

INDIAN OCEAN
GEOLOGICAL MAP
OF
WESTERN AUSTRALIA
2015
TIMOR SEA



Government of Western Australia
Department of Mines and Petroleum

Geological Survey of
Western Australia



1962-2015
DIRECTOR GENERAL



Geological Survey of Western Australia
Geological Mapping, Reporting, and Data
The Geological Survey of Western Australia is a government department responsible for the geological mapping, reporting, and data of Western Australia. It is a part of the Department of Mines and Petroleum. The Survey is responsible for the collection, interpretation, and dissemination of geological information. It also provides technical advice to government and industry on geological matters. The Survey is a member of the International Geoscience and Earth History Association (IGEH) and the International Association of Geological Sciences (IAGS).

Mapping
Western Australia
State geological maps 1894–2015

by A Riganti, JF Johnston, RM Hocking, and DMcB Martin



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Western Australia**



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Mapping Western Australia

State geological maps 1894–2015

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The early maps

Introduction

The 'Geological map of Western Australia' released in December 2015 is the 14th in a series that began with the Harry Page Woodward map of 1894, published six years after the Geological Survey of Western Australia (GSWA) was established. Since then, 'State' maps have been released roughly every 10 years, with a longer hiatus between the 2015 map and the previous edition of 1998. Over the years, our understanding of the geological framework of the State has increased immensely, thanks to the continuous development of analytical and remote-sensing techniques. Fieldwork has changed in style, as have compilation methods — from the manual cartography of the early days to the digital revolution of the 21st century. The journey is alluded to in this volume through the lens of each State map, starting from the early days of exploration with camels and horses, up to the helicopter- and computer-aided mapping of today. The collection of Western Australia's State maps is a tribute to the passion of all the geologists who, since the 19th century, have mapped every inch of this vast and richly endowed State, and produced ever more detailed geological maps documenting the rock formations that have shaped Western Australia for nearly four billion years.

Establishment of the Geological Survey of Western Australia

Between 1847 and 1885 the colonial government of Western Australia appointed three Government Geologists to undertake specific investigations: Ferdinand von Sommer (1847–1848), Henry Yorke Lyell Brown (1870–1872), and Edward Townley Hardman (1882–1885).

In 1885 Sir Thomas Cockburn-Campbell and John Forrest, then Surveyor General of the colony, led the debate to establish a permanent Geological Department, but failed because of staunch opposition by McKenzie Grant and Septimus Burt. These members of the Legislative Council '... denied scientific men had contributed in any way to the important mineral discoveries which had made the fortunes of the other colonies; those discoveries were due to accident or to the labors of practical men, of the pick-and-shovel persuasion'. They were very scathing of the 'good' any geologist as a 'scientific man' had ever done for Western Australia, specifically belittling the work of ET Hardman in the east Kimberley. Hardman's role in the Kimberley gold discoveries that same year was subsequently publicly acknowledged, and on 26 August 1886 the Legislative Council passed a resolution in favour of establishing a Geological Survey. The position of



The early maps

permanent Government Geologist was offered to Hardman in mid-1887, but he had unfortunately died of typhoid fever in Ireland two months earlier. Harry Page Woodward, the other applicant, was offered the position, and arrived in Perth in January 1888. This marks the establishment of the Geological Survey of Western Australia (GSWA). In 1893 Woodward gained his first professional staff member, a Hungarian geologist, Stephen Göczel.

In the wake of major gold discoveries at Coolgardie (1892) and Kalgoorlie (1893), the Department of Mines was established in 1894 under the supervision of WE Marmion MLA, and the Geological Survey became a part of the new department. The first Minister for Mines, EH Wittenoom MLC, was appointed in December of that year. Today the Geological Survey is part of the Department of Mines and Petroleum.

Since Woodward's resignation in 1895, there have been 11 Government Geologists or Directors of the Geological Survey. Of these, the longest serving has been Andrew Gibb Maitland who, from 1896 to 1926, actively pursued the systematic geological mapping of the State. By the end of his tenure, half of Western Australia had been mapped at 4 miles to the inch (nearly 1:250 000 scale). The completion of mapping of the whole State at 1:250 000 scale was the major goal of JH (Joe) Lord's directorship between 1961 and 1980 — the mapping was completed in 1979 in the Wheatbelt. The introduction to the 1979 Annual report of GSWA states 'After many years of regional geological mapping on 1:250 000 scale, the field work required to give a complete coverage of the State was completed this year. It will probably take another 3 or 4 years to compile, to draw and to publish the remaining maps. ... There are a number of sheets which require remapping and no doubt there will be many others in the future.' GSWA continues to map, although the principal mapping scale is now 1:100 000 with regional compilations at 1:500 000, and mapping focuses on tectonic units rather than rectilinear map sheets.

Early geological maps of Western Australia

GSWA was voted into reality in 1886 by the Western Australian parliament, and effectively founded in 1888 with the appointment of HP Woodward as permanent Government Geologist. Prior to this, however, there were temporary appointments to the position of Government Geologist dating back to 1847. These generally focused on a specific target for each appointee. The achievements of these early geologists together with the regional maps they prepared are outlined below. The maps are not part of the series of State maps, but are important nonetheless.

1848 — F von Sommer's maps

Ferdinand von Sommer migrated from Germany to Australia in 1845 and arrived in Western Australia in February 1847. After a brief stint with the Western Australian Mining Company (during which he failed to locate

The early maps

often regarded as less useful economically than prospectors or miners. He led field parties on horseback through unknown areas, potentially subject to Aboriginal attack. He was able to find his way, keep out of trouble, and return. His reports show an approach to Aboriginal people that was liberal for the times, and in one report he pays tribute to his assistants, a courtesy sometimes omitted by other explorers.

1849 to 1870 — between von Sommer's and Brown's maps

After the departure of Ferdinand von Sommer, and before the Geological Survey was officially set up in 1888, the Government employed another two geologists on a temporary basis for specific tasks: Henry Yorke Lyell Brown (1870–1872) and Edward Townley Hardman (1882–1885). However, portions of the State were mapped in the intervening period by a number of surveyors and amateur geologists.

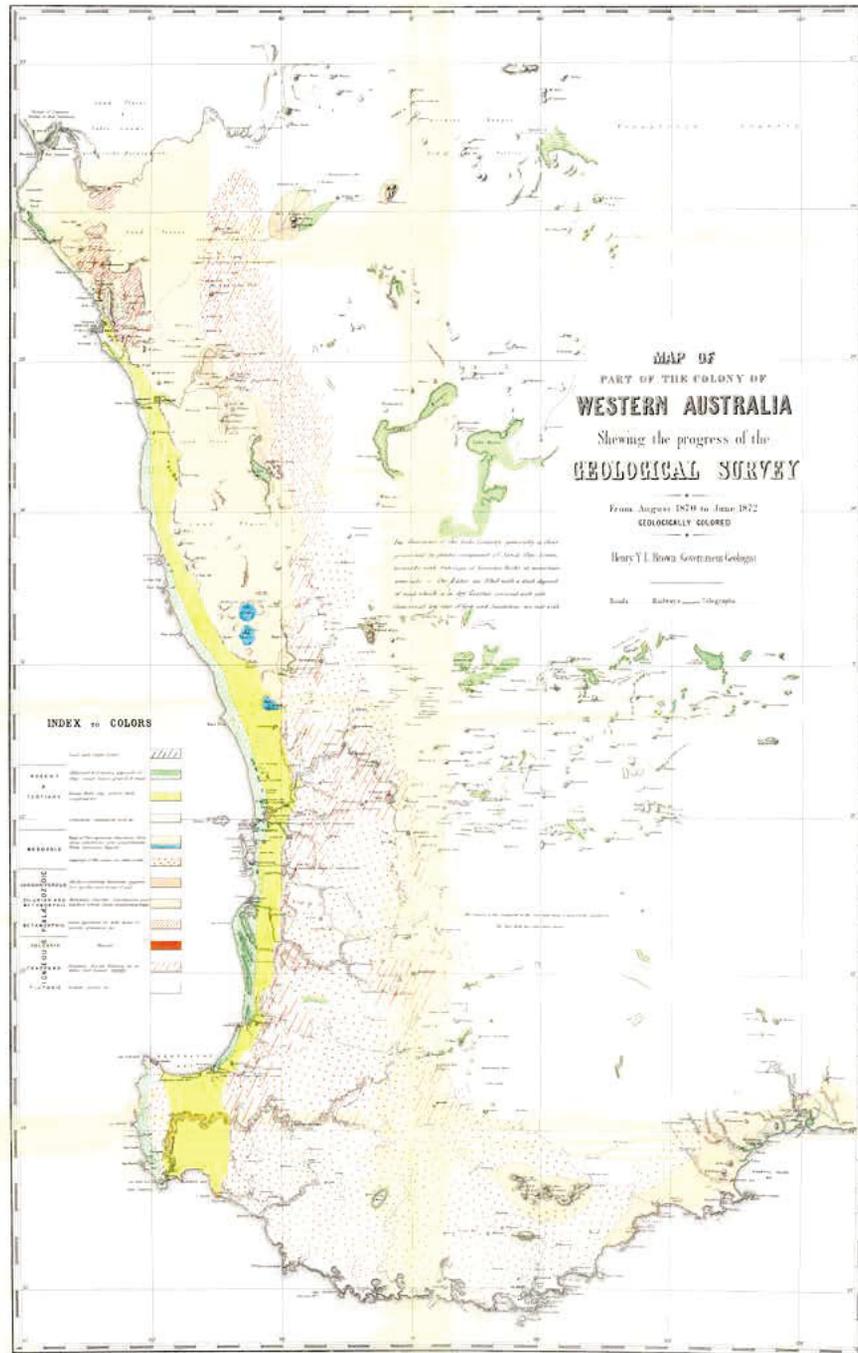
J Beete Jukes called in to Western Australia in 1843, while serving as a geologist and naturalist with the expedition of HMS Fly in the New Guinea and Great Barrier Reef region. He made geological observations on a short trip to Bolgart (north of Toodyay) from Perth. In 1850 he produced 'A sketch of the physical structure of Australia'. The Western Australian portion was mainly based on the published observations of the coastal navigators, but also included his own and those published by von Sommer and the Gregory brothers.

The Gregory brothers (AC and FT Gregory) were employed by the Western Australian Government Survey department under John Septimus Roe. Because of their bush skills they were appointed to lead several parties in the search for new pasture lands. Using their geological knowledge they also made notes on the rocks they passed over. On an expedition in 1846 they discovered coal in the Irwin River valley and on an 1848 expedition their party discovered galena in the Murchison River valley (later to become the Geraldine mine, the State's first commercial mining operation). The 1860 map was mainly derived from an expedition led by FT Gregory in 1858 following up the courses of the Murchison and Gascoyne Rivers. The brothers published two sketches of the geology of Western Australia in the Journal of the Geological Society of London, one in 1848 and the other in 1860.

In the 'Annual general report for 1888–1889', the Gregory brothers' contribution is described by Woodward as 'such good work that no professional geologist would be ashamed to own it, and indeed so accurate is their geological map of the colony (published in London in 1860), as I found in that portion which I examined last year, that their mapping will be retained provisionally for those portions not yet re-examined'.

1870 to 1872 — HYL Brown's map

Henry YL Brown was born in Canada and graduated from the Royal School of Mines in London. He was employed as Government Geologist in Western Australia in 1870, after stints in Victoria and New Zealand. He travelled extensively in the South West of the State and spent some time in the Northampton and Murchison regions. He did not make any notable mineral discoveries, but did put down the first successful artesian bore in the Perth area while boring for coal near the Canning River.



The early maps

Henry Brown held office as Government Geologist from 1870 to 1872, and in this period issued ten reports and three geological maps, culminating in a 'General report on a geological exploration of the portion of the colony of Western Australia lying southward of the Murchison River and westward of Esperance Bay' (see map overleaf). This map appears to have been compiled mainly from his own observations and was not extended to include those of the Gregory brothers to the north.

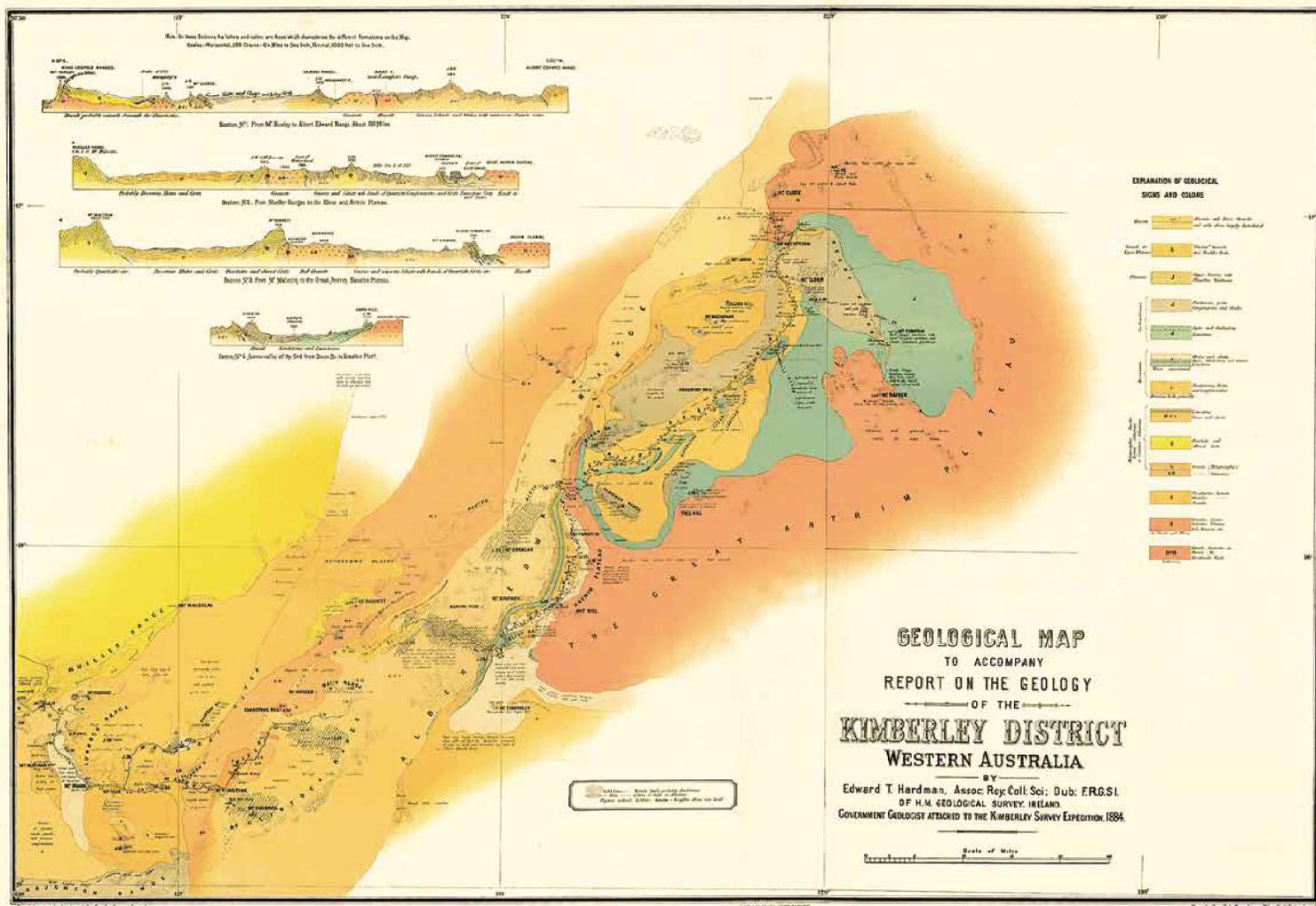
Brown convinced the Governor and Legislature that 'The colony is extraordinarily rich in lead, silver, copper, iron, plumbago and many other minerals ... and indications of coal and petroleum are not wanting'. He was confident that gold would be discovered in payable quantities, and recommended several areas for prospecting, some of which ultimately proved to be auriferous. However, in 1872 the colony was in straitened circumstances and Brown had fallen foul of some parliamentarians who found his use of geological terminology, rather than practical everyday language, offensive and referred to him as 'Mr Geology Brown'. Governor Weld wrote '... I was obliged to forego my desire of making it (the geological department) a permanent part of the establishment', and Brown's services were relinquished. Brown afterwards had a long and successful career in eastern Australia.

1884 — the ET Hardman 'gold' map: the geological map that started the gold rushes in Western Australia

In 1882 the finances of the colony improved sufficiently for Edward Townley Hardman, formerly of the Geological Survey of Ireland, to be appointed as Government Geologist, principally to report on the mineral resources of the Kimberley region. In the 1884 land survey expedition to the east Kimberley, one of Hardman's tasks was to examine and map the area where the prospector Phillip Saunders had first found colours of gold in 1882 in the Ord River. Using gold-coloured ink on his original map (see map on adjacent page), Hardman clearly shows areas of alluvial gold and reef gold, which were later found to be payable.

Soon after Hardman's map was printed in 1885, a copy was made available to the prospecting party of Hall and Slattery, who used it to make their famous discovery of payable amounts of gold at Halls Creek. This sparked the first gold rush in Western Australia, and the Kimberley Goldfield was proclaimed in 1886. Prospectors and others seeking their luck flocked to the east Kimberley from elsewhere in Australia, New Zealand, and California, but the easily won alluvial gold and reef gold soon ran out, and by 1887 the rush was over. Many of the experienced prospectors who quit the goldfield decided to remain in Western Australia and they went on to make further major gold discoveries in the Pilbara, Yilgarn, Murchison, and Eastern Goldfields. As for Hardman, the government would not agree to make the Government

Size of map: 737 mm x 1,270 mm



Geologist a permanent position, due to the cost and the poor opinion of his predecessor Brown by some parliamentarians, so he returned to Ireland where he died of typhoid fever in 1887.

Following the 1885 gold discovery at Halls Creek, the economy of Western Australia was transformed by the establishment of a major gold mining industry that was the basis for rapid economic development at the end of the 19th century.

CG Nicolay map, c. 1886

In his 'Annual general report for 1888–1889', HP Woodward (the first Government Geologist to be employed in the formally established Geological Survey) provides an historical account of geological work in Western Australia up to the end of 1887. He writes that 'For a great many years the country has been greatly indebted to the Revd CG Nicolay, MA, for his indefatigable services in testing and reporting on samples for anyone who was in the least doubt as to what he found. He also started the Geological Reference Museum at Fremantle, where after long years of continual hard

The early maps

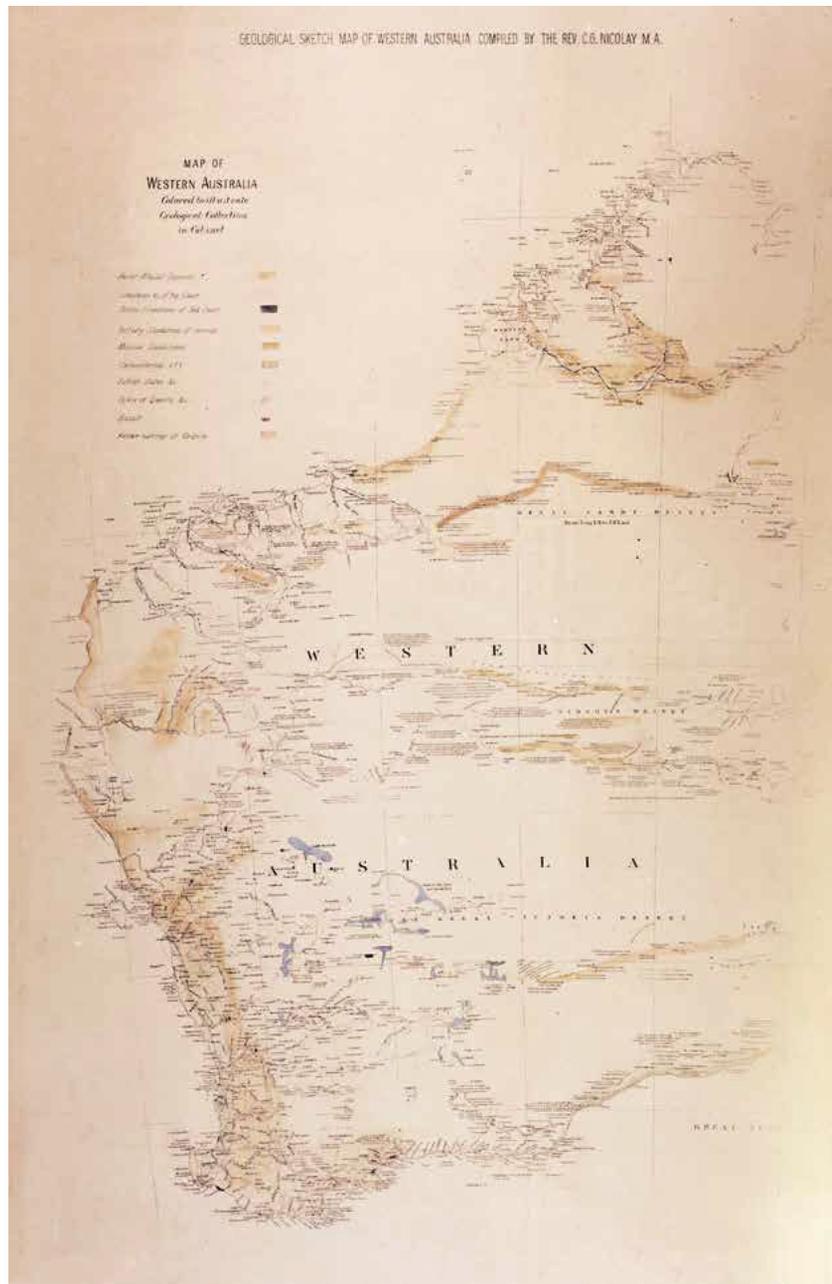
work he has accumulated a very good typical collection of the rocks and minerals of this country. Moreover his work has not been confined to the Museum and Laboratory, for on several occasions he made long and tedious journeys to settle important questions as to the value of reported mineral discoveries. Being an enthusiast he neither cares for gain nor minds hardships, but only hopes that his work may prove of use and that he may do his share in solving the great problem of the formation of the earth on which we live.'

The Reverend Charles Grenfell Nicolay (1815–1897) came to Western Australia in 1868 to take up a position as chaplain in Geraldton. He took an immediate interest in the colony's affairs and resources. After unsuccessfully trying to set up a coffee plantation west of the Moresby Range near Geraldton (based on previous Brazilian experience), he became the editor of the 'Western Australian Times' until about 1875. In 1877, while acting as curate of the parish of Perth and as chaplain at the gaol, he prepared a report for the Intelligence Branch of the War Office on the colony's defence organization. In 1876 he was commissioned to prepare a 'Handbook of Western Australia' for prospective migrants, which was published in 1880 and contained geographical information on the colony. In it he expressed sympathetic views for Aboriginal welfare far more liberal than those of most of his contemporaries.

Nicolay was the founder of Western Australia's first publicly owned museum, the Geological Reference Museum at Fremantle. In 1881 he received authorization from Governor Robinson to begin a public collection of rocks, minerals, and fossils. While curator of the museum, Nicolay also acted intermittently as geological consultant to the Government and carried out some projects requiring field inspection. Between 1873 and 1874 he investigated the feasibility of cutting a canal between the coast and Rocky Bay, in the lower reaches of the Swan River, and in 1875 he was commissioned to investigate reports of coal in the Fitzgerald River near the south coast. He also advised the Government on the geology of the Guildford–Clackline railway route. In 1886 Nicolay prepared a circular on gold prospecting, and also published 'Some notes on the geology of Western Australia' and 'Notes on the Aborigines of Western Australia' for the Colonial and Indian Exhibition of 1886. Despite his lack of a university geology degree and a quick temper that often antagonized some people, Nicolay was clearly a talented and scholarly man, a humanist with a broad interest in science.

From a geological point of view, Nicolay's most significant achievement was the compilation of the first geological map produced in Western Australia that depicts the whole State (see map on adjacent page). This map was not produced under the patronage of the Geological Survey of Western Australia and it is therefore not counted in the numbered editions of State maps. An original of this map could not be located despite an extensive

search of Western Australian and British possible sources, hence the poor quality of the reproduction presented here, which is derived from a 35 mm photographic slide. The Nicolay map is to date the smallest of the geological maps depicting Western Australia in its entirety, measuring about 922 mm in height by 608 mm in width (the map bears no scale; all original dimensions of statewide maps are indicated alongside each map). With a simple palette of browns and black, colouring the map ‘... to illustrate the geological collection in cabinet’, the map identifies the main drainage systems of the State, siliciclastic and carbonate rocks of Phanerozoic age, as well as schist, granitic outcrops, basalt, and quartz ‘dykes’ along what had been the main exploration routes for the State at the time. Annotations complement the colour-coding of lithological types; unfortunately the current state of the image makes interpretation impossible.



State geological maps

1894 State map — known as the ‘Woodward map’

Harry Page Woodward graduated from the Royal School of Mines, London, and worked under HYL Brown in South Australia before being appointed Government Geologist in Western Australia at the end of 1887, to commence in January 1888. The post was permanent for the first time, and this is generally taken as marking the founding of the Geological Survey of Western Australia. Over the next five years he travelled extensively throughout the State visiting the Yilgarn, Pilbara, east Kimberley, Yalgoo, Murchison, and Ashburton goldfields, the Northampton, Irwin River, and Collie areas, and the Southern district. In 1893 he compiled a ‘Mining handbook to the colony of Western Australia’ (published in 1894) and accompanied by a ‘Geological sketch map of Western Australia’ at a scale of 1:3 000 000, published by George Philip and Son, London and Liverpool.

This map is mainly based on Woodward’s own observations, except for Hardman’s work in the Kimberley and local detail from von Sommer, the Gregory brothers, and HYL Brown. He did not include the geological observations of explorers such as Forrest and Giles to the east of the Yilgarn Goldfields as had been done by Brough-Smyth in his ‘First sketch of a geological map of Australia including Tasmania’, which was compiled in 1873 and published in 1875 and must have been available to Woodward. As Woodward’s map does not include Calgoola (Kalgoorlie) as a gold-bearing area, it must have been compiled before the middle of 1893 (when gold was discovered in the Eastern Goldfields) despite bearing the date 1894.

Geologically, the map follows the same approach as the Nicolay map, but with better defined boundaries and the addition of areas prospective for gold, copper, lead, tin, and coal. Phanerozoic sedimentary rocks are divided into ‘Recent and Tertiary’, ‘Mesozoic’, and ‘Palæozoic’; the remaining outcrops being identified as ‘Metamorphic’, ‘Crystalline (schist and granite)’, and ‘Volcanic and plutonic’ with a distinction between granite and basalt. Geology is better defined along the coast and for a few hundred kilometres inland, with information on the State’s interior being limited to topographic and route details.



GEOLOGICAL SKETCH MAP OF WESTERN AUSTRALIA

1894

SCALE OF NATURE 1:500,000

English Miles

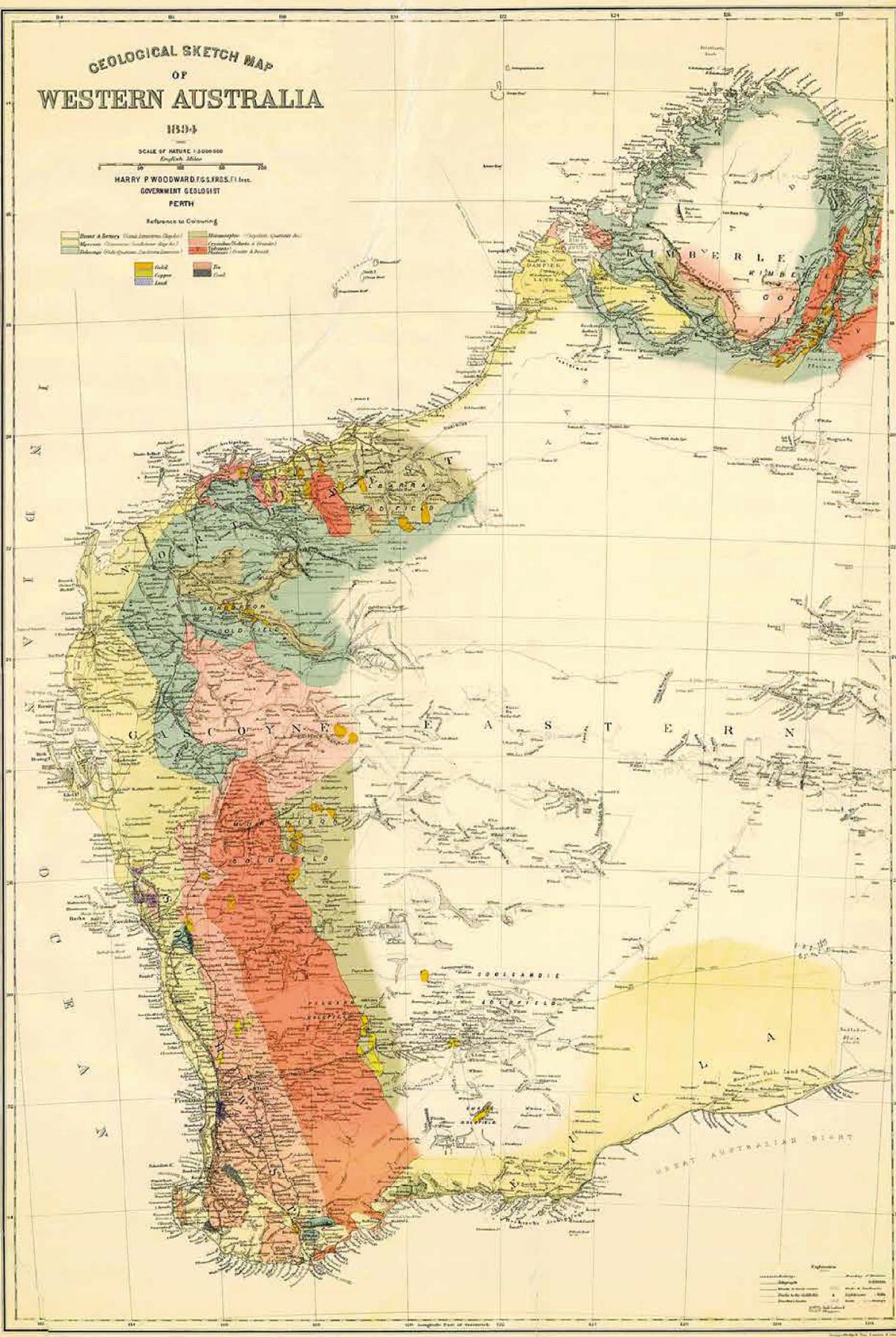
HARRY P. WOODWARD, G.S. PROS. F. Inst.

GOVERNMENT GEOLOGIST

PERTH

Reference to Colouring

Blue & Green (Sandstone, Gneiss)	Metamorphic (Gneiss, Quartzite, etc.)
Yellow (Sandstone, Gneiss, etc.)	Granite (Schist & Gneiss)
Orange (Sandstone, Gneiss, etc.)	Coal
Red (Sandstone, Gneiss, etc.)	Iron
Green (Sandstone, Gneiss, etc.)	Lead



Size of map: 882 mm X 595 mm

State geological maps

1910 State map

The 1910 map was produced as a hand-coloured compilation, from which a black and white sketch map dated 1911 was drafted and published to illustrate the 1912 GSWA Bulletin 50 entitled 'The geology and mineral industry of Western Australia' by A Gibb Maitland and A Montgomery. Neither map bears their names. The coloured version has the logo of the Department of Lands and Surveys and the name of Harry F Johnston, then Surveyor General, whereas the ornate GSWA logo appears (for the first time on a statewide map) on the black and white sketch. Both maps were produced by the Government Lithographer, HJ Pether, Perth.

Andrew Gibb Maitland became the second permanent Government Geologist in 1896, and by 1910 the Geological Survey had a staff of five geologists and a surveyor. Considerable work had already been done in the Yilgarn, Eastern Goldfields, and the Pilbara (the latter by Gibb Maitland himself).

This map is a generalized view of the broad geology of the State as known at that time, and it is the first to have geology interpreted throughout the whole of Western Australia. It did include information gained by the early explorers. Surprisingly, it does not include the detailed mapping carried out by S Göczel in the Eastern Goldfields (published in the 'Report of the Department of Mines for the year 1895'). Göczel was employed in 1893 to assist Woodward, and spent most of his time studying the geology of the newly discovered Eastern Goldfields. He, like most of the prospectors, had identified the importance of the greenstones as a host for the gold. He also recognized the linear nature of the greenstones and bravely, if rather rashly, linked them up in a series of north-northwesterly trending belts. As was found by later work, the belts link up in a more northerly direction but nevertheless this map shows the extent of the knowledge in the years since Woodward's map was drafted.

The 1910 State map has a topographic reference and a simplified geological explanation at the bottom, with rocks simply divided in Recent (R), Mesozoic (M), Palæozoic (P), Metamorphic (Sc), Greenstones (Di), and Granite and gneiss (Gn). In contrast, the 1911 sketch has a different layout, no topographic reference, and a slightly more simplified geology — but a closer look indicates some conceptual differences. For example, the 1911 sketch has a single Mesozoic block for the broad Eucla region instead of a subdivision into an inland region of Mesozoic age and Recent outcrops along the coast. A belt extending roughly easterly from the present-day Gascoyne to the Musgrave region is labelled simply as Metamorphic on the 1910 map, but as sediments of possible 'Pre-Cambrian' age on the black and white 1911 sketch. The latter also identifies greenstones as possibly Precambrian in age, but not the surrounding granites and gneisses, whose age is indicated as unknown. On both maps, however, it appears that the geological framework of Western Australia is starting to emerge clearly, with the Yilgarn, Pilbara, and Kimberley blocks, a Precambrian metamorphic belt in the centre, and Phanerozoic deposits in the remaining areas.

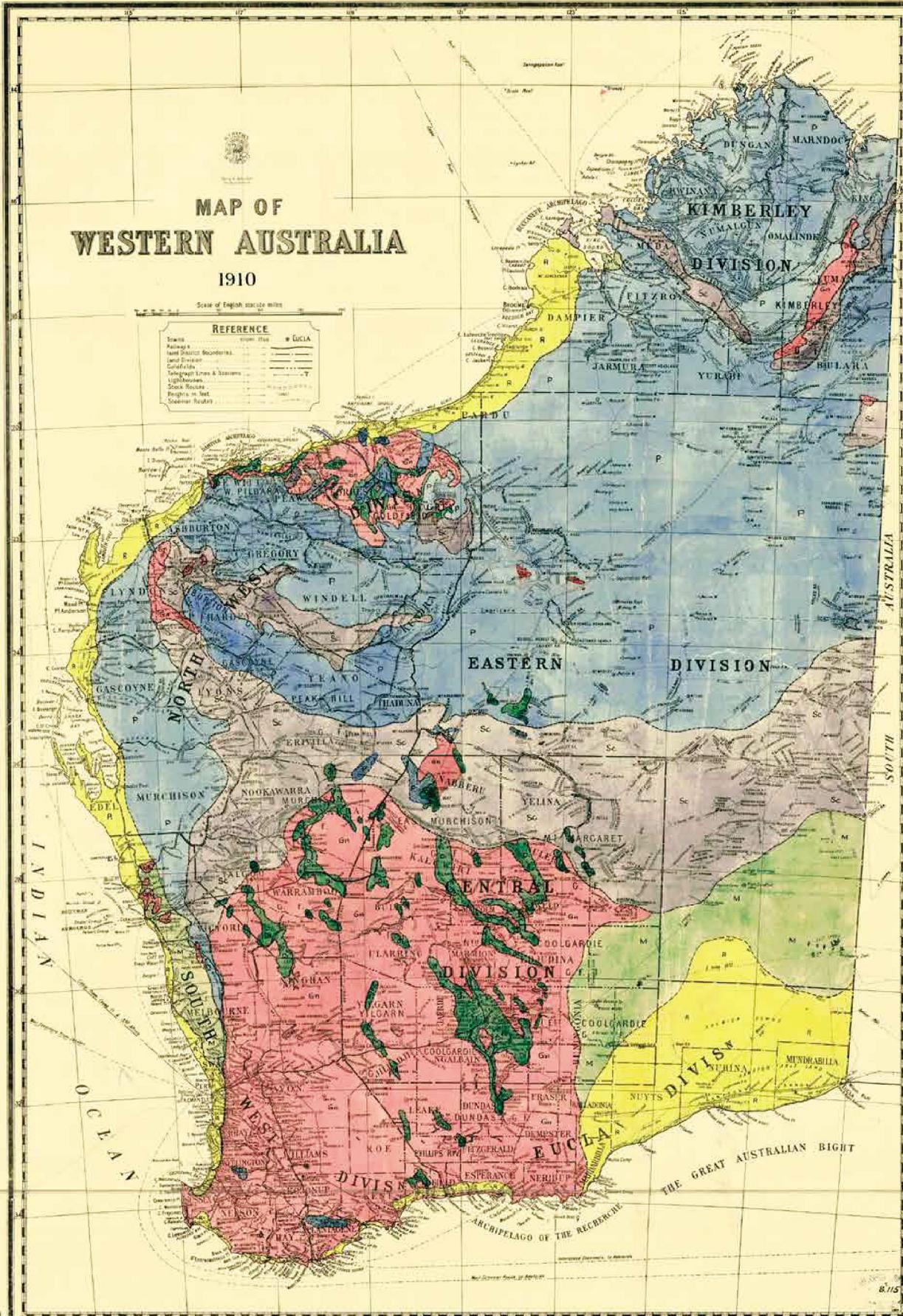


MAP OF WESTERN AUSTRALIA

1910

Scale of English statute miles

REFERENCE	
Towns	◆
Railways	—
Land Division Boundaries	—
Land Division	—
Counties	—
Telegraph Lines & Stations	—
Lighthouses	—
Stock Routes	—
Peagies or Salt	—
Superior Roads	—



Size of map, 857 mm x 577 mm



EXPLANATION					
R	Recent	M	Mesozoic	P	Palaeozoic
Sc	Metamorphic	Gn	Granite & Gneiss	Bl	Greenstones

State geological maps

1916 State map

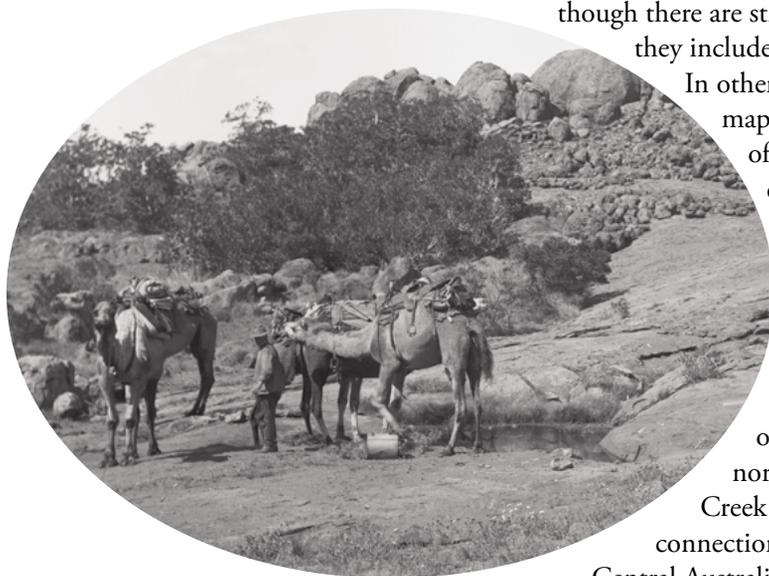
Little is known about this map. Compiled by FS Brockman as Acting Surveyor General and printed by the Government Lithographer, HJ Pether, it bears the logo of the Department of Lands and Surveys. The only copy available is a badly torn version that depicts less geology than represented on the 1910 State map, leaving large tracts of the interior barren of any interpretation. However, some of the geology illustrated is delineated in more detail than previously, notably the greenstone belts in the central Yilgarn and Murchison regions.

A note in the 'Report of the Department of Mines for the year 1916', refers to the endeavour of producing a geological sketch map of Western Australia as the main aim of the Survey since its inception. The map was '... being prepared from all sources', but with new material '... always coming to hand as our observations proceed' the necessity of closing the record on a given date was acknowledged, and to this purpose the end of the year 1916 had been tentatively fixed. The note acknowledges that areas imperfectly explored had to be left blank, and that '... The geological formations of Western Australia are in all probability much more numerous than those shown on the map, and within the large areas of Pre-Cambrian rocks no subdivision has yet been attempted,

though there are strong scientific reasons for believing that they include several discordant stratigraphic units.

In other cases, the relatively small scale of the map (1:1,584,000) precludes the possibility of showing formational divisions. The expedition to the South Australian Border has brought to light many important facts regarding the geology of a portion of the State, about which little was known, and the discoveries have more than local significance.

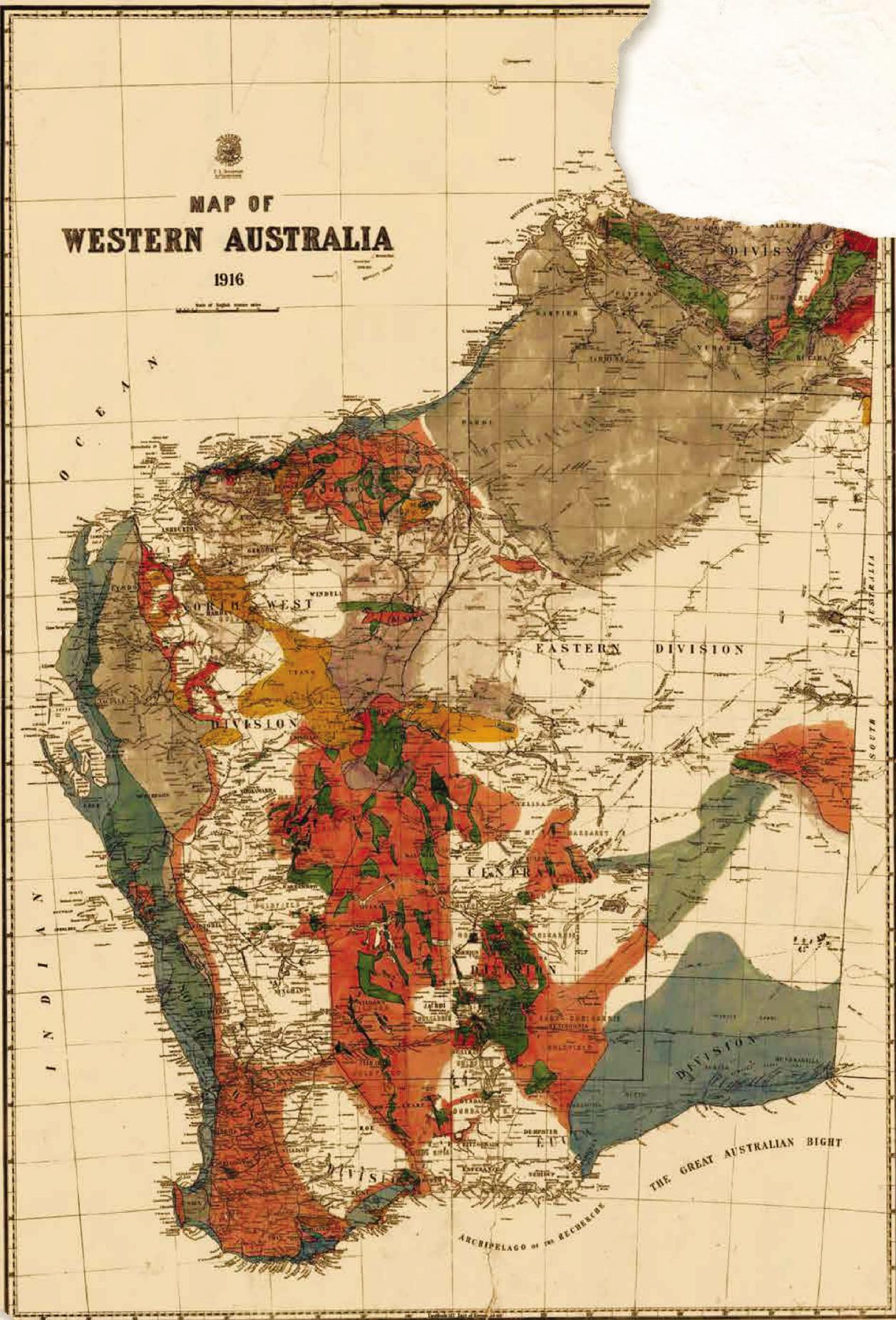
These, in conjunction with the results of the traverse from Wiluna, across the north-eastern portion of the State to Hall's Creek and Tanami, have enabled a geological connection to be effected with known areas in Central Australia.'



The 1916 State map in GSWA's archive probably represents an interim draft; work on a State map was likely delayed by the war effort as several employees '... responded well to the call of their King and country', with a number of staff enlisting for active service. From the note referred to above it appears however that under the direction of Gibb Maitland the Geological Survey was becoming more assertive of its role '... to lay a basis for future scientific observations by accurately mapping the relation of the various formations met with in a given district' — as also indicated by the fact that the next State map will bear the Geological Survey logo for the first time.


MAP OF
WESTERN AUSTRALIA
 1916

Scale of English linear units



Size of map: 817 mm X 553 mm

State geological maps

1919 and 1920 State maps

Compiled by FR Feldtmann under Gibb Maitland's direction, the 1920 State map was first published as a preliminary edition to accompany the Geological Survey of Western Australia annual report for 1918. The 1920 edition was published to accompany Gibb Maitland's magnum opus, his Memoir 'The mining handbook of Western Australia'. The name of the Hon. J Scaddan MLA, the then Minister for Mines, appears below the Geological Survey logo. The maps were drafted by CB Kidson, and printed by Fred WM Simpson, the Government Printer in Perth at the time.

Before 1910 most of the geological mapping carried out by the Geological Survey had been linked to areas of known prospectivity. After 1910, Maitland organized reconnaissance mapping over broader areas, and results of this mapping were published in a series at a scale of 1 inch to 4 miles (~1:250 000). The 1920 map includes the results of this work — and the results of the expedition of HWB Talbot (his initial is inscribed in rock in the image below) and E de C Clarke to the Warburton Range area in 1916, where Talbot and his field assistant were attacked and speared by Aboriginals. The field assistant was wounded so badly the expedition had to be delayed. This is the only known example of direct physical conflict between Aboriginals and staff of the Geological Survey.

Ever since 1908, Gibb Maitland's ambition had been to publish a four-sheet map of the geology of Western Australia at a scale of 1 inch to 25 miles (~1:600 000). This never eventuated — the Geological Survey lost staff during the First World War, and after 1920 was reduced in strength to three geologists. The opportunity was lost, and Gibb Maitland retired in 1926 a disillusioned man.

Like the 1910 edition, the 1919 and 1920 State maps have a topographic reference and a geological explanation at the bottom, but with the latter introducing more detail. For example, the Mesozoic is partitioned into Cretaceous and 'Jurassic and undifferentiated Cretaceous', the 'Palæozoic' into 'Permo-Carboniferous and Carboniferous', Devonian, Ordovician, and Cambrian. Precambrian rocks are subdivided into Proterozoic and 'Archæozoic' for the first time, and the first 'stratigraphic' names make their appearance on a State map legend with the possibly upper Proterozoic Nullagine system, and the Proterozoic Mosquito Creek and Stirling Range Beds. Igneous rocks are not given ages, being subdivided into 'Granite and gneiss', 'Porphyries and porphyrites', 'Basalt', 'Dolerite dykes and sills', and 'Gabbro, dolerite, epidiorite, serpentine'. The latter two lithological groupings are identified as post- and pre-gold greenstones, clearly indicating increased understanding of the geology of gold mineralization within these belts. Emphasis on gold mineralization in Proterozoic rocks is evident, with references to auriferous conglomerates and reefs.





GEOLOGICAL SKETCH MAP OF WESTERN AUSTRALIA.

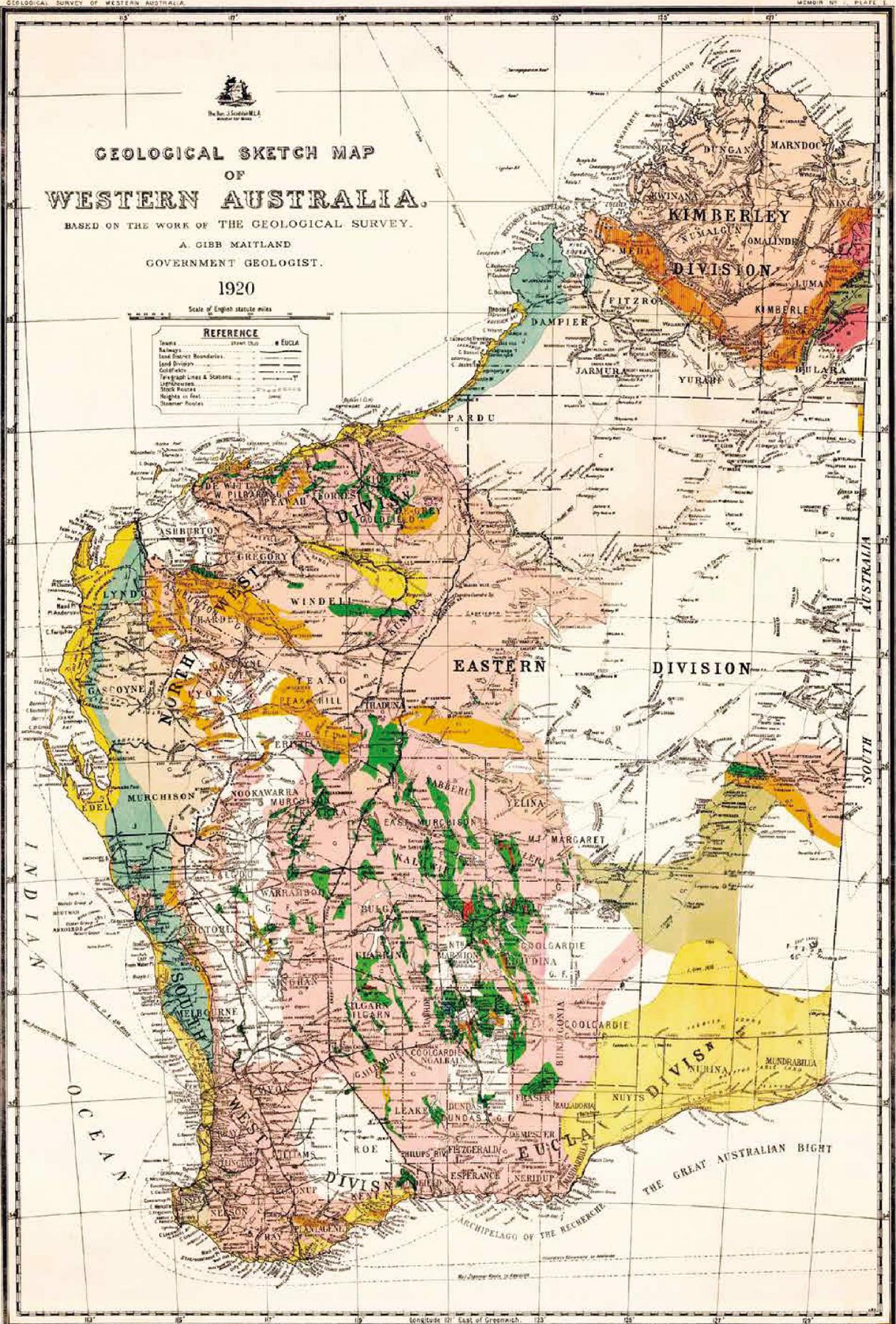
BASED ON THE WORK OF THE GEOLOGICAL SURVEY.

A. GIBB MAITLAND
GOVERNMENT GEOLOGIST.

1920

Scale of English statute miles

REFERENCE	
Towns	Open Circle
Railways	Open Line
Land District Boundaries	Thin Solid Line
Local Divisions	Thick Solid Line
Gold Fields	Star
Tramway Lines & Stations	Line with Cross-ticks
Lighthouses	Star with Circle
Windmills	Star with Square
Heights in Feet	Number in Circle
Steamer Routes	Dashed Line



CENOZOIC		MESOZOIC		PALAEOZOIC		PROTEROZOIC		ARCHAEOZOIC		IGNEOUS		
K	J	M	C	D	O	P	A	G	S	B	D	
Quaternary and Post-Tertiary Cenozoic Tertiary Pleistocene, Pliocene, Miocene, etc.	Cretaceous	Jurassic and Cretaceous Triassic and Permian	Permian, Carboniferous and Carboniferous	Devonian	Ordovician	Cambrian	Proterozoic (Archaean and Palaeozoic) Murchison, Green, and Shilling Range Series (Archaean and Palaeozoic)	Archaean Unfractionated metamorphic rocks (Archaean)	Granite and gneiss	Diorites and gabbros	Basalt	Diabase Gabbro Andesite (The andesites are of the same age)

Size of map: 880 mm x 504 mm

State geological maps

1933 State map

This map was compiled by F Armstrong under T Blatchford's direction (under the Hon. SW Munsie MLA as Minister for Mines). Printed by Fred WM Simpson, the Government Printer, it bears the price of two shillings.

The 1933 State map differs very little from that of 1920 as, with a reduced staff, the Geological Survey had not been able to undertake any regional work. The main differences are in some rearrangements in age attribution on the legend at the bottom of the map, some generalization in the Canning Basin, the separation of Cretaceous from Jurassic at Gingin and Shark Bay, the distinction of Cambrian basalts in the east Kimberley, the 'formalization' of a Kalgoorlie Series, and, interestingly, the inclusion of the geology of the Rawlinson Range near the Northern Territory border. In the later part of 1931, while on leave from the Geological Survey, Blatchford had unofficially joined a party led by Bob Buck in the search for Lasseter's Reef. The party, which included Blatchford's old colleague HWB Talbot, reached the Rawlinson Range from the Northern Territory side. No mention was made of this adventure officially.

Another interesting aspect of this map is that it was compiled by Florence Armstrong who, although a graduate in geology from The University of Western Australia, was employed by the Geological Survey as a clerical assistant. It was another 30 years before the Survey employed its first female geologist and even more before women were allowed to do fieldwork in the late 1960s.



GEOLOGICAL SKETCH MAP OF WESTERN AUSTRALIA.

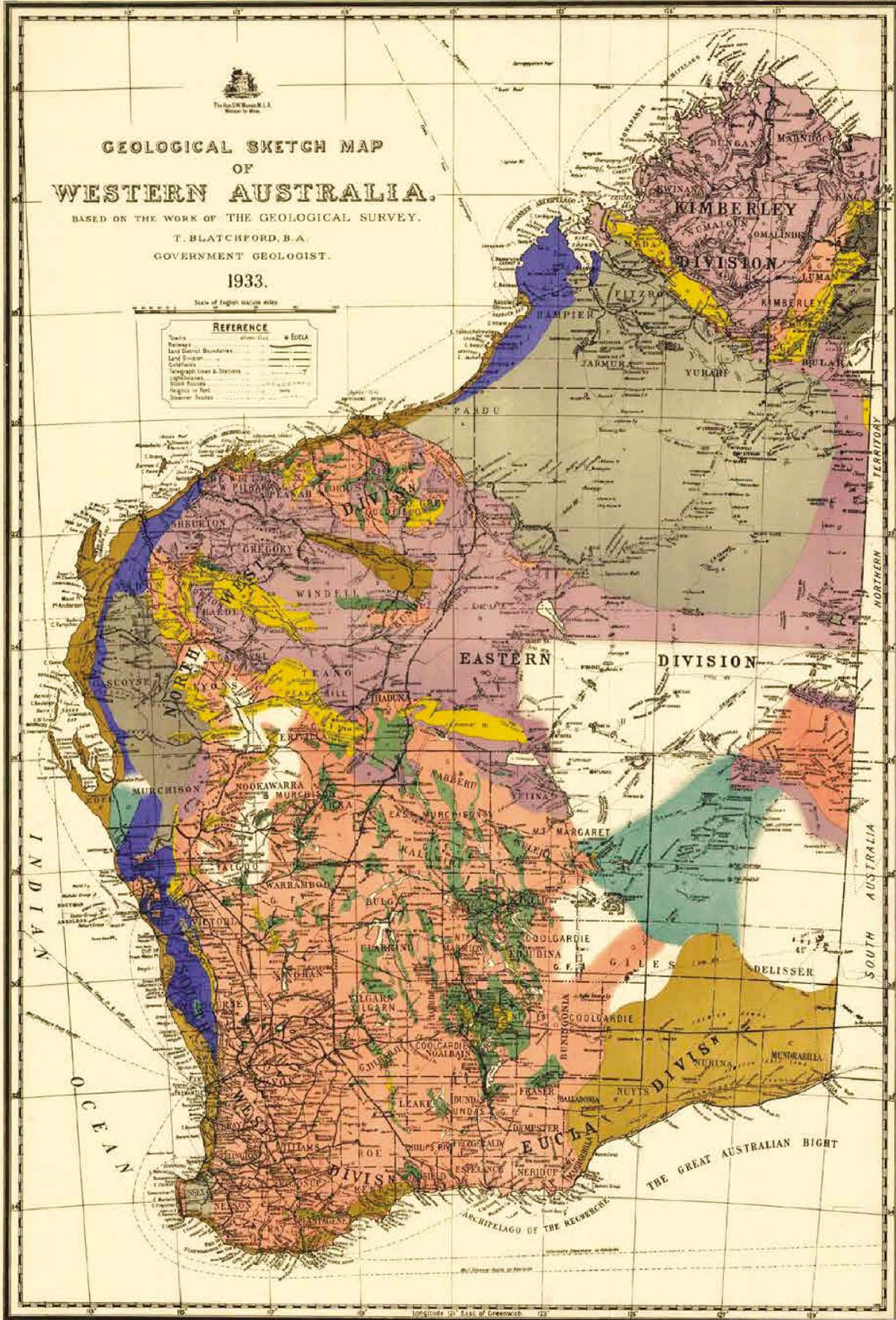
BASED ON THE WORK OF THE GEOLOGICAL SURVEY.

T. BLATCHFORD, B.A.
GOVERNMENT GEOLOGIST.

1933.

Scale of English statute miles

REFERENCE	
Swells	—
Railways	—
Land District Boundaries	—
Land Division	—
Coastline	—
Telegraph Lines & Stations	—
Lighthouses	—
Stake Posts	—
Height in feet	—
Geometrical Figures	—



Geology compiled by F. Armstrong, B.Sc.

CENOZOIC	MESOZOIC	PALEOZOIC	PROTEROZOIC	WECAMBERIAN (Unaffiliated)
Tertiary and Post-Tertiary	Cretaceous	Permian	Silurian	WECAMBERIAN (Unaffiliated)
Quaternary	Jurassic	Carboniferous	Devonian	WECAMBERIAN (Unaffiliated)
Recent	Triassic	Permian	Carboniferous	WECAMBERIAN (Unaffiliated)
Recent	Triassic	Permian	Carboniferous	WECAMBERIAN (Unaffiliated)
Recent	Triassic	Permian	Carboniferous	WECAMBERIAN (Unaffiliated)

Price 2/-

Size of map: 890 mm X 568 mm

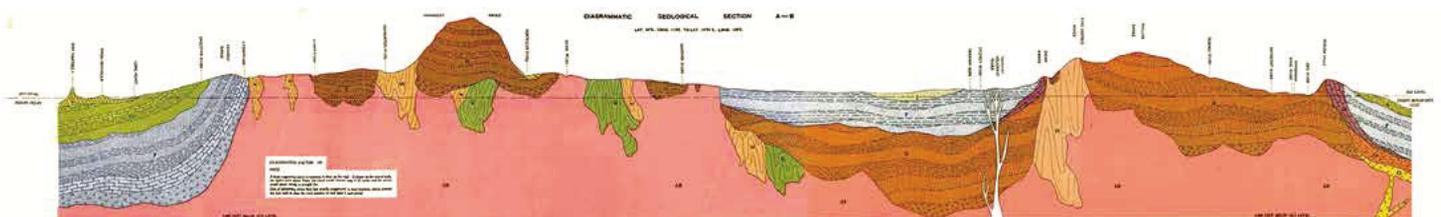
State geological maps

1950 State map

This map was compiled by JH Lord and NM Grey under Government Geologist HA Ellis (and the Hon. CH Simpson MLC as Minister for Mines). It was used as a Plate in GSWA Bulletin 95 — a revised edition of GSWA Bulletin 61 'The physiography (geomorphology) of Western Australia' by JT Jutson.

On this map, modifications to the 1933 map are the result of surveys conducted in the Yilgarn (1935–1938), at Mount Margaret (1939–1946), and in the Yalgoo – west Murchison Goldfields (1949). Also included are data derived from AGGSNA (Aerial Geological and Geophysical Survey of Northern Australia) in the Pilbara, and from oil companies and the Commonwealth Bureau of Mineral Resources (now Geoscience Australia) in the Canning–Fitzroy and Carnarvon Basins, as well as contributions by the Department of Geology of The University of Western Australia and 'various mining companies' — a sign of the productive collaboration of the Survey with industry and academia that continues to the present day.

Several new elements characterize the layout of this map. The scale is labelled for the first time not in English statute miles (to differentiate from nautical miles), but as '40 miles to 1 inch' and as 1:2 534 400, very close to the standard 1:2 500 000 scale of more-recent State maps. The ornate logo of the Geological Survey is replaced by the simpler one that is still current. The legend is still located at the bottom, but the coloured boxes and simple codes are accompanied by notations on 'Occurrence' that also include estimates of thicknesses of sedimentary deposits. Triassic rocks are tentatively identified for the first time; Silurian is also listed in the legend, though with 'No occurrence yet known'. But perhaps the most remarkable aspect of the 1950 State map is the inclusion of cross sections for the first (and last) time. Two cross sections are drawn in a northeasterly direction: one from Margaret River through Coolgardie to the West Australian border, the other from Shark Bay through the Gascoyne region to the West Kimberley — thus intersecting all of the major tectonic blocks of the State. The cross sections are drawn horizontally and vertically on the map, and are accompanied by notes on the interpretation of various geological packages.



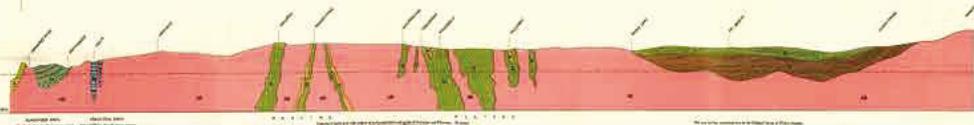
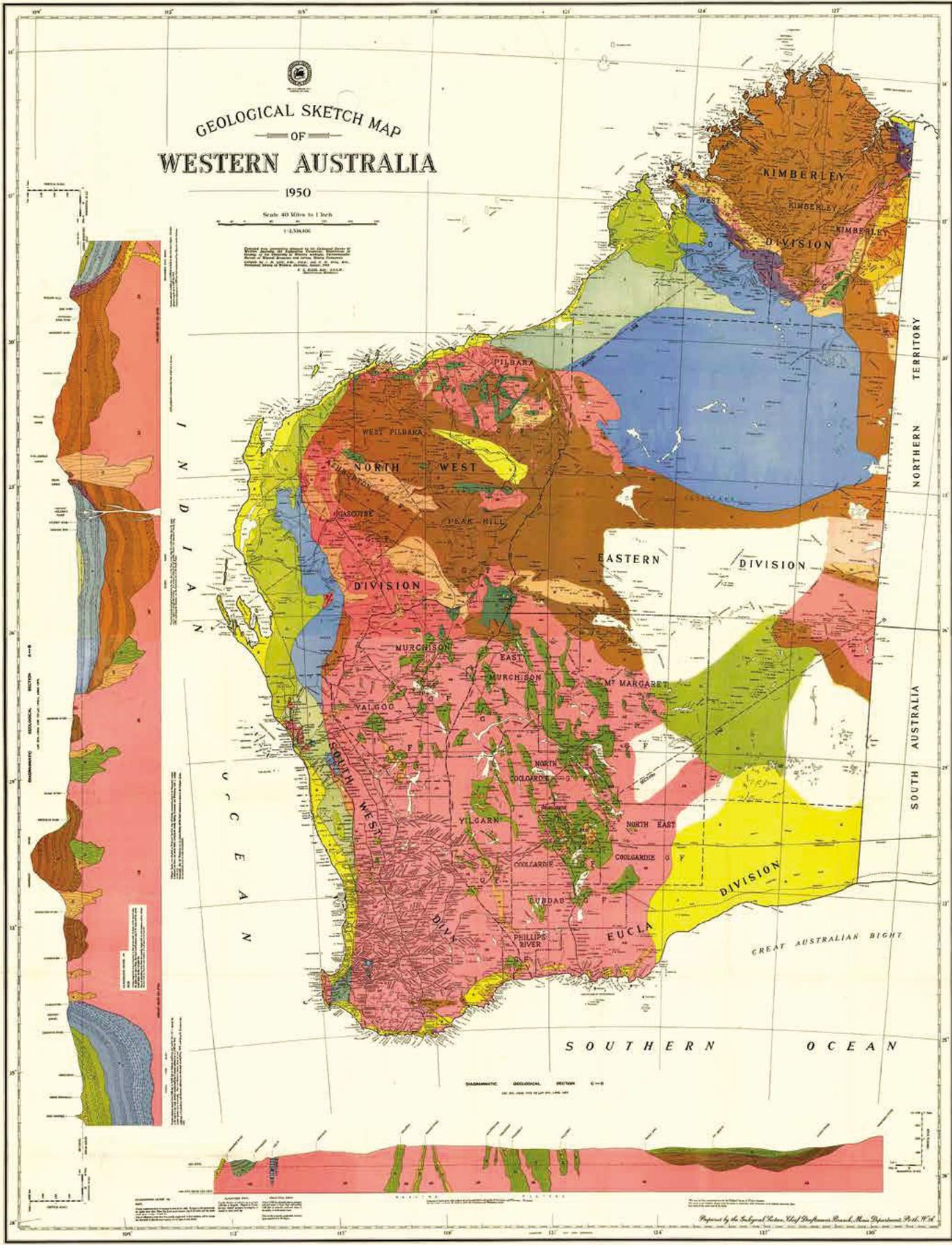
GEOLOGICAL SKETCH MAP OF WESTERN AUSTRALIA

1950

Scale 40 Miles to 1 Inch

1:3,168,000

Geological Survey of Western Australia
Geological Department, Perth, Western Australia
1950



SYMBOLS: GEOLOGICAL SECTION G-10

Prepared by the Geological Section, Chief Geographer's Branch, Mining Department, Perth, W.A.

SYMBOL	DESCRIPTION
[Symbol]	Unconsolidated deposits
[Symbol]	Consolidated deposits
[Symbol]	Quaternary
[Symbol]	Tertiary
[Symbol]	Cretaceous
[Symbol]	Jurassic
[Symbol]	Triassic
[Symbol]	Permian
[Symbol]	Carboniferous
[Symbol]	Devonian
[Symbol]	Silurian
[Symbol]	Ordovician
[Symbol]	Pre-Cambrian

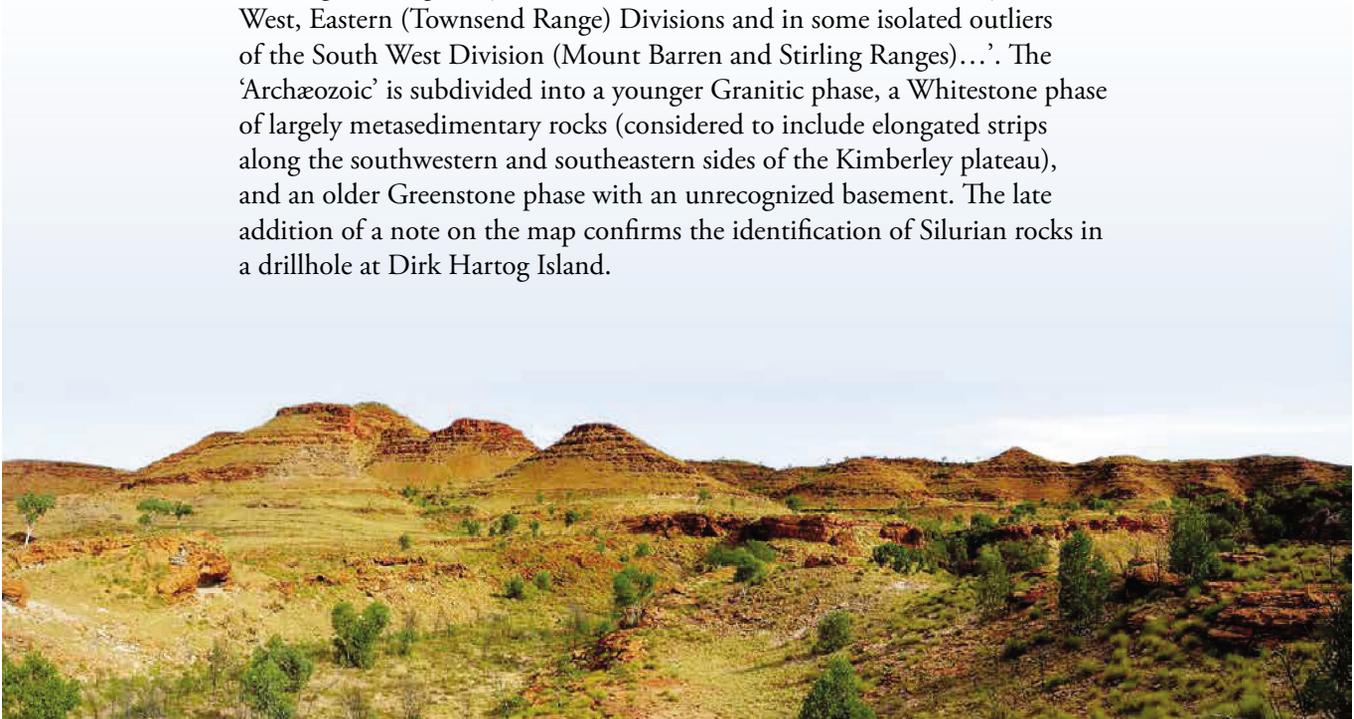
Size of map: 1,247 mm x 910 mm

State geological maps

1957 State map

This map was compiled by GH Low and RR Connolly under Government Geologist HA Ellis. The Minister for Mines was LF Kelly MLA. The map differs very little from the 1950 map, except in the areas of the Canning and Carnarvon Basins, which were modified after 1 inch to 4 mile (~1:250 000-scale) sheet mapping carried out by the Bureau of Mineral Resources and from results of exploration by oil companies, particularly WAPET (West Australian Petroleum) which had discovered oil at Rough Range in 1954.

This is the last State map that depended largely on mapping carried out by traditional methods (plane-table, telemetry, and pace and compass) and guesswork. In a departure in style from the preceding four State maps (1910 to 1950), the legend for this boldly coloured map is not confined to a strip at the bottom but is incorporated in two sections on the left hand side of the map itself. The lower section explains the lithologies/colours used on the map, whereas the upper part is a lengthy textual explanation of the legend itself, listing where rocks of each age have been identified, their broad lithological characteristics, and indicating the estimated thickness of sedimentary sequences. Several stratigraphic names and tectonic subdivisions are identified, some of which are still current today. Phanerozoic rocks are starting to be described in some detail, but Precambrian rocks are still only broadly assigned — the subdivision of these awaits the advent of geochronological dating. Proterozoic outcrops are simply designated as part of a single Nullagine System (or Series), identified in the ‘Kimberley, North West, Eastern (Townsend Range) Divisions and in some isolated outliers of the South West Division (Mount Barren and Stirling Ranges)...’. The ‘Archæozoic’ is subdivided into a younger Granitic phase, a Whitestone phase of largely metasedimentary rocks (considered to include elongated strips along the southwestern and southeastern sides of the Kimberley plateau), and an older Greenstone phase with an unrecognized basement. The late addition of a note on the map confirms the identification of Silurian rocks in a drillhole at Dirk Hartog Island.



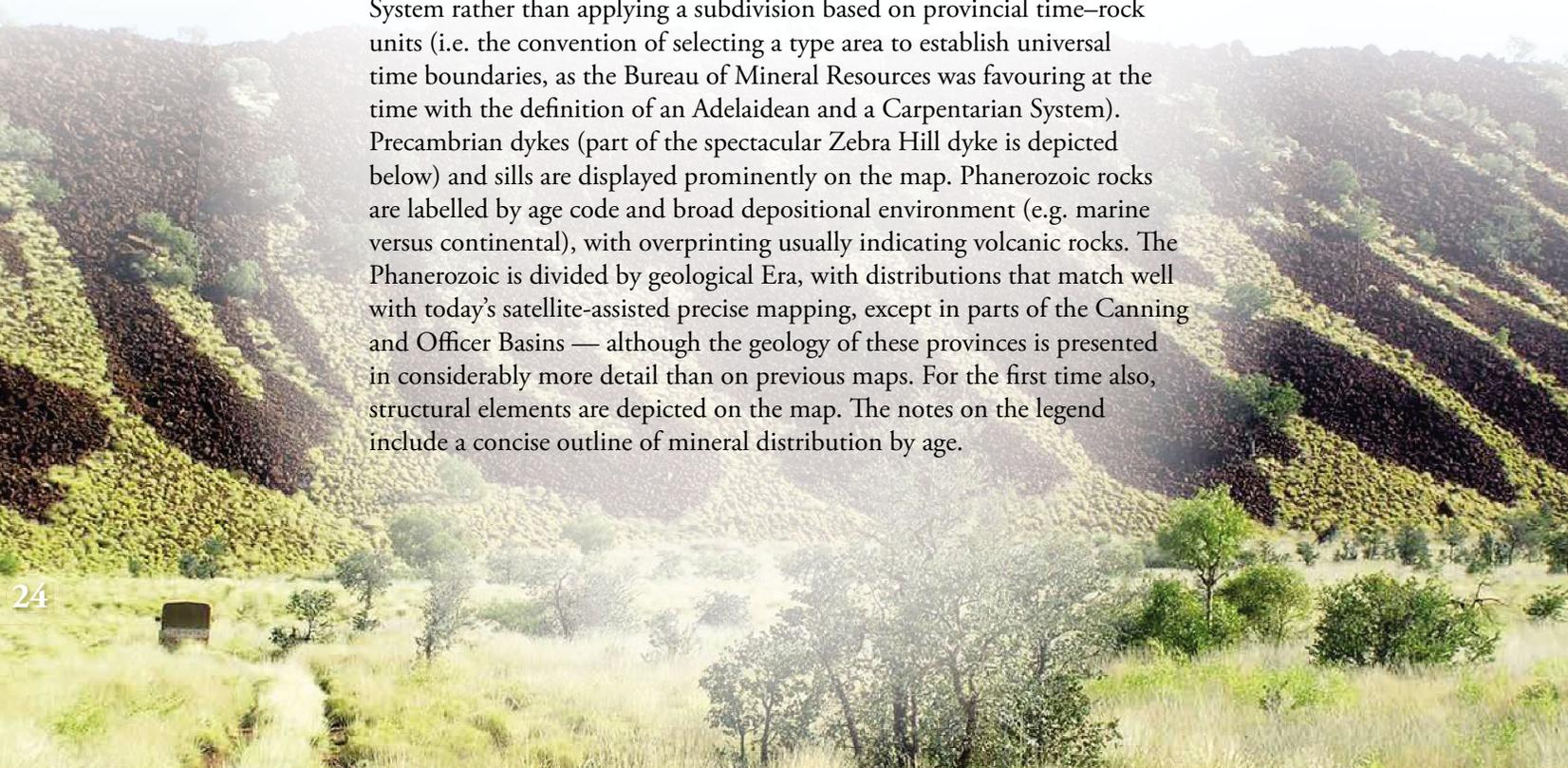
State geological maps

1966 State map

This map was compiled by RC Horwitz and the regional mapping section under the direction of JH Lord, and shows the Hon. AF Griffith MLC as Minister for Mines. Brief explanatory notes on the legend were published in the 'Annual report of the Geological Survey for 1965'. The map was printed by Alex B Davies, the then Government Printer.

Until 1966 the published geological maps of the State were revisions of the 1920 map of Gibb Maitland. The 1966 State map is a completely new version based on aerial photograph interpretation and benefitted from the ongoing 1:250 000-scale regional-mapping program started in the mid-1950s, as well as from interpretation of aeromagnetic data flown at one- to ten-mile intervals — variations in reliability are indicated by a diagram in the bottom-right corner of the map. For the first time since the 1910 State map, the geology of Western Australia encompasses the entire State, without any gaps in interpretation. The scale is also changed from the previous Imperial 1 inch to 40 miles to the metric 1:2 500 000, with both scale bars shown.

As stated in the explanatory notes for the 1966 State map legend, where possible, units on the map are classified according to age. Radiometric age determinations, although not precise, allowed the subdivision of Precambrian rocks on a more-detailed basis than had been previously feasible. Intrusive rocks and zones of high-grade metamorphism are arranged separately on the legend, and areas of 'undetermined' Precambrian are still present where their absolute age was unknown or they had not been differentiated. The Proterozoic rocks are divided into lower (2440 to 1640 Ma), middle (1640 to 900 Ma), and upper Proterozoic (900 to 600 Ma), following the Canadian System rather than applying a subdivision based on provincial time–rock units (i.e. the convention of selecting a type area to establish universal time boundaries, as the Bureau of Mineral Resources was favouring at the time with the definition of an Adelaidean and a Carpentarian System). Precambrian dykes (part of the spectacular Zebra Hill dyke is depicted below) and sills are displayed prominently on the map. Phanerozoic rocks are labelled by age code and broad depositional environment (e.g. marine versus continental), with overprinting usually indicating volcanic rocks. The Phanerozoic is divided by geological Era, with distributions that match well with today's satellite-assisted precise mapping, except in parts of the Canning and Officer Basins — although the geology of these provinces is presented in considerably more detail than on previous maps. For the first time also, structural elements are depicted on the map. The notes on the legend include a concise outline of mineral distribution by age.



State geological maps

1973 State map

This map was specifically compiled for inclusion in Memoir 2, a flagship publication of the Geological Survey that summarizes the status of the geological knowledge for Western Australia and was prompted by a suggestion from the Geological Society of Australia. The stratigraphy of Western Australia had last been summarized in 1958, in a special issue of the *Journal of the Geological Society of Australia*, and much of this content and style carried over into Memoir 2. Memoir 2, titled 'The geology of Western Australia', was published in 1975, four years after its intended release due to '... a dramatic upsurge of exploration activity in the State which depleted the Geological Survey of intended authors' with six of the nine proposed senior geologists resigning to enter industry (quote taken from AF Trendall's 1983 preface to the second impression of Memoir 2) — a problem that the Survey experienced again and again after the nickel exploration boom of the 1970s. The map and Memoir 2 were intended to celebrate the 75th anniversary of the permanent establishment of the Geological Survey of Western Australia.

No specific author is identified; instead the map is presented as a combined effort of Geological Survey staff. The accompanying Memoir 2 was coordinated by AF Trendall for the Precambrian and PE Playford for the Phanerozoic. This is the second State map produced under the directorship of JH Lord; the Hon. DG May MLA was then Minister for Mines. The map was printed by the Government Printing Office, and for the first time Crown Copyright is specifically reserved on the map.

The most striking difference between the 1966 and 1973 State maps is the introduction of a new colour scheme for rock units, a scheme that with minor additions and modifications is currently used. The Phanerozoic legend is only minimally different from the 1966 map, but Precambrian rocks are further subdivided compared to previous editions. For this map the geology was completely reinterpreted and recompiled in the light of the intensive 1:250 000-scale regional-mapping program in progress at the time, using modern aerial photography (as shown below). Quaternary cover, largely unrepresented on previous State maps, is depicted in some detail. The inclusion of blue-coloured bathymetry for the offshore of Western Australia is also new, and a legend for topographic symbols is again provided (the latter was missing on the 1950, 1957, and 1966 State maps). Structures (mostly regional-scale faults and folds) are depicted in more detail. For the first time a 'Main tectonic units' inset map is present, which forms the natural basis for the descriptive geological account given in Memoir 2. The map is noticeably a modern surface geology map, rather than a sketch map.



State geological maps

1979 State map

This map was released to celebrate the sesquicentennial of the State of Western Australia. It was added to a reprint of Memoir 2, made necessary by depletion of stock and continued demand for the publication. As AF Trendall stated in the 1983 preface to the reprinted Memoir 2, a decision to reprint rather than update Memoir 2 was made as the State was ‘... once more on the crest of an accelerating wave of geological knowledge’ and a choice to reprint was made rather than releasing a dated volume. This State map was the third published under the directorship of JH Lord, with a new Minister for Mines, the Hon. A Mensaros. Like the previous edition, copyright is reserved to the Crown, and copies of the map were made available through the Geological Survey’s office at Mineral House, then addressed as 66 Adelaide Terrace. The map was compiled by RD Gee and other geologists of GSWA (principally for the Phanerozoic basins) with additional data from the Commonwealth Bureau of Mineral Resources, The University of Western Australia, and oil and mineral exploration companies.

The year 1979 saw the completion of the systematic mapping of the State at 1:250 000 scale (see example below). The 1979 State map clearly reflects the improved geological knowledge from previously unmapped regions — note the difference in the reliability diagram of this map compared to the one on the 1973 State map, which itself showed considerable advances over the 1966 map. The ‘Main tectonic units’ inset is modified to include a new understanding of the tectonic framework of Western Australia (e.g. the newly investigated Nabberu Basin) and the adoption of terminology between the ‘Kimberley Block’ and the ‘Musgrave Block’ that follows that established for Central Australia.

For the first time, a time scale in million years is introduced on a State map, testimony to the increasing accuracy of geochronological dating and the augmented knowledge of the lateral and vertical relationships of different rock units stemming from the intense mapping program carried out by the Geological Survey. This is also reflected in the more-detailed stratigraphic relations depicted in the legend.



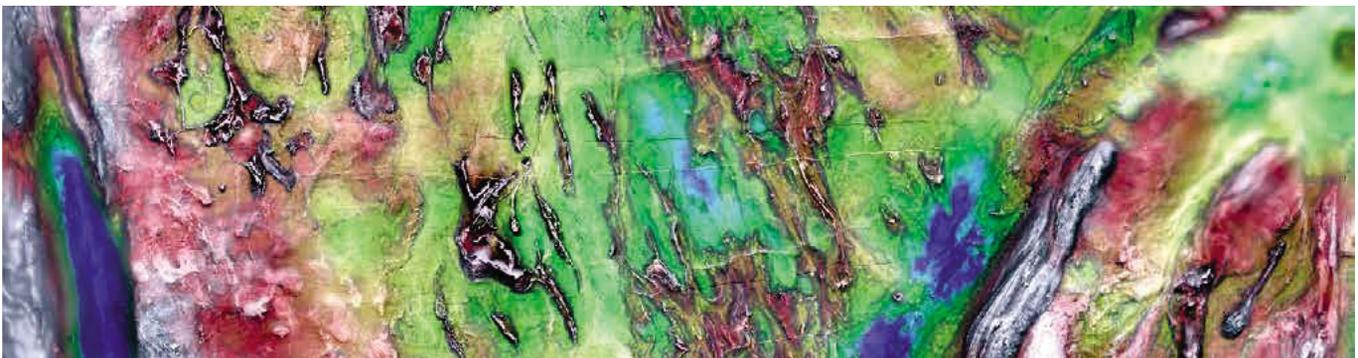
State geological maps

1988 State map

The 1988 State map was released to celebrate the centenary of the establishment of the Geological Survey of Western Australia and was included in Memoir 3 'Geology and mineral resources of Western Australia'. It was compiled by JS Myers and RM Hocking under the directorship of PE Playford, with the Hon. Jeff Carr MLA as the Minister for Mines, and DR Kelly as the Director General of Mines. The map is the first to specify the edition on the map face. Copies were available through the Survey's office at 100 Plain Street in East Perth — the office had not moved but its main entrance had been shifted around the corner from Adelaide Terrace when a new wing of Mineral House was built.

Although similar at first impression, this map represents a substantial advance on the previous edition. It contains more detailed stratigraphic and structural information for many areas, notably the Kimberley, Pilbara, and south coast and Wheatbelt regions. Also included on the map face for the first time are symbols showing syenite intrusions, diatremes, diapirs, and impact structures of significance. Large amounts of information from the considerable progress made by Survey geologists in unravelling the geological history of the State are synthesized in a newly structured legend, the details of which are explained in a separate booklet included with Memoir 3.

A different nomenclature is applied to the main structural subdivisions, using cratons (represented by red units), orogens (orange units), and basins (green units) as principal entities — as shown on the small sketch map. Major units are indicated by capital letters, and complexes and basins within the cratons and orogens are shown in lower-case letters. A more comprehensive legend than before stems from the use of sequence-based stratigraphy within Phanerozoic successions that recognized major unconformity-bounded units; subdivisions in the Precambrian are based on age, stratigraphy, and lithology. The time legend in millions of years includes blue lines to indicate the age range for the units shown as various coloured rectangles; two changes in scale — between Paleocene and Cretaceous and between Cambrian and Precambrian — allow more detailed representation of the Phanerozoic units.



GEOLOGICAL MAP OF WESTERN AUSTRALIA

1988



MAIN GEOLOGICAL UNITS

SYMBOLS

Geological boundary	—
Fault	—
Water	—
North-south magnetic meridian	—
Geological survey boundary	—
Survey boundary	—

PHANEROZOIC ROCKS

Period	System	Group	Formation	Age
Cenozoic	Quaternary	Alluvium	Recent	Q1
			Recent	Q2
			Recent	Q3
			Recent	Q4
			Recent	Q5
			Recent	Q6
			Recent	Q7
			Recent	Q8
			Recent	Q9
			Recent	Q10
Tertiary	Cenozoic	Cenozoic	Recent	Q11
			Recent	Q12
			Recent	Q13
			Recent	Q14
			Recent	Q15
			Recent	Q16
			Recent	Q17
			Recent	Q18
			Recent	Q19
			Recent	Q20

PRECAMBRIAN ROCKS

Group	Formation	Age
Murchisonian	Yalgoo	1800-1700 Ma
	Yalgoo	1700-1600 Ma
	Yalgoo	1600-1500 Ma
	Yalgoo	1500-1400 Ma
	Yalgoo	1400-1300 Ma
	Yalgoo	1300-1200 Ma
	Yalgoo	1200-1100 Ma
	Yalgoo	1100-1000 Ma
	Yalgoo	1000-900 Ma
	Yalgoo	900-800 Ma
Gardinerian	Yalgoo	800-700 Ma
	Yalgoo	700-600 Ma
	Yalgoo	600-500 Ma
	Yalgoo	500-400 Ma
	Yalgoo	400-300 Ma
	Yalgoo	300-200 Ma
	Yalgoo	200-100 Ma
	Yalgoo	100-0 Ma
	Yalgoo	0-0 Ma
	Yalgoo	0-0 Ma

SCALE 1:250,000



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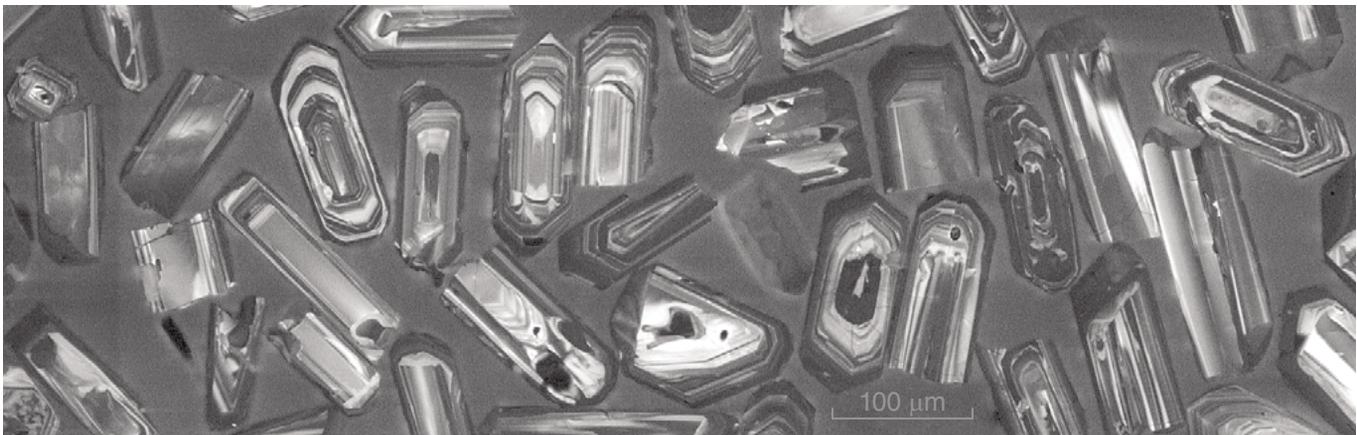
Size of map: 1,120 mm × 881 mm

State geological maps

1998 State map

This map, like the 1988 edition, was compiled by JS Myers and RM Hocking under the directorship of David Blight; LC Ranford and the Hon. Norman Moore MLC were, respectively, the Director General and Minister of the Department of Minerals and Energy at the time. This edition is the first to fully benefit from the complete mapping coverage of Western Australia at 1:250 000 scale. It was compiled at 1:1 000 000 scale from reductions of 1:250 000-scale maps, unlike the 1988 map for which Precambrian areas were compiled at final scale with a 0.1 mm Rapidograph pen. As a result, the 1998 State map is more accurate, but only as accurate as the 1:250 000-scale geology, compilation of which in places dated back to the mid-1950s.

The 1998 map benefitted from satellite imagery, the increased accuracy of aeromagnetic images captured in the preceding 10 years, the continued Survey mapping at 1:100 000 scale, and the routine use of geochronology (see zircons ready for dating, below). As a result it contains much more accurate structural information, and greater detail where mapping had extended earlier work. For example, there is far less Quaternary cover shown in the Murchison region of the northwest Yilgarn Craton because mapping and geochronology had resolved many geological uncertainties in that area. For the first time, a structural interpretation of areas offshore is also incorporated, based on Australian Geological Survey Organisation (now Geoscience Australia) interpretation. Increased geological knowledge for some areas led to a significant revision of stratigraphy in the onshore sedimentary basins. As with the 1973, 1979, and 1988 editions, the map depicts surface geology, but stacked units were utilized to show the bedrock geology beneath widespread or thick Cenozoic cover through many of the sedimentary basins. Other new additions to the map were paleodrainages (based on GSWA work from the 1970s), depth to Phanerozoic basement, and depth to Neoproterozoic basement (compiled statewide in the early 1990s). Additional impact structures were added, based on 1998 field mapping.



2015 State geological map

2015 State map

The 2015 Geological map of Western Australia was compiled by DMcB Martin, with assistance from RM Hocking, A Riganti, and IM Tyler, under the directorship of Rick Rogerson, with Richard Sellers and Hon. Bill Marmion MLA as the Director General and Minister for Mines and Petroleum respectively. The 2015 map was compiled as a 'roll-up' from statewide digital datasets assembled at 1:500 000 scale, and State geology is thus depicted at an unprecedented level of detail and accuracy because the accuracy is inherited from the 1:500 000-scale dataset. This is the first time that a State map has been compiled in this way, finally implementing a new procedure envisaged by Ian Tyler and Roger Hocking at the turn of the century, to deliver smart, spatially accurate geology over Western Australia.

The first step towards smart, spatially accurate statewide geology was made in 2001, when a digital 1:500 000-scale seamless interpreted bedrock geology (IBG) layer was compiled, primarily from extant 1:250 000-scale maps, by F Vanderhor and DJ Flint. This was then used to generate a new, detailed 1:500 000-scale tectonic units map of Western Australia, authored by IM Tyler and RM Hocking. The IBG and tectonic units layers were revised incrementally but slowly, and a new tectonic units version was released in 2007. Since then, small amendments have continued to be made on the tectonic units and the 1:500 000-scale geology datasets, but the big advances since 2001 were in developing the back end to the digital process. This came to fruition in 2014 with the release of fully reinterpreted and recompiled 1:500 000-scale geology and tectonic unit digital layers.

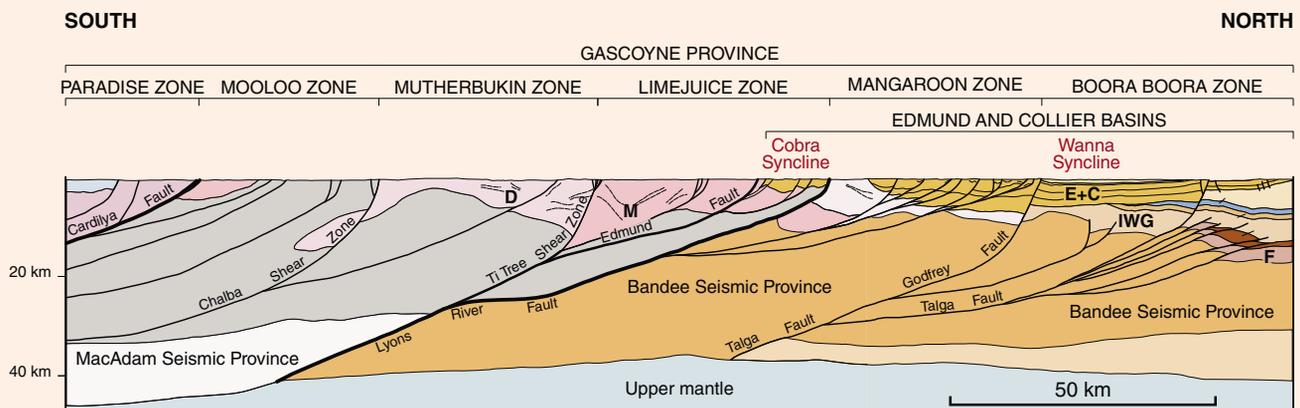
The 2015 edition of the 1:2 500 000 State geology map is released as two discrete products. There is a printed, hardcopy map, also available as a PDF file. The hardcopy map was derived from a collection of several, themed digital spatial datasets available online in GIS format — these make up the second product. Complementary explanatory notes are released as GSWA Record 2015/14 for the printed map. GSWA's Explanatory Notes System (ENS) has a similar function for the digital GIS layers, which include State interpreted bedrock geology (known as IBG), State Cenozoic geology, State interpreted dyke suites, and State interpreted bedrock geology structural lines. Together, the State digital layers and ENS constitute the incremental construction of a 'virtual Memoir 4'.

The layout of the 2015 hardcopy edition is conceptually similar to the 1998 State map. Geologically, however, the map incorporates major or significant reinterpretations brought about by the advances in geochronological and isotopic dating techniques of the last 15 years, as well as insights into the 3D structure of the Western Australian crust gained through deep crustal seismic and magnetotelluric surveys conducted since the early 1990s (see examples in figures overleaf). These reinterpretations have affected almost every area of Precambrian geology in the State, notably in the Capricorn,

2015 State geological map

Albany–Fraser, and Paterson Orogens, the Pilbara and Yilgarn Cratons, and the Musgrave and east Kimberley provinces. The 2015 map also abandons the concept of complexes for orogenic regions, and introduces suites and supersuites as major lithostratigraphic mappable units for igneous intrusive rocks. Geological features that are too small to show accurately at 1:2 500 000 scale have been updated, and include alkaline intrusions (previously classified as lamproite, kimberlite, and carbonatite diatremes), confirmed impact structures, syenite intrusions, and diapirs. The structural architecture of the State has been depicted in more detail than ever before, but with highly interpretive aspects, such as the offshore structure, having been removed or downplayed. The tectonic units inset map is now much more detailed, reflecting the significant advances made in understanding the basic architecture of the State over the last 17 years, and is now reproduced at 1:10 000 000 scale.

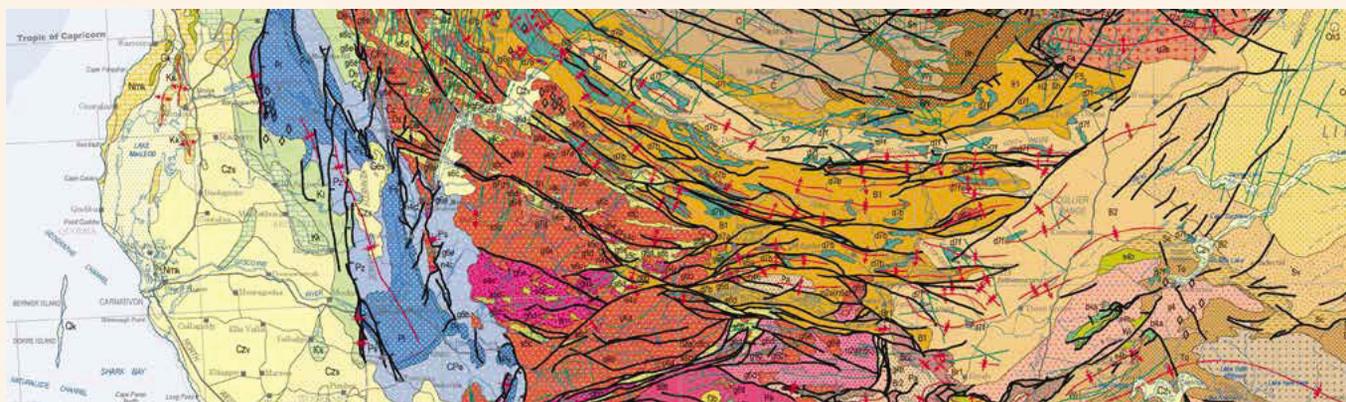
The legend for the 2015 edition is superficially similar to that of the 1998 map, but includes some notable changes and new additions. The grouping of the 100 million-year time slices used to subdivide the Precambrian has been adjusted to reflect currently recognized major periods of orogenesis and magmatism. Precambrian units are also more strictly subdivided according to lithostratigraphy. Formal units are distinguished and separately coded, with the known age ranges for each unit depicted with a blue line. Informal lithological units are more finely subdivided based on their known age ranges, shown with blue lines. Also, the Precambrian and Phanerozoic time scales have been united, albeit with some scale changes in the Phanerozoic to allow the depiction of more detail for these units. The coding system for the Phanerozoic, although different from the Precambrian, is now more detailed to allow the depiction of lateral facies variations. For the first time, the legend also depicts the temporal and broad spatial distribution of orogenic and tectonic events across the State as an annotated column showing the age range of each event. Also, dyke suites are shown in more detail than previously, thanks to the vast improvement in resolution of the statewide aeromagnetic dataset from which they are interpreted.



The digital data, from which the hardcopy 2015 State map was derived, incorporate four separate layers: the primary 1:2 500 000 State interpreted bedrock geology, the 1:2 500 000 State Cenozoic geology, the 1:2 500 000 Interpreted dyke suites of Western Australia, and the 1:2 500 000 State linear structures layer. The Cenozoic geology layer can be superimposed over the bedrock layer to allow the extension of older bedrock geology under Cenozoic cover where geological and geophysical information permits, and to depict Cenozoic paleovalleys and additional significant Cenozoic cover. The dyke suites layer is primarily interpreted from aeromagnetic data, using mapped dyke extents as a guide; individual dykes are formally named wherever possible. The attribution of linear structures and dykes as concealed or exposed takes into account both the interpreted bedrock and the Cenozoic geology layers and does not reflect regolith cover. Detailed fault attribution has been simplified from the 1:500 000 scale, except in the case of major fault systems or tectonic boundaries. The nomenclature and hierarchy of lithostratigraphic units is based on the GSWA Explanatory Notes System, September 2015. Stratigraphic units are mostly displayed at greater than or equal to Group or Suite level; Subgroups and Formations are only displayed where areal extent warrants it and the unit does not have a higher order parent.

The digital data behind the 2015 State geological map can be viewed using GeoVIEW.WA (www.dmp.wa.gov.au/geoview) an online GIS-based visual tool for exploring GSWA's geoscience datasets, or the WA Geology application (www.dmp.wa.gov.au/wageology), a free, device-independent GIS viewer. The layers for the digital State map can also be downloaded from the Department's Data and Software Centre (www.dmp.wa.gov.au/datacentre). GeoVIEW.WA allows the data layers of the 2015 State map to be viewed in conjunction with additional datasets, which are updated on the Department's website at regular intervals (usually daily or weekly). All these datasets complement the printed map and add valuable information impossible to display on a single sheet of paper. They include geological information such as geochronological and geochemical data, tectonic boundaries, the distribution of orogenic events, as well as mineral and tenement data, and information on the availability of geophysical imagery.

Explanatory notes for the more than 440 lithostratigraphic units represented on the digital 2015 State map data layers are also delivered through GeoVIEW.WA. Dedicated search tools allow textual and spatial interrogation



Bibliography

Information in this volume is largely derived from the publications listed below, excerpts of which have been replicated with permission from the authors. Other evidence has been gained from GSWA's annual progress reports and bulletins, as well as oral and written contributions by many past and present GSWA staff. The initial contribution from PR Dunn is acknowledged.

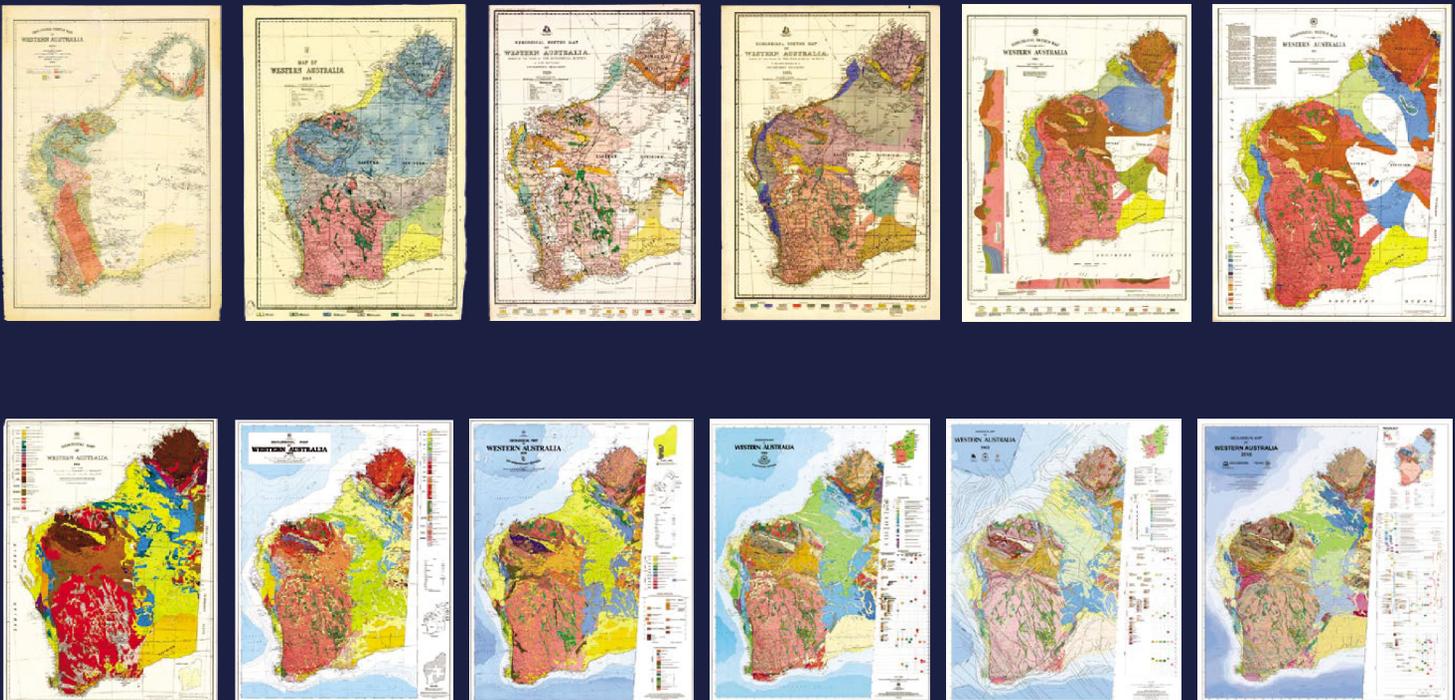
- Blockley, JG and Riganti, A 2013, The glass-negative photographic collection of the Geological Survey of Western Australia: Newsletter of the Earth Sciences History Group, Geological Society of Australia, v. 44, p. 41–47.
- Connolly, RR 1976, History of the Geological Survey of Western Australia, *in* History and role of Government Geological Surveys in Australia *edited by* RK Johns: Government Printer, South Australia, p. 80–93.
- Geological Survey of Western Australia 1975, The geology of Western Australia: Geological Survey of Western Australia, Memoir 2, 541p.
- Geological Survey of Western Australia 1990, Geology and mineral resources of Western Australia: Geological Survey of Western Australia, Memoir 3, 827p.
- Glover, J 2005, The enigmatic history of Ferdinand von Sommer, our first Government Geologist: a preliminary account: West Australian Geologist, v. 452, p. 10.
- Glover, J 2006, Ferdinand von Sommer: German research answers some questions about our first Government Geologist: West Australian Geologist, v. 458, p. 12–13.
- Glover, J and Bevan, JC 2010, Forgotten explorers: pioneer geologists of Western Australia, 1826–1926: Hesperian Press, Perth, Western Australia, 231p.
- Kimberly, WB 1897, Chapter XXI, The Goldfields 1893 to 1897, *in* History of West Australia a narrative of her past, together with biographies of her leading men: FW Niven & Co., Printers and Publishers, Melbourne and Ballarat, Victoria, p. 311–340.
- Maitland, AG 1919, A summary of the geology of Western Australia, *in* The Mining Handbook: Geological Survey of Western Australia, Memoir 1, p. 2–55.
- Martin, DMcB, Hocking, RM, Riganti, A and Tyler, IM 2015, Geological map of Western Australia, 14th Edition — Explanatory Notes: Geological Survey of Western Australia, Record 2015/14.
- Playford, PE 1988, The Geological Survey of Western Australia: A survey of a hundred years, 1888–1988, *in* Geology and mineral resources of Western Australia: Geological Survey of Western Australia, Memoir 3, p. xxiii–xxviii.
- Playford, PE and Pridmore, I 1974, The Reverend CG Nicolay, Western Australia's first Museum Curator: Records of the Western Australian Museum, v. 3, no. 1, p. 78–81.
- Spillman, K 1993, A rich endowment: government and mining in Western Australia 1829–1994: UWA Press, Perth, Western Australia, 352p.
- The Argus newspaper, 1873, Geological map of Australia and Tasmania: The Argus, Melbourne, Australia, Saturday 7 June 1873; viewed on 1 February 2016 <<http://nla.gov.au/nla.news-article5855100>>
- Woodward, Harry P 1894, Mining handbook to the Colony of Western Australia, written especially for prospectors and strangers to the colony who are interested in mining: Government Printer, Perth, Western Australia, 126p.
- Woodward, Harry P 1895, Mining handbook to the Colony of Western Australia, written especially for prospectors and strangers to the colony who are interested in mining: Government Printer, Perth, Western Australia, 2nd edition, 216p.

About this book

The 2015 Geological Map of Western Australia at a scale of 1:2 500 000 is the latest in a series that stretches back to 1894.

These maps come in all forms, sizes and colours, as geological knowledge, accuracy and detail is continually enhanced. Improvements in cartographic techniques run in parallel with the geological changes. The 2015 State map was compiled as a 'roll-up' from statewide digital datasets assembled at larger scale — the first time that a Western Australian State map has been compiled in this way, and one of the first such smart maps in the world, with searchable data layers that underlie the digital version of the map itself.

The collection of Western Australia's State geological maps (12 of the 14 maps are represented below) is a tribute to the passion of the geologists who, since the 19th century, have journeyed to and mapped almost every inch of this vast and richly endowed region.



Further details of geological publications and maps produced by the Geological Survey of Western Australia can be obtained by contacting:

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