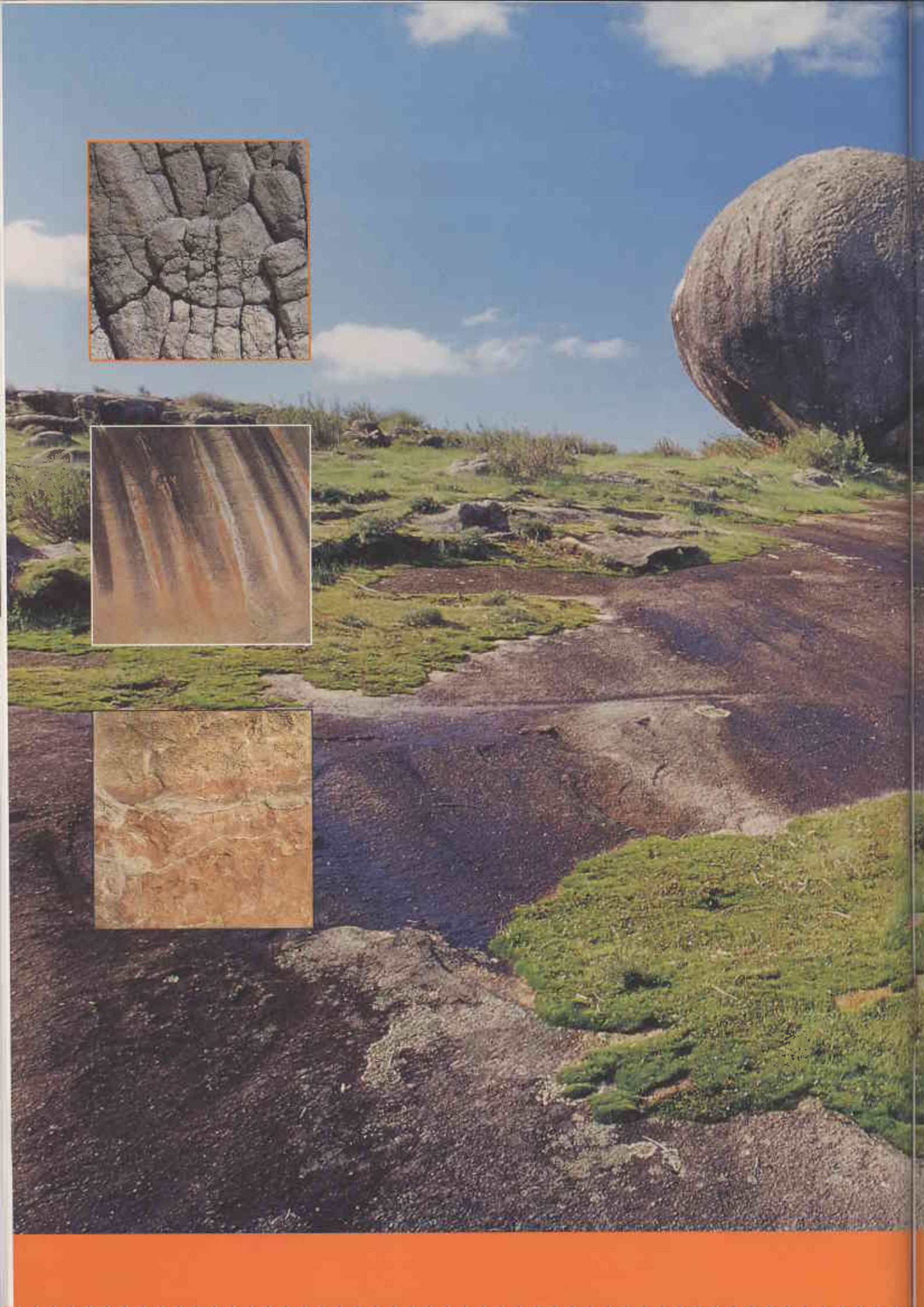
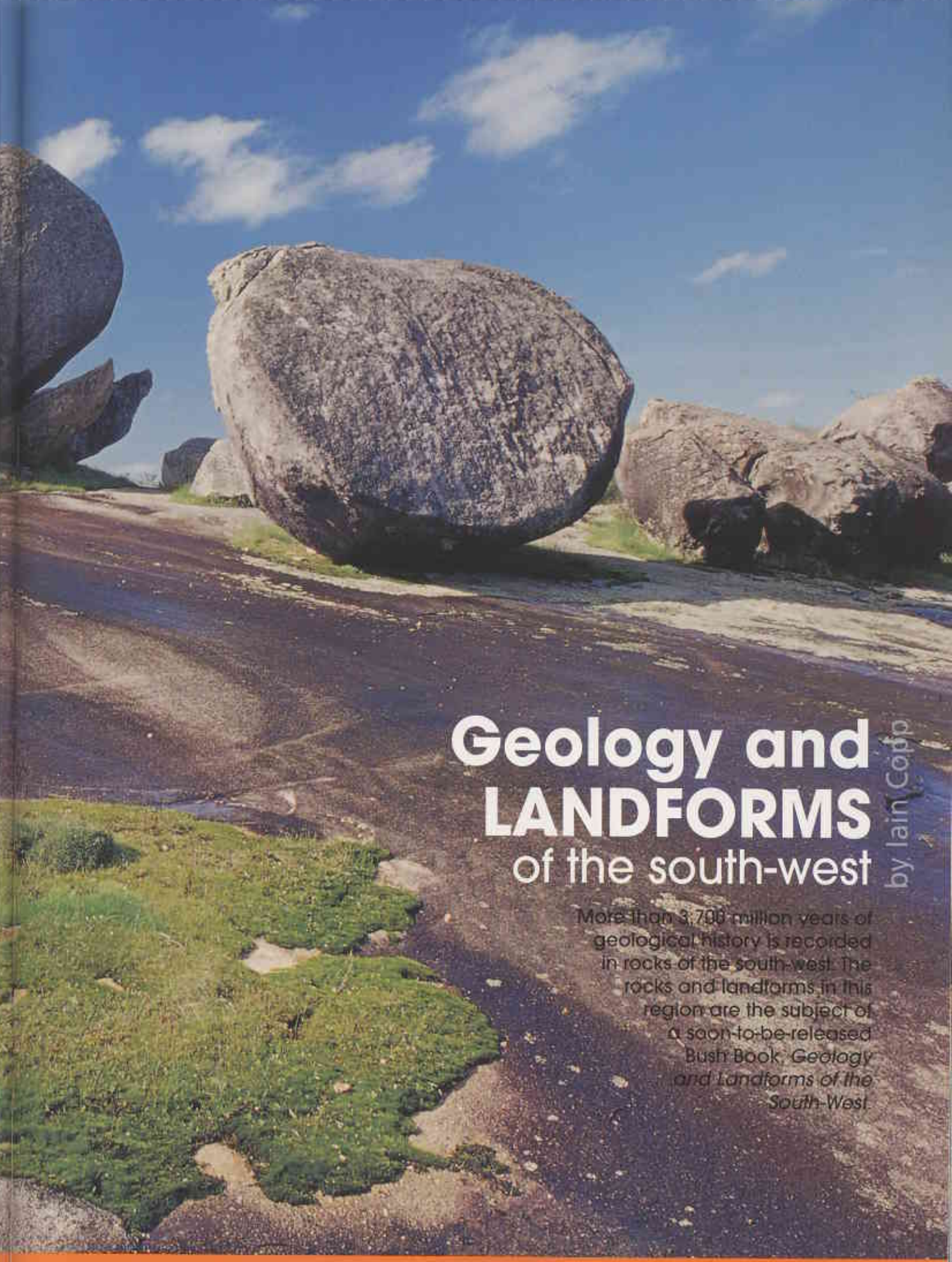




Geology and LANDFORMS of the south-west

by Iain Copp

More than 3,700 million years of geological history is recorded in rocks of the south-west. The rocks and landforms in this region are the subject of a soon-to-be-released Bush Book, *Geology and Landforms of the South-West*.

The oldest rocks are found in the Yilgarn Craton, a large piece of the Earth's crust that underlies most of the south-west. It formed between about 3,700 and 2,400 million years ago by the joining together of several smaller pieces of crust, resulting in a vast geologically stable new continent. Huge volumes of molten rock (magma) were produced during this time, either finding their way to the surface to be erupted from volcanoes, or crystallising many kilometres below the surface. Other parts of the craton were subject to extreme pressures and temperatures and were transformed, or metamorphosed, into other types of rocks, such as gneiss. Under the most extreme conditions, some rocks began to melt and form migmatites. All these types of rocks can be found throughout the Darling Range and the Wheatbelt.

BREAK-UPS AND LIAISONS

Between about 2,000 and 1,800 million years ago, the Yilgarn Craton collided with the Pilbara Craton to the north, forming a large new continent known as the West Australian Craton. This slowly drifted north-eastward until, 450 million years later, it collided with another large continent, the Mawson Craton (comprising the South Australian Craton and East Antarctica), which was drifting westward. This collision took place about 1,345 million years ago along most of what is now the south coast. The Mawson Craton was thrust over the West Australian Craton, producing a huge thickness of crumpled crust, similar to the way that the Himalayas formed when India collided with Asia. Igneous rocks such as granite were formed during this upheaval and older granites were metamorphosed into gneiss. Slices of crust containing sedimentary rocks, such as the Barren Ranges, were buried within this collision zone. The roots of this mountain range are known as the Albany-Fraser Orogen, and can be traced into Antarctica. The collision of the West Australian and Mawson Cratons took place as part of the assembly of a supercontinent called Rodinia.

Another continent probably collided with the West Australian Craton about 1,100 million years ago, and a similar mountain range, called the Pinjarra Orogen, began to form along the western edge of the Yilgarn Craton. Most of the rocks that formed then now lie buried deep beneath today's coastal plains. The Darling Fault, which can be traced from near Shark Bay down to the south coast, marked the edge of this mountain range. During the following 500 million years, magma was periodically squeezed into surrounding rocks, which between Cape Naturaliste and Cape Leeuwin were then slowly metamorphosed into gneiss. About 750 million years ago Rodinia began to break up into smaller plates. These reassembled into a new supercontinent called Gondwana about 250 million years later. It included Australia, Antarctica, Greater India, New Zealand, South America, Africa and parts of south-east Asia.

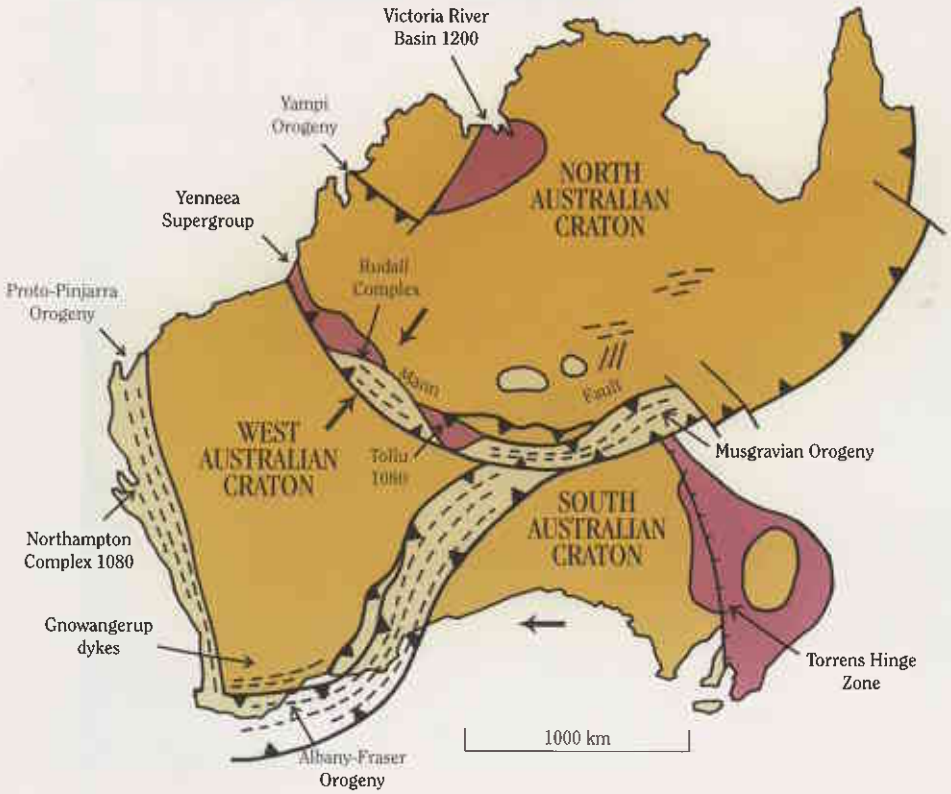
GLACIERS AND LAVA FLOWS

About 430 million years ago, the Darling Fault became very active again and formed an elongate trough called the Perth Basin. Over the next 300 million years, the basin filled up with more than 10 kilometres of sedimentary rocks. During part of this time, around 295 million years ago,

Previous page
Main: Boulder rock.
Photo – Chris Garnett
Insets from top: Basalt.
Photo – Gordon Roberts
Granite.
Photo – Ashley de Prazier
Limestone.
Photo – Bill Bachman

Left: The supercontinent Rodinia, about 750 million years ago, showing the main areas of mountain building (in black).

Below: The assembly of Australian cratons between 1,300 and 1,000 million years ago.
Illustrations – Ian Dickinson



Above: The rocks that now make up the Stirling Range were originally laid down as sand, silt and clay in water. Hence, ripple marks can be seen in rocks on some peaks.

Right: The hexagonal columns at Black Point, in D'Entrecasteaux National Park, were formed by a lava flow around 135 million years ago.
Photos – Jiri Lochman

Australia was close to the South Pole and extensive ice caps covered the south-west. Glaciers carved valleys in the landscape and blankets of broken and ground-up rocks were deposited as the ice melted.

A rift developed within Gondwana's crust around 135 million years ago, slowly tearing from north to south, and Greater India drifted away from Australia as a result. Magma was generated as the crust split, reaching the Earth's surface and forming extensive flows of basalt lava in the south-west (known as Bunbury Basalt). The only outcrops can be seen on the beach at the northern end of Ocean Beach in Bunbury and at Black Point in D'Entrecasteaux National Park, south-east of Augusta. The basalt at Bunbury is fairly unspectacular but nonetheless fascinating and, being close to a road, easy to see. It formed a flow about two kilometres long and 100 metres wide. The hexagonal columns at Black Point, however, are stunning, even more so as they are constantly buffeted by waves of the Southern Ocean. Access to this remote area is by four-wheel-drive only.

Rifting then commenced along the present day south coast about 15 million years later, as Antarctica separated from Australia. This splitting of the Earth's crust caused the southern part of the south-west to be gently uplifted several times over about the next 35 million years.

RISE AND FALL

Following the separation, the newly formed coastline of the south-west was then subject to periodic changes in sea level, the hinterland being sometimes covered by warm shallow seas. During the Eocene, about 40 million years ago, such a sea covered much of the south-west and was rich in sponges and other marine organisms. During this time, the sea level was about 300 metres higher than its present level. The coast was up to 65 kilometres inland, forming a huge embayment that extended from near Albany to Israelite Bay and up to Norseman. Many islands were left within this new warm shallow sea, including the Barren Ranges, Porongurup Range and Mount Manypeaks. Sediment, rich with the skeletons of sponges, slowly settled onto the new seabed forming a blanket

SEQUENCE OF EVENTS IN GEOLOGICAL INTERVALS

Swan Coastal plain	Yalgorup Lake system	Quaternary	younger than 130,000 yrs
	drowning of the coastline (e.g. Stokes Inlet)	Quaternary	younger than 130,000 yrs
	Leeuwin-Naturaliste caves	Quaternary	younger than 1 m yrs
	Pinnacles	Quaternary	younger than 1 m yrs
	coastal limestone deposits	Quaternary	younger than 1 m yrs
	mineral sands	Pleistocene	300,000–100,000 yrs
	aluminium and gold deposits in laterite	Eocene-Oligocene	40–25 m yrs
	laterite formation	Eocene-Oligocene	40–25 m yrs
Perth and Collie basins	Australia split from Greater India	Cretaceous	135 m yrs
	Bunbury Basalt	Cretaceous	135 m yrs
	Collie coal	Permian	280 m yrs
	glaciation	Permian	295 m yrs
Leeuwin complex	gneiss and granites	Proterozoic	1,100–530 m yrs
Albany-Fraser orogen	sponge-rich ocean sediments	Eocene	40 m yrs
	Australia split from Antarctica	Cretaceous	120 m yrs
	Stirling Range	Proterozoic	590 m yrs
	Porongurup Range	Proterozoic	1,200 m yrs
	continental collision along the south coast	Proterozoic	1,345–1,140 m yrs
	Barren Ranges	Proterozoic	1,830 m yrs
	Peak Charles	Proterozoic	2,350 m yrs
Yilgarn craton	Greenbushes tantalum, lithium and tin	Archaean	2,530 m yrs
	Darling Fault formed	Archaean	2,600 m yrs
	Monadnocks (Darling Range Batholith)	Archaean	2,650 m yrs
	Boddington volcanic rocks	Archaean	2,700 m yrs
	Yilgarn Craton formed	Archaean	3,700–2,400 m yrs

over the area. Over time and due to the pressure of overlying sediments, this material was consolidated into a rock known as spongelite. As the sea level fell again, the rivers draining the hinterland cut deeply into the soft spongelite, forming colourful gorges now exposed along the Fitzgerald and Hamersley Rivers in the Fitzgerald River National Park.

In the last two million years, during the Pleistocene, the polar ice caps have contracted and expanded many times, making the sea level rise and fall repeatedly. Belts of coastal sand dunes have followed this forever-changing coastline, and have been preserved as limestone in the cliffs around the south-west's coastline.

EVOLUTION OF THE LANDSCAPE

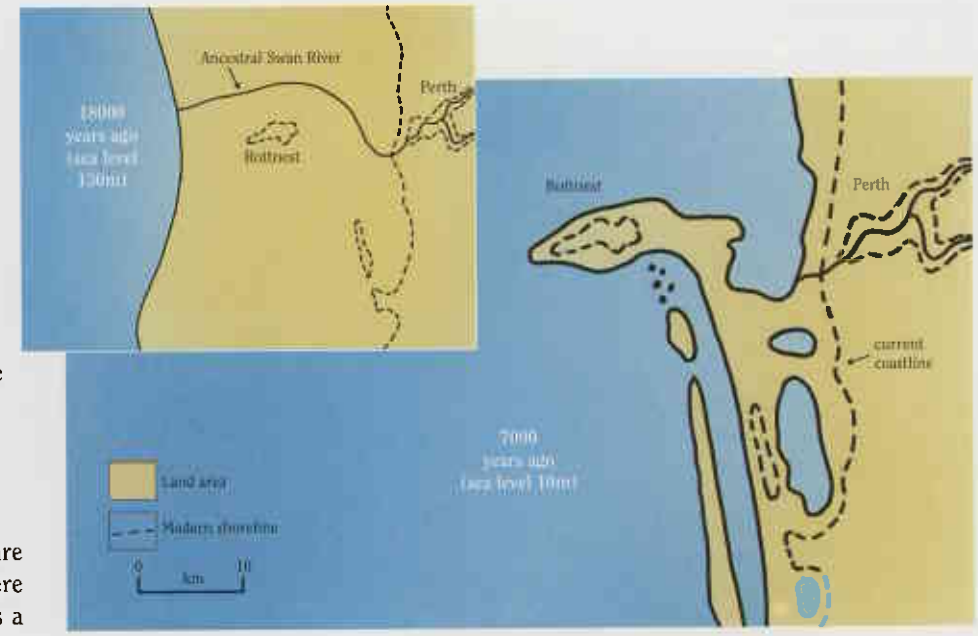
The landscape of the south-west is very old, having probably begun to develop about 295 million years ago when a large ice cap covered most of its surface. During this time, Australia was close to the South Pole and glaciers carved broad deep valleys into the landscape. Over the next 200 million years, the Darling Fault was very active and parts of the Yilgarn Craton were uplifted, forming a hinterland to the Perth Basin, which was mostly under water. The effects of heat, cold and rain on this ancient land surface weathered and eroded the hills and valleys that were formed by glacial action. Slowly, the gently undulating hills that characterise the Darling Plateau began to form. Around 95 million years ago, an extensive system of rivers was established over much of the south-west, further eroding the underlying rocks and forming the drainage pattern that we see today.

The south-west experienced a moist, temperate to tropical climate about 65 million years ago, resulting in deep inland penetration of rain-bearing westerly winds. This lasted for about 30 million years (to the end of the Eocene), with the rain and surface run-off continuing to erode the rocks. It was during this period that a huge rise in sea level occurred, flooding large areas of the hinterland along the south coast with a warm sea rich in sponges. Only the highest points, such as the Stirling Range, Porongurup Range and the Barren Ranges, remained above sea level, forming islands and peninsulas. Over several million years, the continuous buffeting action by waves gradually reduced their size and cut platforms into their slopes. Between about 40 and 25 million years ago, a tropical climate allowed deep weathering of the rocks to take place. Alternating wet and dry periods leached out the more soluble minerals, leaving behind deeply weathered rocks overlain by mottled soils and an iron-rich capping called duricrust.

When the climate finally changed and started to dry out, most of the major river systems stopped flowing regularly. During the last two million years, the coastline changed position many times in response to the expansion and contraction of the polar icecaps.

RECENT TIMES

Just before the last ice age, 130,000 years ago, the Swan Coastal Plain was narrower than it is today. Thus, even though the sea level was roughly the same as it is at present, the coast lay 10



Right: The south-west and Perth coast was subject to periodic changes in sea level.
Illustration – Ian Dickinson

Below: The Monadnocks—large, rounded, bald hills that reach up to 585 metres above sea level, form the highest point of the Darling Plateau.
Photo – Iain Copp

Below right: Rottnest Island was once connected to the mainland.
Photo – Dennis Sarson/Lochman Transparencies

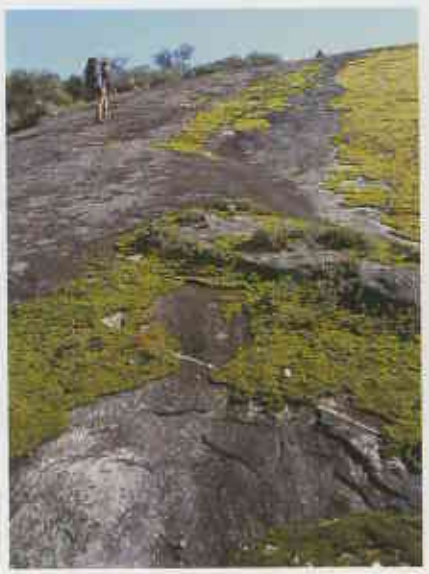
kilometres further inland, and what are now the grey soils at Bassendean were the coastal sand dunes. Rottnest was a coral reef 30 kilometres offshore.

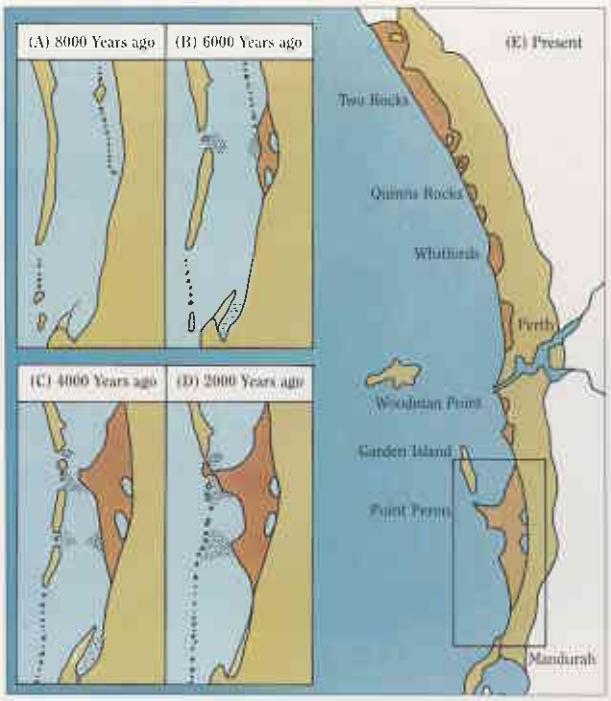
The Würm Ice Age then set in, and as the Earth's ice caps grew, the sea level fell, fluctuating as it did so. The coastline gradually moved westward as the sea level dropped. Today you can still discern a series of barrier dunes parallel to the coast, and they mark the successive shorelines in this retreat. Finally, 18,000 years ago, the sea level reached its lowest point—130 metres below the present sea level. At that time, the coastline in this region lay 40 kilometres west of the present position. The barrier dunes formed a central spine down the wide coastal plain, with a branch out towards Rottnest.

The sands making up these dunes contained a high proportion of lime sand, derived from sea shells and minute marine organisms. This lime was dissolved by the acid in rainwater, then deposited again when the water evaporated, cementing the sand grains together and turning the dunes into limestone. This limestone, which occurs from Shark Bay to the South Coast of Western Australia, is called Tamala Limestone, and forms the Spearwood Dune System. At Penguin Island and other places you can see obvious cross-bedding in the coastal limestone, which is evidence of its origin as wind-blown sand dunes. The thin strata are inclined at various oblique angles, often set abruptly juxtaposed with others, reflecting the original pattern of sand accumulation and changes in wind action. Some of this limestone was partly dissolved by percolating rainwater and groundwater, forming caves and pinnacles.

The last ice age ended 10,000 years ago, heralding the start of the Holocene period and the end of the Pleistocene geological era (which lasted from about 2.5 million years ago to 10,000 years ago). Rising temperatures and melting ice sheets caused the sea level to rise, and it reached its present height about 6,500 years ago. As a result, the westernmost ridges of the Spearwood Dunes were partially or wholly drowned, forming a series of shallow reefs and long islands separated by linear troughs. The higher eastern ridges formed the mainland coastline. Old river valleys were slowly flooded and formed inlets along the coast, some finally being cut off from the ocean by the migration of recent sand dunes.

With the higher sea levels, a new regime of dune building began. Sand was swept across the newly drowned coastal plain and washed ashore. In addition, the south-westerly winds and





Point Peron at Rockingham was once an offshore island that was 'captured' by an outgrowth of sand.
Illustration – Ian Dickinson

Penguin Island, offshore from Rockingham, is composed of Tamala Limestone. It has consolidated from wind-blown dune deposits of shell fragments and quartz.
Photo – Michael James

waves eroded the offshore ridges, reducing them over 6,500 years to the chains of islands and reefs off the present Perth coast. In the Shoalwater Islands Marine Park, for instance, features such as the Murray Reef, The Sisters, Passage Rock, Penguin Island, Seal Island, Bird Island and Peron Peninsula make up a definite north-south line that can be clearly seen in aerial photographs.

The eroded sediments deposited onshore formed the young Holocene sand dunes, known as the Quindalup Dunes, that make up most of the shoreline today. Onshore winds blew sand from the beaches to form foredunes along the new coastline.

Where the coast was sheltered by an island or shallow reef, the force of the waves was reduced and sediment was preferentially deposited, as the islands and reefs eroded. A triangular spit built out from the mainland towards the adjacent island, and formed a low promontory consisting of line after line of low parallel dunes. The land surrounding Rockingham is made up of such a structure (see diagram above). Row after row of dunes (two to five metres high and 50–100 metres apart) have been built out seawards from the original limestone coastline, which lay along the eastern sides of Lakes Coolongup and Walyungup. Point Peron was once an offshore island that was 'captured' by the advancing outgrowth of sand.

To find out more about the fascinating formations of this part of WA, look out for the new Bush Book *Geology and Landforms of the South-West*.

Left: Wave Rock's unusual shape is probably the result of weathering by groundwater when most of it was covered by sand and soil.
Photo – Ashley de Prazier

Iain Copp is a geologist and freelance writer/photographer. He worked for many years with the Geological Survey of Western Australia and also in exploration for mineral and petroleum companies.

The author would like to acknowledge Ian Tyler and the Geological Survey of Western Australia for their assistance in producing the forthcoming Bush Book *Geology and Landforms of the South-West*.

Winner of the 1998 Alex Harris Medal for excellence in science and environment reporting

LANDSCOPE

VOLUME SEVENTEEN, NUMBER 1, SPRING 2001

Within 40 years, the numbat has risen from near extinction to endangered with 10 populations in WA and interstate. See 'Numbats Forever' (page 17).

The forces that shaped the geology and landforms of the south-west began more than 3,500 million years ago. Read the facinating story on page 10.

The Marine Community Monitoring Program is a new and ambitious program to involve the community in keeping our oceans clean. See page 35.

Shark Bay Marine Park provides spectacular opportunities for divers and snorkellers. No wonder it is called Bay of Delights. See page 23.

The history of Aboriginal occupation in the Leeuwin-Naturaliste region spans 50,000 years. Find out more in 'History from the Caves' (page 40).

FEATURES

REGULARS

COVER

Leschenaultias are some of the most widely known and recognisable plants in Western Australia. They have fantastic horticultural value and provide glorious floral displays. The wreath leschenaltia is a favourite with visitors during our wildflower season. See page 23.

Cover illustration by Philippa Nikulinsky

Executive editor: Ron Kawalilak
Editors: David Gough, Carolyn Thomson-Dans
Story editors: Verna Costello, Sue McKenna
Advertising copy and editorial assistance: Caris Bailey
Scientific/technical advice: Andrew Burbidge, Chris Simpson, Keith Morris, Paul Jones and staff of Science Division
Design and production: Tiffany Aberin, Maria Duthie, Gooitzen van der Meer
Illustration: Ian Dickinson, Gooitzen van der Meer
Cartography: Promaco Geodraft
Marketing: Estelle de San Miguel ☎ (08) 9334 0296 Fax: (08) 9334 0498
Subscription enquiries: ☎ (08) 9334 0481 or (08) 9334 0437
Colour Separation by Colourbox Digital
Printed in Western Australia by Lamb Print

Please do not send unsolicited material to *LANDSCOPE*, but feel free to telephone the editors.

Visit NatureBase at www.naturebase.net

Published by the Department of Conservation and Land Management, Dick Perry Avenue, Kensington, Western Australia

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA