A Natural History and Field Guide to Australia's Top End

Penny van Oosterzee
Ian Morris
Diane Lucas
Noel Preece





Biographies

Penny van Oosterzee

Penny van Oosterzee is a multi-award winning author including two-time winner of the Eureka Science Prizes and four-time winner of the prestigious Whitley Awards for her books including Exploring Nature in the Deserts: The Young Naturalist Series, The Centre: the natural history of Australia's desert regions, Where Worlds Collide: The Wallace Line, and The Discovery of the Hobbit: The Scientific Breakthrough that Changed the Face of Human History.

Penny holds a PhD from Charles Darwin University where she is a University Fellow. She is also an adjunct Senior Research Fellow at James Cook University. She is currently involved with an international team in an Australian Research Council project examining cost effective rainforest restoration.

Ian Morris

Ian Morris is a biologist, educator, conservationist, and author. He has worked with the Aboriginal Traditional Owners of Arnhem Land region since his early life as a science teacher. He was then involved with the beginning of the federal government's first Indigenous joint-management project – Kakadu National Park.

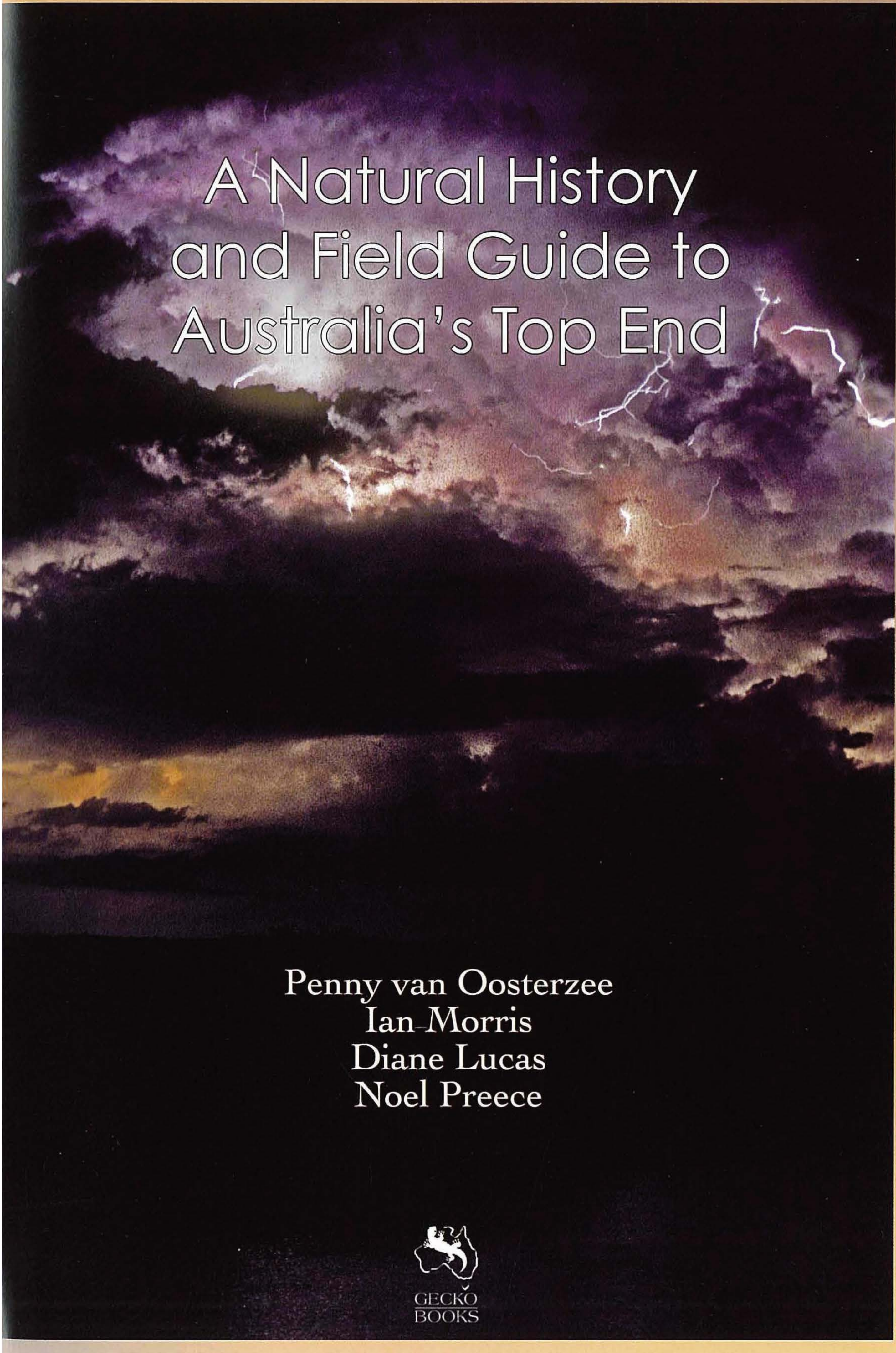
Today, Ian continues his work, promoting the magic of the bush as an NT-based environmental consultant working with wildlife documentary makers like the BBC Natural History Unit, National Geographic Society, etc. He continues his conservation work for federal and state governments as a consultant for many national parks in Australia. He greatly values his continued connection with his Indigenous mates across the north.

Diane Lucas

Diane Lucas is an educator who works with children and the broader community to enthuse, and open peoples' eyes to the wonders of the natural world. She is the author of five children's natural history picture books and a CD of songs for children. Her songs, stories and verses celebrate the north Australian bush. Together with Ian, her contribution to this book has been to bring to fruition a project commenced many years ago by Penny and Noel.

Noel Preece

Noel is a conservation ecologist and environmental scientist with expertise in northern and central Australian ecosystems. He has been a Director of four companies. He has published extensively on his work. Noel holds a PhD from Charles Darwin University, and a Master of Science from the University of Queensland and Northern Territory Uni. Noel is also an Adjunct Principal Research Fellow at James Cook University and a University Fellow at Charles Darwin University.



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Ichthyosaur page 14 Heinrich Harder http://commons.wikimedia.org/wiki/File:Ichthyosaurs.jpg
Plesiosaur page 14 William Buckland http://commons.wikimedia.org/wiki/File:Anningplesiosaur.png
Graph on page 34 taken from Bureau of Meteorology NT website showing cyclone intensities from 1963 - 2006

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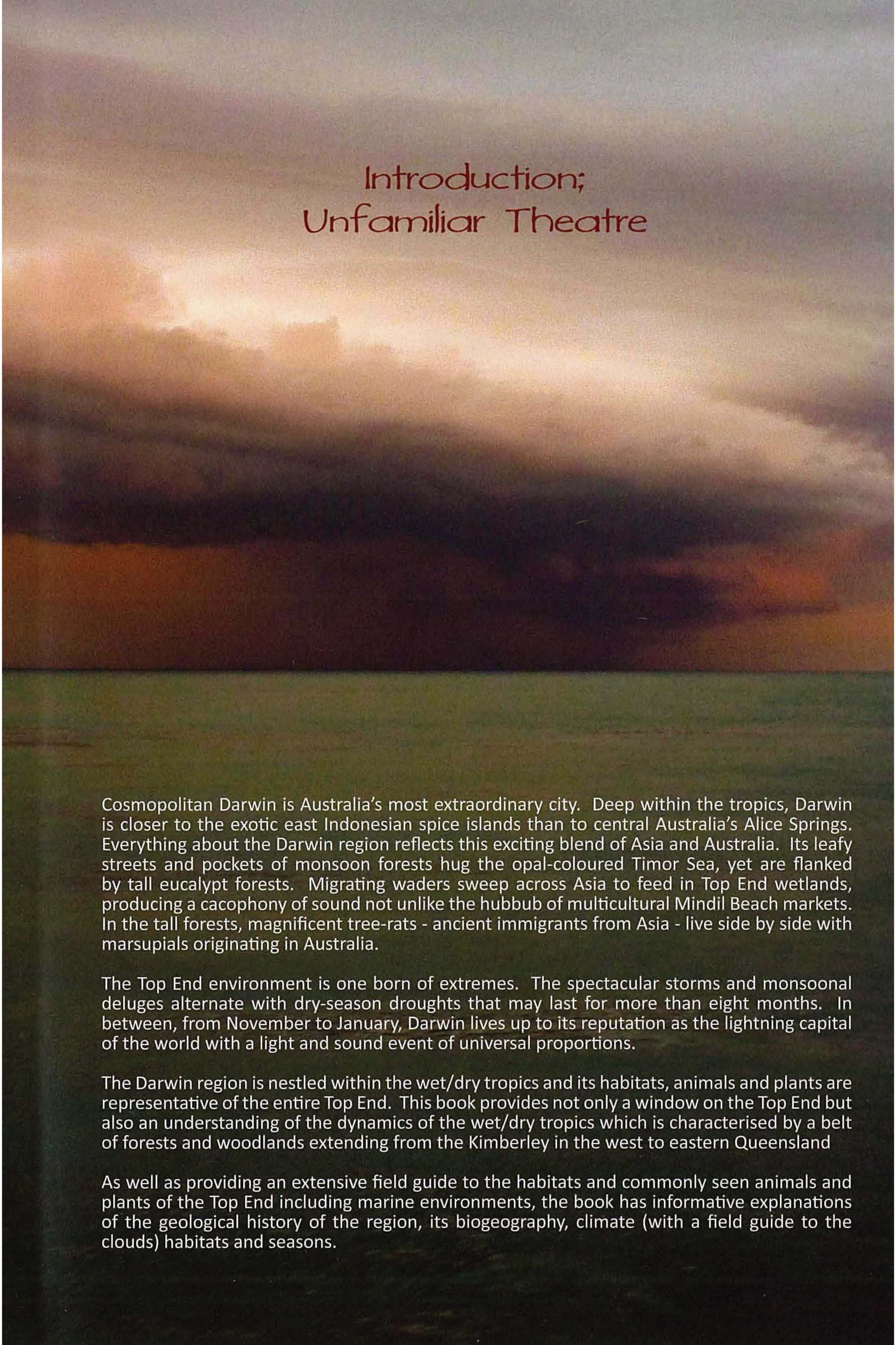
JB books provided their vision and encouragement to proceed with the book.

Dedicated to families and country.

Contents



Introduction; Unfamiliar Theatre

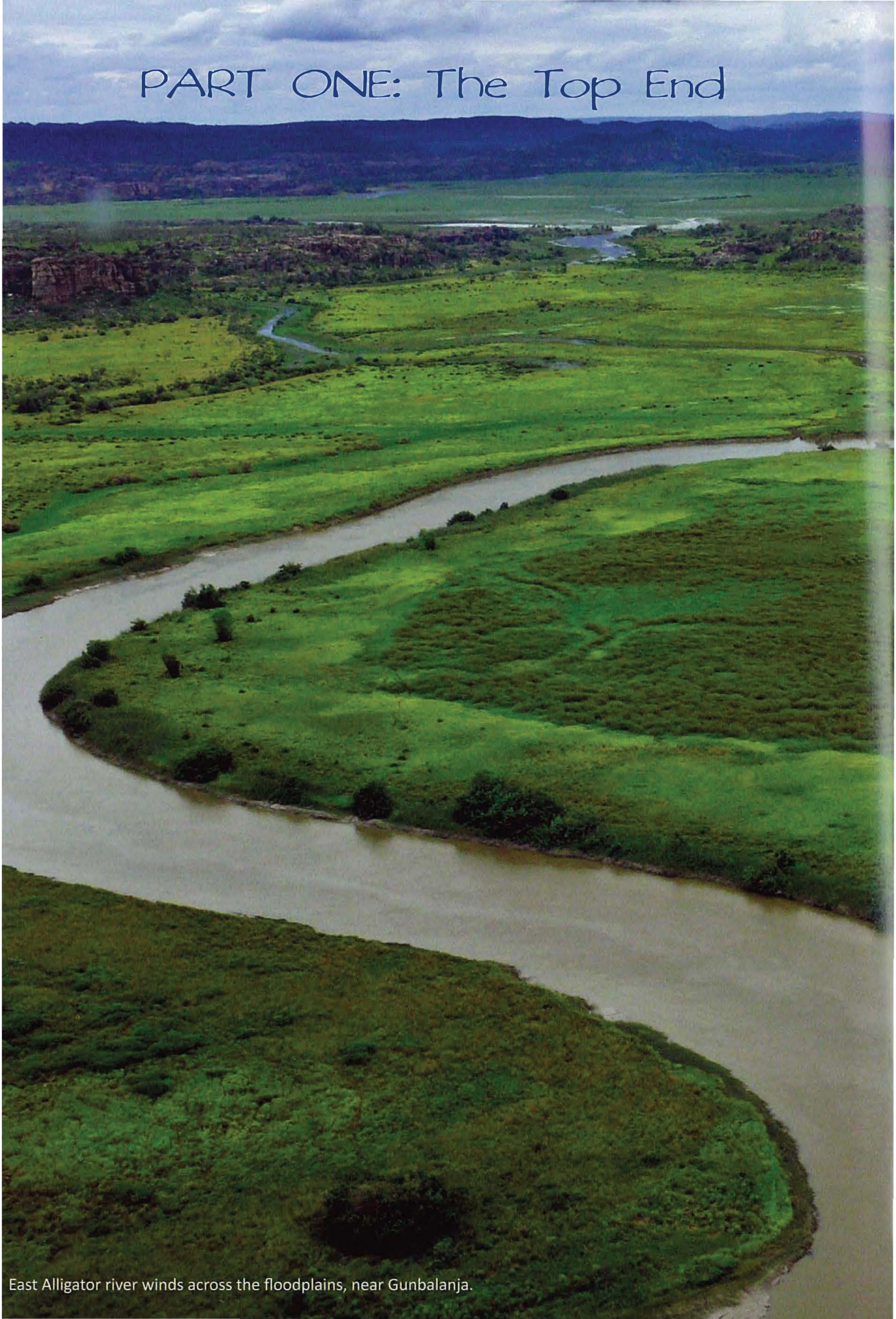
Cosmopolitan Darwin is Australia's most extraordinary city. Deep within the tropics, Darwin is closer to the exotic east Indonesian spice islands than to central Australia's Alice Springs. Everything about the Darwin region reflects this exciting blend of Asia and Australia. Its leafy streets and pockets of monsoon forests hug the opal-coloured Timor Sea, yet are flanked by tall eucalypt forests. Migrating waders sweep across Asia to feed in Top End wetlands, producing a cacophony of sound not unlike the hubbub of multicultural Mindil Beach markets. In the tall forests, magnificent tree-rats - ancient immigrants from Asia - live side by side with marsupials originating in Australia.

The Top End environment is one born of extremes. The spectacular storms and monsoonal deluges alternate with dry-season droughts that may last for more than eight months. In between, from November to January, Darwin lives up to its reputation as the lightning capital of the world with a light and sound event of universal proportions.

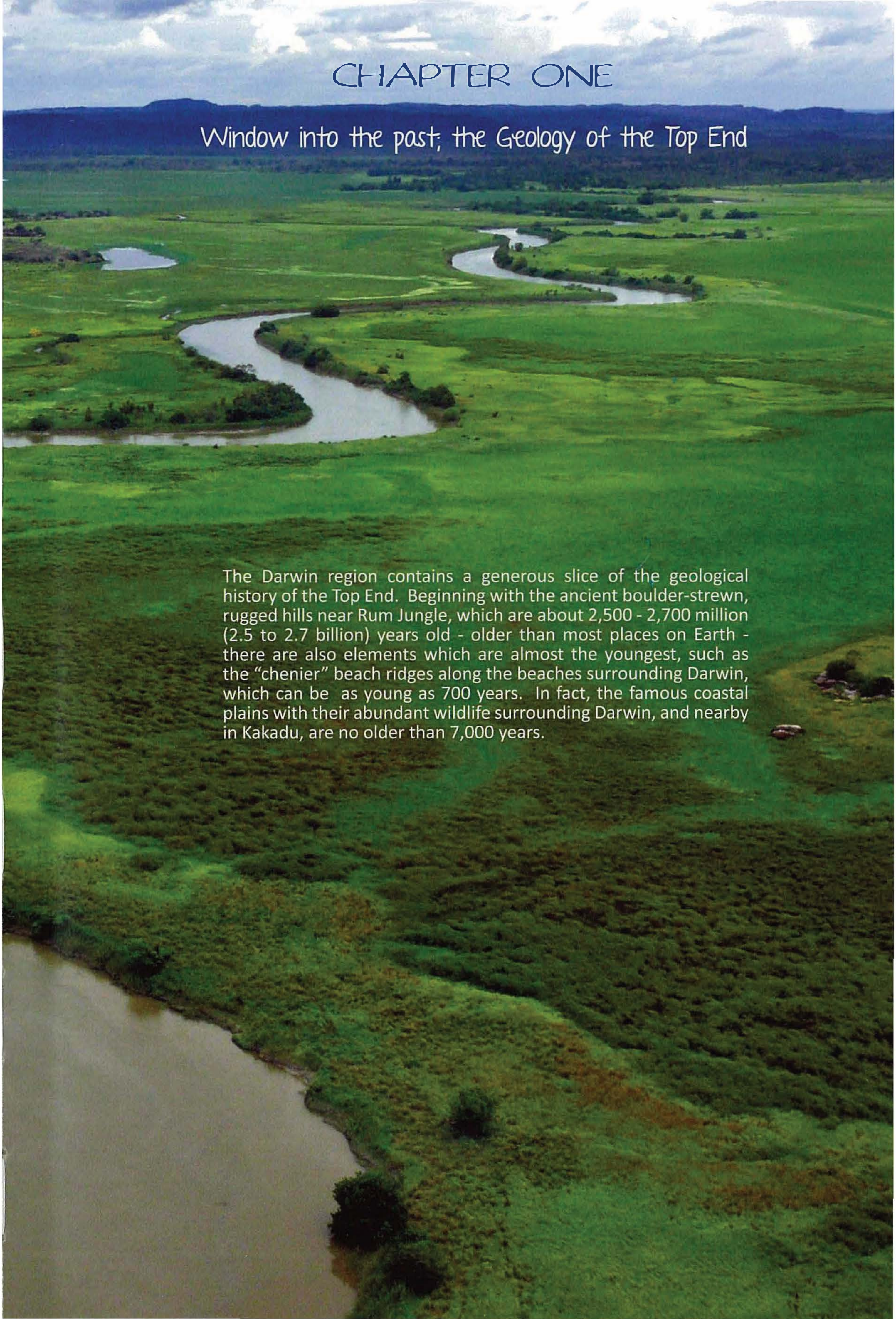
The Darwin region is nestled within the wet/dry tropics and its habitats, animals and plants are representative of the entire Top End. This book provides not only a window on the Top End but also an understanding of the dynamics of the wet/dry tropics which is characterised by a belt of forests and woodlands extending from the Kimberley in the west to eastern Queensland

As well as providing an extensive field guide to the habitats and commonly seen animals and plants of the Top End including marine environments, the book has informative explanations of the geological history of the region, its biogeography, climate (with a field guide to the clouds) habitats and seasons.

PART ONE: The Top End



East Alligator river winds across the floodplains, near Gunbalanja.

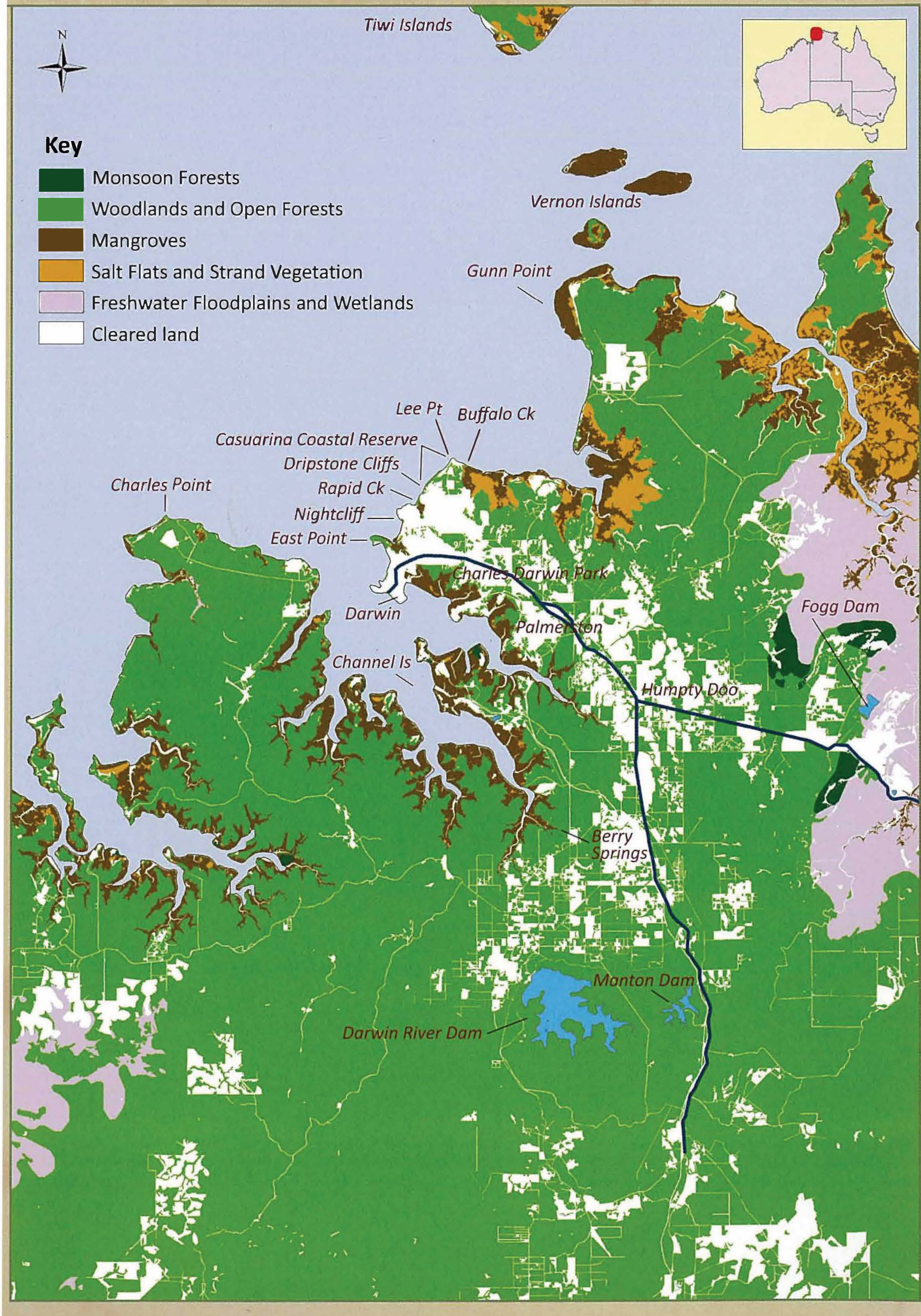


CHAPTER ONE

Window into the past; the Geology of the Top End

The Darwin region contains a generous slice of the geological history of the Top End. Beginning with the ancient boulder-strewn, rugged hills near Rum Jungle, which are about 2,500 - 2,700 million (2.5 to 2.7 billion) years old - older than most places on Earth - there are also elements which are almost the youngest, such as the "chenier" beach ridges along the beaches surrounding Darwin, which can be as young as 700 years. In fact, the famous coastal plains with their abundant wildlife surrounding Darwin, and nearby in Kakadu, are no older than 7,000 years.

Vegetation map of the Darwin region

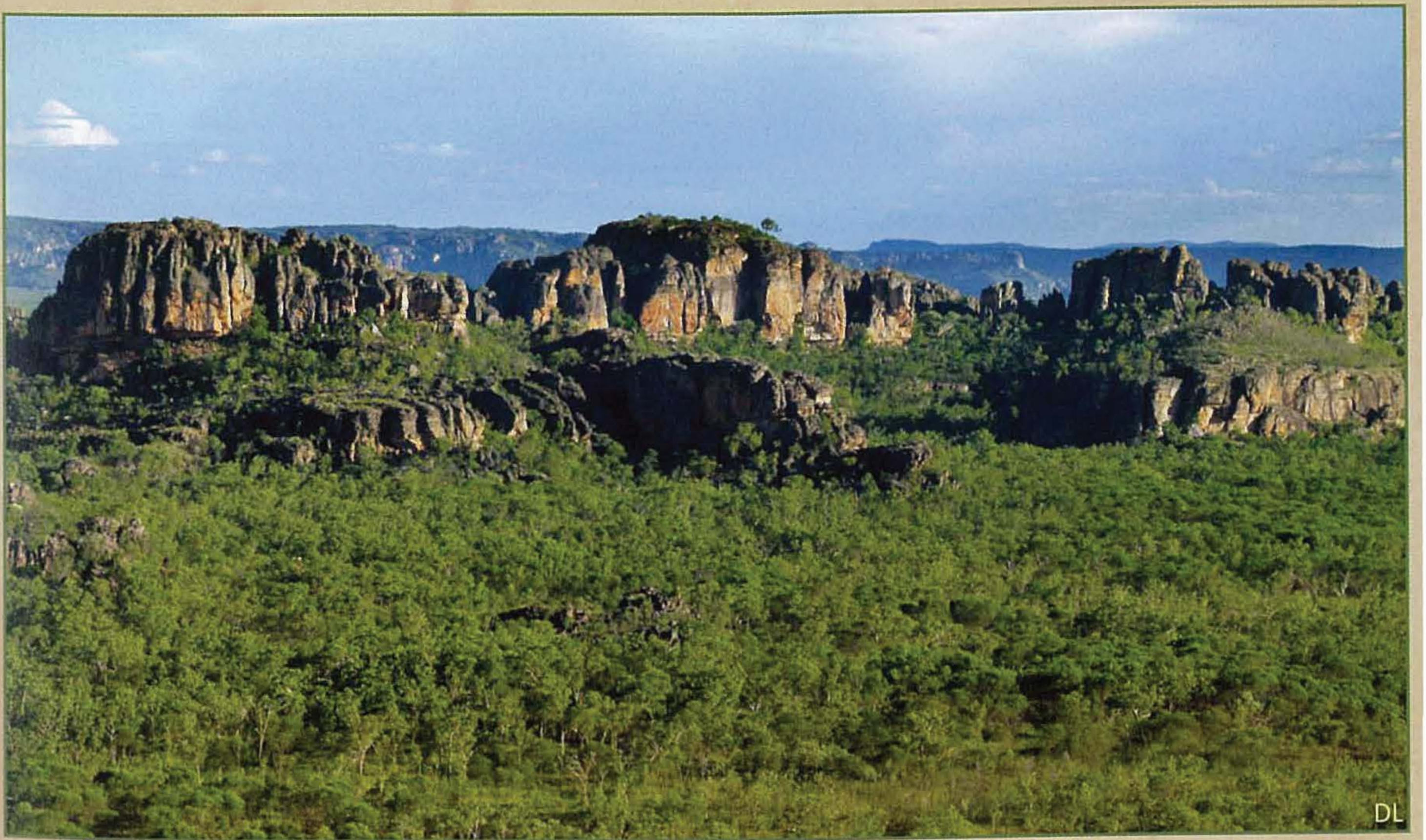


If you know how to read them, rocks can tell the story of a place. Sometimes the writing is rubbed out, sometimes it is big and bold, and other times very subtle. The rocks underlying the Darwin region are so old that they were deposited when life was little more than single-celled animals swimming in primordial seas. This flight through geological history provides an underpinning to the main landscapes we see today (see map opposite page).

The oldest rocks are dated at about 2700 million years. And even these age-worn rocks trap evidence of an earlier event, having been deformed and tightly folded through at least one mountain building episode. These formed when two tectonic plates of the Earth, one of which contained embryonic Australia, collided, heaping the rock at the plate edges into mountains. Heaved above the sea, the land was leveled by erosion for 500 million years. To put this time-frame into perspective, 500 million years is the time it has taken the very first jawless fish to evolve into mammals and primates such as us.

Rocky outcrop Finniss Valley Batchelor

This lifeless landscape lay near a shallow sea with inlets and lagoons, in which mounds of cyanobacteria, single-celled early plant colonies known as stromatolites, were growing. At about this time, 2200 million years ago, a rift-valley developed. Rift-valleys are the surface expression of the boundary of two of the Earth's giant plates, beginning to rift apart. Today this rift-valley is known as the Pine Creek Geosyncline (meaning, literally, geological trough). This vast, lake-sprinkled valley - resembling the rift-valley of east Africa - stretched from Kakadu to the Kimberley.



Djabiluku outlier system, part of the Kakadu escarpment

Ranger Uranium Mine, with escarpment in the background, Kakadu.

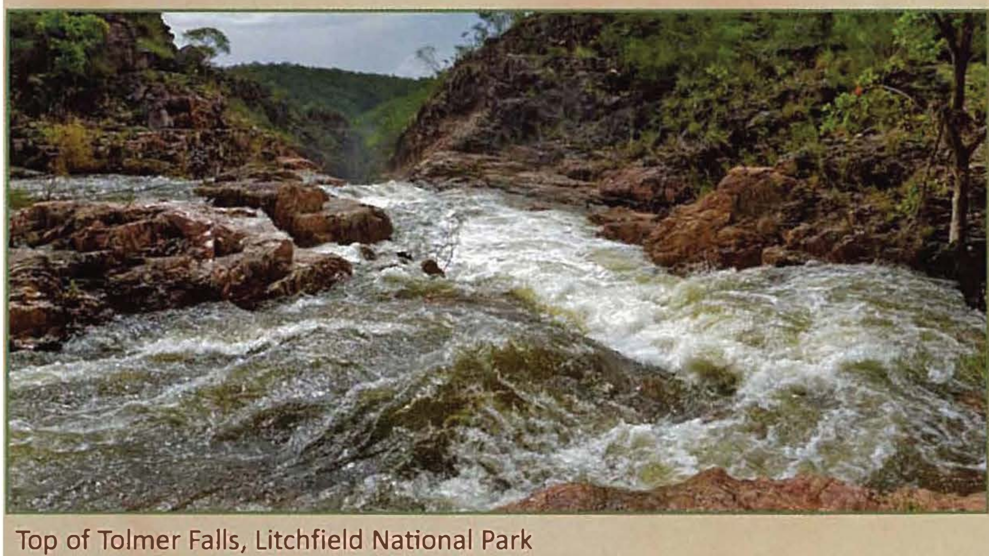
Over millions of years, the rift valley deepened and broadened, trapping 14,000 metres of sediment, which was stripped from the already old hills and mountains of the surrounding environment. The first layer of sediment, dated at the base of the Ranger Uranium Mine, near the township of Jabiru, was deposited at about 2200 million to 2000 million years ago, as alluvial fans brought down by rivers. The alluvial fans graded to a broad continental shelf to the north and north-east, over which the sea was rising, depositing sandstone, claystone and limestone. Nearby submarine volcanoes oozed lava at the tectonic plate, or continental margin boundary.

A period of uplift followed, allowing erosion once again to strip the region to a plain, which the sea again claimed, leaving its calling card as layers of sandstone, claystone and limestone.

Relentless drifting over the surface of the Earth saw the rifting process cease, and the region finally slumped against a submarine trough where one of the Earth's tectonic plates was plunging underneath the plate on which the Top End drifted. The collision crumpled the Top End into lofty mountains once again.

Volcanoes, like the ones to our north today in Indonesia (where the same process of plate subduction is occurring), exploded ash and tuff over the earth's surface. If Top End rocks could talk, this would probably be the most memorable event of their existence to date. It is known as the Top End Orogeny by geologists and the evidence in the rocks indicates that it resulted in the birth of a massive, probably Himalayan-sized, mountain range - now wiped away by time and erosion. This mountain building episode, starting at about 1870 million years ago, endured for about 90 million years.

It was during this period that furnace-hot volcanoes and boiling groundwater distilled uranium and other ores from older sediments and deposited them in rich layers or as veins in other rocks. These ore bodies would later be mined by humans who were yet to evolve from the single-celled animals swimming in the seas at that time.



Top of Tolmer Falls, Litchfield National Park

Several tens of millions of years of erosion tore down the mountains of the Top End Orogeny, until the seas threw them back onto the region as sand, beginning about 1700 million years ago. These sediments now form the Arnhem Land Plateau and probably also the sandstone that crops out in the Mount Tolmer plateau of Litchfield National Park, and other plateaux south and west of Darwin.

Tolmer Falls, Litchfield National Park

Kakadu escarpment

A remarkably long stable interval followed, from about 1650 to 150 million years ago, during which the rocks, which we know as Australia, had drifted at least half way around the world, from the north pole to the south pole. During all this time the extraordinarily resistant Arnhem Land sandstone has operated as an effective cap-rock, protecting and preserving the mineral rich deposits beneath.

The sandstone plateaux eroded from their edges and where they have eroded, they have exposed portions of the ancient Proterozoic landscape. These have persisted with surprisingly little modification to form significant elements of the landscape today, such as the hills we see as we drive south down the Stuart Highway towards Katherine, and east along the Arnhem Highway towards Kakadu National Park. The road cuttings through hills on these routes nearly all reveal rocks that are older than 2,000 million years which were deposited in the ancient rift-valley.

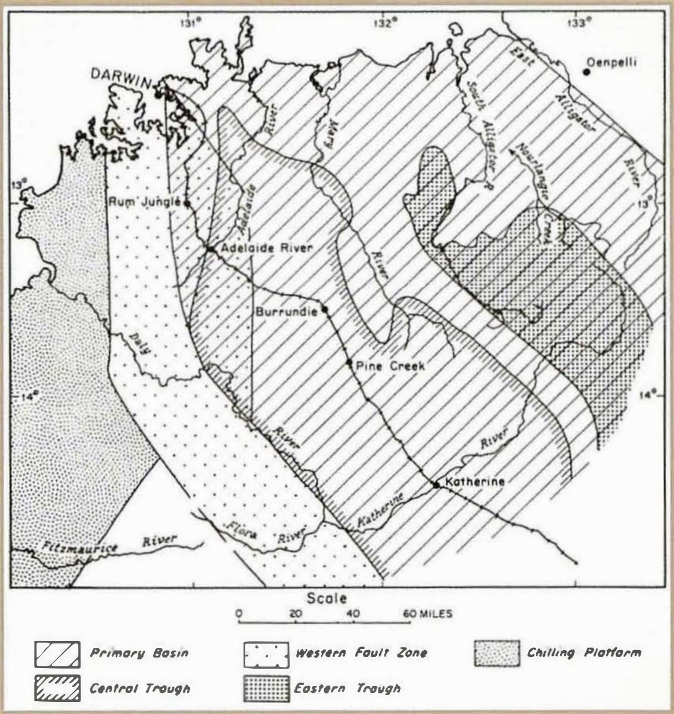


Diagram 1: Map showing Geosyncline through Pine Creek.

At about 150 million years ago the region was fringed by fresh water lakes, lagoons and estuaries, and about 115 million years ago, during the Cretaceous, the sea flooded the region from the north-west. At this time much of Australia lay within a warmer Antarctic circle. Northern Australia lay at about the latitude of Tasmania today. The flat-lying, young Cretaceous sediments are deposited on top of the steeply dipping ancient rocks of the Pine Creek Geosyncline. Often enough, rocks of startlingly different ages sit like this, on top of one another. The gap in between indicates that the region has been land and exposed to erosion. Geologists call this an "unconformity". The boundary between the Cretaceous sediments and the rocks of the Pine Creek Geosyncline is one of the most extraordinary unconformities that exist in the world today, since it represents a gap of some 1,700 million years.

The unconformity is well-exposed in the cliff faces of the south-west part of the Shoal Bay Peninsula and on the southern fringes of the Cox Peninsula.

The sea retreated to the north-west about 110 million years ago, and exposed the sedimentary rocks to a long period of erosion. These rocks form the main, present day features in Darwin. The thickness of the Cretaceous rock varies from 2 metres at Doctor's Gully to 40 metres at Lee Point. Various units of this rock, known by geologists as the Darwin Member of the Bathurst Island Group of rocks, can be recognised in several places, particularly at Bullocky Point.

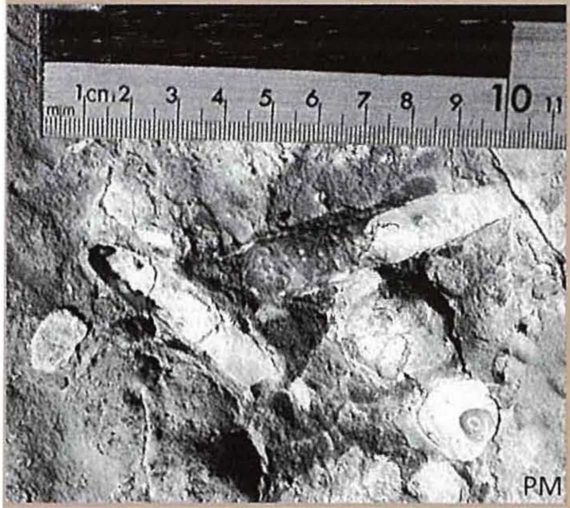
Darwin Member rock, East Point.

Porcellanite

Some of the old buildings in Darwin such as the former Palmerston Town Hall and Infirmary are built from porcellanite. This rock is actually the claystone/siltstone unit of the Cretaceous-aged Darwin Member rocks, which are exposed along the cliffs around Darwin. Porcellanite, in particular, has been impregnated with silica-rich groundwater which has hardened and strengthened the otherwise weak claystone.

Porcellanite, Nightcliff Beach

Porcellanite, foreground with laterite and layered conglomerates on laterite in the background, Nightcliff Beach

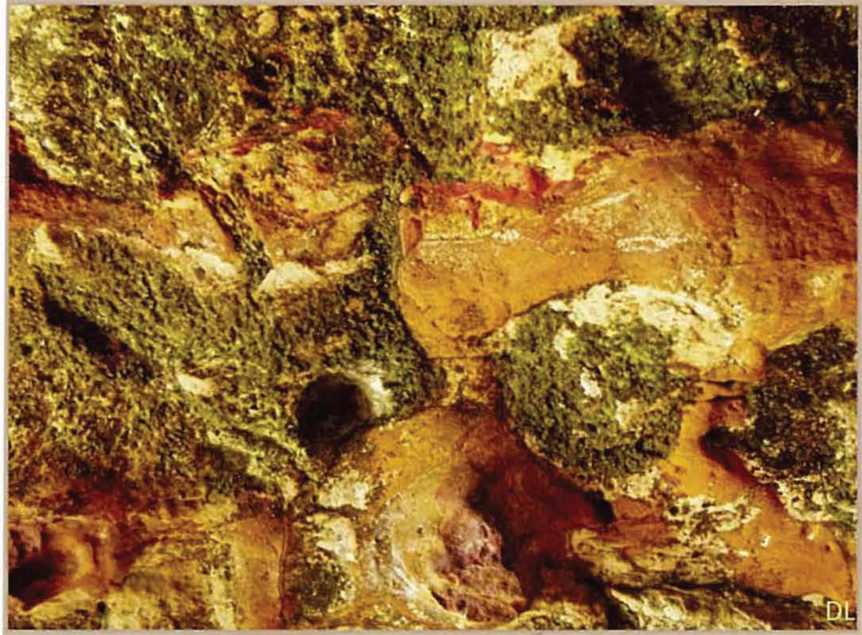


Casts of belemnites, probably Dimitobelus sp. No internal structure is present in the casts, their composition appears to be identical to the phosphatic nodules lying adjacent to them.

The lowest layer is conglomerate with granule to cobble-sized grains, derived from the ancient rock beneath. Next comes a brown-coloured sandstone which has a greenish tinge when freshly exposed. On top of this is the main unit of the Darwin Member, a fine-grained claystone and silty claystone. Exposures of this unit can be up to 30 metres thick and are invariably colourful and mottled, due to selective leaching and redeposition of iron oxides. The Darwin Member contains interesting fossils, including those of "sea monsters" such as Ichthyosaurs and Plesiosaurs, over 110 million years old (see pg 14-16).

The claystone of the Darwin Member is also rich in fossils of radiolarians. Radiolarians are single-celled, marine planktonic animals which are rarely preserved in sediments because their silicon skeletons are usually dissolved. Belemnite casts are also common in the claystone. Belemnites were marine molluscs, related to today's squids and octopuses.

The Dripstone Caves area at Casuarina Coastal Reserve has massive beds of the Darwin Member. These rocks contain fossils of a disorderly array of worm tubes. These "bioturbated" layers (churned-up sediment resulting from the activity of animals) are not more than 30 cm thick and are interbedded with similarly thick layers of rock containing nodules and pellets of a rock type known as phosphorite, which is possibly derived from the fossiliferous layers. Bioturbated beds are best developed in the claystone on eastern Cox Peninsula where the beds are several metres thick and contain abundant burrows up to 60 cm in length and 1.5 cm in diameter.



Inside Dripstone Caves, Casuarina Coastal Reserve

After the Cretaceous sea drained away to the north-west, a long period of intense chemical weathering followed. This has led to what is known as laterisation. Here, the fabric of the original rock is obliterated and replaced by weathered material cemented together by iron oxide and silica. Laterites are common in the Top End and, because they are often tougher than the parent rock, cap many of the hills and cliffs. The cliffs around Darwin are capped in places by laterite. Good examples can be seen at Dudley Point, East Point Reserve.

A period of uplift about 15 million years ago resulted in rejuvenated erosion. Rivers, laden with sediment, debouched from the plateaux and dissected foothills, dumping sediment in alluvial fans. In time these fans coalesced to form a broad apron which slopes gently northward. This is known as the Koolpinyah surface - the gently rolling, forest-covered landscape (other than the coastal plains) that surrounds Darwin.

Woodland up to laterite cliffs of Warruwi (Goulburn Island)

One interesting feature of the Koolpinyah landscape is the presence of numerous closed depressions, which form the little billabongs sprinkled around Darwin. Some of these billabongs are aligned, and seem to represent buried, old river systems. Others occur apparently at random and their origin is a mystery. Whatever their origin, today they are of considerable importance to the animal life during the long dry season.

Howard Swamp

Here, in leafy, warm Darwin, it is hard to believe that we live in an ice-age. The present ice age is characterised by regular glacials, punctuated by short interglacials (one of which we are currently in). Because we are human, and live in the present, we tend to view today's climate as the norm. Nothing, however, could be further from the truth.

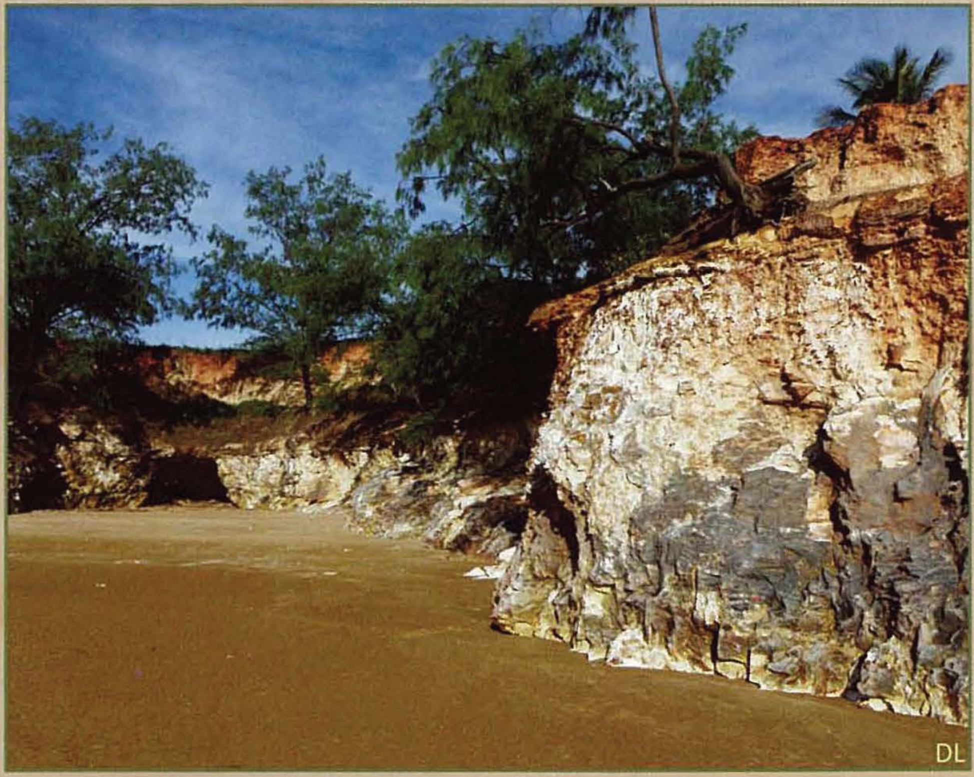
The last time conditions were like they are today was 125,000 years ago, during the last short inter-glacial. We are, ourselves, ice-age animals, which have evolved during the past 2.5 million years during which there have been 25 recognisable glacial-interglacial cycles. During these cycles, the great continental ice sheets of the northern hemisphere and Antarctica wax and wane, in turn locking-up and releasing water, resulting in world sea levels rising and falling through 150 metres. The last time of very low sea level was 20,000 years ago, when much of Australia was colder, drier - with about half as much rainfall - and windier than today. Australia, New Guinea and Tasmania formed a single land mass and the northern coastline was 400 km to the north of the Top End as Diagram 2 shows.

Diagram 2: Map of Australia, New Guinea and Tasmania 20,000 years ago.

As the ice sheets melted and sea levels rose, the prehistoric inhabitants of northern Australia were forced relentlessly inland. The melting of the ice-caps resulted in an average horizontal loss of land to the sea of around one metre per week! Imagine this: at a rate of 1 metre per week on Australia's northern shore the social and ecological effects would have been dramatic, perhaps even disastrous in some ways.

It was an incursion that even short-lived human beings would notice! Camps on the hind-dunes and beach fronts would have to be abandoned monthly, lines of dead trees would have marked the new edge of the encroaching sea, inland populations would have had to deal with new invaders forced from their homelands. Mangrove coasts would have been destroyed, eliminating important food sources, reefs and sea-grass beds would have disappeared "out to sea", wiping out important fishing grounds.

Shoal Bay coastal plains, looking towards Palmerston



Dripstone Cliffs, Casuarina Beach

The land bridge between Australia and New Guinea was severed by 9,000 years ago, and by 6,000 years ago the sea had reached its present level, although it was actually further inland than it is now, resulting in what is known as a "big swamp" phase. Our coastal plains are, in fact, younger than 6,000 or 7,000 years. Mangroves soon trapped the sediment washed down from rivers, burying the big swamp, raising the level of the land and pushing the sea back. Even today, a dam cannot be dug more than about two metres deep on the coastal plain because of the reaction of oxygen with the anaerobic mud which forms acidic soils, which can leach toxic metals from the soil and cause fish kills.

By 4,000 years ago, meandering tidal rivers traversed this newly formed, flat coastal plain in large sinuous loops. By 2,000 years ago many of the loops pinched closed and detached from the parent river, forming lagoons and other wetlands. The rivers became less sinuous, and for reasons not completely clear, less of an impediment to salt water which once again tended to flow back onto the plains. Looked at in this way, salt water incursion - today seen as one of the largest environmental problems of the region - is in reality only the result of inexorable long term processes, as the land and the sea seek to strike an equilibrium with each other.

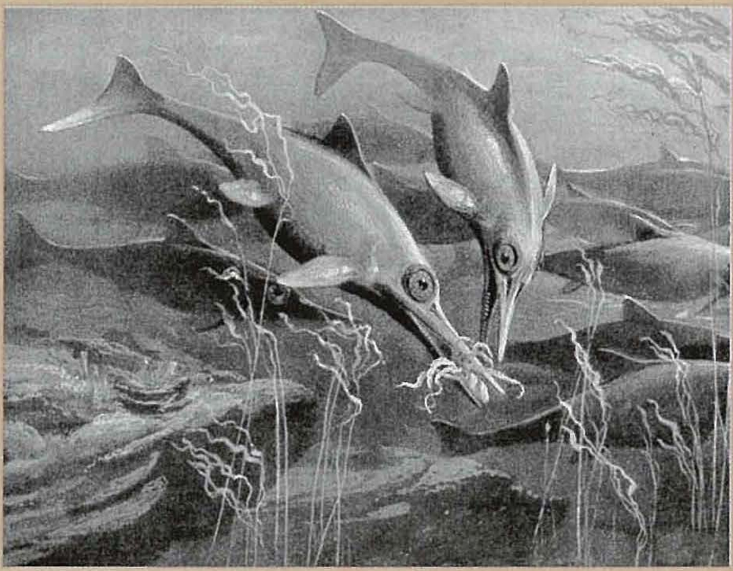
Dudley Point, East Point

One of the intriguing geomorphological features on the coastal plains in the Darwin region is the result of the slowly growing coast line. Roughly parallel to the shoreline but converging towards the various headlands is a series of low, narrow ridges or "beaches" built of shelly sand and studded with Pandanus palms. They are called "cheniers" and often result from infrequent catastrophic storms which smash shells and hurl them into mounds to form a beach. In front of the chenier ridge the mangrove belt once again advances slowly seaward. Behind the chenier ridges, sedges eventually colonise the now protected mud-flats, raising the surface of the land until the flats emerge above tidal limits.

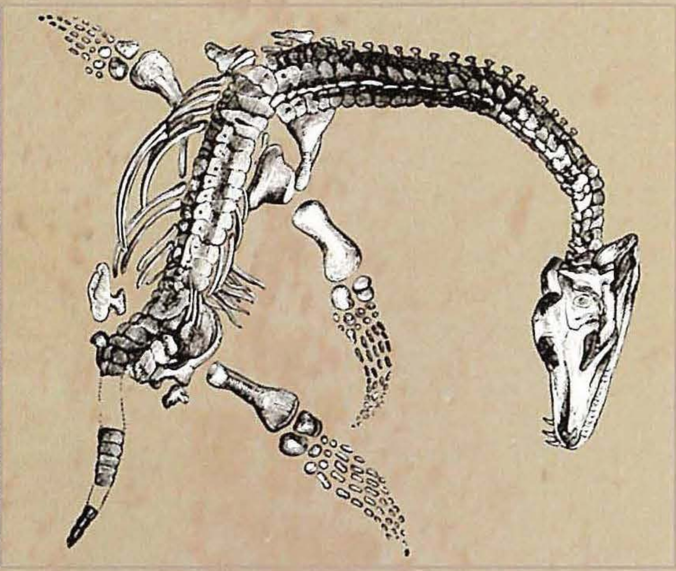
Chenier ridges have been dated in various places in the Top End, and vary from 4,490 years old to 670 years old. Cameron Beach has the best developed chenier plain in the area and radio-carbon ages there indicate a rapid growth of the chenier plain seaward since 2350 years ago - the age of the hindmost ridges. While Cameron Beach constitutes the best chenier plain, you can see chenier ridges on most beaches which are open to the sea. Mindil Beach, Coconut Grove and Casuarina Beach all have chenier ridges. Chenier ridges and coastal plains are the youngest and most dynamic features in an otherwise ancient landscape where the tempo of change is much slower.


Chenier ridge edging beach and coastal plain

Darwin's "Sea Monsters" from the Cretaceous



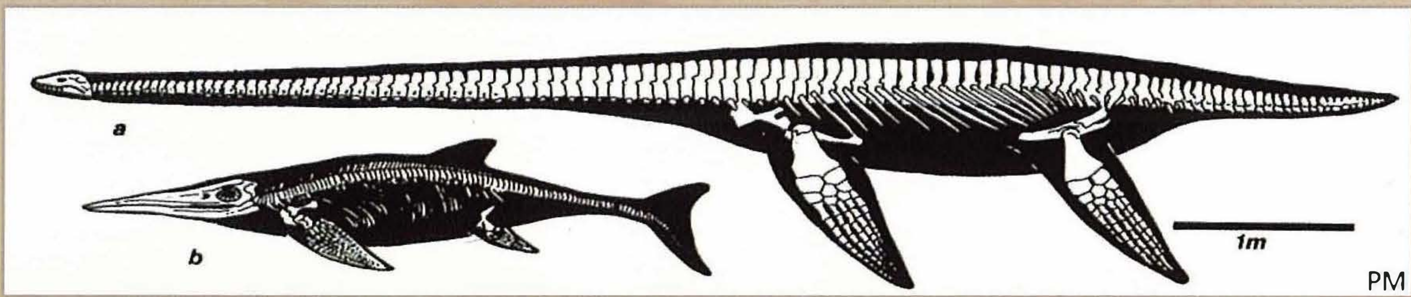
Ichthyosaur, illustration



Plesiosaur, illustration

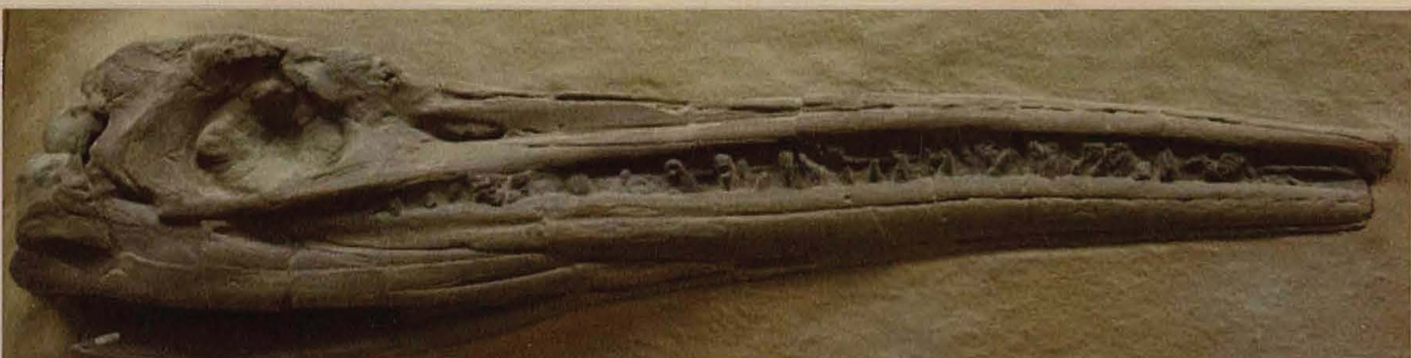
In Darwin, it is not so much Jurassic Park, as Cretaceous Park. On the geological time scale the Jurassic and Cretaceous are next to each other, with the Cretaceous being the younger. About 110 million years ago, in the Cretaceous, the area around Darwin was washed by a gentle, shallow sea in which swam reptilian ichthyosaurs: in fact the word is a compound from ancient Greek, meaning "fish" and "lizard".

Ichthyosaurs were reptiles, shaped like sharks but with long, dolphin-like snouts. From their gut contents we know that they ate fish, now-extinct belemnites (a little like squids), and squids. All these are fast and agile - ichthyosaurs must have been an agile and fast swimmers. They grew to about seven metres.



Scale restorations of Darwin Area plesiosaur and ichthyosaur, based on sizes of representative fragments: **a,** Elasmosauridae *gen. et sp. indet*, **b,** *Platypterygius sp.*

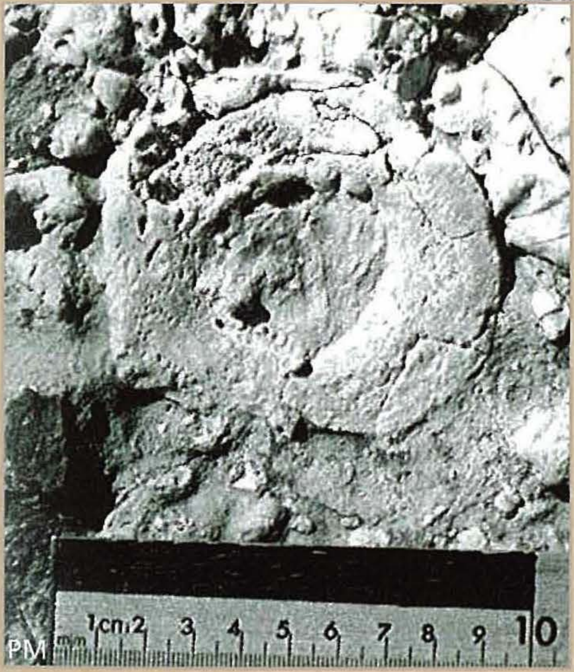
At least three localities around the cliffs of Darwin contain fossils of ichthyosaurs. Unfortunately, while the fossils are relatively common, they are not well preserved. In fact, the rather daunting scientific name of the Darwin animal, Platypterygius gen. et sp. indet., simply means that scientists are not yet sure of the exact identity of the animal, hence it is 'indeterminate'. Fragments of the Darwin ichthyosaur have so far been found in rock outcrops near Nightcliff, Casuarina and Fannie Bay. The exact location of the Fannie Bay ichthyosaur has not been documented, since the chunk of rock containing it was removed in the early part of this century.



Ichthyosaur fossil RT

At Nightcliff, the fossils are found in a thin (4 – 6 cm) bed of fossiliferous shaly siltstone which is overlain by 20-30 cm of reddish brown, lateritised, fine sandstone. At Casuarina, the outcrop is exposed only during spring tides. The top of the siltstone 'reef' containing the ichthyosaur fragments can be seen, projecting less than one metre above the adjacent and surrounding sandy beach.

People looking for Ichthyosaurus fossils, Nightcliff foreshore.



Isolated adult ichthyosaur dorsal vertebral-centra consisting of silicified bone. - Nightcliff

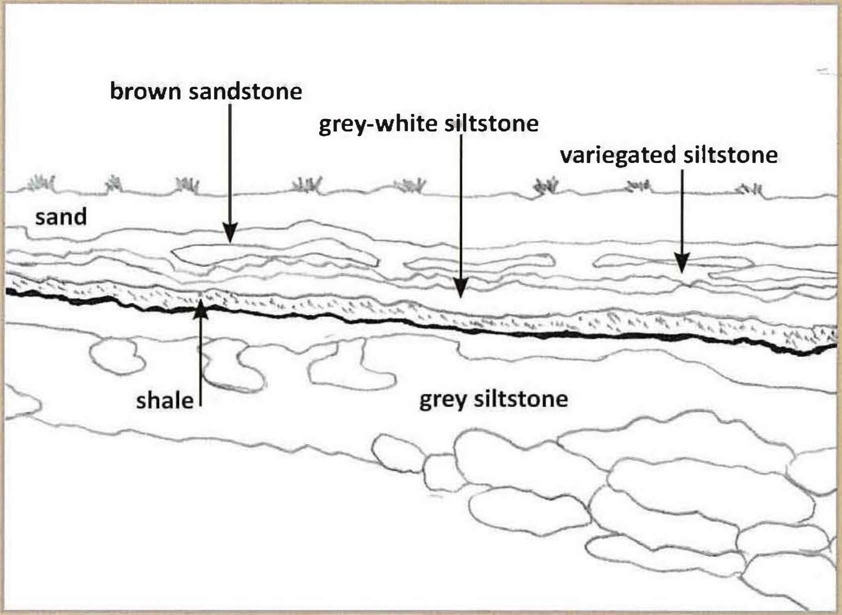
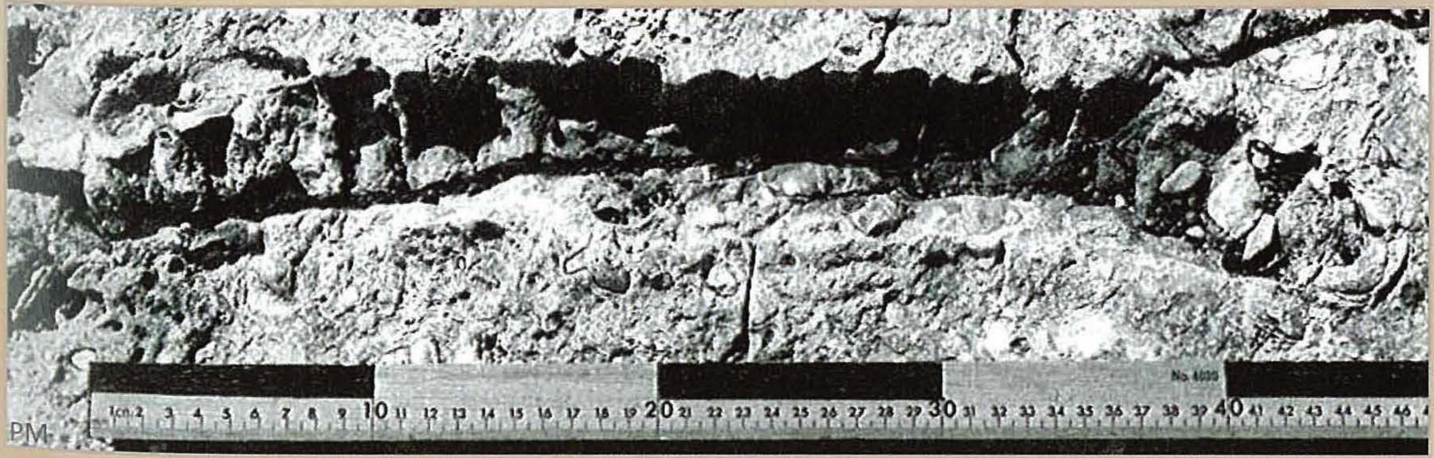


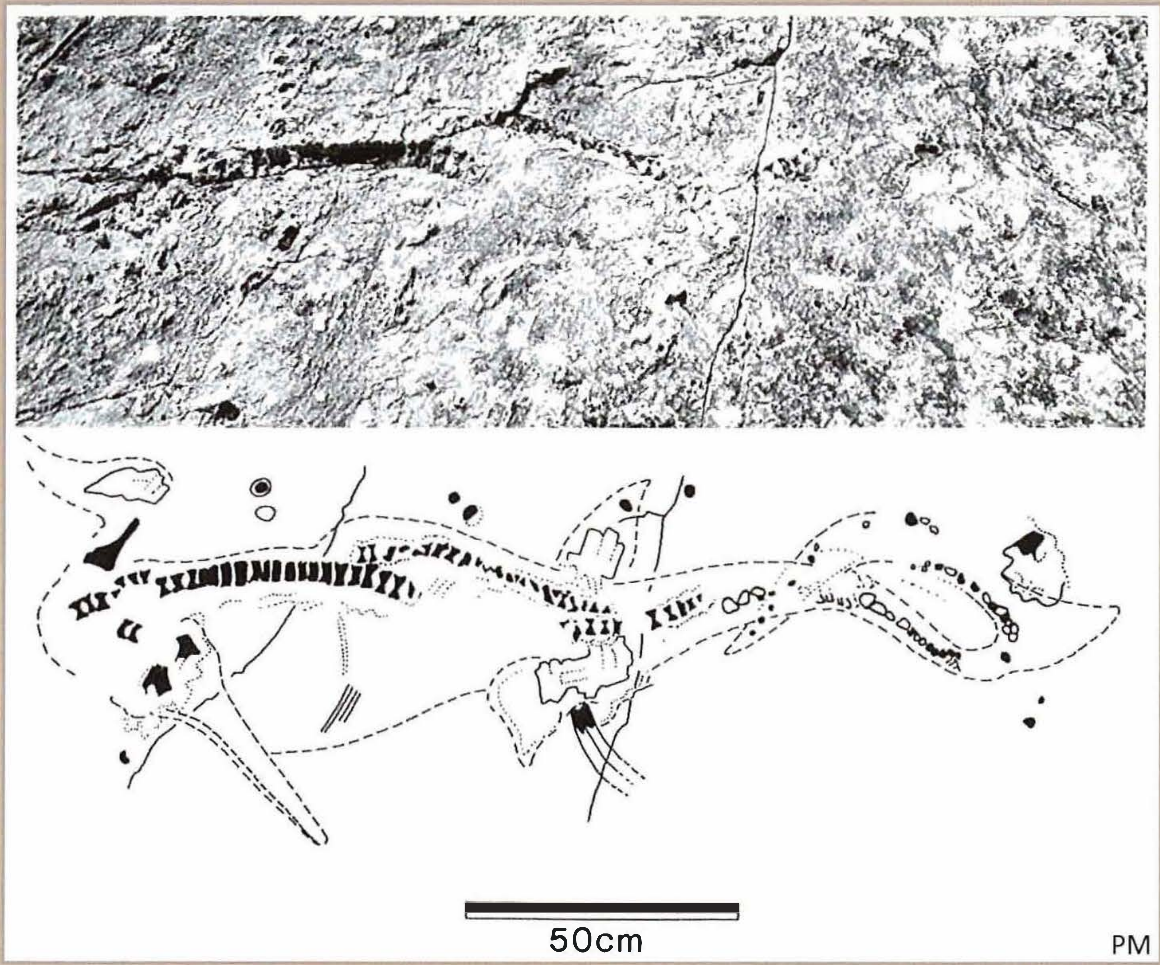
Diagram 3. Cross section of Nightcliff foreshore.

This outcrop also has embedded in it fossil bones of a plesiosaur, another marine reptile, much larger than the ichthyosaur. The relative size of the ichthyosaur and plesiosaur are indicated in the diagram adjacent. Access to the locality is by road to the "Casuarina Free Beach". Most of the fossils are of vertebrae or casts of vertebrae. The ichthyosaur fossils are often associated with fossils of invertebrates such as molluscs and belemnites, and, in Casuarina, of fossilised wood.

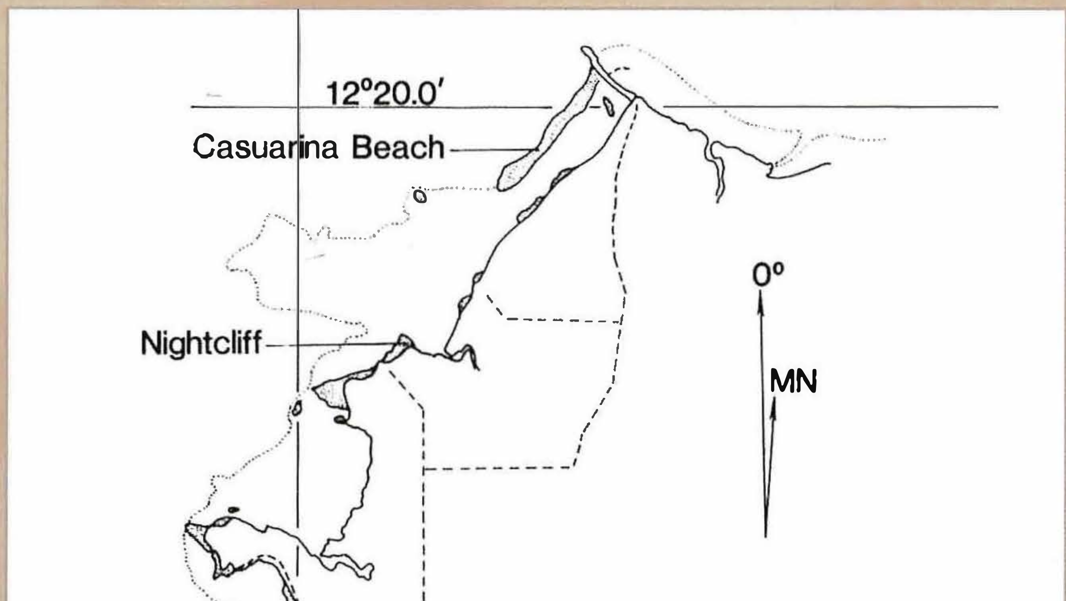
The fossilised wood is a bit of a mystery. Palaeontologists have pondered on the idea that carcasses of ichthyosaurs, like drift-wood, ended up stranded along the Cretaceous sea shoreline, which, around Darwin, was in a similar position to the coastline of today. Because of the nature of Darwin's ichthyosaur fossils - the fact that they were deposited in an active marine environment (as opposed to a deep ocean), and the fact that carcasses of today's marine animals, such as seals and whales, can float for weeks without disintegrating - palaeontologists believe that the Darwin region may have been an area where dead ichthyosaurs from more distant regions ended up.



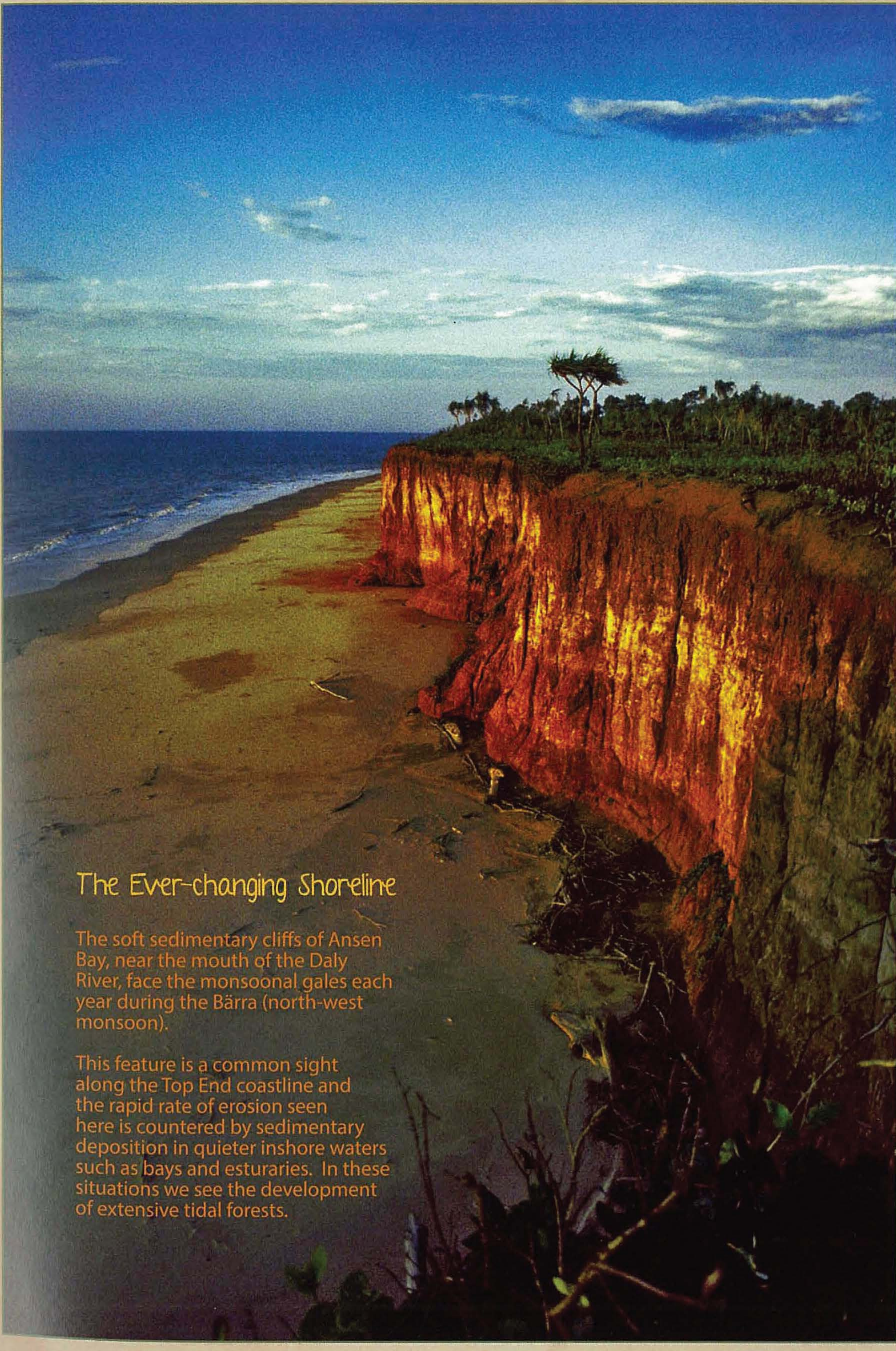
Ichthyosaur fossil, Nightcliff



Ichthyosaur fossil, Nightcliff with diagram



Ichthyosaur locatities, Darwin region



The Ever-changing Shoreline

The soft sedimentary cliffs of Ansen Bay, near the mouth of the Daly River, face the monsoonal gales each year during the Bärra (north-west monsoon).

This feature is a common sight along the Top End coastline and the rapid rate of erosion seen here is countered by sedimentary deposition in quieter inshore waters such as bays and estuaries. In these situations we see the development of extensive tidal forests.