GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
1:2 500 000 GEOLOGICAL MAP—EXPLANATORY NOTES

GEOLOGICAL MAP
OF
WESTERN AUSTRALIA

1988

CENTENNIAL EDITION

DEPARTMENT OF MINES WESTERN AUSTRALIA

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

GEOLOGICAL MAP
OF
WESTERN AUSTRALIA

EXPLANATORY NOTES

by

J. S. Myers and R. M. Hocking

State Printing Division
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FOREWORD

This Centennial Edition of the Geological Map of Western Australia is the twelfth in a series that began with Harry P. Woodward's 1894 map, published six years after the Geological Survey was first established. The last edition, in 1979, was published to mark the 150th anniversary of the founding of Western Australia.

This new map represents a substantial advance on the previous edition. More detailed stratigraphic and structural information has been included in many areas, notably in the Kimberley, Pilbara, and south coast regions. A different nomenclature has been applied to the main structural subdivisions, using cratons, orogens, and basins as the principal units. The legend is more comprehensive than previously. Sequence stratigraphy has been applied in subdividing the Phanerozoic succession, and the Precambrian has been subdivided on the basis of age, stratigraphy, and lithology. The main purpose of these explanatory notes is to further explain the basis of this legend.

The map was compiled by John Myers and Roger Hocking, and was drafted by staff of the Surveys and Mapping Division of the Mines Department.

Phillip E. Playford
DIRECTOR

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INTRODUCTION

The Centennial Edition of the geological map of Western Australia is a completely new compilation based on the most recent published and unpublished information available to the Geological Survey up to December 1987. The geology of the State is described in detail in the Geological Survey's Memoir 3, "The geology and mineral resources of Western Australia", to be published in 1989, which also contains extensive references. These notes on the map therefore do not attempt to outline the geology of the State or give references to other work. They provide a brief explanation of the geological units shown on the map. Ages of rock units are given in millions of years (Ma).

MAIN GEOLOGICAL UNITS

The main geological units of Western Australia are shown on an inset map above the map legend; a black and white version of this map is included here as Figure 1. Three categories of unit are distinguished by the following colours on the inset map:

(a) RED — cratons, regions of crust stable since 2400 Ma;

(b) ORANGE — orogens, magmatic and metamorphic rocks formed in orogenic belts after 2400 Ma; and

(c) GREEN — basins, deposits of sedimentary rocks younger than 2400 Ma, not in orogenic belts.

Both cratons and orogens contain complexes of high-grade metamorphic rocks and basins of low-grade metamorphic rocks. The major units are indicated by capital letters; complexes and basins within the cratons and orogens are shown in lower-case letters. The Northampton and Leeuwin Complexes are part of the Pinjarra Orogen; however, the latter is largely overlain by the Perth Basin so it is not named on the map.

AGE OF ROCK UNITS

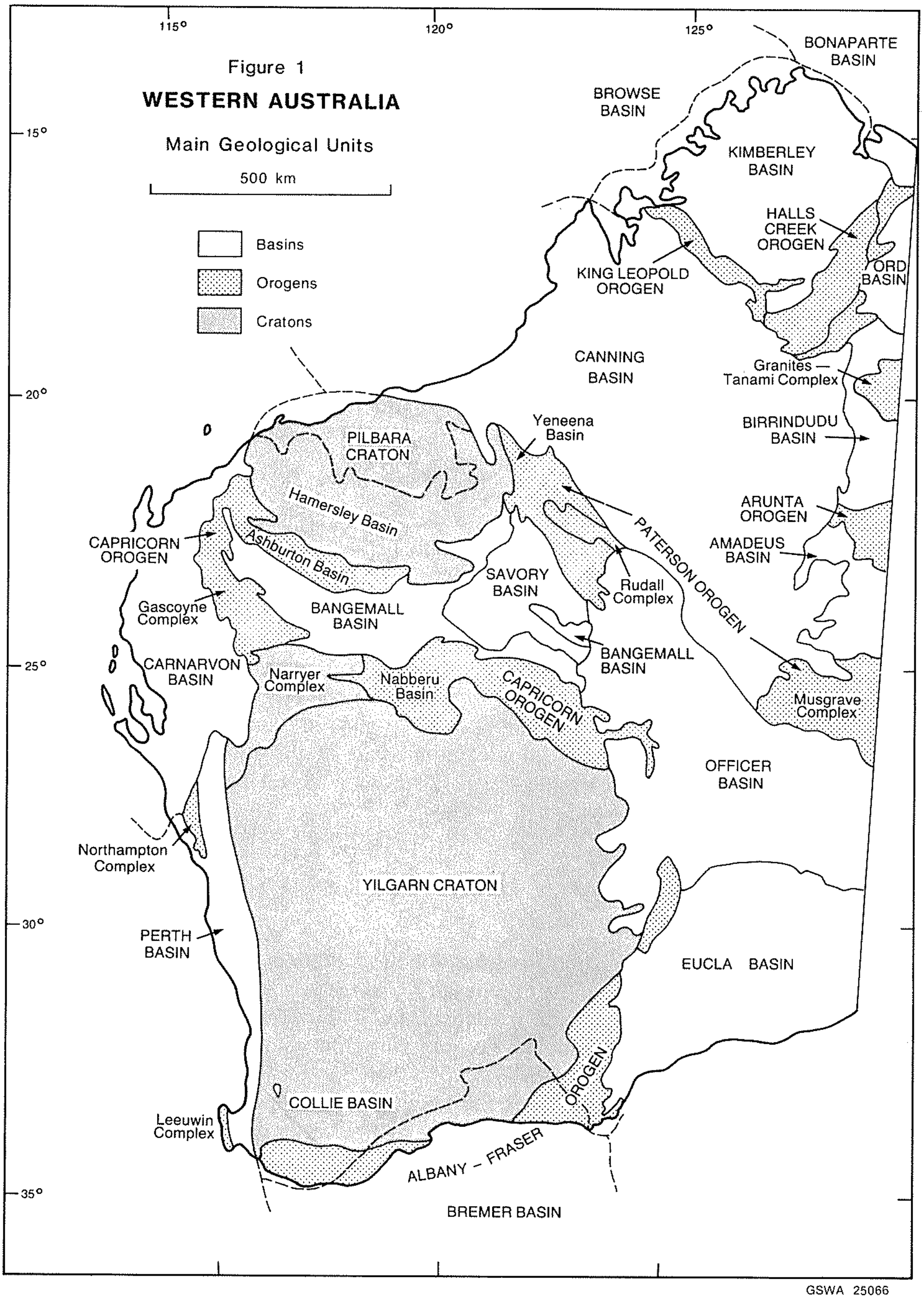
Ages are shown in blue on the right-hand side of the legend (but note that there are two changes in scale: between Paleocene and Cretaceous; and between Cambrian and Precambrian). Vertical blue lines in the legend indicate the age range for the rock units shown as various coloured rectangles. For any particular rock unit, the age range shown by the blue line does not necessarily imply that the rock unit formed continuously throughout that range. In many cases the ages are not precisely known and the range represents the maximum and minimum ages, as they are currently known.

PRECAMBRIAN ROCKS

The Precambrian rocks fall into two groups:

Group 1 — sedimentary and volcanic rocks of major named lithostratigraphic units, mainly of low metamorphic grade, are shown in the left-hand column of the legend; and

Group 2 — other sedimentary, volcanic and intrusive rocks of low to high metamorphic grade are shown in the right-hand columns of the legend.


115°
120°
125°
Figure 1
WESTERN AUSTRALIA
Main Geological Units
500 km
Basins
Orogens
Cratons
15°
20°
25°
30°
35°
BONAPARTE BASIN
BROWSE BASIN
KIMBERLEY BASIN
HALLS CREEK OROGEN
ORD BASIN
KING LEOPOLD OROGEN
CANNING BASIN
Granites — Tanami Complex
BIRRINDUDU BASIN
Yeneena Basin
PILBARA CRATON
Hamersley Basin
Ashburton Basin
CAPRICORN OROGEN
ARUNTA OROGEN
AMADEUS BASIN
PATERSON OROGEN
Rudall Complex
SAVORY BASIN
Gascoyne Complex
BANGEMALL BASIN
BANGEMALL BASIN
CARNARVON BASIN
Narryer Complex
Nabberu Basin
CAPRICORN OROGEN
Musgrave Complex
OFFICER BASIN
Northampton Complex
YILGARN CRATON
PERTH BASIN
EUCLA BASIN
OROGEN
COLLIE BASIN
Leeuwin Complex
ALBANY - FRASER
BREMER BASIN
GSWA 25066

The rocks of Group 1 are indicated by one (*e.g.* F) or two (*e.g.* HB) capital letters, or a combination of capital and lower-case letters (*e.g.* Sv). Stratigraphic sequences within individual named units are shown by an upward sequence of numbers attached to a capital letter indicating the lithostratigraphic unit. Thus, the Fortescue Group, designated F, contains an upward sequence designated F1, F2, F3. The correlation between these subdivisions and the detailed lithostratigraphy is shown in Table 1.

The rocks of Group 2 are indicated by single lower-case letters which refer to various rock types:

s — sedimentary rocks

f — acid volcanic rocks

b — basic and ultrabasic volcanic rocks

d — dolerite, gabbro and ultrabasic intrusions

g — granite intrusions (syenite gy)

p — granophyre and porphyry intrusions

n — gneiss

Each of these letters is followed by a number (1 to 5) which provides a rough guide to age as follows:

1 — 3750–3000 Ma

2 — 3000–2400 Ma

3 — 2400–1500 Ma

4 — mainly 1500–1000 Ma

5 — 1000–590 Ma

Further subdivision is made for some gneisses and granitoids. Capital letters that follow the rock type and age symbols of gneisses in n1M, n1D, n1S, n4B, and n4N, refer to lithotectonic units described in "Explanation of mapped geological units" following. The small letter b, in g2b, indicates a distinct group of granitoid rocks in the northwestern part of the Yilgarn Craton that has precisely known ages (2600–2550 Ma), younger than the main body of adjacent granite g2. However, the precise ages of g2 granites, in other regions, are not well enough known to enable this subdivision. The subdivision gy refers to quartz syenite intrusions which are discussed in "Explanation of mapped geological units".

PHANEROZOIC ROCKS

The Phanerozoic map legend is based on the fourteen depositional sequences that occur in the Phanerozoic sedimentary rocks of Western Australia. These sequences are not confined to single basins, and are described in detail in Memoir 3. Each has a relatively distinct character, which can be attributed to regional climatic, eustatic and tectonic patterns. Differences in each sequence, between basins, arise because of climatic variations, and differences in tectonic setting and basin geometry.

The sequences, and thus the map units, are lithostratigraphic units. They are based on the lithological characteristics of Phanerozoic sedimentary rocks in Western Australia, rather than the age of those rocks. The boundaries of each sequence are approximately synchronous, although some diachronism exists because of differing elevations of portions of Western Australia during the Phanerozoic, and variable rates of subsidence and transgression.

TABLE 1. PRECAMBRIAN LITHOSTRATIGRAPHIC UNITS

Map unit	*Main lithostratigraphic units*		*Main geological units*
Sv3	Durba Sandstone	Savory Group	Savory Basin
	McFadden Sandstone		
	Skates Hill Formation		
Sv2	Boondawari Formation		
Sv1	Mundadjini Formation		
	Coondra Formation		
	Watch Point Formation		
SM	Albert Edward Group		Kimberley Basin, Halls Creek and King Leopold Orogens
	Louisa Downs Group		
	Duerdin Group		
	Kuniandi Group		
	Mount House Group		
	Maurice Formation		Amadeus Basin
	Sir Fredrick Conglomerate		
	Ellis Sandstone		
	Carnegie Formation		
	Boord Formation		
HB	Bitter Springs Formation		Amadeus Basin
	Dean Quartzite		
	Heavitree Quartzite		
	Boee beds		Birrindudu Basin
	Jawilga beds		
	Denison beds		
	Hidden Basin beds		
	Redcliff Pound Group		
	Helicopter Siltstone		Halls Creek Orogen
	Wade Creek Group		
	Carr Boyd Group		
	Ilma beds		Officer Basin
	Townsend Quartzite		
R	Karara Formation		Paterson Orogen
Y	Yeneena Group		
B2	Mucalana Subgroup	Bangemall Group	Bangemall Basin
	Manganese Subgroup		
	Kahrban Subgroup		
	Diedil Subgroup		
	Collier Subgroup		
B1	Edmund Subgroup		
SB	Yandanooka Group		margins of Yilgarn Craton
	Moora Group		
	Cardup Group		
	Stirling Range Formation		
	Mount Barren Group		
	Woodline beds		
	Mount Ragged beds		Albany–Fraser Orogen

TABLE 1. PRECAMBRIAN LITHOSTRATIGRAPHIC UNITS (continued)

Map unit	*Main lithostratigraphic units*		*Main geological units*
Bh	Bresnahan Group		Bresnahan Basin (on Ashburton Basin)
Br	Gardiner Sandstone	Birrindudu Group	Birrindudu Basin
	Talbot Well Formation		
	Coomarie Sandstone		
	Baines beds		
	Ima Ima beds		
	Pindar beds		
	Lake Wilson beds		
	Mount Parker Sandstone		Halls Creek Orogen
	Bungle Bungle Dolomite		
	Oscar Range Succession		King Leopold Orogen
CM	Capricorn Formation		on Ashburton Basin
	Mount Minnie Formation		on Gascoyne Complex
	Mount James Formation		on Gascoyne Complex
N5	Miningarra Subgroup	Earaheedy Group	Nabberu Basin
N4	Tooloo Subgroup		
	Padbury Group		
N3	Labouchere Formation	Glengarry Group	
	Horseshoe Formation		
N2	Thaduna Greywacke		
	Narracoota Volcanics		
N1	Karalundi Formation		
	Doolgunna Formation		
	Johnson Cairn Shale		
	Juderina Formation		
	Finlayson Sandstone		
Km6	Crowhurst Group		Kimberley Basin
	Bastion Group		
Km5	Pentecost Sandstone	Kimberley Group	
Km4	Elgee Siltstone		
	Warton Sandstone		
Km3	Carson Volcanics		
Km2	King Leopold Sandstone		
Km1	Speewah Group		
W2	Ashburton Formation	Wyloo Group	Ashburton Basin
W1	June Hill Volcanics		
	Duck Creek Dolomite		
	Mount McGrath Formation		
	Wooly Dolomite		
	Cheela Springs Basalt		
	Beasley River Quartzite		

TABLE 1. PRECAMBRIAN LITHOSTRATIGRAPHIC UNITS (continued)

Map unit	Main lithostratigraphic units		Main geological units
TU	Turee Creek Formation		Hamersley Basin
H5	Boolgeeda Iron Formation	Hamersley Group	Hamersley Basin
H4	Woongarra Volcanics	Hamersley Group	Hamersley Basin
H3	Weeli Wolli Formation Brockman Iron Formation	Hamersley Group	Hamersley Basin
H2	Mount McCrae Shale Mount Sylvia Formation Wittenoom Dolomite Carawine Dolomite	Hamersley Group	Hamersley Basin
H1	Marra Mamba Iron Formation		Hamersley Basin
F3	Jeerinah Formation Maddina Basalt Pearana Basalt Kuruna Siltstone Nymerina Basalt	Fortescue Group	Hamersley Basin
F2	Tumbiana Formation	Fortescue Group	Hamersley Basin
F1	Kylena Basalt Hardey Sandstone Mount Roe Basalt	Fortescue Group	Hamersley Basin

EXPLANATION OF MAPPED GEOLOGICAL UNITS

EARLY ARCHAEAN (3750–3000 Ma)

The oldest rock unit (n1M Meeberrie Gneiss) occurs in the northwestern part of the Yilgarn Craton and is derived from monzogranite. It is tectonically interleaved with Dugel Gneiss (n1D) which is derived from syenogranite, and mainly siliceous metasedimentary rocks (n1S). The latter contain detrital zircons with a radiometric age of 4300–4100 Ma, the oldest known crystals on Earth. The gneisses n1M and n1D contain remnants of an older, 3730 Ma, layered anorthosite–gabbro complex.

Other early Archaean gneisses of the Yilgarn Craton are designated n1. These rocks have not yet been mapped in detail and may contain significant components of late Archaean gneiss (n2) and granite (g2).

Early Archaean rocks of the Pilbara Craton comprise granite (g1), basic and ultrabasic volcanic rocks (b1 —Talga Talga and Salgash Subgroups of the Warrawoona Group) and acid volcanic rocks (f1 — Duffer Formation of the Warrawoona Group).

LATE ARCHAEAN (3000–2500 Ma)

Late Archaean rocks form most of the Yilgarn Craton and a substantial part of the Pilbara Craton.

Greenstone belts of the Yilgarn Craton are divided into metamorphosed sedimentary rocks (s2), acid volcanic rocks (f2), basic and ultrabasic volcanic rocks (b2), and basic and ultrabasic intrusions (d2). A major part of the greenstone belts of the northwestern part of the Yilgarn Craton formed at about 3000 Ma, whereas most ages of greenstone belts in the rest of the craton are about 2750–2650 Ma.

Late Archaean granitoid rocks of the Yilgarn Craton are divided into granite (g2), most of which is relatively little deformed and metamorphosed at low metamorphic grade, and gneiss (n2) mainly comprising moderately deformed granite, metamorphosed in amphibolite or granulite facies. In the southwestern part of the craton this gneiss (n2) formed at about 2650 Ma and was intruded by granite (g2) at about 2600 Ma. In the northwestern part of the craton most of the gneiss (n2) formed at about 2650 Ma. Metamorphosed granite (g2) formed between 2650 Ma and 2600 Ma and was intruded between 2600 Ma and 2550 Ma by plutons which range in composition from granite to tonalite (g2b) and are not metamorphosed.

Small intrusions, mainly of quartz syenite, occur in a 200 km wide belt extending north–south across the entire Yilgarn Craton, between 121° and 123° west. Large bodies of syenite are identified by the symbol "gy" and small bodies are shown by the symbol "X".

Late Archaean rocks of the Pilbara Craton include metamorphosed sedimentary and volcanic rocks (s1) of the Gorge Creek Group (c. 3000 Ma), Whim Creek Group (c. 3000–2800 Ma), and Louden and Mount Negri Volcanics (c. 2800 Ma). They are intruded by sills and layered intrusions of gabbro and ultramafic rocks (d1) and by granitic rocks (g2). These rocks are overlain by sedimentary and volcanic rocks of the Fortescue Group (F1, F2, F3; Table 1) deposited between 2800 Ma and 2700 Ma. Sills and layered intrusions of gabbro and ultramafic rocks associated with volcanics in the Fortescue Group are designated d2. Acid volcanic and sub-volcanic rocks associated with the Fortescue Group (Gidley Granophyre, Spinaway Porphyry, Bamboo Creek Porphyry) are designated p2. Granite contemporaneous with, or younger than, the Fortescue Group is included with the pre-Fortescue Group granite and is designated g2.

In the eastern part of the Pilbara Craton unit f2 comprises acid volcanic and sub-volcanic rocks (Koongaling Volcanics), and biotite and hornblende granite, including rapakivi granite (Gregory Granitic Complex). These rocks are overlain by basalt that is equivalent to the Kylena Basalt of the Fortescue Group (F1).

LATE ARCHAEAN–EARLY PROTEROZOIC (2500–2400 Ma)

The Hamersley Group of the Pilbara Craton rests conformably upon the Fortescue Group. Hamersley Group deposition extended across the 2500 Ma boundary that is often used to divide the Precambrian into Archaean and Proterozoic, but most of the group was deposited between 2500 Ma and 2400 Ma. The precise time gap between the end of deposition of the Fortescue Group and the beginning of deposition of the Hamersley Group, is unknown.

EARLY PROTEROZOIC (2400–1500 Ma)

Major lithostratigraphic units deposited during the early Proterozoic include the Turee Creek Group (Tu) and Wyloo Group (W1, W2) on the southern margin of the Pilbara Craton; the Glengarry Group (N1, N2, N3) and Earaheedy Group (N4, N5) in the Nabberu Basin on the northern margin of the Yilgarn Craton; and a sequence of rocks (Km1–Km6) in the Kimberley Basin. Scattered small outcrops, mainly of sandstone — the Capricorn, Mount Minnie, and Mount James Formations which are grouped together as unit CM — occur in the Ashburton Basin and on the southern part of the Gascoyne Complex. In the eastern part of the Ashburton Basin these deposits are overlain by another clastic sedimentary sequence, the Bresnahan Group (Bh).

Substantially deformed and metamorphosed early Proterozoic sedimentary rocks (s3) include the Halls Creek Group of the Halls Creek and King Leopold Orogens, the Killi Killi Beds of the Granites–Tanami Complex, the Morrissey Metamorphic Suite in the Gascoyne Complex, and metasedimentary rocks in the Musgrave and Rudall Complexes, and Albany–Fraser and Arunta Orogens.

Deformed and metamorphosed acid volcanic rocks (f3) comprise the Whitewater Volcanics of the Halls Creek and King Leopold Orogens. Basic and ultrabasic intrusions (d3) include the extensive Hart Dolerite of the Kimberley Basin and Halls Creek and King Leopold Orogens, layered gabbro intrusions in the Halls Creek Orogen, and metamorphosed dolerite and gabbro in the Rudall Complex.

Early Proterozoic granite (g3) occurs in the Arunta, Halls Creek and King Leopold Orogens, and in the Gascoyne, Granites–Tanami, Musgrave, Northampton, and Rudall Complexes. Early Proterozoic gneiss (n3) derived from metamorphosed sedimentary and plutonic igneous rocks (in upper amphibolite or granulite facies) occurs in the Gascoyne, Musgrave, Northampton and Rudall Complexes.

The age of many Proterozoic sedimentary rocks along the eastern margin of Western Australia is poorly known, but those believed to be early Proterozoic (and possibly mid-Proterozoic) are grouped together as the map unit Br. Most of those rocks occur in the Birrindudu Basin where they comprise the Birrindudu Group (Gardiner Sandstone, Talbot Well Formation, Comarie Sandstone), Baines beds, Ima Ima beds, Pinda beds and Lake Willson beds. Also included within this map unit (Br) are the Bungle Bungle Dolomite and Mount Parker Sandstone in the Halls Creek Orogen, and the Oscar Range succession of the King Leopold Orogen.

MID-PROTEROZOIC (1500–1000 Ma)

The main mid-Proterozoic lithostratigraphic unit is the Bangemall Group (B1, B2) which occupies the Bangemall Basin. It is subdivided into the Edmund Subgroup (B1) and the Collier, Diedil, Kahrban, Manganese and Mucalana Subgroups (B2). The Bangemall Group is intruded by large numbers of dolerite sills (d4). The Edmund Subgroup is unconformably overlain by the Mucalana and Collier Subgroups, and all the Bangemall Group is folded and metamorphosed at low metamorphic grade. Other metasedimentary rocks broadly correlated with the Bangemall Group (B1) are the Uaroo Group and Badgeradda Group located over the northwestern parts of the Gascoyne Complex and Yilgarn Craton, respectively.

Other mid-Proterozoic lithostratigraphic units are collectively designated SB and include the Yandanooka, Moora and Cardup Groups on the western margin of the Yilgarn Craton; the Stirling Range Formation, Mount Barren Group, and Woodline beds on the southern and southwestern margins of the Yilgarn Craton; and the Mount Ragged beds in the southeastern exposed part of the Albany–Fraser Orogen.

Mid-Proterozoic acid volcanic rocks (f4), basic volcanic rocks (b4) and layered gabbro intrusions — Giles Complex (d4) — occur in the Musgrave Complex. Tectonic slices of lower crustal gabbro intrusions — Fraser Complex (d4) — also form a major component of the northern part of the Albany–Fraser Orogen.

Mid-Proterozoic granite (g4) occurs in the Musgrave Complex in association with acid volcanic rocks (f4), and is a major component of the Albany–Fraser Orogen. The latter also contains two gneiss complexes: the Biranup Complex (n4B) comprising intensely deformed tectonic slices of lower crustal rocks in granulite facies; and the Nornalup Complex (n4N) consisting of orthogneiss and paragneiss in amphibolite or granulite facies. The precise age of these gneiss complexes is unknown.

LATE PROTEROZOIC (1000–590 Ma)

Late Proterozoic lithostratigraphic units include the Yeneena Group (Y) and Karara Formation (R) of the Paterson Orogen, together with a diverse group of poorly dated stratigraphic units near the eastern border of Western Australia that are collectively designated HB. The latter contains the following units: the Heavitree Quartzite, Dean Quartzite and Bitter Springs Formation of the Amadeus Basin; the Redcliff Pound Group, Hidden Basin beds, Denison beds, Jawilga beds and Boee beds of the Birrindudu Basin; the Carr Boyd Group, Helicopter Siltstone, and Wade Creek Sandstone in the eastern part of the Halls Creek Orogen; and the Townsend Quartzite, Ilma beds, and unnamed units in the Officer Basin.

The youngest Proterozoic lithostratigraphic units (Sv1–Sv3 and SM) include deposits resulting from late Precambrian glaciation. The Savory Group in the Savory Basin comprises the Watch Point, Coondra and Mundadjini Formations (collectively designated Sv1); a glacigene marine sequence called the Boondawari Formation (Sv2); and the Skates Hill Formation, McFadden Sandstone and Durba Sandstone (collectively designated Sv3). Lithostratigraphic units of broadly similar age occur in the northern and eastern part of Western Australia and are collectively designated SM, after the Sturtian–Marinoan glaciations. These units include the Mount House, Kuniandi and Duerdin Groups (c. 750 Ma), and the Louisa Downs and Albert Edward Groups (c. 650 Ma) of the Kimberley Basin, and Halls Creek and King Leopold Orogens; the Boord Formation, Carnegie Formation, Ellis Sandstone, Sir Frederick Conglomerate and Maurice Formation of the Amadeus Basin; and similar deposits in the Officer Basin.

Late Proterozoic intrusions of dolerite, gabbro and ultrabasic rocks (d5) occur in the Savory Group, and intrusions of granite occur in the northern part of the Paterson Orogen. Gneiss (n5) forms the Leeuwin Complex; its position in the legend is based on only a few Sm–Nd T_{CHUR} model ages and Rb–Sr isochrons and its magmatic age is unknown.

PALAEOZOIC (590–253 Ma)

Palaeozoic sedimentary rocks are present in all Phanerozoic basins except the Bremer and Eucla Basins. In general, the age of initiation of the basins decreases from north to south: the oldest sedimentary rocks in the Bonaparte and Ord Basins are Cambrian; those in the Carnarvon Basin are Silurian; while those in the southern Perth Basin are Permian. Five Palaeozoic sequences are recognized (Pz1–Pz5), and these have been divided into eight map units (Table 2).

TABLE 2. PHANEROZOIC LITHOSTRATIGRAPHIC UNITS

Map unit	*Depositional sequence*	*Main lithostratigraphic units*	*Main geological units*
Czm	Cz4	Numerous named units in different areas	Widespread
Czc		Numerous named units in different areas	Widespread
Tm	Cz3	Cape Range Group	Carnarvon Basin
		Nullarbor and Abrakurrie Limestones	Eucla Basin
Te	Cz2	Giralia Calcarenite, Merlinleigh Sandstone	Carnarvon Basin
		Wilson Bluff and Toolinna Limestones	Eucla Basin
		Plantagenet Group	Bremer Basin
		Robe Pisolite and Poondano Formation	Pilbara Craton
Czv	Cz1–Cz4	No regional names	Widespread
Tp	Cz1	Cardabia Calcarenite	Carnarvon Basin
Ku	Mz5	Toolonga Calcilutite	Carnarvon Basin
		Upper Coolyena Group	Perth Basin
K	Mz4	Broome Sandstone, several minor units	Canning Basin
		Winning Group	Carnarvon Basin
		Warnbro Group, lower Coolyena Group	Perth Basin
		Bejah Claystone, Madura and Samuel Formations	Officer Basin
Kv		Bunbury Basalt	Perth Basin
JK	Mz3	Upper part of Wallal Sandstone, Anketell Formation and Jarlemai Siltstone	Canning Basin
		Yarragadee Formation, Champion Bay Group	Perth Basin
J	Mz2	Lower part of Wallal Sandstone	Canning Basin
		Cockleshell Gully Formation, Chapman Group	Perth Basin
₮	Mz1	Blina Shale, Erskine and Culvida Sandstones	Canning Basin
		Lesueur Sandstone and Kockatea Shale	Perth Basin
P	Pz5B	Several formations	Perth and Collie Basins
		Wooramel, Byro and Kennedy Groups	Carnarvon Basin
		Liveringa Group, Noonkanbah Formation, Poole Sandstone	Canning Basin
		Kinmore Group	Bonaparte Basin
CP	Pz5a	Nangetty Formation, Holmwood Shale, Stockton Formation	Perth and Collie Basins
		Lyons Group, Callytharra Formation	Carnarvon Basin
		Grant Group	Canning Basin
		Kulshill Group	Bonaparte Basin
		Paterson Formation	Officer Basin
C	Pz4b	Unnamed sequence	Perth Basin
		Moogooree Limestone and Yindagindy Formation	Carnarvon Basin
		Anderson Formation and Fairfield Group	Canning Basin
		Weaber and Langfield Groups	Bonaparte Basin
D	Pz4a	Unnamed sequence	Perth Basin
		Gneudna Formation and Munabia Sandstone	Carnarvon Basin
		Several upgrouped units	Canning Basin
		Ningbing and Cockatoo Groups	Bonaparte Basin
		Mahony Group	Ord Basin
		Wanna Formation and Lennis Sandstone	Officer Basin

TABLE 2. PHANEROZOIC LITHOSTRATIGRAPHIC UNITS (continued)

Map unit	*Depositional sequence*	*Main lithostratigraphic units*	*Main geological units*
S	Pz3	Kalbarri Group Carribuddy Group (subsurface) Unnamed sequence (subsurface)	Carnarvon Basin Canning Basin Bonaparte Basin
O	Pz2	Prices Creek Group and subsurface units	Canning Basin
ЄO	Pz1	Carlton and Goose Hole Groups	Bonaparte and Ord Basins
Єv		Antrim Plateau Volcanics Table Hill Volcanics	Bonaparte and Ord Basins Officer Basin

Most of the Cambrian rocks in Western Australia are subaerial volcanics (Єv). These are interbedded with minor continental sedimentary rocks, and are part of a blanket of Cambrian volcanics which extended across northern Australia to the Barkly Tableland in Queensland. In the Bonaparte and Ord Basins, the volcanic sequence is overlain by a predominantly siliciclastic, shallow-marine to marginal-marine sequence (ЄO), deposition of which continued into the Early Ordovician. The preserved rocks (Sequence Pz1) are remnants of a depositional province which was much larger than the present basins. Deposition did not extend to the Canning and Officer Basins, or the Western Australian portion of the Amadeus Basin.

Lower and Middle Ordovician sedimentary rocks, which belong to Sequence Pz2 (O), are exposed along the northern margin of the Canning Basin. They are sandy, nearshore and shoreline, marginal correlatives of a widespread Ordovician sequence in the subsurface of the Canning Basin. One isolated, poorly dated outcrop of Ordovician rocks in the Amadeus Basin, east of Lake Hopkins, may have been deposited in a seaway which connected the Canning Basin to the central Amadeus Basin in the Northern Territory.

Silurian outcrops (S) belong to Sequence Pz3 and are present in the southern Carnarvon Basin and northern Perth Basin. The sequence is widespread in the subsurface of the Carnarvon, Canning and offshore Bonaparte Basins, where it extends into the Devonian. The outcrops are of a sandy, fluvial and tidal, red-bed sequence; in the subsurface, Sequence Pz3 is dominated by fine-grained siliciclastic sedimentary rocks, carbonates and lesser evaporites.

Middle and Upper Devonian sedimentary rocks which are part of Sequence Pz4 (D) outcrop in all but the Eucla and Bremer Basins (Table 2), although their age is poorly established in the Perth and Officer Basins. Deposition was primarily in a low- to medium-energy, mixed marine-shelf environment. Sandy and conglomeratic deposition occurred near basin margins and over much of the central Officer Basin. During the Late Devonian, in the Canning and Bonaparte Basins, there was extensive reefal development. Because a minor unconformity separates Devonian and Lower Carboniferous sedimentary rocks, the Devonian sequence is referred to as Sub-sequence Pz4a.

Lower Carboniferous sedimentary rocks (C) are assigned to Sub-sequence Pz4b, and occur in all but the Officer, Eucla and Bremer Basins (Table 2). Deposition took place in mixed carbonate and siliciclastic settings, similar to those which prevailed during the Devonian. Except in the Perth Basin, deposition commenced under the influence of a tropical climate that slowly cooled during the Carboniferous. In the northern Perth Basin, Lower Carboniferous sedimentary rocks were deposited, at least in part, under alpine-glacial conditions. Deposition ceased during the Tournaisian except in the deepest troughs of the Canning and Bonaparte Basins, and was followed in the Perth and Carnarvon Basins by folding and faulting in the mid-Carboniferous.

Sequence Pz5 was deposited while Western Australia was located in high-temperate to sub-polar latitudes, and has two distinct sub-sequences (Table 2). A pronounced glacial influence characterizes Sub-sequence Pz5a (CP), which extends from Late Carboniferous to middle Early Permian. Deposition spanned several glacial advances and retreats, and environments were varied, but tended to be dominated by siliciclastic deposition. In the Canning and Bonaparte Basins there are only scattered glacial indicators in pre-Stephanian rocks; this suggests that there were isolated alpine glaciers as precursors to the later, more widespread, glaciation.

Sub-sequence Pz5b (P) consists of an initial deltaic episode, followed by siliciclastic, marine-shelf, paralic and continental deposition, and has indications of only intermittent glaciation. Extensive coal measures occur in this sequence. There was a hiatus of variable duration in the Late Permian.

MESOZOIC (253–65 Ma)

Mesozoic deposition in Western Australia was dominated by continental breakup, first along the northwestern margin of the State in the Jurassic, and then along the western and southern margins in the Cretaceous. Five depositional sequences have been recognized (Mz1–Mz5), each of which has a map unit (Table 2). Except in the Perth Basin, the Mesozoic depocentres were offshore. In the onshore parts of the Carnarvon, Canning and Bonaparte Basins, the preserved Mesozoic sedimentary rocks are much thinner than in the offshore parts of the basins.

Triassic sedimentary rocks (Ŧ) are part of Sequence Mz1 (Table 2), and are regressive overall. The sequence contains two major components: a lower shale-dominated unit and an upper sandy unit. A basal, transgressive sandy unit is present locally, and a limestone near the base of the shale reflects temporary basin starvation. In the Perth Basin, where a thick sandy sequence overlies the shale, deposition continued throughout the Triassic. In the Canning Basin — the only other basin containing outcrops of Triassic sedimentary rocks — deposition ceased at the end of the Early Triassic, after a relatively thin, sandy sequence was deposited.

Sequences Mz2 (J) and Mz3 (JK) are defined primarily on the North West Shelf. The former contains the sedimentary rocks deposited prior to continental breakup on the North West Shelf, and the latter, the post-breakup sedimentary rocks. In the Perth Basin, deposition was continuous from the Triassic into the Early Cretaceous. A thick sandy sequence was deposited in a rapidly subsiding trough, primarily in fluvial to coastal conditions. In the Canning Basin, Lower Jurassic sedimentary rocks are absent onshore, and the sequence is clearly transgressive, from sandy, fluvial deposition at the base, to nearshore-marine deposition at the top. The preserved thickness is much less than in the Perth Basin.

Sequence Mz4 (K) is the most extensive of the Mesozoic sequences. Except in the Perth Basin it is generally less than 200 m thick, and consists of a basal transgressive sandstone overlain by fine-grained siliciclastic sedimentary rocks (Table 2). There were several transgressive and regressive episodes within the sequence. In the upper part of the sequence, the transgressive peaks were marked by siliceous pelagic deposition. Subaerial basalt flows (Kv) are exposed at the base of the sequence in the southern Perth Basin.

A change in global oceanic circulation patterns in the Late Cretaceous, coupled with an increase in aridity, led to a change from siliceous to calcareous pelagic deposition. The resultant sequence (Mz5, Ku) is preserved onshore in the Perth and Carnarvon Basins (Table 2), and extends along the entire offshore North West Shelf; the onshore deposits are the feather-edge of the offshore sequence. Sequence Mz5 marks the beginning of the prograding carbonate-shelf phase of deposition which persisted along the Western Australian coastline throughout the Cainozoic.

CAINOZOIC (65–0 Ma)

Significant deposition, through the progradation of a carbonate wedge, occurred around most of the offshore margin of Western Australia during the Cainozoic. All the Cainozoic depositional sequences (Cz1 to Cz4, Table 2) occur in outcrop, but significant marine transgression over onshore areas took place only in the Eocene and Miocene (Sequences Cz2 and Cz3).

Deposition of the Paleocene to Middle Eocene Sequence Cz1 (Tp) extended onshore only in the Carnarvon Basin, where marine limestone outcrops in several anticlines near the present coast.

Eocene sedimentary rocks (Te) are grouped as Sequence Cz2, and include marine-shelf limestone in the Eucla Basin and near-coastal parts of the Carnarvon Basin; nearshore and continental sandstone in much of the remainder of the onshore Carnarvon Basin; paralic to nearshore, lacustrine sedimentary rocks in the Officer and Canning Basins; spongolite and low-energy marine carbonate and siltstone in the Bremer Basin and on the southern Yilgarn Craton; and pisolitic ironstone in palaeodrainages on the Pilbara Craton (Table 2). Sediments which infill the extensive palaeodrainage system in Western Australia (Czv) are primarily of Eocene age, when the system was most active, although deposition had a total span from the Late Mesozoic to the Quaternary.

Late Oligocene and Miocene sedimentary rocks (Tm) are assigned to Sequence Cz3, and are exposed in the Eucla and Carnarvon Basins (Table 2). In both areas, they are shallow-water extensions of a more extensive, thicker, deeper water sequence which extends around most of the Western Australian coastline. The sequence consists solely of carbonate, except for minor siliciclastic coastal deposits in the northern Carnarvon Basin, and is the most extensive Cainozoic marine sequence.

Late Miocene to Quaternary sediments (Sequence Cz4, Table 2) are grouped into two units: sediments for which marine or coastal processes dominated deposition (Czm), and sediments for which continental (alluvial and interior eolian) processes were dominant (Czc). The latter are essentially the superficial sediments of Western Australia, and developed in a climate that was dominantly arid but had some humid phases. The former are correlatives of a much thicker offshore sequence on which the recognition of Sequence Cz4 was based. The two units are shown only where significant thicknesses are present.

DIATREMES

Diatremes include numerous small intrusions of leucite and olivine lamproite, a few of kimberlite and olivine monchiquite, and carbonatite plugs. Most lamproites were emplaced through the King Leopold Orogen and adjacent Phanerozoic cover in the Canning Basin between 17 Ma and 25 Ma. Some olivine lamproites contain diamond. The Argyle olivine lamproite, in the Halls Creek Orogen, formed about 1150 Ma and is very rich in diamond. Kimberlite diatremes and dykes in the northern part of the Kimberley Basin and Halls Creek Orogen were intruded at about 800 Ma.

Olivine monchiquite diatremes in the Carnarvon Basin formed at 160 Ma, and similar rocks were emplaced into the margin of the adjacent Yilgarn Craton at about 900 Ma. The main carbonatite intrusions occur at Mount Weld (2000 Ma) in the Yilgarn Craton and at Cummins Range (900 Ma) in the Halls Creek Orogen.

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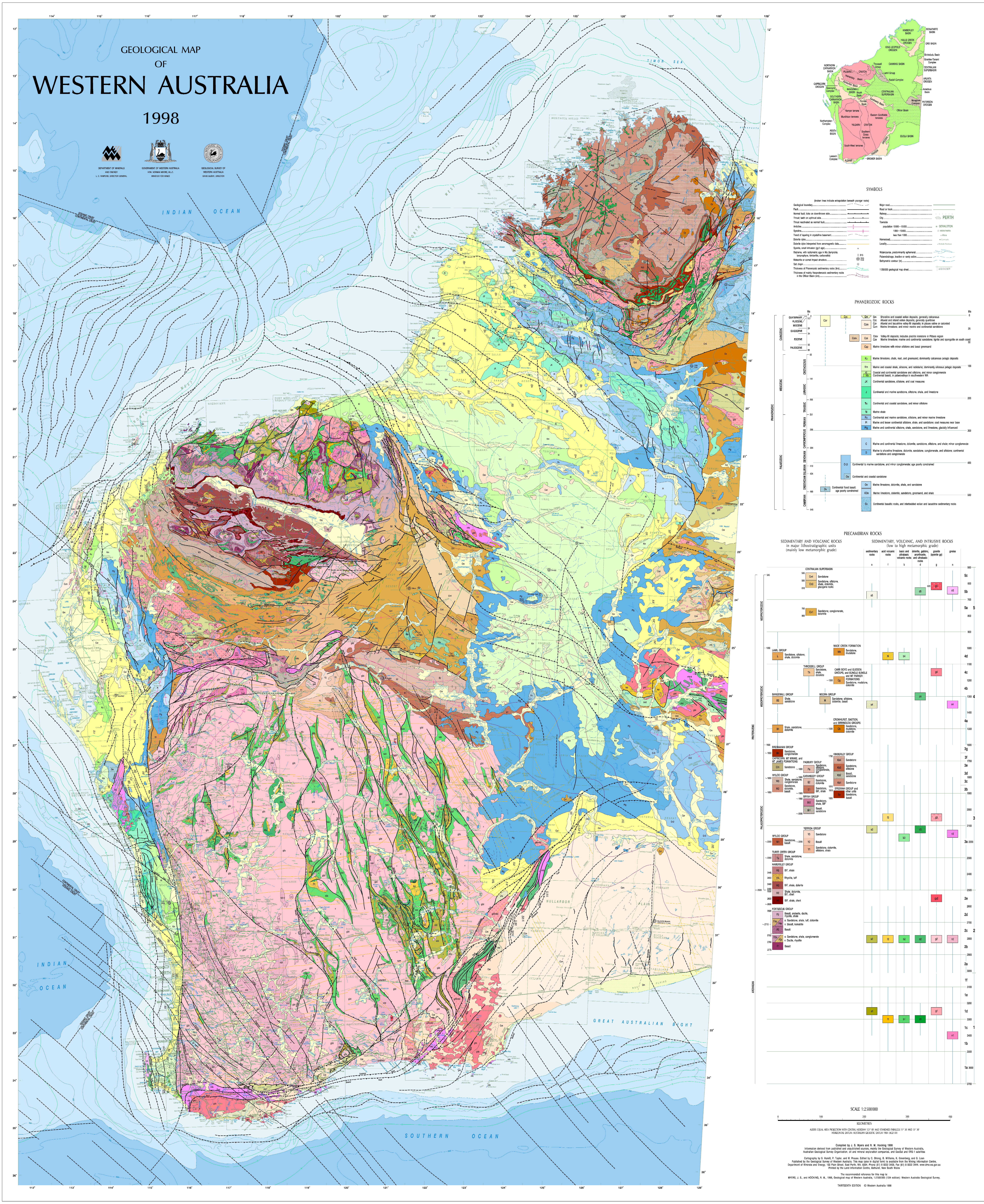

GEOLOGICAL MAP
OF
WESTERN AUSTRALIA
1998
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INDIAN OCEAN
OCEANIC CRUST
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TIMOR SEA
GREAT AUSTRALIAN BIGHT
SOUTHERN OCEAN
NULLARBOR
SYMBOLS
PHANEROZOIC ROCKS
PRECAMBRIAN ROCKS
SCALE 1:2 500 000
KILOMETRES
ALBERS EQUAL AREA PROJECTION WITH CENTRAL MERIDIAN 121° 00' AND STANDARD PARALLELS 17° 30' AND 31° 30'
HORIZONTAL DATUM: AUSTRALIAN GEODETIC DATUM 1984 (AGD 84)
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