COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

PATERSON RANGE—4-MILE GEOLOGICAL SERIES.

Sheet F/51-6, Australian National Grid.

EXPLANATORY NOTES No. 17.

Issued under the authority of Senator the Hon. W. H. Spooner,
Minister for National Development.
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5. Springsure, 1957.
6. Sydney, 1957.
7. Jerilderie, 1958.
8. Derby, 1958.
9. Mount Anderson, 1958.
10. Noonkanbah, 1958.
11. Lennard River, 1958.
12. Anketell, 1957.
13. Cloncurry, 1959.
14. Westmoreland, 1959.
15. Dobbyn, 1959.
16. Yarrie, 1959.
17. Paterson Range, 1959.
18. Tabletop, 1960.
19. Mount Bannerman, 1960.

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DEPARTMENT OF NATIONAL DEVELOPMENT.

Minister: Senator the Hon. W. H. Spooner, M.M.
Secretary: H. G. Raggatt, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Director: J. M. Rayner.
Acting Deputy Director: H. Temple Watts.

These Notes were prepared in the Geological Section.
Chief Geologist: N. H. Fisher.

Explanatory Notes on the Paterson Range 4-Mile Geological Sheet.

Compiled by

A. T. Wells.

INTRODUCTION.

The Paterson Range 4-mile Sheet covers part of the south-western margin of the Canning Basin. The Sheet lies between latitudes 21° and 22° south, and longitudes 121°30′ and 123°00′ east. Its north-western corner is 195 miles on a true bearing of 102° from Port Hedland on the coast.

The Canning Basin is defined for geological purposes as the sedimentary basin between the Kimberley and the Pilbara areas of Precambrian rocks: it extends north-westward on to the present continental shelf and contains Palaeozoic and younger sediments. The geographical name "Great Sandy Desert" was first used for the desert area of the Canning Basin by Colonel P. E. Warburton in 1872.

The Paterson Range Sheet area is uninhabited by white people and is not crossed by any road or vehicular track. Access to the area by 4-wheel-drive vehicle was by way of Warrawagine Station on the adjoining Yarrie Sheet, but easier access is by way of Ragged Hills Lead Mine, which is west of the Paterson Range Sheet. The general conditions encountered and a description of the methods of investigation are given in Traves & Casey (1954, 1955, and 1956).

Most of the area is semi-desert and receives generally less than ten inches of rain annually; surface water is scarce and supplies can only be obtained from small springs or native soaks and rockholes which in most cases are not permanent. The area is inhabited by scattered groups of nomadic aborigines who depend for their existence on the scant fauna of lizards, snakes, kangaroos, rabbits and birds.

Previous Investigations.

Very little systematic geological work has been carried out on the Sheet. The earliest exploratory investigation of the area was by Colonel P. E. Warburton (1875), who crossed the northern part of the Sheet area near the end of his east to west crossing from Alice Springs to the Oakover River. W. F. Rudall (1897), as Leader of the Calvert Search Party, covered much of this area while looking for the lost members of Wells' exploring party. Talbot (1920) investigated the Paterson Range area and refers to the "Paterson Range Series"; he recognized the unconformity between this series and the underlying Precambrian rocks, and correlated the Paterson Range Series with outcrops seen along the Canning Stock Route, particularly north of Well 26, where a similar unconformity was described by him. C. St. J. Bremner (1942) carried out an aerial reconnaissance of the southern portion of the Canning Basin for Caltex (Aust.) Oil Development Pty. Ltd. He recognized that Devonian limestones are absent, and Permian sandstones are the first sediments seen north of the Precambrian basement. Reeves (1949) investigated large areas of the Canning Basin for the Vacuum Oil Company. He visited the Paterson Range and was of the opinion that the boulder beds were merely a basal conglomerate. Recent work has shown that they are fluvioglacial. The sheet was photographed by the R.A.A.F. in 1953 from 25,000 feet, giving vertical coverage at a scale of approximately 1 : 50,000. Semi-controlled 4-mile photo-mosaics were supplied by the National Mapping Division and were used for the geological compilation.

The Bureau of Mineral Resources Party which investigated the area in 1954 (Traves, Casey, & Wells, 1956) was the first to use 4-wheel-drive vehicles for cross-country travelling in the desert. State Lands Department surveyors accompanied the party and observed astrofixes at several localities. An airborne magnetometer traverse from Halls Creek to Marble Bar carried out by the Geophysical Section of the Bureau of Mineral Resources crosses the south-western corner of the sheet.

PHYSIOGRAPHY.

Although the area varies little in altitude it can be divided broadly into dissected highlands and the sandy plains of the desert. The highland division includes the north-west-trending Paterson and Throssell Ranges, which are formed primarily of strike ridges of resistant Precambrian metamorphics with some residuals of Palaeozoic rocks. The ranges have a maximum altitude of about 1,200 feet and are isolated by intervening sand plains. Small hills and mesas of flat-lying Palaeozoic or Mesozoic rocks rise less than 150 feet above the level of the sand plain. Cuncudgerie Hill in the north-west corner of the Sheet is a small monadnock rising 130 feet above the general level of the plain. Numerous small rounded ironstone rises scattered throughout the area are usually no higher than the surrounding sand dunes.

The sand plain varies little in elevation from Cuncudgerie Hill to 40 miles east of Lake Waukarlycarly, averaging 900 feet in altitude between these points; salt lakes in wide shallow depressions mark the lowest elevations. The sand plain is underlain by the less resistant Palaeozoic and Mesozoic rocks and the Precambrian granite. It is characterized by innumerable east-north-east-trending seif dunes, generally half to one mile apart and as much as 50 miles long; their average height is 50 feet. The dunes are commonly braided, and one dune may possess several crests; where they anastomose the acute angle of the junction always points west-north-west in the direction of migration.

Playa lakes are common, Lake Waukarlycarly being the largest. Part of Lake Dora, another large salt lake in the south-east corner of the Sheet, has an impervious base composed of the Permian Dora Shale, whereas Lake Waukarlycarly has formed in a shallow depression in Precambrian rocks. Smaller lakes lie near the margins of both lakes, and small claypans are found within dunes near the shores.

Drainage channels are poorly developed throughout the area and occur only on the higher hills and mesas. The short streams that drain the dissected hills of the highlands contain water only during storms, which occur at long intervals. The valleys of the streams are narrow, almost V-shaped; where the valleys leave the hill country and enter the sand plains short distributaries form, but few extend far into the desert. Drainage channels are almost completely absent on the sand plain and the greater part of the drainage is subterranean.

The area appears to have been subject to uniform uplift, the initial surface being composed for the most part of a plain of deposition. Its structure is compound, with sediments covering an undermass of deformed rocks, and this greatly influenced the

TABLE 1. STRATIGRAPHY OF PATERSON RANGE 4-MILE SHEET.

Age.	Map Symbol.	Formation.	Minimum Thickness (feet).	Lithology.	Fossils.	Economic Geology.	Time Equivalent.
QUATERNARY	Qs	Sand	0–120	Hematite-stained quartz sand	—	Shallow water in favourable localities especially near high dunes	
	Qc	Caliche	2	Unconsolidated powdery travertine			
	Ql	Travertine	10	Hard marl and limestone with varying amounts of chalcedony		Shallow water; limestone	Similar deposits occur in neighbouring parts of the basin
	Qt	Salt	1	Halite, gypsum, and sodium sulphate			
TERTIARY	—	Laterite (not mapped)	20	Laterite and pisolitic ironstone	—	Road-surfacing	
CRETACEOUS	Ka	Anketell Sandstone	100	Sandstone, shale, and fine siltstone	—		May be equivalent to Frezier Sandstone (Lindner & Drew, *in* McWhae et al., 1958) and to beds at Rumbalara, N.T.
MESOZOIC	Ms	Undifferentiated (includes the Callawa Formation)	400	Ferruginized sandstone and some conglomerate	Plant fossils in Callawa Formation	Water	Possibly part equivalent of Erskine Sandstone of Fitzroy Basin, and possibly Parda Formation (Linder & Drew, *in* McWhae et al., 1958).
				SLIGHT ANGULAR UNCONFORMITY			
PERMIAN	Pt	Triwhite Sandstone	75	Fine to medium grained sandstone with some fine conglomerate bands and lenses of claystone	Plant remains	Water	Upper Noonkanbah or Lower Liveringa Formation of Fitzroy Bason
	Pd	Dora Shale	40	Predominantly shale and sandstone; originally calcareous?	Foraminifera	—	Noonkanbah Formation of Fitzroy Basin
	Pc	Cuncudgerie Sandstone	130	Predominantly sandstone with beds of fine conglomerate and greywacke	Marine fossils abundant	Water	Nura-Nura Member of Poole Sandstone, Fitzroy Basin
	Pa	Paterson Formation	100	Claystone and conglomerate, possibly fluvioglacial. Unsorted with some slumping and contortion	—	—	Braeside Tillite (Yarrie Sheet). Grant Formation of Fitzroy Basin and Lyons Group of Carnarvon Basin
				ANGULAR UNCONFORMITY			
PROTEROZOIC Upper	Pu	Undifferentiated Upper Proterozoic	200	Sandstone, conglomerate, and shale. No outcrop visited	—	—	Part of Nullagine " Series " of Pilbara area
				ANGULAR UNCONFORMITY			
PROTEROZOIC Lower	Plg	Lower Proterozoic Granite	—	Slightly gneissic fine-grained granodiorite and fine-grained biotite granite with pegmatite, quartz, and aplite veins			Probably Lamboo Complex of Fitzroy Basin
	Plm	Lower Proterozoic Metamorphics	—	Quartz, slate, schist, and some marble and dolomite. Veins of quartz numerous. Intruded by granite	—	Metamorphics worth prospecting for metallic deposits	Probably Halls Creek Metamorphics of Fitzroy Basin and Warraoona " Series " of Pilbara area

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development of sequential forms. At this stage some monadnocks of basement rocks were possibly exposed. The cycle of erosion may have commenced under more pluvial conditions. A good deal of sediment cover was stripped from the undermass to expose a fossil erosion surface, and a resistant lateritic capping developed on some areas of younger sediments. The landforms as seen to-day are the result of an arid erosion cycle. Pediments and scree material were subject to wind abrasion and seif dunes were formed. This desert weathering is in a mature stage with only isolated breakaways, and has produced a plain of arid erosion. Playa lakes form local independent base levels with streams draining underground into them. In recent times the dunes have become partially fixed by a discontinuous growth of vegetation.

STRATIGRAPHY AND PALAEONTOLOGY.*

When the area was investigated by the 1954 Bureau party, emphasis was placed on the stratigraphy of the Permian and Mesozoic rocks and little time was spent on the Precambrian basement rocks. Precambrian, Permian, Mesozoic, and Tertiary rocks have been recognized. The post-Precambrian sediments are represented by a small thickness of predominantly clastic sediments containing few fossils. Wherever possible existing names have been used, with some slight revision in accordance with the current Australian Code of Stratigraphic Nomenclature.

PRECAMBRIAN.

Outcropping Upper and Lower Proterozoic rocks are confined principally to the central and south-western portion of the sheet and include the Throssell and Paterson Ranges. The oldest rocks, the Lower Proterozoic Metamorphics, consist of steeply dipping quartzite, slate, schist, and some marble and dolomite. These rocks have been intruded by extensive batholiths of granite. Large areas of granite were seen east of Lake Waukarlycarly and between Lamil Hills and Mt. Crofton. The granite mapped east of the Paterson Range does not crop out everywhere, but is interpreted mostly from aerial photographs. It ranges from a slightly gneissic fine-grained granodiorite to a fine-grained biotite granite with pegmatite veins. Roof pendants of quartzite form hills in the otherwise low, partly sand-covered surface of the granite. In the Mt. Crofton area a coarse biotite granite is traversed by veins of quartz and aplite. The granite cuts folded pinkish slate and limestone, which are also cut by quartz veins along shears.

One or two scattered outcrops of Upper Proterozoic rocks, mapped only by photo-interpretation, are present in the western portion of the Sheet. Reeves (1949) reports a 200-foot scarp of red sandstone and pebble conglomerate overlying granite and greenstone two miles east of the well at the 759-mile post on the rabbit-proof fence. This locality is close to the central western margin of the Sheet. The sandstone and conglomerate are probably Upper Proterozoic: Upper Proterozoic rocks of similar lithology overlie granite on the adjacent Rudall Sheet.

PERMIAN.

Paterson Formation (Traves et al., 1956).—Probable Permian fluvioglacial sediments of the Paterson Formation unconformably overlie Precambrian rocks in the Paterson Range. The formation is not overlain by any younger sediments here. It is

* The localities from which rock specimens housed in the Bureau of Mineral Resources Museum, Canberra, were taken are marked on the map by numbers such as P 7.

thought to be equivalent to the Braeside Tillite of the Nullagine River area, which is overlain by a Jurassic plant-bearing sandstone. Some outliers in the Throssell Range area, mapped only by photo-interpretation, are regarded as Paterson Formation.

Cuncudgerie Sandstone.—Permian marine fossils were found 10 miles east-south-east of Cuncudgerie Hill in the north-western corner of the Sheet, and the formation has been called the Cuncudgerie Sandstone (Traves et al., 1956). It consists predominantly of sandstone with beds of fine conglomerate and greywacke. In places the rock consists of claystone with numerous vertical inverted-cone-shaped worm burrows. One hundred feet of the formation, containing abundant bryozoa, pelecypods, and gastropods, and a few brachiopods, was measured at the type locality (Dickins & Thomas *in* Traves et al., 1956, p. 51). At Cuncudgerie Hill the formation is 130 feet thick. It crops out only in the north-west corner of this Sheet. Most large areas underlain by the Cuncudgerie Sandstone are isolated low rises covered by sand, with discontinuous outcrops. The formation is correlated with the Nura Nura member of the Poole Sandstone (Guppy et al., 1958).

Dora Shale (Traves et al., 1956).—The Dora Shale is limited to the south-east corner of the Sheet, at Lake Dora. It is predominantly shale with some sandstone, and may have originally been calcareous. A clay pellet and claystone breccia overlying the shale here probably represents the top of the formation, with the Triwhite Sandstone above. The maximum thickness measured was 40 feet. The Shale is correlated with the Noonkanbah Formation, on the evidence of foraminifera. It forms the bed of Lake Dora, and the outcrop and structure of the impervious shale have controlled the distribution and permanency of the salt lake arc that exists to the south.

Triwhite Sandstone (Traves et al, 1956).—The Triwhite Sandstone is also confined to the south-eastern part of the Sheet, and crops out at P21. Marine fossils found near Dunn Soak on the Tabletop Sheet indicate that the formation is equivalent to either the upper Noonkanbah or lower Liveringa Formation.

Mesozoic.

Sediments lithologically similar to the *Callawa Formation* (Traves et al., 1956) are included in the undifferentiated Mesozoic sediments in the north-east corner of the Sheet area. Younger Cretaceous rocks of the *Anketell Sandstone* also crop out in this area. The Mesozoic rocks appear to transgress the Permian sediments and often directly overlie Precambrian rocks. They are predominantly ferruginized sandstone, and Permian and Mesozoic rocks of similar lithology are very hard to distinguish from each other; outcrops of undifferentiated Mesozoic rocks and Cuncudgerie Sandstone on the north-eastern portion of the Sheet can readily be confused as both form low outcrops and give a clay soil pattern. The Mesozoic sediments are about 400 feet thick. Most of the outcrops on this Sheet were photo-interpreted and only one outcrop of doubtful age, at P5 east of Lake Waukarlycarly, was seen. The undifferentiated Mesozoic rocks mostly form dark ferruginized rises with very few breakaway scarps.

No outcrops of the *Anketell Sandstone* (Traves et al., 1956) were visited, and the rocks are photo-interpreted, continuing the photo-pattern of this formation from the Anketell Sheet: the formation gives a rather smoother and lighter coloured pattern than the ferruginized rises.

Outcrops of the formation on neighbouring sheets are sandstone, shale, and fine siltstone. East of Lake Waukarlycarly joints are common in outcrops of the Anketell Sandstone and may indicate undifferentiated Mesozoic rocks with a very thin veneer of the Anketell Sandstone. The age of the formation is based on the presence of *Rhizocorallium* (Dr. A. A. Öpik, pers. comm.) and Lower Cretaceous foraminifera in the outcrops on the Anketell Sheet. It overlies the Callawa Formation. The total thickness of the formation is probably less than one hundred feet.

TERTIARY.

A few scattered remnants of laterite are present over the area, but the evidence suggests that much of the area was not lateritized. Remnants of laterite were examined east of Lake Waukarlycarly at P8, where 20 feet of the ferruginous zone overlies a mottled zone about 20 feet thick. Outcrops at the northern end of the Paterson Range are capped in places by laterite. The laterite has not been mapped on the Sheet.

QUATERNARY.

The widespread sand deposits are derived primarily from the underlying ferruginized Mesozoic and Permian sediments or from the disintegration of the laterite capping, which probably contributed to the colour of the sand. The iron-stained sand has been blown into long parallel seif dunes that are now partly fixed by vegetation. The interdune valleys are also covered by sand, with travertine protruding through in places.

Massive travertine and soft caliche are widespread, particularly in the vicinity of the salt lakes, and may represent old extensions of the lakes; but some of the travertine has no doubt been formed by precipitation from springs and evaporation of ground water close to the surface. Some of the travertine deposits south of Lake Waukarlycarly have a similar pattern to, and may be allied to, the Tertiary Oakover Beds mapped on the adjacent Yarrie Sheet, although there is no other evidence for this correlation.

Alluvial deposits are of insignificant extent and attain no great thickness.

STRUCTURE.

Precambrian rocks form the floor for Palaeozoic and Mesozoic sedimentation, which probably extended much farther over the Precambrian rocks than at present. The higher ranges of Precambrian rocks were possibly islands during Mesozoic and middle and late Permian times, but during Lower Permian (Sakmarian) time the Paterson Formation (glacial) was originally quite extensive and probably covered very large areas of the marginal basement rocks, as both terrestrial and marine deposits.

The fossils, lithology, and distribution of the Permian and Mesozoic rocks indicate that they are intracratonic basin sediments. They show no pronounced structures and only regional dips of a half to two degrees were recorded, at widely spaced localities. The sediments probably thicken gradually towards the north-east, although the basement topography is not known at present. A small fault at P17 north of Lake Waukarlycarly cuts the Cuncudgerie Sandstone, but apparently has not affected the overlying Mesozoic conglomerate which fills the small irregularities in the surface of the Sandstone. Other small parallel north-west-trending faults are photo-interpreted in the surrounding areas of sediments. In several places angular unconformities between the basin sediments and the basement rocks were observed. From these unconformities it appears that the area was subject to repeated transgression and regression.

The fold axes and the strike lines of the Lower Proterozoic rocks generally trend north-west, nearly parallel to the margin of the Canning Basin. A north-trending fault on the south-western corner of the Sheet has Upper Proterozoic rocks on its western side, and what have been photo-interpreted as probable Permian glacials of the Paterson Formation on its north-eastern side.

An aeromagnetic traverse carried out by the Bureau of Mineral Resources crosses the south-western corner of the Sheet but indicates no major structures that are not revealed by the surface geology.

ECONOMIC GEOLOGY.

Petroleum.—A study of the area has indicated what rock units may be expected in the centre of the Canning Basin, below the Mesozoic and Quaternary deposits. The basement topography has not yet been delineated by geophysical surveys. Geological reconnaissance has not shown any Palaeozoic rocks between the Permian sediments and the Precambrian basement rocks. (The possibility remains that the permeable Permian rocks could act as structural traps up-dip from older concealed Palaeozoic sediments.)

Aeromagnetic survey and gravity traverses carried out by the Bureau of Mineral Resources and West Australian Petroleum Pty. Ltd. along the coast at the Eighty Mile beach indicated very large relief on the basement, and a structural trend eastward into the basin; so it may extend into the Paterson Range Sheet area, which is about 120 miles from the coast. The presence of marine fossiliferous Permian and Mesozoic rocks indicates the possibility of source rocks for petroleum.

Evaporites.—A thin layer of Quaternary evaporites covers the bed of Lake Waukarlycarly and Lake Dora. At Lake Dora the 3-in. surface layer of evaporites consists of 48-49 per cent. $NaCl$, 44-45 per cent. $CaSO_4$, and 6 per cent. Na_2SO_4. Some samples of travertine contain up to 96 per cent. $CaCO_3$.

Water.—Supplies of underground water can be obtained from most parts of the desert area; particularly in areas of Palaeozoic and Mesozoic sediments, ground water should be present at depths ranging from 15 to 80 feet.

Minerals.—No metallic deposits were found on the Sheet. The area bordering the eastern edge of Mt. Crofton and south to the Paterson Range and in the Throssell Range consists of Lower Proterozoic Metamorphics (including marble and dolomite), in places partly granitized and digested and cut by pegmatite and quartz veins. These areas appear worthy of prospecting for metallic deposits.

Road Metal.—Pisolitic ironstone is available for road-metal, if required.

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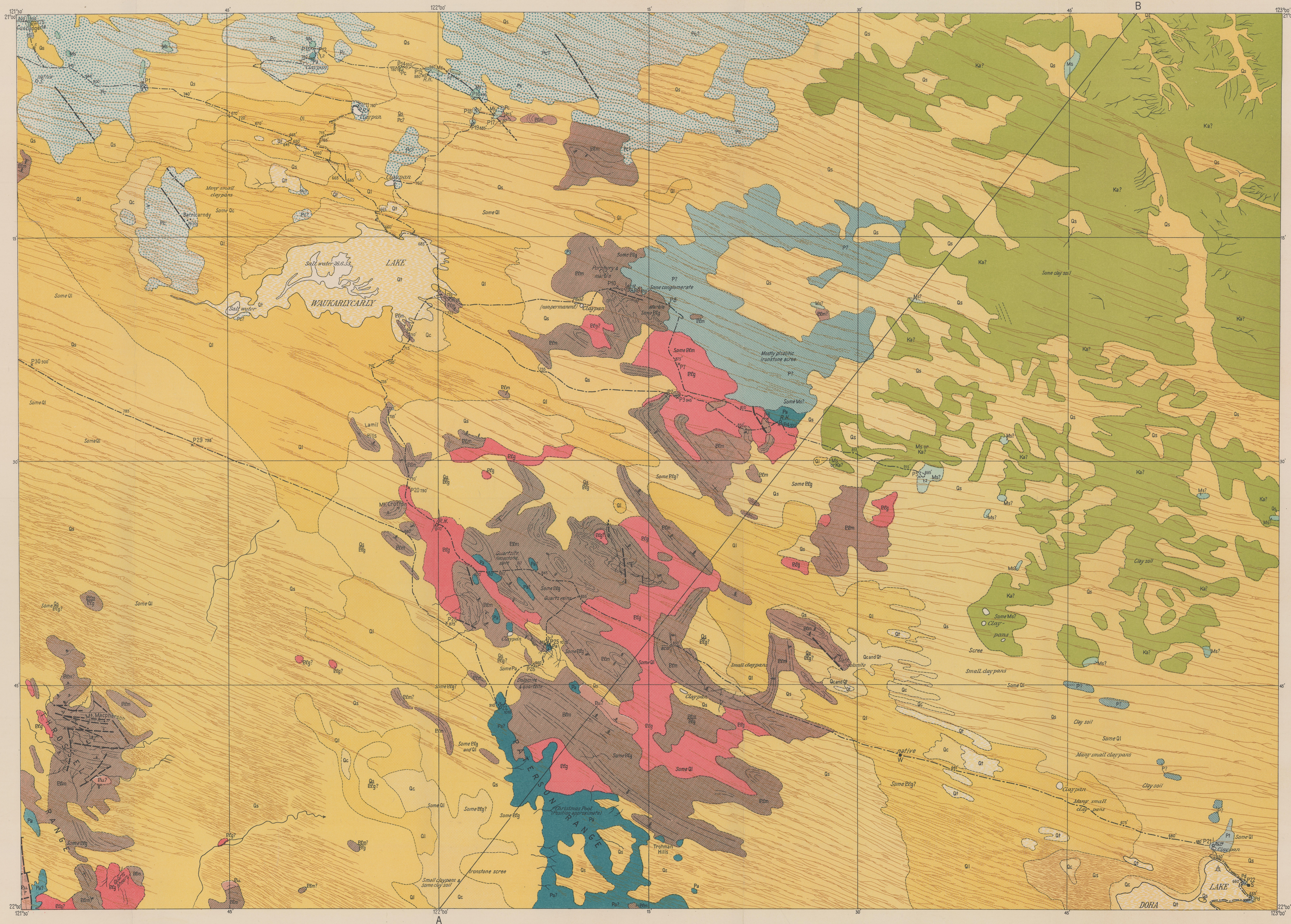
PATERSON RANGE

WESTERN AUSTRALIA

4 MILE GEOLOGICAL SERIES SHEET F 51–6



Reference

CAINOZOIC — QUATERNARY

- Qs — Sand
- Ql — Hard travertine, tufa
- Qc — Caliche or travertine powder
- Qt — Salt

MESOZOIC — CRETACEOUS

- Anketell Sandstone: Ka — Sandstone, shale

?Disconformity?

MESOZOIC — Undifferentiated

- Ms — Sandstone and strongly ferruginized conglomerate (includes equivalent of Callawa Formation)

Unconformity

PALAEOZOIC — PERMIAN

- Triwhite Sandstone: Pt — Sandstone, greywacke, sandstone with concretions, marine fossils
- Dora Shale: Pd — Shale, fine sandstone, marine fossils
- Cuncudgerie Sandstone: Pc — Coarse to fine sandstone and greywacke, marine fossils
- Paterson Formation: Pa — Conglomerate, sandstone, claystone, (probably fluvioglacial)
- Undifferentiated: P — Sediments

Unconformity

PROTEROZOIC — UPPER

- Pu — Sediments

Unconformity

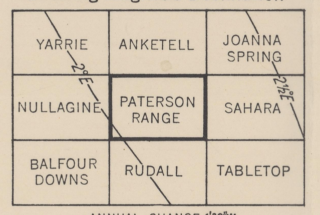
PROTEROZOIC — LOWER

- Plg — Granite
- Plm — Metamorphics

Established geological boundary—position approximate
Inferred geological boundary
Inferred fault
Inferred fault—concealed
Strike and dip of strata—inclined
Strike and dip of strata—vertical
Trend line of bedding
Dip of inclined strata 0–15°
Dip of inclined strata 15°–45°
Dip of inclined strata >45°
Joint patterns
(Trend line of bedding to Joint patterns: determined by air-photo-interpretation)
×P4 Text reference of specimen locality
Marine macrofossil locality
Marine microfossil locality
•720′ Barometric spot height—datum: mean sea level
Route of geological party's traverse
Sand dune
•S Spring
•W Well
○R.H. Rockhole
○S. Soak
BC14 Astro station

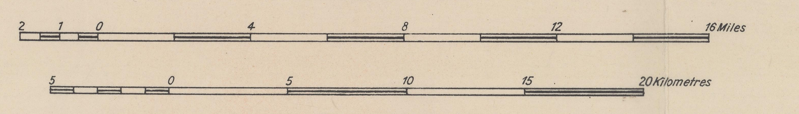
Compiled and published by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development.
Air-photography, complete vertical coverage at medium scale by Royal Australian Air Force.
Transverse Mercator Projection

INDEX TO ADJOINING SHEETS
Showing Magnetic Declination

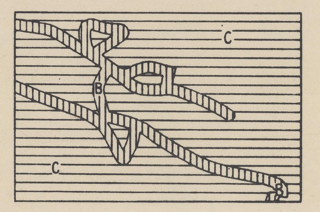


ANNUAL CHANGE 1′30″W

Scale
4 Miles to 1 Inch

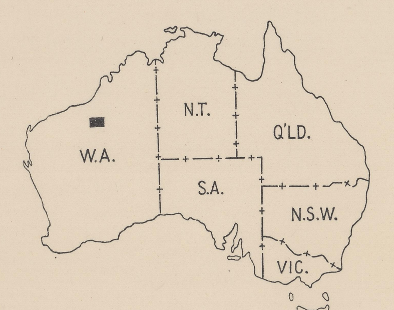


GEOLOGICAL RELIABILITY DIAGRAM

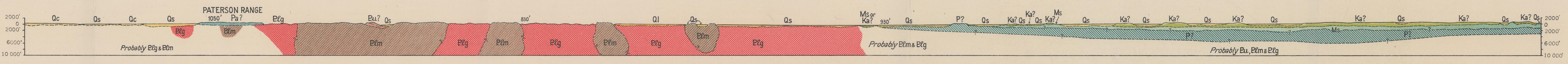


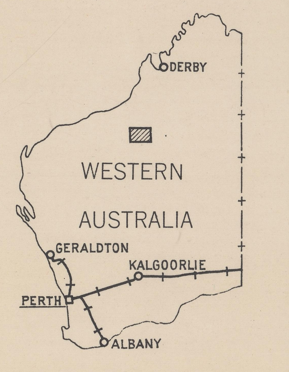
B Reconnaissance—regional traverse and air-photo-interpretation
C Sketchy—air-photo-interpretation

Geology by: D. M. Traves, J. N. Casey, A. T. Wells
Compiled, March 1956, by: J. N. Casey, A. T. Wells, H. F. Boltz
Drawn by: W. G. Krause



Section A-B





PATERSON RANGE
SHEET F 51–6

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