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EXPLANATORY NOTES ON THE MANUKA GEOLOGICAL SHEET

Compiled by

D. J. Casey

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EXPLANATORY NOTES ON THE MANUKA GEOLOGICAL SHEET

Compiled by

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Records 1965/160

The Manuka 1:250,000 Sheet area was mapped in 1962 by a joint geological party of the Commonwealth Bureau of Mineral Resources and the Geological Survey of Queensland. This survey was part of a project to map the northern part of the Eromanga Basin.

Vertical air photographs at an approximate scale of 1:48,000, taken by the R.A.A.F. in 1951, provide a complete coverage of the area. Planimetric maps at 4 miles to 1 inch are available from the Queensland Department of Lands, Brisbane and at photo-scale and 1:250,000 from the Division of National Mapping, Canberra.

The Landsborough Highway from Brisbane to the Northern Territory, via Winton and Cloncurry, and the Kennedy Developmental Road from Hughenden to Winton pass through this area; a main road also connects Winton to Richmond. Other formed roads provide access to groups of properties. The highways and main roads are formed but unsurfaced; all are impassable for a few days after heavy rain. Station tracks provide excellent access in dry weather throughout the rest of the area.

A branch railway connects Winton and Hughenden.

Previous Investigations

Before the 1963 survey little systematic geological work had been done in MANUKA.* Whitehouse (1954) was the first to attempt to map the Great Artesian Basin as a whole and co-ordinate recorded observations and stratigraphic nomenclature. The most complete amounts of the geology of the whole basin, with comprehensive bibliographies, were compiled by Whitehouse (op. cit.) and Hill and Denmead (eds. 1960).

A photo interpretation of the whole area was made by the Institut Francais du Petrole and the Bureau of Mineral Resources (Scanvic, de Lassus St. Genies, and Perry 1962).

A detailed gravity survey of the southern part of MANUKA was made by the Magellan Petroleum Corporation (1961). A gravity survey, based on a seven mile grid, was carried out by the Bureau of Mineral Resources throughout the rest of the area (Flavelle, 1964). Isolated gravity traverses were also made earlier by the University of Sydney (Marshall and Narain, 1954) and by the Bureau of Mineral Resources. Bouguer values from these surveys are shown on the face of the map.

A regional aeromagnetic survey with an average flight line spacing of 9 miles was made by Central Queensland Petroleum Pty. Ltd. and The Catawba Corporation (1957). The results are available on open file at the Geological Survey of Queensland; magnetic basement contours interpreted from this survey are recorded by Magellan Petroleum Corporation (1961). Other isolated aeromagnetic traverses have been flown by the Bureau of Mineral Resources (Jewell, 1960a).

* Subsequent reference to 1:250,000 sheet areas is signified by the use of capital letters for the geographic prefix, e.g. MANUKA.

The Cairnhope-Rimbanda Seismic Survey (Namco International Inc., 1963), which was subsidised under the Petroleum Search Subsidy Acts, 1959-1964, investigated photo-geomorphological anomalies in the east of the area.

Results of the geophysical surveys are discussed under Structure.

Physiography

The Ayrshire Hills, in the south-west of MANUKA, are a relic of a Tertiary to early Quaternary erosion surface at which duricrust was developed on Cretaceous and Tertiary sediments. The rest of the area consists of rolling downs - a mature erosional landform of gently undulating grassland. Minor relief is provided by low rubbly rises of the more resistant beds of the Cretaceous sequence.

The watershed between streams of the Lake Eyre internal drainage system and streams of the Gulf of Carpentaria system crosses MANUKA but is no more than a slight topographic culmination in the rolling downs. All streams are intermittent, stream gradients are low, and most watercourses are braided.

STRATIGRAPHY

Table 1 summarizes the stratigraphy of MANUKA.

Only the Albaru Member of the Wilgunya Formation and younger sediments crop out. Information on the lower part of the sequence has been obtained from: mapping in the adjacent RICHMOND and HUGHENDEN areas, near the northern margin of the Eromanga Basin; studies of the Corfield Town Bore, which was deepened to basement as Magellan Corfield No. 1 (Harris, 1960; Jewell, 1960b; Evans, 1962); interpretation of gamma-ray logs of three water bores (Registered Numbers 12039, 13869 and 15824) logged by the Bureau of Mineral Resources (Jesson and Radeski, in prep.); and interpretation of water-bore drillers' logs.*

The two youngest formal units, the Winton and Mackunda Formations, are lithologically similar, but several important differences serve to distinguish them. The main differences are: sandstone of the Winton Formation is generally slightly coarser than that in the Mackunda Formation; marine fossils are restricted to the Mackunda Formation; coal seams, commonly recorded in logs of water bores, are mostly restricted to the Winton Formation; intraformational conglomerate is abundant throughout the Winton Formation but is common only in the uppermost part of the Mackunda Formation; and individual beds are generally thicker in the Winton Formation than in the Mackunda Formation. The last difference was also noted by Jesson & Radeski (1961) in the electric logs of the Winton No. 2 Town Bore.

The Wilgunya Formation is known only from bore information and poor exposures in the north-east of MANUKA.

Water bore drillers' logs are insufficiently detailed to enable identification of members of the Wilgunya Formation. However, the 40 to 60 feet thick

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* The Irrigation and Water Supply Commission, Brisbane has, during this century, endeavoured to collect as much information as possible on all bores in Queensland. Their records contain invaluable geological data in the form of drillers' logs of water bores, and hydrological data. The assistance of the Commission in making these records freely available is gratefully acknowledged. Drillers' logs for MANUKA were assembled as an appendix to an earlier unpublished report (Vine, Bastian and Casey, 1963).

Toolebuc Member can be recognised by the marked deflection it causes on electric and gamma-ray logs and this enables the formation to be subdivided. Table 2 lists the interval identified as Toolebuc Member in 4 bores for which electric and gamma ray logs are available.

TABLE 2

Bore	Grid reference	Interval (depths, in feet)	Log
12039	168368	220- 280(1)	Gamma-ray
13869	623368	900- 940	Gamma-ray
15824	151362	570- 620	Gamma-ray
14125 (Corfield Town Bore)	668287	1680-1717	Gamma-ray and resistivity

Note (1) a zone of anomalous, but lower, radioactivity extends to a depth of 410'; however the thickness inferred from the maximum anomaly is comparable with thickness of the Toolebuc Member in outcrop in RICHMOND.

The Allaru Member is identified as the argillaceous sequence between the Toolebuc Member and the Mackunda Formation.

Members older than the Toolebuc Member cannot be identified in the Corfield Town Bore because the units present lack diagnostic electric or radioactive log characteristics. This sequence is, therefore, shown as undifferentiated Wilgunya Formation in Table 1.

Evans (1962), on the basis of palynological studies, identified a sequence ranging in age from Permian to Lower Cretaceous below the Wilgunya Formation in Corfield No. 1. He suggested that the sequence consists of four units with unconformities or disconformities between all of them. These divisions are used in Table 1. Lithological differences between the units are small, and most of the water-bore drillers' logs are insufficiently detailed to enable the units to be recognised with confidence. However the Triassic and Permian units are characterised by the presence of red beds and coal respectively and these are recorded in several of the drillers' logs (Table 3). The intervals identified by Evans (op.cit.) are listed for comparison.

Table 3. Indications of pre-Jurassic rocks

Bore	Grid Reference	Record in drillers' log (depths below surface)	Interpretation
60	613342	Grey & red marl 2643'-2704'	Triassic
123	161339	Red marl at 2090, 2183'-2200'	Triassic
1051	152359	Red shale 1860'-2000', 2012'-2168'	Triassic
1085	607308	Red marl 3148'-3150'	Triassic
1968	615330	Red marl 2891'-2902'	Triassic
2927	573310	Red marl 3105'-3144', 3182'-3373' Red marl & sandrock, 3373'-3556'	Triassic

Bore	Grid Reference	Record in drillers' log (depths below surface)	Interpretation
3355	165269	Pink shale 3153'-3225' Red shale & sandrock 3250'-3297'	Triassic
3600	681362	Red marl 2085'-2105'	Triassic
3602	124364	Red marl 2040'-2046'	Triassic
3619	651373	Red shale 2148'-2158' Red, white, black, yellow & blue shale 2158'-2203'	Triassic
3670	610352	Red marl 2450'-2458'	Triassic
4370	655306	Red shale 2805'-2840'	Triassic
4375	646297	Granite 3100'-3182'	Basement
4376	659316	Red shale 2856'-2865' Red marl & rock 2881'-2889' Dross coal 3661'-3722' Black lignite 3783'-3805'	Triassic Permian
4444	135368	Red marl 1854'-1864'	Triassic
5150	165372	Red shale 1432'-1437'	Triassic
7197	587303	Hard pink rock 3364'-3375'	Triassic
14125 (Corfield No. 1, from Evans, 1962)	668287	Sandstone, with intercalations of dark red shale & green siltstone. 3560'-4100'. Sandstone, with interbeds of coal, 4100'-4488'. Coarsely crystalline granite, 4488'-4507'.	Triassic Permian Basement

Crystalline basement, of weathered granite, was drilled in Corfield No. 1 from a depth of 3646 feet below sea level. The basement core is unsuitable for age determination. Only one driller's log of a water bore (Narollah Homestead Bore, Reg. No. 4357) contains any description which can confidently be interpreted as indicating basement. In that bore, situated 13 miles west-north-west of Corfield No. 1, granite was penetrated from a depth of 2343 feet below sea level.

STRUCTURE

The simplicity of the geological map gives little indication of subsurface structure. Distribution of the stratigraphic units indicates a very gentle regional dip to the south-south-west, the result of basinal sagging. The regional dip is also apparent on the structural map (Fig. 1) drawn from the interpretation of water-bore drillers' logs. Interpretation of drillers' logs (Vine, Bastian & Casey, 1963) gave the first indication of the Wetherby Structure, here named after Wetherby Homestead. It is evident as a linear structure, downthrown to the west and with a maximum displacement of the order of 400 feet. Fairly detailed surface mapping of the boundary between the Winton and Mackunda Formations north of Wetherby Homestead subsequently confirmed the structure. Lineated bedding trends delineate the structure near Werna Homestead where displacement is inferred to be greatest. The Wetherby Structure is interpreted as probably a monocline in the Cretaceous sediments, but grading to a fault at depth. A strong, linear, steep gravity gradient, which approximates the position of the Wetherby Structure along most of its length, indicates that it coincides with a major basement discontinuity.

The Cork Fault (Vine, 1964) extends through south-east MACKUNDA, north-west WINTON, and through MANUKA as far north as the Corfield area. It is evident on air photos as a narrow belt of lineated trend lines, and approximates the position of a steep gravity gradient (Magellan Petroleum Corporation, 1961). The gravity results indicate that the fault is upthrown to the south-east, whereas a previous regional aeromagnetic survey (Jewell, 1960) suggests an upthrow to the north-west. A seismic traverse by the Bureau of Mineral Resources across the fault zone in WINTON (in Magellan Petroleum Corporation, 1961) indicates that the Cork Fault may not be a simple structure, but is possibly a zone of weakness along which faulting has taken place intermittently (Casey, in press). The structural map (Fig. 1) indicates that displacement at the base of the Wilgunya Formation is about 500 feet down to the west at latitude 22°S, but decreases sharply to where the fault fades out near Corfield.

The Eyriewald Anticline is a gentle asymetrical fold delineated by the Cairnhope-Rimbanda seismic survey (Namco International, Inc., 1963). It continues south into WINTON (Casey, in press). The western flank is the steeper, and at depth grades into a fault. To the west of the fault the seismic results indicate a thickness of about 6000 feet of sediments, i.e. about 3000 feet below the base of the Wingunya Formation.

The two recorded occurrences of granite basement (Corfield No. 1 and Narollah Homestead Bore) are only 13 miles apart, but the basement surface at Corfield is approximately 1300 feet lower than at Narollah. The two occurrences are associated with a gravity minimum and a gravity maximum respectively, separated by a strong gravity gradient. This gravity gradient is aligned with the Cork Fault gravity gradient but the two gradients are in opposite directions. Probably both reflect basement faulting, trending north-east through Corfield; the reversed gravity gradient may reflect scissors faulting with a zone of no displacement near Corfield. Alternatively, the block south-east of the fault line may be faulted with considerable down throwing of the northern part.

GEOLOGICAL HISTORY

A full discussion of the geological history of the northern Eromanga Basin is being prepared by Vine (In prep.).

The only basement rocks known in MANUKA are the granite penetrated in Corfield No. 1 and water bore R4375. In contrast, several bores in WINTON bottomed in low grade metamorphics; similar metamorphic rocks probably form crystalline basement in part of MANUKA.

Deep reflections, recorded by a Bureau of Mineral Resources seismic survey (in Magellan Petroleum Corporation, 1961) north-west of the Cork Fault in WINTON, were interpreted as originating in pre-Mesozoic sediments. The 3000 feet of sediments older than the Wilgunya Formation west of the Eyriewald Anticline (interpreted from seismic results) is greater than the known Jurassic and Triassic sequence in the area, and probably includes some Palaeozoic sediments.

Permian sediments were encountered in Corfield No. 1, and in Beryl No. 1 to the south of WINTON and probably include a coal-bearing interval in water bore R4376. The extent of Permian sedimentation in the area is unknown. There are no indications that the Permian sediments were marine and the coal measures indicate that the depositional environment was at least partly paludel.

Widely scattered occurrences of arenites with intercalations of red beds suggests that there was widespread sedimentation in Lower Triassic times. Sedimentation probably took place in conditions of strong weathering on extensive piedmonts flanking mountain ranges of Lower Palaeozoic metamorphics in RICHMOND and HUGHENDEN (Vine, in prep.).

Widespread sedimentation did not recur until the Jurassic. From then until the early Cretaceous predominantly arenitic sediments were deposited intermittently. An abrupt change to the argillaceous sediments of the Wilgunya Formation in the Lower Cretaceous corresponds to a change to a marine environment; no marine fossils have yet been found below the Wilgunya Formation in the north-east Eromanga Basin. The Cretaceous sea was extensive, extremely shallow, and had only restricted access to the open ocean. (Vine, in prep.). The richly fossiliferous Toolebuc Member represents a change from the conditions under which the rest of the Wilgunya Formation was laid down to better water circulation and a reduction of terrigenous sedimentation; swarms of Globigerina indicate open water conditions.

The Mackunda Formation represents a transitional period of paralic sedimentation between the marine deposition of the argillaceous sediments of the Wilgunya Formation and the non-marine deposition of the more arenaceous sediments of the Winton Formation. Vine (in prep.) suggests that the Winton Formation was laid down in an area of very low relief with many sluggish streams, wide river flats, and local development of short-lived lakes and swamps.

Deposition of the Winton Formation was followed by a period of lateritization which resulted in the development of a duricrust at the top of a deep weathering profile. This was followed by a period of erosion; subsequent surface silicification produced a younger duricrust.

ECONOMIC GEOLOGY

Underground Water

Abundant underground water supplies are available in aquifers in the sandstone sequence below the Wilgunya Formation. In low lying parts of MANUKA the head is sufficiently high to produce flowing bores. On higher ground an adequate supply is obtained from the aquifers by pumping from shallow depths.

Limited non-artesian aquifers in the Winton and Mackunda Formations supply most of the subsurface water in the southern half of MANUKA. However, the relatively small (many less than 600 g.p.h.) supplies from these aquifers are much more variable in quality than the consistently fresh water produced by the artesian bores. An appreciable number of these non-artesian bores have had to be abandoned because of inadequate supply or because the water is too salty for stock to drink.

The depth at which artesian aquifers occur increased from about 1,400 feet in the north to approximately 3,000 feet in the south. Bores to these depths are expensive, and it is no longer economical to drill to the deep aquifers in the southern part of the area. Station owners now generally sink large earth tanks or drill for shallow supplies (less than 600 feet) from the Mackunda or Winton Formations.

Oil and Gas

Corfield No. 1, the only oil exploration well in the area, is actually a water bore deepened by Magellan Petroleum Corporation for stratigraphic information. It produced no shows of oil or gas and was completed as a water bore.

Gas has been recorded in the following water bores. Each occurrence, except for the Wyora Bore, was associated with artesian water obtained from aquifers in the sandstone sequence below the Wilgunya Formation.

Bore	Grid reference
1083 (Albion Downs Homestead)	591313
1085 (On Wetherby Station)	607308
1321 (Ascot Homestead)	571285
3609 (On Clare Valley Station)	645373
? (Wyora)*	Quoted as Lat. 21°56'S, Long. 143°05'E.*

Only the gas from the Wyora bore was analysed. It consisted of carbon dioxide 1.2%, methane 10.3%, inert gas 88.3% (Geological Survey of Queensland, 1960); the assay cannot now be found in the assay register of the Geological Survey of Queensland.

Bore 1085 is close to the Wetherby Structure; the others are not related to any known structure.

The sediments older than the Wilgunya Formation contain several sandstone beds with good reservoir characteristics. Interbedded argillaceous sediments could provide suitable cap rocks provided they are not lenticular on the crests of anticlines.

Limited seismic work has revealed gentle folding, including the Eyriewald Anticline. It is reasonable to predict that other structures will be found with further work. In particular, folding is probably associated with movements on the Cork Fault and Wetherby Structure.

The petroleum prospects seem, therefore, to depend primarily on establishing the presence of source beds. The hypothetical pre-Mesozoic sequence north-west of the Cork Fault needs reliable supporting evidence before it can be considered. There is, as yet, no evidence in the northern Eromanga Basin of a marine Permian sequence comparable with that regarded as possible source beds in the Bowen and Surat Basins to the south-east. The rest of the pre-Wilgunya sequence lacks definite indications of marine conditions.

The Wilgunya Formation is an argillaceous marine unit and must, therefore, be considered as a possible source sequence. However, sandstone in the overlying Mackunda and Winton Formations does not have good reservoir characteristics, and aquifers in them appear to be restricted.

Along the Cork Fault and Wetherby Structure displacement has brought the Wilgunya Formation in contact with older sandstone, in a belt where there has probably

* from Geological Survey of Queensland, 1960; this bore cannot be related to any registered bore in the area.

also been folding. These areas appears most worthy of further investigation. Such investigation could also examine the possibility of a pre-Mesozoic sedimentary sequence north-west of the Cork Fault.

Construction Materials

There are no good construction materials in the area. Silcrete gravel from the duricrust-capped Ayrshire Hills has been used for road surfacing without much success. Most material for road work has to be brought from outside MANUKA, e.g. platy limestone and calcareous shale from the Toolebuc Member is carried up to forty miles to surface roads in the north of the area.

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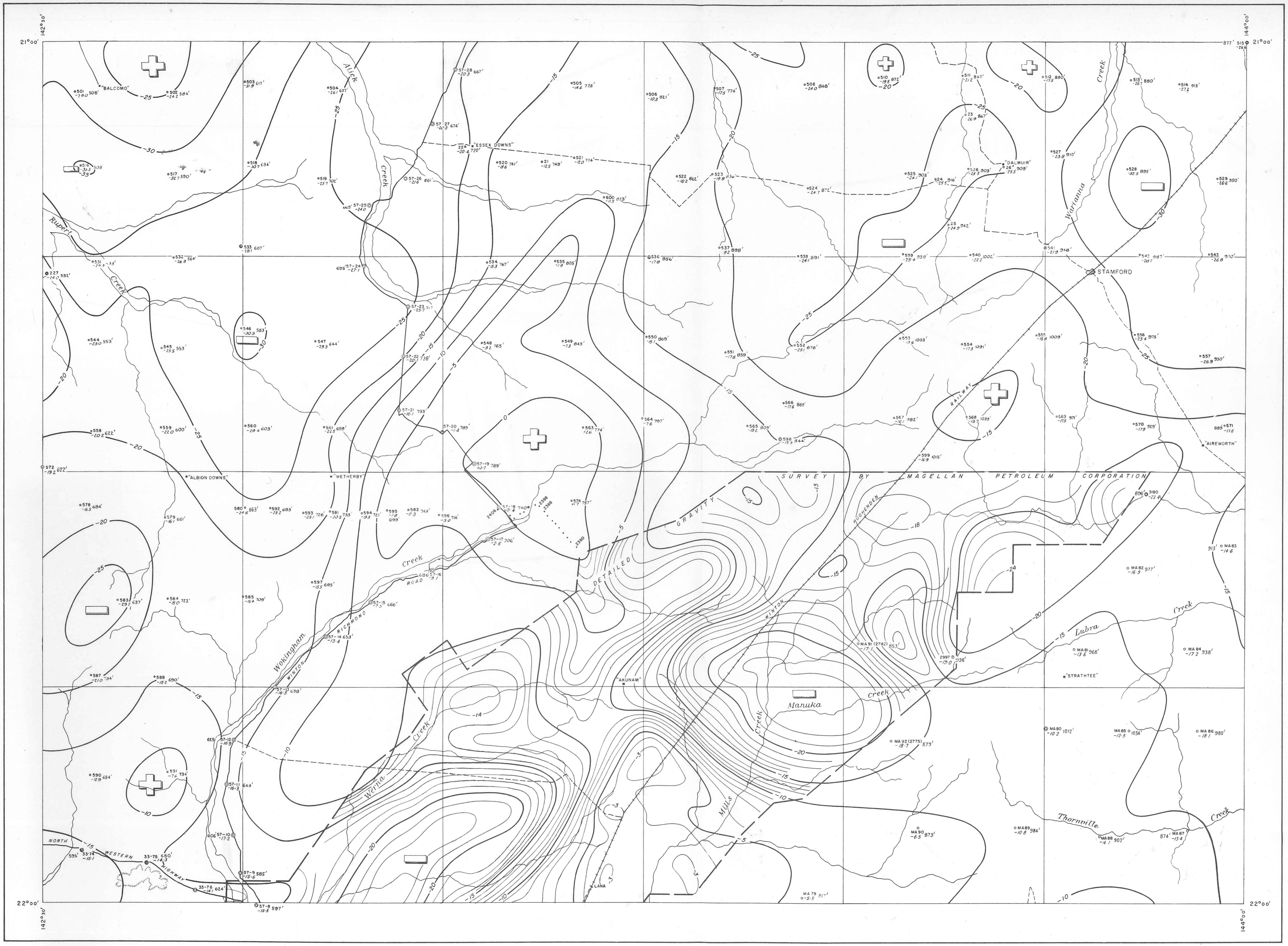
MANUKA



LOCATION DIAGRAM

REFERENCE TO AUSTRALIA STANDARD MAP SERIES

JULIA CREEK	RICHMOND	HUGHENDEN
MCKINLAY	MANUKA	TANGORIN
MACKUNDA	WINTON	MUTTABURRA

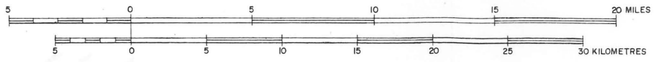
Projection: Transverse Mercator, Australia Series

Planimetry: After the Division of National Mapping 1:250,000 series SF54-8, provisional planimetric map of the same area

Elevation datum: Queensland State

Station Bouguer Anomaly reliability:
Standard Deviation <1milligal

BOUGUER ANOMALIES



Contour interval 5 milligals

TOPOGRAPHY

- ▨ Built-up area
- ■ Homestead
- ┼ Railway
- Drainage
- Principal road
- Minor road
- - - - Track

GRAVITY

- ○ Gravity station
- ◎ " " (permanently marked)
- • " " (Magellan Pet. Corp.)
- +12.6 Bouguer anomaly (milligals)
- 204' Elevation (feet)
- -5 Isogals
- ✚ 'High' anomaly
- ▭ 'Low' anomaly

Bouguer anomalies are based on the observed gravity values at BMR pendulum stations:
N°53 Hughenden......978,604·2 milligals
N°55 Cloncurry......978,651·4 milligals
N°54 Longreach......978,790·2 milligals

For the calculation of Bouguer anomalies 1·9 g/cm³ has been adopted as an average rock density

Geophysical field data from BMR gravity and microbarometer surveys in 1963 and Magellan Petroleum Corp. in 1959.

Elevation control by Department of Interior levelling

Department of National Development
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
Compiled and drawn in Geophysical Branch, Melbourne
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MANUKA, QLD
REFER TO THIS MAP AS: **F54/B2-8(R)**
MAY 1964

The Preliminary Edition of MANUKA will be amended for the first edition as follows:-

(a) recompiled on accurate planimetric base, with slight changes in position of geological boundaries.

(b) addition of all structural names and features discussed in the text.

(c) amendment of all bore symbols.

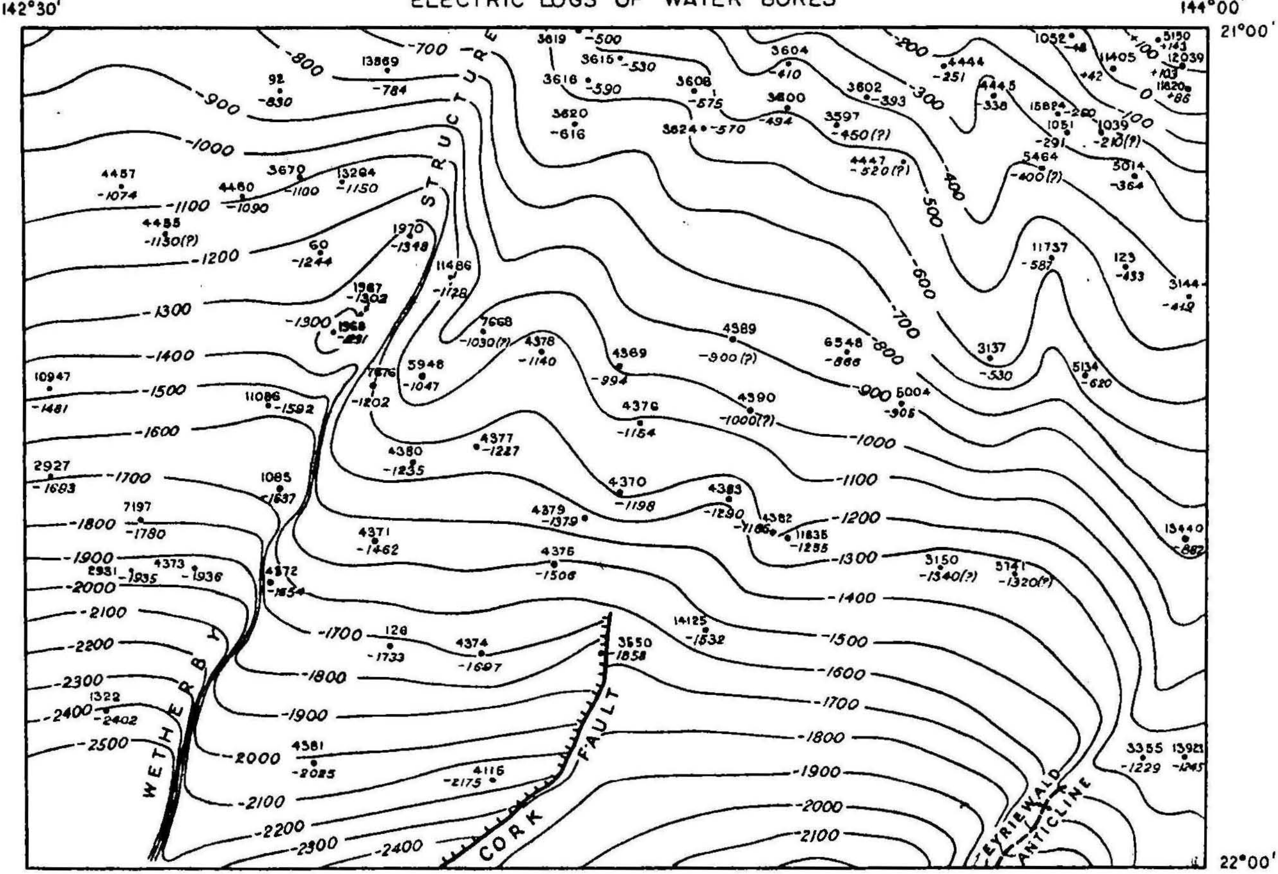
(d) change road names to those currently used by Queensland State authorities.

(e) bring geological terminology up to date, to agree with stratigraphic table.

Fig. 1

CONTOURS ON THE BASE OF THE WILGUNYA FORMATION

INTERPRETED FROM DRILLERS' LOGS, GAMMA-RAY LOGS AND ELECTRIC LOGS OF WATER BORES



4457 *Registered number of bore*

• *Water bore*

-1074 *Elevation on the base of Wilgunya Formation*

Fault, hachures on downthrown side

Anticline, interpreted from seismic surveys

Datum : mean sea level

SCALE

10 0 10 20 30 40 MILES

To accompany
Records 1965/160

Bureau of Mineral Resources, Geology & Geophysics. Nov, 1965

F54/A8/1

AUSTRALIA 1:250,000

MANUKA
QUEENSLAND

1:250,000 GEOLOGICAL SERIES SHEET SF 54-8

PRELIMINARY EDITION, 1963
SUBJECT TO AMENDMENT

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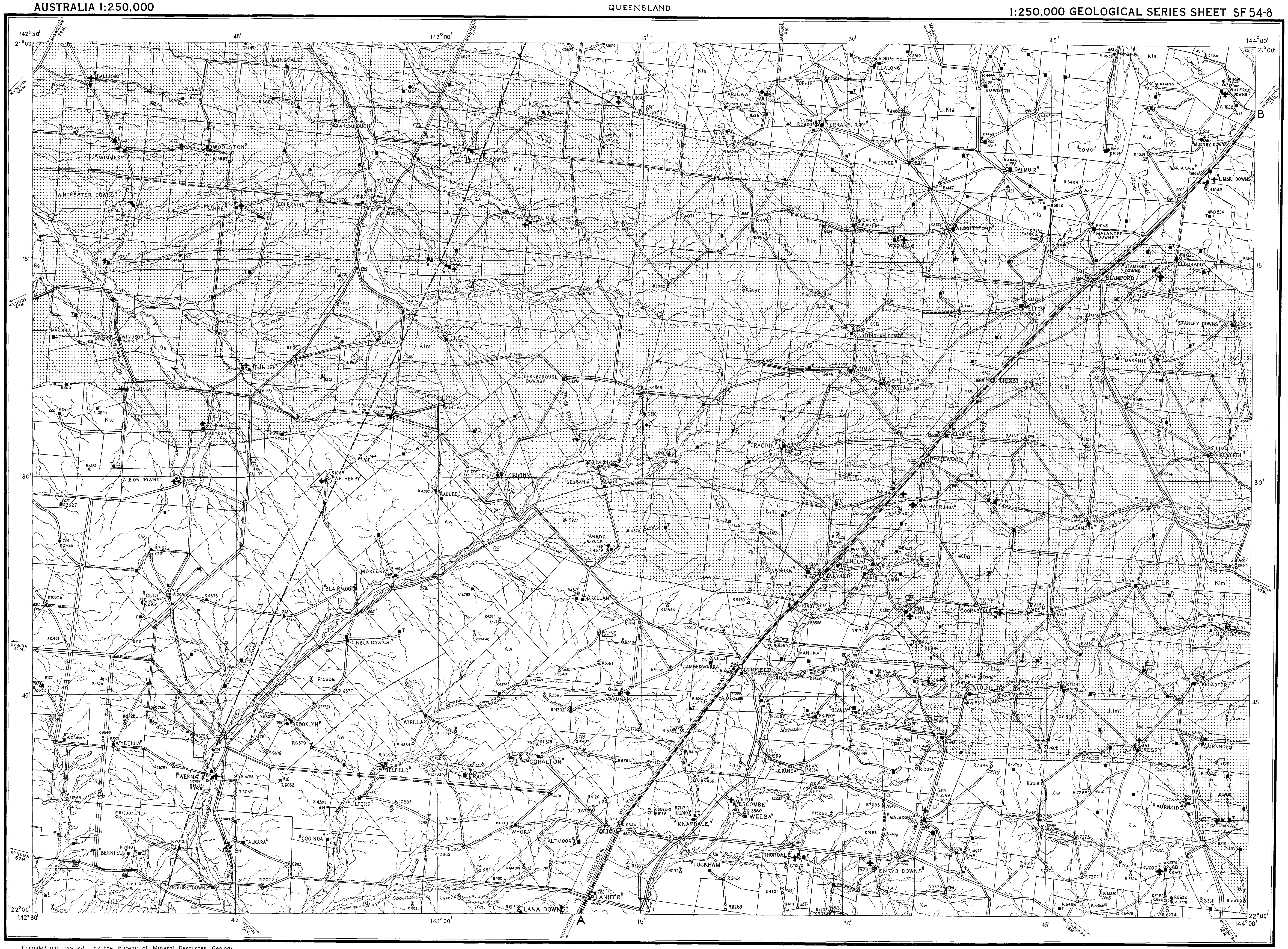


CAINOZOIC	QUATERNARY		Qa	*Alluvium*
	UNDIFFERENTIATED		Czd	*Duricrust (Silcrete, laterite)*
MESOZOIC	LOWER–UPPER CRETACEOUS	Winton Formation	Kw	*Lithic sandstone, siltstone, claystone, sandy limestone*
	LOWER CRETACEOUS	Mackunda Beds	Klm	*Lithic sandstone, siltstone, claystone, sandy limestone*
			Kla	*Claystone, siltstone, silty limestone*
		Wilgunya Formation	Klw	*Claystone, siltstone, limestone*
	UNDIFFERENTIATED		M	*Sandstone, conglomerate, shale.*
PALAEOZOIC	PERMIAN		P	*Sandstone, coal, shale*
?	PRE-PERMIAN		?Pzg	*Granite*

Section only

——	*Geological boundary*
━ ━	*Fault*

Where location of boundaries, folds, and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are *shown by short dashes*

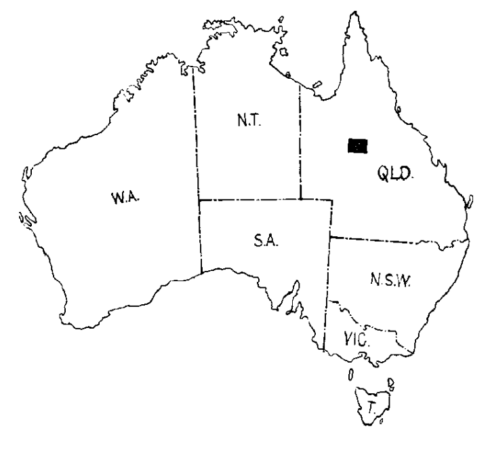
×	*Specimen locality*
◎	*Macrofossil locality*
A	*Microfossil locality*
⚘	*Plant fossil locality*
▭	*Fossil wood locality*
G742	*Locality reference number*
●	*Flowing bore*
○	*Non-flowing bore*
⊘	*Dud bore*
⊠	*Abandoned bore, previously productive*

R3131 *refers to bore registered number of Queensland Irrigation and Water Supply Commission records*

▷	*Dam*
■T	*Earth tank*
Ɪ	*Windpump*
═	*Road*
╌	*Vehicle track*
─○─	*Railway with siding*
—	*Fence*
┼	*Dog netting fence*
"BURNSIDE" ■	*Homestead*
✈	*Landing ground*
□ Yd.	*Yard*
• 1056'	*Height in feet, instrument levelled*
• 991'	*Height in feet, barometric*
PD	*Position doubtful*

Datum, mean sea level

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Topographic base compiled by the Division of National Mapping and the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Aerial photography by the Royal Australian Air Force; complete vertical coverage at 1:46,500 scale.
Transverse Mercator Projection.



INDEX TO ADJOINING SHEETS

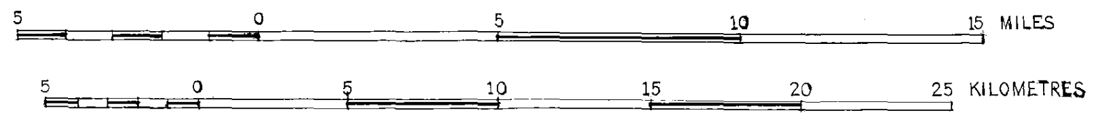
Showing Magnetic Declination

DOBBYN	MILLUNGERA	GILBERTON	CLARKE RIVER	TOWNSVILLE
CLONCURRY	JULIA CREEK	RICHMOND	HUGHENDEN	CHARTERS TOWERS
DUCHESS	McKINLAY	MANUKA	TANGORIN	BUCHANAN
BOULIA	MACKUNDA	WINTON	MUTTABURRA	GALILEE
SPRINGVALE	BRIGHTON DOWNS	MANEROO	LONGREACH	JERICHO

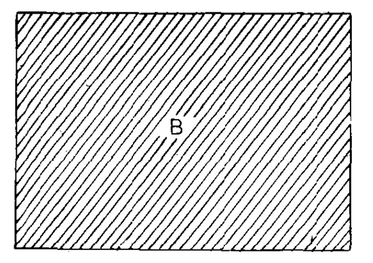
6°E 6°30'E 7°E 7°30'E

Annual Change 2'30"E

Scale 1 : 250,000

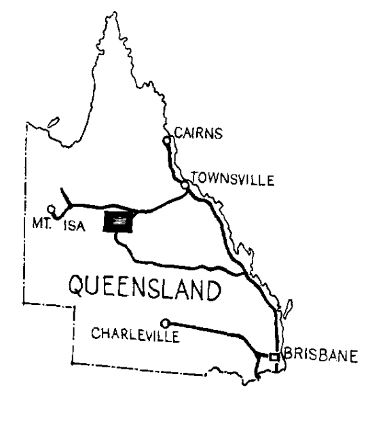


GEOLOGICAL RELIABILITY DIAGRAM

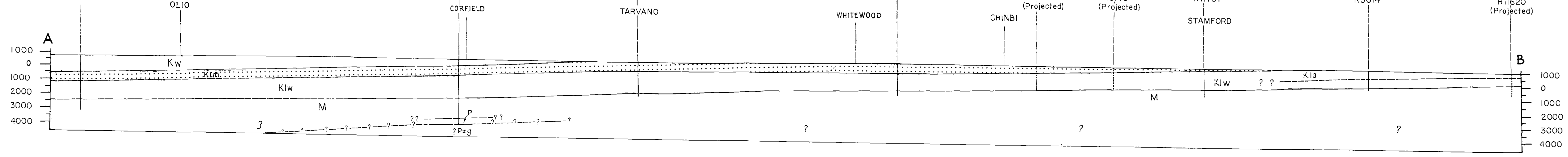


B *Detailed reconnaissance – numerous traverses and air-photo interpretation*

Geology, 1962, by: R.R. Vine, L.V. Bastian, (B.M.R.)
D.J. Casey (Q.G.S.)
Compiled, 1962, by: R.R. Vine, L.V. Bastian, D.J. Casey.
Drawn by. I. Chertok.



Section A-B
(along railway line)
Scale $\frac{V}{H} = 4$
(Alluvium omitted from section)



MANUKA SF 54-8