves tracks in its wake: repeated, curved rills called 'scrolls', which fill with water to become billabongs. Changing flows also frequently cut off whole loops of river channel, called meanders, to create flood-filled 'oxbow' billabongs.

Fast-flowing rivers with steep gradients have small meanders, which can sweep across their narrow floodplains in just a few decades. But slow-moving lowland rivers — such as the Murray, the Ovens and the Murrumbidgee — have far larger, looping meanders that sweep much more slowly across wide floodplains. River meanders are irregular, but not random. Their looping paths have quite measurable wavelengths, which depend on the downhill gradient and the volume of water the river carries. Lower volume rivers have smaller loops, which in the underfit rivers of the Murray Basin are often superimposed on the wider loops of older, greater rivers.

Fossils of armoured fish and a very rare air-breathing, lobe-finned fish that lived 360 million years ago, from Canowindra in New South Wales. The air-breathing fish is named *Canowindra grossi*, after the town. A range of fossil types are found at sites throughout the Basin. Geological history and geomorphology largely determine the Basin's natural heritage. *David Eastburn, MDBC*



Lake Bungunnia at its greatest extent

About two million years ago Australia's 'inland' sea retreated and a large lake had formed in the west. Lake Bungunnia straddled the present South Australian border region, stretching from about Euston in the east and nearly to Mannum in the west.

CHAPTER 3

Time scales

The span of Australia's entire 'modern' history, since the arrival of the English First Fleet at Sydney Cove in 1788, is almost negligible when compared with Aboriginal occupation. The past two centuries probably represents less than a third of one percent of the time humans have been in Australia. But in geological terms, Aborigines are also relative newcomers. The Murray-Darling Basin has existed, in something like its present shape, for about 60 million years. For 99.9 percent of that time it has been unoccupied by humans. Aborigines have been here for less than 0.1 percent of its existence, Europeans a mere 0.003 percent. Floodplains operate at many different scales, both in time and in space. To an organism which spawns a new generation every few days, 100 years in a billabong is a very long time — easily long enough for it to evolve into a completely new species. But 100 years is scarcely a generation in the life of a river red gum, and it is just an eyeblink in the life of a river — just as one river's life might be a mere eyeblink in the life of a drainage basin.

Over long ages Australia's inland river systems have passed through many dramatic changes. The animals and plants that live in them have been forced to adapt time and again to major disruptions. The changes wrought by humans are the most recent in a long line, even if they are happening faster than anything that has gone before. So does it really matter what we do? It is all a question of choosing a time-scale appropriate to our concerns.

On a 100-year scale, the ecological changes wrought to the Murray-Darling river systems since European settlement are extremely severe. On a 1,000-year scale, they are still profound. On a 100,000-year scale, recent human activities begin to fade, although they remain significant — for example species which have survived many millions of years have vanished in the past two centuries. On a million-year scale most human impacts on other species (so far) are relatively minor compared with the changes caused by geological disruptions. On a billion-year scale, even a human-caused global mass extinction — which many scientists now believe is under way — would cause only another interesting ripple in the fossil record.

However, humans do not live in geological time. Our concerns tend to be confined almost entirely to the time span of our own generation. Even the most far-sighted people seldom try to plan even 100 years into the future. In a brief flash of geological time Australians have caused widespread and sudden changes to our floodplain systems, and have wiped out, endangered or vastly depleted many long-surviving native species. In just two centuries we have set in motion ecological disruptions which will impoverish and haunt future human generations, and which will echo through the world's biota for many thousands of years to come.

An Aboriginal fishing camp on the Wakool River.
***Illustrated Sydney News* 11 May 1872.**
National Library of Australia

The Wakool River flows westward from near Deniliquin in southern New South Wales and joins the Murray near Tooleybuc. It was once the main channel of the Murray and at the Junction, the Wakool is the larger river.