COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1968 / 35



# The Geology of the Barrolka, Eromanga, Durham Downs, Thargomindah, Tickalara and Bulloo 1:250,000 Sheet Areas, Queensland

by

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ILLUSTRATIONS TO ACCOMPANY
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| | |
|---|---|
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| Eromanga | G54/12 |
| Durham Downs | G54/15 |
| Thargomindah | G54/16 |
| Tickalara | H54/3 |
| Bulloo | H54/4 |

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## SUMMARY

This report describes the geology of a portion of the Eromanga Basin in south west Queensland. The area is in the arid zone of western Queensland (Fig. 1).

Basement in the area consists of low grade metamorphics and early Palaeozoic clastics.

Marine, paralic and continental sediments of Devonian to Carboniferous age occur in the Warrabin Trough, and are comparable with those of the Adavale Basin. These were gently folded and subjected to erosion during Carboniferous times.

Permian to Triassic continental sediments are mainly confined to the Cooper Basin. The northeast part of the Cooper Basin is in the mapped area. Further folding and erosion took place late in Triassic time.

Jurassic to Cretaceous continental and marine sediments of the Eromanga Basin form a blanket over the whole area. The Allaru Mudstone is the oldest Formation exposed within the mapped area. Slight erosion forming an extensive almost flat plain, was followed by deep chemical alteration in late Cretaceous to early Tertiary time.

Tertiary fluviatile sediments are thickest in the area of the Cooper Basin. These sediments were subjected to silicification at several levels to form beds of silcrete; not all silcrete is duricrust.

Further erosion in Quaternary time has resulted in alluvial deposits up to 500 feet thick in the depressed areas. Water in Quaternary sediments is fresh near intakes but saline elsewhere.

The Cooper Basin is subject to active petroleum exploration due to the discovery of commercail gas fields in Permian sediments in South Australia, and good oil shows in the Triassic in Queensland.

Precious opal occurs in the Winton Formation within the zone of deep chemical alteration. Opalization is possibly related to the subsequent silicification of Tertiary sediments.

Fresh to brackish water is available at depths of 1100 to 5000 feet in the Jurassic and early Cretaceous arenitic sequences. Most bores tapping these aquifers flow.

## INTRODUCTION

A reconnaissance geological survey of six 1:250,000 Sheet areas was undertaken in 1967. The survey area is situated in south western Queensland. This region is part of the Eromanga Basin; a sub-basin of the Great Artesian Basin.

Four geologists worked full time on the project, namely M.C. Galloway (Party Leader), B.R. Senior, J.A. Ingram and Daniele Senior. During August, Professor J. Mabbutt (University of New South Wales) visited the party and studied the geomorphological aspects of the area. Other visitors were B.M.R. geologists, J.N. Casey and R.R. Vine. M.C. Galloway was Party Leader and organized and co-ordinated field work but took little part in the writing of this record.

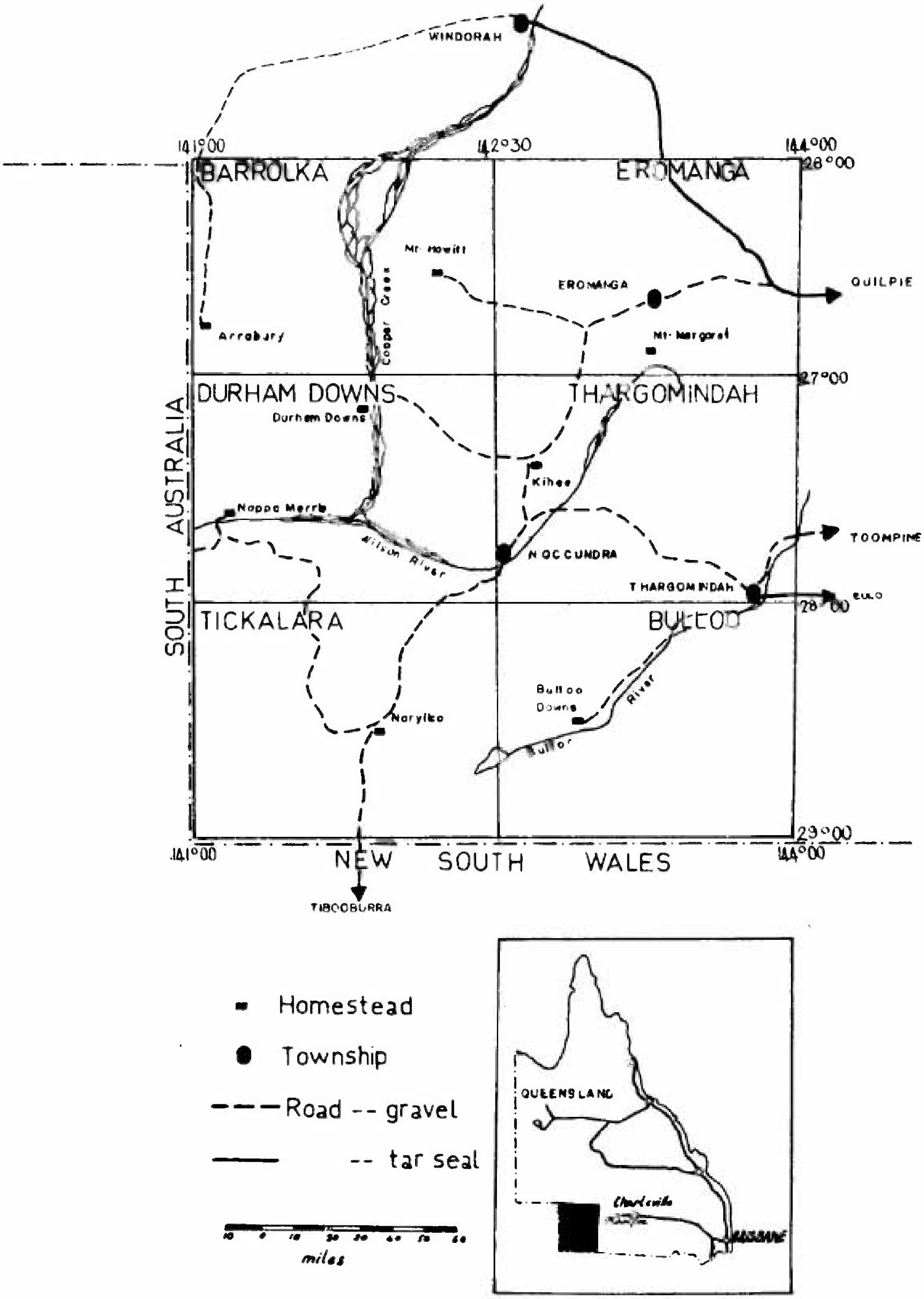
A Cessna 187 aircraft, chartered from Business Aviation Pty. Ltd., was used for a few days each month for geological and geomorphological reconnaissance, and to plot the position of water bores.

Geological data was supplemented by shallow stratigraphic drilling (B.M.R. drilling party, J. Kuenen, driller). Eleven stratigraphic holes were drilled, which involved approximately 2186 feet of drilling, and included 310 feet of coring.

Access from Brisbane is via Quilpie. Graded and formed dirt roads extend into the survey area as far as Mount Howitt Homestead (Barrolka Sheet Area), Durham Downs Homestead (Durham Downs Sheet area). Access is also good

FIG 1.

# LOCALITY MAP

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as far as Thargomindah township. Numerous other roads especially in the eastern half of the area are maintained in fair condition by the local authorities. In the remainder of the area, especially the western Sheet areas, access is along station tracks. Transport facilities within the area are disrupted after heavy rain. This survey was delayed for about one month due to unseasonal rain and the subsequent flooding of Cooper Creek.

The area has complete vertical aerial photograph coverage at a nominal scale of 1:50,000. Royal Australian Air Force photography taken in 1948 is available for Thargomindah, Bulloo and Durham Downs Sheet areas: 1952 photography for Tickalara Sheet. Barrolka and Eromanga Sheet areas are covered by 1958 photography taken by ADASTRA.

Photo mosaics at approximately 1 mile to 1 inch scale have been compiled from the aerial photographs for Barrolka, Eromanga, and Bulloo Sheet areas, and at 4 miles to 1 inch scale for Durham Downs, Thargomindah, and Tickalara Sheet areas. Cadastral maps are available from the Department of Public Lands, Brisbane. Planimetric maps compiled from the aerial photography by the Division of National Mapping were used as the base for the geological maps, but were amended to show all bore positions, and cultural features which post-date the photography.

## PREVIOUS INVESTIGATIONS

Within the area mapped, there has been little regional geological investigation prior to this present survey. However Whitehouse (1940, 1948, 1954), travelled through parts of the area and made brief notes on some aspects of the geology. Woolnough (1927) discussed hard cappings and opal in relation to duricrust in Queensland. Also, more recently, rapid reconnaissance work and detailed air photo interpretation on various structures of the area have taken place.

Wilson and Fitzpatrick (1958a,b, 1959) studied the Curalle Dome (Barrolka Sheet area), Durham Downs Anticline and Innamincka Dome (Durham Downs Sheet area), and the Betoota Anticline (Betoota Sheet area). Sprigg (1958a,b, 1961, 1965, 1966), discussed the Great Artesian Basin and petroleum potential in the Great Artesian Basin. Wopfner (1960, 1964) named the Curalle Dome and Haddon Syncline and named the elevated area extending southwards, from the Curalle Dome, the Cordillo Uplift.

Geologists with the Bureau of Mineral Resources have been engaged in systematic mapping in areas to the north of this season's mapped area (Gregory et al., 1967). Geologists of the New South Wales, Department of Mines have mapped Urisino and Milparinka Sheet areas (Brunker, 1966; Mines Dept., 1967) which are adjacent to Tickalara and Bulloo Sheet areas.

In the mapped area, where opal mineralization has been exploited, (mainly Eromanga Sheet area), there has been some local detailed geological investigation. General papers on opal mineralization have been compiled by a number of authors (Jackson, 1902; Woolnough, 1927; Whitehouse, 1940; Cribb, 1948; Noakes, 1949; Hiern, 1966; Connah, 1966).

Other workers, (Mabbutt, 1962, 1965; Jessup, 1960 a & b; Wopfner, 1963; Langford-Smith & Dury, 1965;) have worked on the Cainozoic sediments in the mapped area, and in South Australia, New South Wales, Northern Territory and other areas in Queensland.

Gravity, seismic, and aeromagnetic surveys by the B.M.R. and private oil exploration companies cover most of the area. Details are discussed later under geophysical surveys.

Drilling by oil exploration companies, and by individuals seeking artesian and sub-artesian water, has contributed much to the knowledge of the deep sub-surface geology. This knowledge was not added to by this survey.

1. Silcrete capped cuestas delineating the western limb of the Curalle Dome.

## PHYSIOGRAPHY

The survey area of approximately ~~3,600~~ 36,000 square miles forms part of the inland plains of south-west Queensland. Part of the Channel Country, it contains the floodplain of the Cooper Creek in the west, Wilson River in the east and the Bulloo River in the south-east. It is drained south westwards towards Lake Eyre by Cooper Creek and Wilson River, and by the Bulloo River which terminates at Lake Bulloo on Tickalara and Bulloo Sheet areas. All these rivers are subject to seasonal flooding. The divides between the river flats consist of stony plains, flat topped hills and plateaux with up to 400 feet of relief; the highest point of the area, 824 feet above sea level, is in the Grey Range on Eromanga Sheet area. (Grid ref. 169749).

The mean annual rainfall at Thargomindah is about 10 inches. Most of the area is within the 5-10 inches annual rainfall area. However the rainfall increases north-eastwards up to 15 inches annually.

Cooper Creek, the largest river, drains an area of 60,000 square miles north of Windorah with an average annual rainfall of 17 inches, and substantial floods occur in the mapped area about one year in four.

Six landscape types (listed below) with common physiographic features have been grouped together into landscape regions as shown in Figure 2.

1. Intact silcrete uplands

This landscape type has gently sloping or flat summits and prominent bounding escarpments formed by resistant silcrete beds. On these uplands, outcrops of silcrete alternate with stony soil-covered tracts. These uplands delineate all the main structures (Photo 1). Silcrete surfaces are particularly extensive on eastern Thargomindah Sheet area.

2. Dissected Mesas and Plains

This landscape type represents a more advanced stage of dissection and consists of groups of flat-topped hills, small plateaux and cuestas above broadly undulating stony lowlands with alluvial flats. Generally these mesas and plains have silcrete cappings, but in some areas, the Glendower Formation which contains silcrete beds, has been completely stripped. The resultant landforms are thus retained by resistant siliceous bands in chemically altered Winton Formation. Mesas and plateaux which have almost completely been eroded of their Glendower surfaces occur particularly on Eromanga Sheet area and on north western Thargomindah Sheet area.

Also included in this landscape type are red sandy earth plains which are derived from the breakdown of the Winton and Glendower Formations. This landform commonly occurs on plateau surfaces which have been stripped of silcrete, and is most evident in the Eromanga and Thargomindah Sheet areas.

3. Rolling Downs

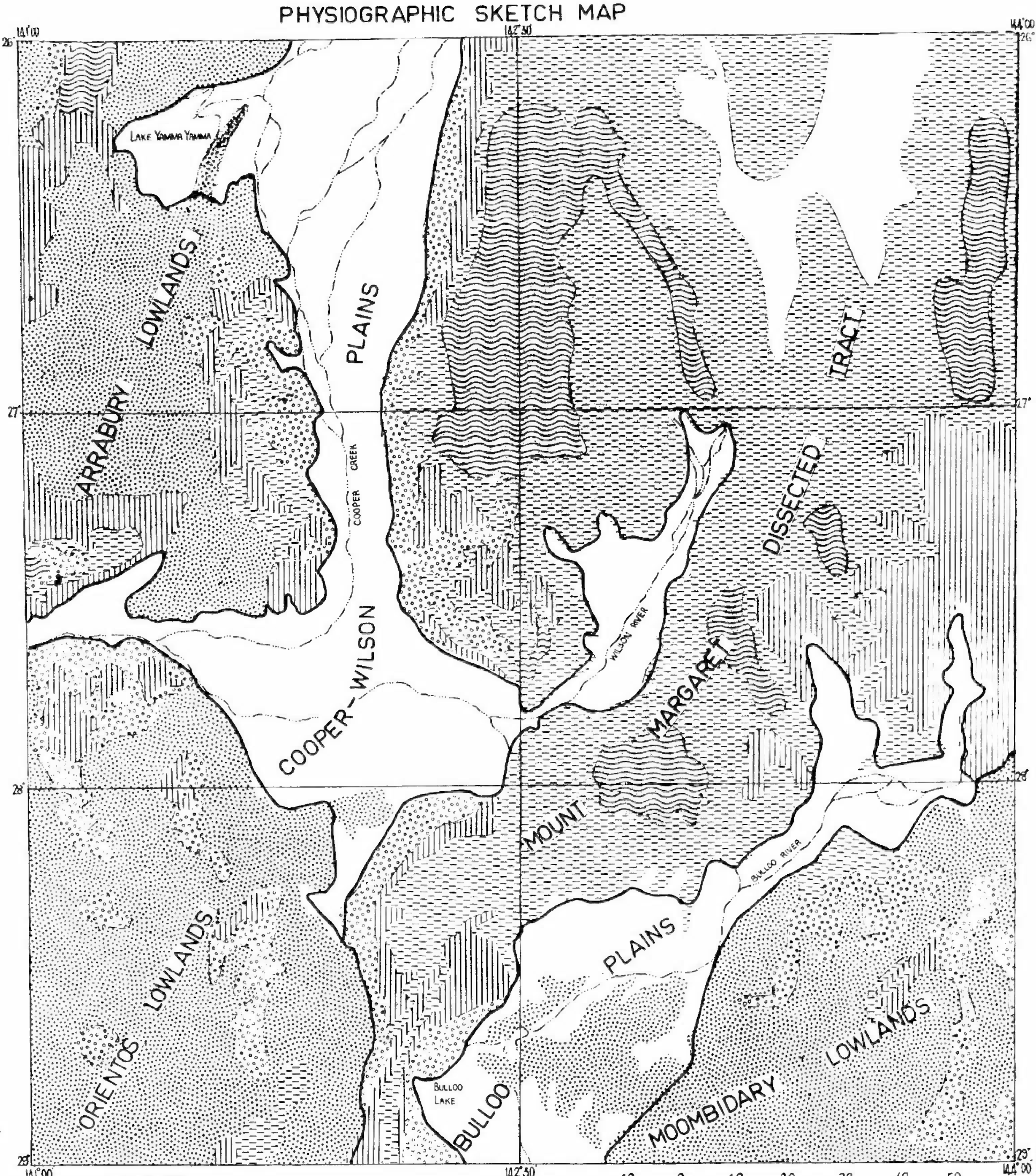
Rolling downs occur in structurally elevated areas which have been subjected to a large amount of erosion. Relatively unweathered Cretaceous outcrop and prolific soil cover form broadly rolling plains with less than 20 feet of relief. These plains are commonly stony, with gilgaied surfaces. They have closely branching drainage systems with alluvial floodplains along the larger water courses. The area of rolling downs development is limited because large areas are covered by Quaternary silcrete gravel and other clastic deposits. However rolling downs are widespread in the Mount Howitt Anticline.

4. Mantled plains and slopes

This landscape type is characterized by strongly undulating surfaces consisting of abundant Quaternary clastic deposits. The clastics include silcrete gravel from the Glendower Formation, and locally abundant 'ironstone' gravel from the chemically altered Winton Formation. Mantled plains and slopes occur in core zones, or as peripheral downslope deposits of the structural highs. The widespread deposits of silcrete gravel indicate the former existence of silcrete beds across the anticline and dome structures.

FIG. 2

# PHYSIOGRAPHIC SKETCH MAP




10 0 10 20 30 40 50 miles.

LANDSCAPE TYPES.

- ROLLING DOWNS
- INTACT SILCRETE UPLANDS
- DISSECTED MESAS+PLAINS
- MANTLED PLAINS+SLOPES
- DUNES AND SAND PLAIN
- ALLUVIAL PLAINS
- / PHYSIOGRAPHIC REGIONS

REFERENCE TO SHEET AREAS

| | |
|---|---|
| BARROLKA | EROMANGA |
| DURHAM DOWNS | THARGOMINDAH |
| TICKALARA | BULLOO |

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3. Reticulate dunes north of Lake Yamma Yamma.

2. Part of the Cooper Creek floodplain.

5. Alluvial plains

Alluvial plains are clay and silt plains of the larger rivers (Cooper, Wilson, Bulloo), falling south-westwards with gradients of less than 1 foot per mile (Photo 2). The Cooper Creek at its confluence with the Wilson River broadens to form a very extensive floodout plain which corresponds in position to a geophysically defined structural depression.

The Cooper Creek has tributary channels which supply sediment to a similar structural depression occupied by Lake Yamma Yamma, (Barrolka Sheet area). The Bulloo River has its own internal drainage system which terminates at Lake Bulloo on south-east Tickalara Sheet area and south-west Bulloo Sheet area.

6. Dunes and sandplain

This landscape type dominates Bulloo and Tickalara Sheet areas and there is extensive development on western Durham Downs and Barrolka Sheet areas. In the western Sheet areas dune sand is dominant. The dunes are predominantly red in colour and are mainly longitudinal, oriented at right-angles to the prevailing wind direction. A small area of reticulate dunes occurs north of Lake Yamma Yamma on Barrolka Sheet (Photo 3).

On eastern Bulloo Sheet area, gently undulating sandplain with rare dunes, is widespread. The sandplain is stabilized by vegetation, however a certain amount of movement occurs on the sand ridges.

The white dunes on the western side of Lake Yamma Yamma, have active crests of white quartz sand, and are developed on a stranded (raised) peripheral beach ridge. The ridge is composed of quartz sand, with numerous water worn pebbles. To the south a stranded wave cut platform replaces this beach ridge. This wave cut platform developed on a hillslope of silcrete gravel. In recent history (property owner, pers. comm.) neither the beach ridge nor wave cut platform have been known to be watercovered by seasonal flooding of Cooper Creek.

## STRATIGRAPHY

### BASEMENT

The term basement is used here to denote igneous and metamorphic rocks and indurated steeply dipping sediments. Figure 3 indicates the basement types of the area mapped, the information being derived mainly from oil bores.

#### Granite

In the southeast of the area the basement is granite at shallow depth. Age determinations of granite cuttings from a water bore (Reg. No. 6644) on the Yantabulla (N.S.W.) Sheet area gave a 375-381 m.y. (Middle to Lower Devonian) age (Harding, 1966). An outcrop sample from the Eulo ridge gave a 361 m.y. (Middle Devonian) age (Evernden and Richards, 1962). These are of Upper Devonian age.

Elsewhere in the area basement information is from oil bores.

#### Cambrian and Proterozoic

On the Gidgealpa structure (S.A.) wells have encountered Middle Cambrian and early Upper Cambrian carbonates (dated by palaeontology in Gidgealpa Nos. 1,5,7) overlying pyroclastics and lavas of possible Lower Cambrian to Proterozoic age (Kapel, 1966).

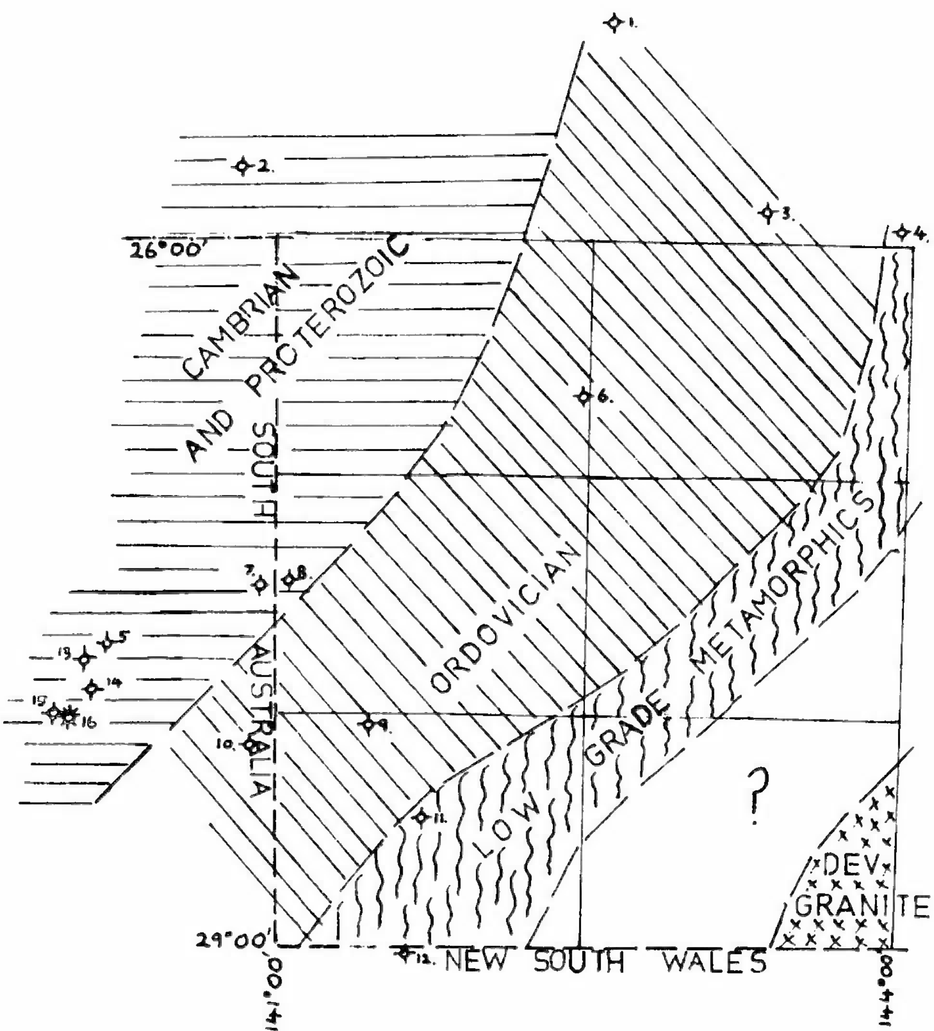
Red beds from Merrimelia No. 2 contain trilobite tracks which, by comparison with the Lake Frome Group, have been tentatively dated as early Middle Cambrian (Delhi-Santos, 1965d). Age determinations of these sediments gave a 550 m.y. (Lower Cambrian) age (Kapel 1966). Similar red beds constitute basement in Merrimelia No. 1 (Delhi-Santos 1965c) and Innimincka No. 1 (Delhi-Santos 1961b). The red beds of Merrimelia No. 2 have been interpreted (Delhi-Santos 1965d) as either contemporaneous with or younger than the volcanics at Gidgealpa. As the detrital minerals in the red beds apparently had a source similar to the volcanics of the Gidgealpa area, Delhi-Santos (1965d) favour the interpretation of contemporaneity of volcanics and red beds.

Basement at Innamincka No. 2 consists of red beds, sandstone, dolomitic sandstone, breccia and red quartzite, and are believed on seismic evidence to be stratigraphically below the red beds of Innamincka No. 1 (Delhi-Santos, 1965e).

Fig 3.

SKETCH MAP SHOWING APPROXIMATE DISTRIBUTION

OF BASEMENT TYPES




OIL WELLS

1. Galway No. 1
2. Betoota No. 1
3. Chandos No. 1
4. Canaway No. 1
5. Merrimelia No. 2
6. Mt Howitt No. 1
7. Innamincka No. 1
8. Innamincka No. 2
9. Orientos No. 1
10. Dullingari No. 1
11. Naryilco No. 1
12. Binerah Downs No. 1
13. Merrimelia No. 1
14. Gidgealpa No. 1
15. Gidgealpa No. 5
16. Gidgealpa No. 7

Scale 50 miles

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The greywacke and boulder-conglomerate in Betoota No. 1 has not been dated but may be of Proterozoic Age (Harrison et al., 1961).

Low Grade Metamorphics

Low grade metamorphics (quartzite and phyllite) were intersected on or adjacent to the Grey Range in Canaway No. 1 (A.O.D. 1963), Naryilco No. 1 (Delhi-Santos, 1962) and Binerah Downs No. 1 (Hanlon, 1966). They have not been dated and could be of Lower Palaeozoic or Proterozoic age. The Binerah Downs phyllite is correlated on lithological grounds with the Willyama phyllite of presumed Proterozoic age from near Tibooburra (Hanlon, 1966).

Ordovician

Basement from the other wells in the area has been assigned by the companies to the Ordovician by lithologic comparison with the graptolite bearing shale of Dullingari No. 1 (Delhi-Santos, 1963b); and Galway No. 1 (479 ± 15 m.y., Jaque and Sweeney, 1966). The lithology consists of steeply dipping hard, dark grey, shale, siltstone and sandstone. The wells in the area with possible Ordovician basement are Orientos No. 1 (Delhi-Santos, 1963d) Mount Howitt No. 1 (Delhi-Santos, 1966) and Chandos No. 1 (Laing & Benedek, 1966).

DEVONIAN AND CARBONIFEROUS

Devonian sediments have been intersected by petroleum exploration wells only in the northeast of the area mapped. Elsewhere, in the Cooper Basin, Permian and Triassic sediments directly overlie basement and on the Thargomindah and Eulo Shelves younger sediments overlie basement. (See fig.6).

To the northwest of the area mapped is the subsurface Devonian Adavale Basin. The basin is bounded on the south, east and west by post Devonian uplift and erosion, and therefore, the original extent of deposition is not represented by the present boundaries ( Tanner, in press; Slanis and Netzel, 1967). The western limit of the basin is the Canaway Arch (Slanis and Netzel, 1967). However, the known western extent of deposition has been extended somewhat by intersection of Devonian sediments in two wells west of the Canaway Ridge, Chandos No. 1 (Laing & Benedek, 1966) and Bodalla 19

No. 1 (Buchan, 1968). These sediments occur in a north-trending trough, the Warrabin Trough which is preserved in a similar fashion to the three synclinal troughs to the south of the Adavale Basin; the Quilpie, Cooladdi and Westgate Troughs. The trough corresponds roughly with a marked gravity 'low' - the "Warrabin Low" and its eastern truncation edge is between B.P. Bodalla No. 1 and Delhi-Santos Mount Howitt No. 1 where Permian rests on basement (see Fig. 6.).

In the Adavale Basin the Devonian - Carboniferous sequence (from the top downwards) is :-

(d) Buckabie Formation
(c) Etonvale Formation
(b) Log Creek Formation
(a) Gumbardo Formation

The lowest Devonian in the Adavale Basin, the Gumbardo Formation (named from Gumbardo No. 1 Phillips-Sunray, 1963) is a sequence of volcanics with an eastern arkosic sandstone facies (Slanis and Netzel, 1967). These volcanics have been recognized in Yongala No. 1 (Laing, 1965) on the western margin of the Adavale Basin, and may be represented in part of the Warrabin Trough.

The succeeding Etonvale Formation was first recognized and named in Etonvale No. 1 (Lewis & Kyranis, 1962). It was subsequently divided into two units, the upper part being called the Etonvale Formation and the lower part below an unconformity, the "Gilmore" Formation (Tanner, in press). The name Gilmore, however, is preoccupied and Galloway (in prep.) proposes its replacement by Log Creek.

Faunal and microfloral studies of the Etonvale Formation favour a Givetian age (upper Middle Devonian), and for the Log Creek Formation an upper Eifelian or Lower Givetian age (Middle Devonian) is favoured (de Jersey, 1966; McKellar, 1966).

The Log Creek Formation in the Adavale Basin has been informally divided into a lower shale member and an upper sandstone member (Tanner, in press, Slanis & Netzel, 1967). The shale member is marine and the sandstone member is shallow marine to continental (Slanis & Netzel, 1967). In Bodalla No. 1 a sequence of grey, green and red sandstones and siltstones below the lowest member of the Etonvale Formation (Cooladdi Dolomite Member) contains a microflora of Middle Devonian age.
However, certain distinctive spores which characterize the Middle Devonian of the Adavale Basin are absent, and de Jersey (1968) suggests that the assemblage may be the result of an "environment which inhibited development and/or preservation of a varied microflora". The sandstone member of the Log Creek Formation is restricted to the central part of the basin, being elsewhere truncated below the unconformity between the Log Creek and Etonvale Formations (Slanis & Netzel, 1967). If the sandstone at Bodalla is equivalent to that of the Adavale Basin its presence at the edge of the Warrabin Trough suggests perhaps that the unconformity is less marked in the west. However it may be that the sandstone is equivalent to the lower shale member of the Adavale Basin.

Seismic evidence (Farley, 1967)suggests that there may be a considerable thickness of sediments below the Cooladdi Dolomite Member in the main part of the Warrabin Trough to the east of Bodalla No. 1.

The Etonvale Formation is a shallow marine to continental accumulation consisting in the Adavale Basin of a lower carbonate member, the Cooladdi Dolomite Member, and an upper sequence of fine calcareous and dolomitic sandstone and red-brown and grey-green shale and siltstone (Slanis & Netzel, 1967). This is conformably overlain by the Buckabie Formation, a dominantly continental sequence of varicoloured primarily red siltstone, sandstone and mudstone (Slanis & Netzel, 1967). It was named by Phillips Petroleum Company from Buckabie No. 1 (Phillips-Sunray, 1962).

The Buckabie Formation is devoid of plant and animal remains and is dated only by its stratigraphic position, conformable above upper Middle Devonian and unconformable beneath Lower Permian. In view of the thickness of the unit it is thought probable that deposition of the sequence extended into early Carboniferous (Tanner, in press; de Jersey 1966; Slanis & Netzel, 1967).

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In the area mapped, the correlation of the Buckabie and Etonvale Formations with the Adavale Basin is based on lithologic and stratigraphic information. A thin dolomite above the Log Creek in Bodalla No. 1, and overlying basement in Chandos No. 1, is correlated with the Cooladdi Dolomite Member of the Adavale Basin. As in the Adavale Basin, this also forms a good seismic reflector. The rocks overlying this, however, and underlying the Permian are a conformable sequence of lithologically monotonous rocks with no yield of flora or fauna. They consist of red and green poorly sorted argillaceous sandstone, siltstone and shale. The Buckabie and Etonvale Formations in these two wells are not divisible (Laing & Benedek, 1966, Buchan, 1968).

## PERMIAN

Permian sediments in the area occur in a north-east trending subsurface Permo-Triassic basin, the Cooper Basin (see Fig. 6) (Kapel, 1966). In the area mapped Permian sediments have been recognized in B.P. Bodalla No. 1, Delhi-Santos Mount Howitt No. 1, Innamincka No. 2 and Orientos No. 1 and rest with unconformity on basement and Devonian sediments. Permian sediments within the basin have been divided into two formations by Martin (1967b),

(b) Gidgealpa Formation
(a) Merrimelia Formation

The Merrimelia Formation was named from Delhi-Santos Merrimelia No. 1. It consists of a sequence of sandstones, conglomerates, conglomeratic shales, shales and siltstones which are considered to be an agglomeration of tillites, glacio-fluvial, interglacial and periglacial sediments (Martin 1967b). These are the result of the cooler climate which followed the Carboniferous epeirogenic movements (Sprigg, 1966; Kapel 1966).

Until the drilling of Mount Howitt No. 1 the Merrimelia Formation was described in well reports as "Permo-Carboniferous" (Martin 1967b). In the area mapped the formation is now recognized in Mount Howitt No. 1 and Innamincka No. 2 where it unconformably overlies basement. The thickness varies from 68 feet in Mount Howitt at the edge of the Cooper Basin to 480 feet in Innamincka No. 2 near the centre of the basin. The age of the formation from palynology is Upper Carboniferous to Lower Permian, Evans (1967) stage 2 (Evans, 1966b).

The Gidgealpa Formation was named from Delhi-Santos Gidgealpa No. 1 (Delhi-Santos, 1963c) and unconformably overlies the Merrimelia Formation. Where the Merrimelia Formation is absent the Gidgealpa Formation unconformably overlies basement as in Orientos No. 1. The formation is a coal measure sequence which has been divided into three sub units (Martin, 1967b). The Lower Member consists mainly of sandstone, shale and coal; the Middle Member is mainly shale and siltstone with minor coal and the Upper Member is sandstone with minor shale and coal (Kapel, 1966; Martin, 1967b). The lower two members are of Lower Permian age, Evans (1967) palynological stage 3 and early stage 4. These are disconformably overlain by the Upper Member of (?) Lower to Upper Permian, i.e., Evans (1967) stage 5 (Evans, 1966b; Evans, 1967; Martin, 1967b). The thickness of the formation in the area varies from 115 feet in Bodalla No. 1 to 2452 feet in Innamincka No. 2. Also, thinning and truncation of the units with proximity to the major anticlinal axes indicates that the structures were tectonically active during Permian time.

The Permian Gidgealpa Formation sediments of the Cooper Basin have yielded gas at the Moomba Gasfield, South Australia and gas and/or gas with a small amount of light oil at the Gidgealpa Gasfield, South Australia (Greer, 1965; Martin, 1967a, b).

## TRIASSIC

The Triassic which conformably overlies the Permian consists of a fluviatile and lacustrine sequence of interbedded grey, green and red mainly fine grained sandstone and micaceous, carbonaceous shale and siltstone. Only Lower Triassic sediments have been recognized in the Cooper Basin. Spores from cores of Chandos No. 1 and Dullingari No. 1 show that palynological units Tr1b - Tr2a are represented in the Cooper Basin (Evans, 1966b). The thickness varies from 233 feet in Bodalla No. 1 to 1,678 feet in Innamincka No. 2. The Middle and Upper Triassic were probably removed during pre-Jurassic epeiogenic movements which resulted in erosion along pre-established lines.

## JURASSIC

Sediments of Jurassic age have been intersected by all of the deep petroleum exploration wells and in deep water bores of the area. Jurassic sediments probably exist over the whole of the mapped area. The lithological succession ranges in age from Lower to Upper Jurassic. A Mesozoic correlation diagram of wireline logs of 10 oil exploration wells is enclosed (Plate 1).

The nomenclature for the Jurassic follows Exon (1966).

### Hutton Sandstone

The Hutton Sandstone or its stratigraphic correlate is present in several petroleum exploration wells within the mapped area. In Delhi Santos Innamincka Nos. 1 and 2, Mount Howitt No. 1 and Bodalla No. 1, this sandstone overlies Lower Triassic sediments. However in Betoota No. 1 and Newlands No. 1 this unit rests unconformably upon Palaeozoic sediments. The Hutton Sandstone has not been identified in Orientos No. 1, Naryilco No. 1 and Binerah Downs No. 1 which are situated in the southern part of the Cooper Basin.

Lithologically the unit consists of fine, medium quartzose sandstone with some coarse to pebbly beds. The fine sandstones are commonly micaceous or carbonaceous. There are minor shaly interbeds and rare thin coal seams. The Hutton Sandstone is rarely glauconitic.

The age of the Hutton Sandstone has been established from palynological evidence to be lower to Middle Jurassic (Evans, 1966). Its presence in oil exploration wells is established on lithological and wireline log evidence.

The Hutton Sandstone is predominantly a fluviatile sequence. Minor marine incursions are suggested by the presence of glauconite at Gumbardo No. 1 (Adavale Sheet area, Phillips-Sunray 1963).

<u>Birkhead Formation</u>

The Birkhead Formation occurs in all the oil exploration wells of the mapped area, with the exception of Binerah Downs No. 1. The unit rests conformably on the Hutton Sandstone. Only slight variations in lithology occur throughout the area and comparisons of the wireline logs show a gradual variation from a mudstone siltstone sequence at Newlands No. 1 in the north, to a mudstone sequence at Naryilco No. 1 in the south. The lithology is carbonaceous mudstone and siltstone with interbeds of coal.

Palynology from Mount Howitt No. 1 suggests that the Birkhead is lower Middle Jurassic in age, no older than J5, and no younger than the top of unit J6 of Evans (1966c); (Delhi Santos, 1966).

The Birkhead Formation lacks marine fossils and was apparently deposited in a lacustrine environment. It varies little in thickness over the mapped area, but tends to thin gradually, towards the southern margin of the Cooper Basin.

Adori Sandstone

The Adori Sandstone is conformable upon the Birkhead Formation. The lithology is mainly medium to coarse quartzose sandstone, though in the southern part of the Cooper Basin, interbeds of argillaceous sediments become numerous. The Adori Sandstone is absent from Binerah Downs No. 1 in the Milparinka Sheet area to the south.

Upper Jurassic spores and pollens were studied by de Jersey and Harris from the Adori Sandstone in Orientos No. 1 (interval 5198 to 5209 feet). (Delhi Santos, 1963d).

On the oil exploration correlation diagram the wireline logs show that the uniform sandstone sequence at Newlands No. 1 gradually changes to an arenaceous and argillaceous sequence at Mount Howitt No. 1. The unit becomes finer grained towards the southern part of the Cooper Basin.

Westbourne Formation

The Westbourne Formation is conformable on the Adori Sandstone. The unit consists of interbedded quartzose medium sandstone, siltstone, and mudstone with abundant carbonaceous material and thin coal seams. The sequence locally is sandier at the base.

As with the older Jurassic units, it varies little in lithology across the mapped area. In Binerah Downs No. 1 the unit is only partially represented and rests unconformably upon Palaeozoic basement.

Hooray Sandstone

The Hooray Sandstone consists of fine to medium quartz sandstone with few interbeds of siltstone in the upper part, and grades down into medium to coarse grained quartz sandstone.

The Hooray Sandstone rests conformably upon the Westbourne Formation. On lithological and wireline log evidence it is often divided into two units by oil companies. The uppermost argillaceous part of the unit is informally called the 'Transition Beds'. The top of the 'Transition Beds' is used as the reference horizon in the oil exploration well correlation diagram. (Plate 1).

The unit is a good seismic reflector known as the C horizon or the 'Blythesdale'.

## CRETACEOUS

### Rolling Downs Group

Sediments of lower and early Upper Cretaceous age were deposited over the whole of the mapped area. The nomenclature of the Rolling Downs Group is that of Vine and Day (1965), modified by Vine et al., (1967). They proposed the following five fold division.

e. Winton Formation
d. Mackunda Formation
c. Allaru Mudstone
b. Toolebuc Limestone
a. Wallumbilla Formation

Only the Winton Formation crops out widely.

a. Wallumbilla Formation

Vine et al., (1967) describe the Wallumbilla Formation as a sequence of mudstone and siltstone, with grey concretionary limestone locally common, minor lenticular sandstone, intraformational conglomerate, and cone in cone limestone. This lithology is consistent with drillers' logs and oil completion reports for the mapped area.

This formation does not crop out but was intersected on several of the deep water bores, and in all of the oil exploration wells of the area.

The formation is dominantly marine, and contains marine shelly macrofossils. Fossils become increasingly plentiful towards the base of the formation. The species present (Vine & Day, 1965) indicate an Aptian to Lower Albian (Lower Cretaceous) age.

The Wallumbilla Formation was deposited following a major marine transgression across a flat surface. Shallow marine, locally paralic (coal seams) conditions indicate possible regression of the sea near the top of the formation.

b. Toolebuc Limestone.

The Toolebuc Limestone (Vine et al., 1967) originally the Toolebuc Member (Vine & Day, 1965) is a platy, grey, coarsely-crystalline limestone, with very thinly interbedded grey calcareous shale. It is normally only a few feet in thickness, and it does not crop out within the mapped area. It is seldom identified by water bore drillers, but in oil exploration wells it is identified on wireline logs. The formation is usually less than 30 feet thick, but is widespread, and thus forms a useful marker.

On gamma-ray logs the formation is identified by a very marked peak. The radioactivity is caused by small amounts of uranium associated with fish scales.

The limestone is possibly not as radioactive as the interbedded or basal shale. The Toolebuc Limestone gamma-ray anomaly might also include some mudstone located at the top of the Wallumbilla Formation (Vine, pers. comm,Galloway and Ingram 1967).

Its diagnostic appearance on gamma-ray logs has allowed subsurface correlation of this unit to be made over a large portion of the Great Artesian Basin. Within the mapped area the Toolebuc Limestone is not evident in the southwest (Tickalara Sheet area). It does not occur in B.P. Bodalla No. 1 in the northeast (Eromanga Sheet area). In the southwest a fish scale zone of grey microcrystalline limestone is a possible correlate of Toolebuc Limestone, but the gamma-ray log does not show the usual distinct anomaly. The Toolebuc Limestone is present in Mount Howitt No. 1, Innamincka No. 2, and Orient Nos. 1 and 2.

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The Toolebuc Limestone is Albian (Lower Cretaceous) in age, based on a restricted marine fauna at Julia Creek, Richmond, and Boulia Sheet areas (Vine & Day, 1965).

c. Allaru Mudstone

The Allaru Mudstone is mainly blue-grey mudstone, but contains minor tough interbeds of thin calcareous siltstone (Vine & Day, 1965). This formation crops out in the core of the Woompah Anticline near the Queensland- New South Wales border. The outcrop is very weathered and B.M.R. Tickalara No. 1 was drilled to obtain fresh samples from the Allaru Mudstone for palaeontological and lithological examination. Fragments of <u>Inoceramus</u> and <u>Aucellina</u> were collected from well excavation debris in the Chesson Anticline. The fossils are enclosed within a blue-grey mudstone and indicate that the Allaru Mudstone, although not outcropping, is very close to the ground surface.

The Allaru Mudstone conformably overlies the Toolebuc Limestone but in the southwest it overlies the Wallumbilla Formation. In outcrop on the northern and eastern margins of the Eromanga Basin it contains a Lower Cretaceous (Albian) marine fauna (Vine & Day, 1965).

This dominantly argillaceous formation shows as a smooth line graph on wireline logs. The upper limit is defined at the change from a smooth to an irregular line graph, representing the sandstone-mudstone sequence of the Mackunda Formation. The marked gamma-ray peak of the Toolebuc Limestone, if present, forms a well-defined lower limit to this formation.

d. Mackunda Formation

The Mackunda Formation contains argillaceous and arenaceous sediments, blue-grey mudstone, and some calcareous siltstone (Vine & Day, 1965). This formation is distinguished from the underlying Allaru Mudstone by the common occurrence of labile sandstone beds.

Only one locality of Mackunda Formation was found in the mapped area, here it was poorly exposed in the core of the Chesson Anticline (Thargomindah Sheet area). Weathering has removed all traces of fossils, but a water-well sited close to the outcrop has excavation debris containing Inoceramus fragments. This well also has Allaru Mudstone, indicating that it was sited near the base of the Mackunda Formation.

Further evidence for the presence of the Mackunda Formation from the Chesson Anticline area, was found by examining cuttings from S.O.E. Orient No. 1. Marine fossils distinguish the Mackunda Formation from the overlying Winton Formation. In Orient No. 1 the marine fossils occur in the interval 50 to 235 feet below the ground surface.

The presence of Mackunda Formation was not recorded by water bore drillers from the area. It is seldom recorded in oil exploration wells, however, labile sandstone containing fossils is recorded in the interval 1330 to 1420 feet in Mount Howitt No. 1 (Delhi-Santos, 1966) and 1970-2200 feet in Orientos No. 1 (Delhi-Santos, 1963d).

The extent of Mackunda Formation is not known. Its response to wireline logging is very similar to that of the Winton Formation. It is probably absent from southern Tickalara and Bulloo Sheet areas.

Mackunda Formation is upper Albian (Lower Cretaceous) in age, indicated by its marine fauna (Vine & Day, 1965).

e. Winton Formation

The Winton Formation crops out over a large area of western Queensland (Hill & Denmead, 1960; Vine and Day, 1965; Gregory et al., 1967). During this survey the known distribution of this unit was greatly increased.

The unit crops out in two forms. Relatively unweathered outcrops are restricted to the eroded structurally high areas. Chemically altered sediments belonging to this formation crop out around the periphery of the structural highs. The chemically altered sediments are commonly overlain by Tertiary sediments.

The rock types of this formation consist mainly of interbedded blue-grey mudstone, and lithic and feldspathic sandstone, in part calcareous, (Vine & Day, 1965).

Within the area mapped, it is commonly deeply weathered and leached but in the cores of structurally high areas, relatively unweathered calcareous labile sandstone outcrops in areas of rolling downs. Outcrops of the latter are restricted to lines or low mounds of rubble interspaced with numerous calcareous, sandy concretions. Areas of rolling downs are, for the most part, soil covered and are usually devoid of trees.

The only lithologies observed are calcareous labile sandstone, with some calcareous siltstone and mudstone. Non-calcareous argillaceous beds and minor coal beds evident in drilling logs and shallow core hole drilling, do not crop out.

Calcareous labile sandstone commonly containing strongly indurated concretions is the most resistant rock type. Concretions range in diameter from a few inches to several feet and many are veined irregularly with calcite. Commonly several concretions are joined together forming a large bulbous concretionary body.

Towards the periphery of domal or anticlinal structures the relatively unweathered Winton Formation grades to a piedmont zone of chemically altered (leached, silicified, and ferruginized) rocks. These are multi-coloured and crop out as scarps or steep sided hills (Photos 4 & 5) and as low mounds.

These rocks have been extensively leached, and secondarily enriched, producing rocks of contrasting appearance and chemical character. Although mineralogical transformations have taken place, the sedimentary bedding and related structures have not been destroyed (Photo 6).

Up to 300 feet of the Winton Formation was affected by the deep weathering processes towards the close of the Cretaceous. These beds are more resistant than the fresh Winton Formation and they form hills, in particular forming cuestas around breached structures.

The process of alteration is discussed in detail in a separate chapter. Preservation of variable thicknesses of the chemically altered Winton Formation sediments below the Glendower Formation is evidence of an unconformity.

Palaeontology and Age

Fragmentary plant material occurs in three modes of preservation:

(a) as disseminated carbonaceous grains, or as thin coal seams;

(b) as impressions mainly of stem material, rarely leaves;

(c) as silicified fragments, which are usually small in size but also occur as logs up to one foot in diameter.

Spores recovered from core samples from B.M.R. Connemara No. 1 indicate an early Upper Cretaceous age (Gregory et al., 1967). Stratigraphic considerations suggest a late Lower Cretaceous to early Upper Cretaceous age for the unit.

The Winton Formation is a fresh water sequence. The sediments are coal-bearing and indicate an interplay of fluviatile and paludal conditions.

The thickness of the unit is variable due to subsequent erosion. The Winton Formation is stripped from a restricted area in the core of the Chesson Anticline (Thargomindah Sheet area) and about one square mile in the core of the Wompah Anticline at the N.S.W. border (Tickalara Sheet area); its maximum thickness is about 4000 feet in the Cooper Syncline (evident from seismic work, Delhi-Santos 1967).

## TERTIARY

### Glendower Formation

Summary

(1) The Glendower Formation is a fluviatile sequence of quartzose arenaceous sediments, containing minor argillaceous interbeds, which unconformably overlies the Cretaceous Winton Formation.

(2) Intense selective silicification has formed beds of silcrete within this formation. Resistant silcrete has been exposed by erosion and commonly forms hard caps to many of the hills.

(3) The Glendower Formation is extremely widespread forming over most of the area a blanket deposit, which averages 30 feet, and locally exceeds 100 feet in thickness.

(4) Broad regional uplift, together with folding, faulting and differential compaction, has produced broad open folds and monoclines.

(5) In some areas, where the Glendower Formation is thin, the whole formation has been silicified to silcrete.

Nomenclature

The term, Glendower Series was introduced by Whitehouse (1940) and later renamed Glendower Formation (Whitehouse, 1954), to cover a sequence of arenaceous sediments which occurs in the valley of the Flinders River near Hughenden. Whitehouse regarded the age of the sediments as Pliocene by inferred relationships with presumed dates of lateritization. Subsequent mapping has shown that the Glendower Formation contains the deposits of an extensive river system (Vine et al., 1965 Gregory et al., 1967) and continues in the area of present study.

Identical sediments to those of the Glendower Formation occur on eastern Cordillo Sheet area to the west of Barrolka Sheet area. These have been described by Wopfner (1963), who proposed the name Mount Howie Sandstone. This sandstone is thought to be Upper Cretaceous in age based on inconclusive macro-paleobotanical evidence (Wopfner, 1963).

Distribution

During early Tertiary times the Glendower Formation was deposited as a thin blanket-like deposit over most of the mapped area. In general the deposits are thick in the west and thin to the east. Local thickness variations are common, for example on the southern limb of the Innamincka Dome the deposit ranges from 12 to over 100 feet over a distance of 10 miles.

Large areas of the Glendower Formation are mantled with Quaternary sediments in the alluviated synclinal areas. The deposit occurs on the flanks of all of the anticlines of the area, but it is doubtful if it preserved across the large synclines.

Topography

The unit crops out in areas of hills in the form of 'gibber' mantled plateaux, mesas, cuestas and as low rises. Where erosion penetrates the silcrete the unit forms cliffs or very steep sided hills. Cavernous weathering occurs in the friable sandstone below the silcrete.

Lines of fissures develop in the silcrete due to removal of underlying friable sediments near the edges of steep scarps. Mass movement takes place when these fissures are lubricated with rainwater and large blocks slump down-slope. These blocks are usually tilted steeply towards the parent hill mass.

Lithology

Quartz sandstone, sandy conglomerate and siliceous siltstone are the dominant lithologies. Variable amounts of reworked chemically altered Winton Formation clasts are common within the sandstones.

Thick iron-stained beds containing very abundant brecciated Winton Formation clasts along with fairly low admixture of introduced quartz are numerous. This lithology is apparently siliceous enough for the formation of silcrete (see notes on silcrete). This type of profile was mapped as Glendower Formation and it is possible that this lithology represents a weathered soil profile which developed in areas which were at a level just above areas of active fluviatile deposition.

7. Conglomerate bed in the Glendower Formation.

The conglomerate beds contain numerous pebbles of milky white quartz (Photo 7). Agate and quartzite pebbles are numerous from widely spaced localities as the Innamincka Dome, Durham Downs and Gilpeppee Anticlines also Wompah, Narranappa, Naryilco, and Orientos Anticlines, and the area south of Nappa Merrie. All of the clasts are well rounded and pebbles are highly polished. Most Glendower Formation sediments have a kaolinitic matrix derived from erosion of the chemically altered Winton Formation.

Cross bedding observed in the quartz sandstones gave a general indication that the sediments were derived from the north east.

Thickness

The upper surface of the Glendower Formation as seen in outcrop is almost everywhere an erosion surface, so the original thickness is not known. Variations from 10 to 100 feet occur locally, the larger thicknesses resulting from channels on the eroded Winton Formation surface.

In general, thicker deposits of Glendower Formation occur in the western sheet areas. This area corresponds to the axis of the Glendower river system. Thick deposits of Glendower Formation may also occur in the Bulloo Depression, Bulloo Sheet area.

Structure

The Glendower Formation has been subjected to epeirogenic earth movements, with additional low amplitude folding and faulting. Some of the broad open fold structures have resulted from a variety of these processes, including differential compaction of Mesozoic sediments over basement highs.

Fold movements took place after the Glendower was deposited and selectively silicified. The fold limbs with dips as low as $1^{\circ}$ are easily identified because of the smooth dipping surface preserved in the extremely resistant silcrete beds.

On a regional scale, silcrete can be used as a structural marker with a considerable amount of success. However it must be noted that sections with up to three silcrete beds were observed from widely spaced localities in the Gray Range and in the Innamincka Dome. Multiple silcretes in the form of lenticular beds occur in above average thicknesses of host Glendower Formation sediments. The lenticularity of the silcrete beds could give untrue dip values and result in mis-correlation.

Age

No identificable fossils were found in the unit. Vermicular tubules containing silt are inferred to be worm borings and in some cases possible root impressions. Polished fragments of silicified wood are common in the conglomerate beds. Fossil evidence for a definite age is lacking but on stratigraphic considerations an early Tertiary age is favoured.

The Mount Howie Sandstone (Wopfner, 1963) is directly correlative with the Glendower Formation. The Mount Howie Sandstone is possibly Upper Cretaceous in age. At present the Formation is ascribed to the early Tertiary, and the name Glendower Formation is preserved to conform with recent mapping by the B.M.R. in western Queensland.

## QUATERNARY UNITS

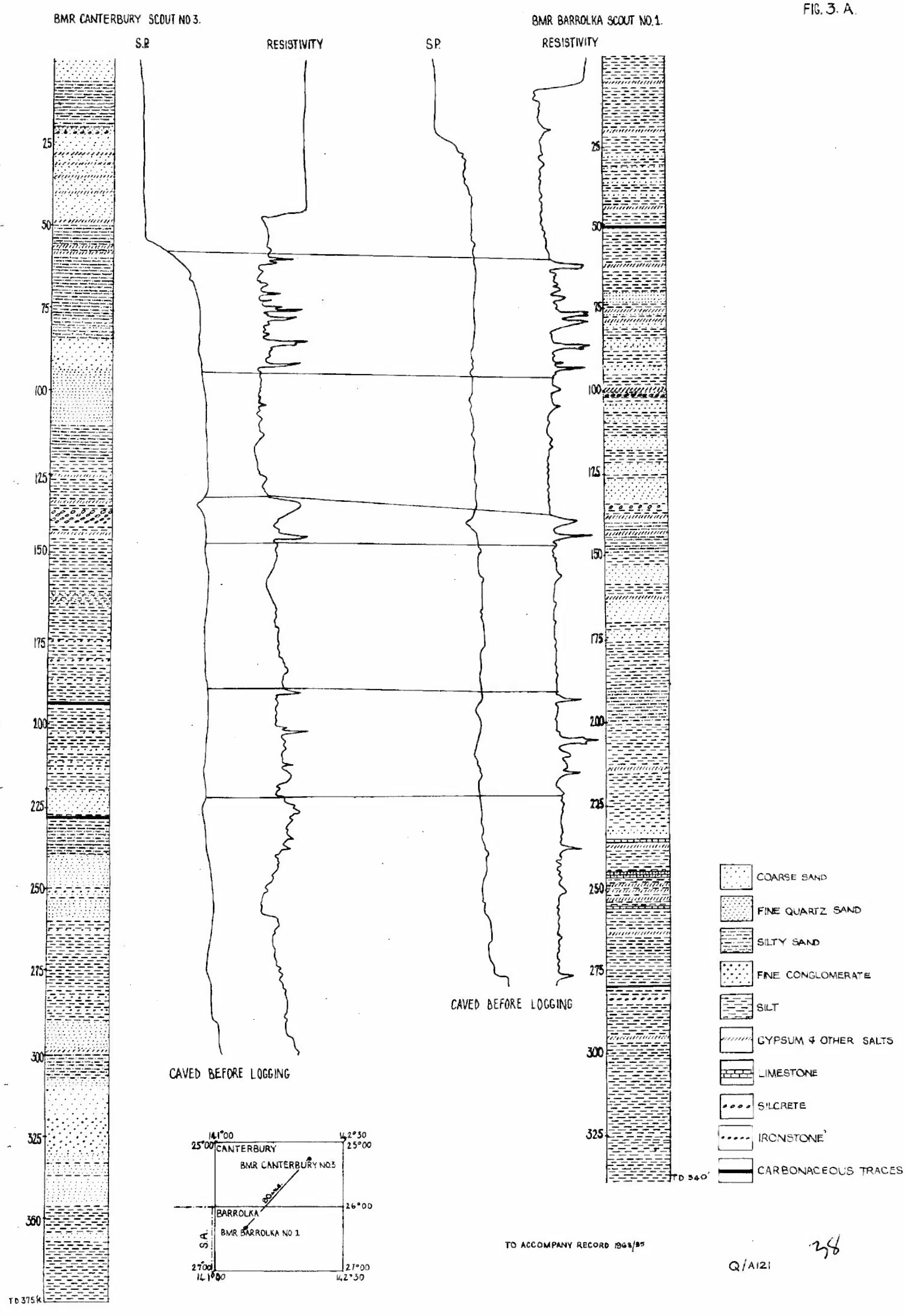
Alluvium (Qa)

Superficial alluvium covers much of the mapped area, however in the vicinity of the major watercourses, particularly Cooper Creek and Wilson River, the alluvium is thick and covers a large area. At the confluence of the Cooper Creek and Wilson River on Durham Downs Sheet area, the alluvium forms a large triangular shaped floodout. Alluvium also occurs in claypans in areas of sand cover.

Thick alluvial development also occurs in the lake areas, particularly Lake Bulloo (Tickalara and Bulloo Sheet areas) and Lake Yamma Yamma (Barrolka Sheet area). At Lake Yamma Yamma a BMR Scout Hole (Barrolka No. 1) intersected 340 feet of alluvium but failed to reach the base of the alluvium owing to the limitations of the rig. Sediments in Barrolka No. 1 include multi-coloured argillaceous sediments with interbeds of gypsum. Electric wireline logs from this hole can be closely correlated with BMR Canterbury Scout 3 on Canterbury Sheet area which is located 93 miles to the north east (Figure 3a). Marked resistivity peaks coincide on the logs (possibly from the gypsum). Gypsum deposition was probably controlled by palaeoclimatic changes.

# WIRELINE LOG CORRELATION DIAGRAM OF QUATERNARY SEDIMENTS

FIG. 3. A.




TO ACCOMPANY RECORD 1968/85

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Dune and sheet sand (Qs)

Large areas have a cover of aeolian sand on Barrolka, Durham Downs, Tickalara and Bulloo Sheet areas. The sand occurs both as sheets and dunes.

The dunes are dominantly longitudinal but have varied orientations, the principal one being northeast. The active dunes around the Cooper Creek tend to be random and have no orientation.

Most dunes are consolidated in the middle and only the crest and northern nose are active. Developed between many dunes, particularly on Durham Downs and Tickalara Sheet areas, are claypans. The silt and clay to form these pans is washed from the adjacent sand dunes.

North of Lake Yamma Yamma (Barrolka Sheet area) reticulate dunes occur (Photo 3). These dunes are interconnected and have active crests. Within each circular 'nest' of dunes is a small circular claypan. The relationship of these reticulate dunes to the longitudinal dunes is not understood.

The sand colour varies from red to white. Redness is caused by iron staining on the individual quartz grains. Red dunes occur in the large areas of sand, away from the main water courses. White dunes occur along the main watercourses, and around lake areas, particularly the Cooper Creek, Lake Yamma Yamma and Lake Pure. The quartz grains in the white dunes have no coatings of iron oxides. This is due to the fact that these white dunes are very youthful and have not had time to accumulate iron oxide coatings. This material has been recently wind transported while the material in the red dunes is partly stabilized. The active crests of the red dunes are only transported relatively short distances and the grains maintain their iron oxide coating.

Islands of red sand do occur in the main watercourses. However these are also stabilized dunes with small active crests.

Silcrete Gravel (Qc)

The flanks and breached centres of the structurally elevated areas are characterized by rounded boulder to pebble sized veneers of silcrete. Large planar areas mantled with this material indicate the former widespread occurrence of the silcrete.

The size of the clasts varies from boulder to pebble size, however some rare residuals may be of gigantic size. Very large boulders occur in areas of largely eroded and slumped silcrete beds on the Eromanga Sheet area.

These mantling deposits of silcrete gravel are resistant to erosion and are being continually let down in situ, whilst soft Winton Formation sediments are eroded beneath them.

Red sandy earths (Qr)

Red earths are extensively developed on the Eromanga and Thargomindah Sheet areas, with only minor development in the other areas. The soil varies in thickness from a few inches to three feet, and in colour from a brick-red to a dark red-brown. It has a friable texture and consists dominantly of silt size to very fine sand size quartz grains. Rock fragments and heavy minerals constitute less than 5 percent and the clay content varies considerably but is less than 30 percent.

Both Tertiary Glendower and chemically altered Winton sediments are covered by these soils which flank the structures and grade into the alluvium and sand sheets of the alluvial plains. They commonly have a thin veneer of mixed gravel of 'ironstone' and silcrete pebbles. Characteristic of the soils is the banded tree pattern with parallel bands of mulga aligned perpendicular to the direction of sheet flow (Photo 8).

8. Banded tree pattern on red earth (Qr)
near Eromanga township.

Chalcedonic Limestone (Qp)

Thin fine grained chalcedonic limestone occurs at widely scattered localities within the area. Outcrop area of this unit is small but drilling results indicate that the limestone may have considerable subsurface extent. The surface outcrops are hard white limestone, containing irregular veins and nodules of cream to flinty grey chalcedony; they are identical to the deposits further north on Canterbury and Connemara Sheet areas (Gregory et al., 1967).

The limestone is mainly restricted to topographic depressions, for example the Haddon Syncline, Yamma Yamma Depression, and a low area to the west of the Durham Downs Anticline and in a syncline west of the Kihee Anticline. Most of the outcrops are too small to be shown at 1:250,000 scale.

In the Haddon Syncline 8 feet of limestone overlies 7 feet of greenish grey, friable, silty sand. The unit has good bedding with horizontal beds ranging between 6 inches and 1 foot in thickness. Chalcedony is concentrated towards the top of the beds indicating secondary near-surface silicification.

Similar limestone occurs close to the western edge of Lake Yamma Yamma. This is a perched deltaic deposit, its upper surface being about three feet higher than the present level of lacustrine sediments in Lake Yamma Yamma.

The deposit is in the form of large broken slabs up to 3½ feet square. The limestone is white to pinkish grey. Veins of chalcedony are common, but the deposit is not as silicified as that in the Haddon Syncline.

Chalcedonic limestone occurs in the interdune areas to the south of Omicron Anticline on Tickalara Sheet and in a syncline to the west of Kihee structure or Thargomindah sheet. Similar deposits, too small to be mapped, occur along many watercourses on western Thargomindah Sheet area and eastern Durham Downs Sheet area.

Similar hard limestones were intersected while drilling shallow stratigraphic holes on Barrolka Sheet area. In BMR Barrolka Scout No. 2, located in the Haddon Syncline, 34 feet of limestone was intersected in the interval 20-54 feet. BMR Barrolka Scout No. 3, located close to Prices Well, encountered limestone lenses between 4 and 14 feet. The limestone in these bores was not as obviously chalcedonic as those exposed at the surface. This suggests that the formation of chalcedony is a comparatively recent surface feature.

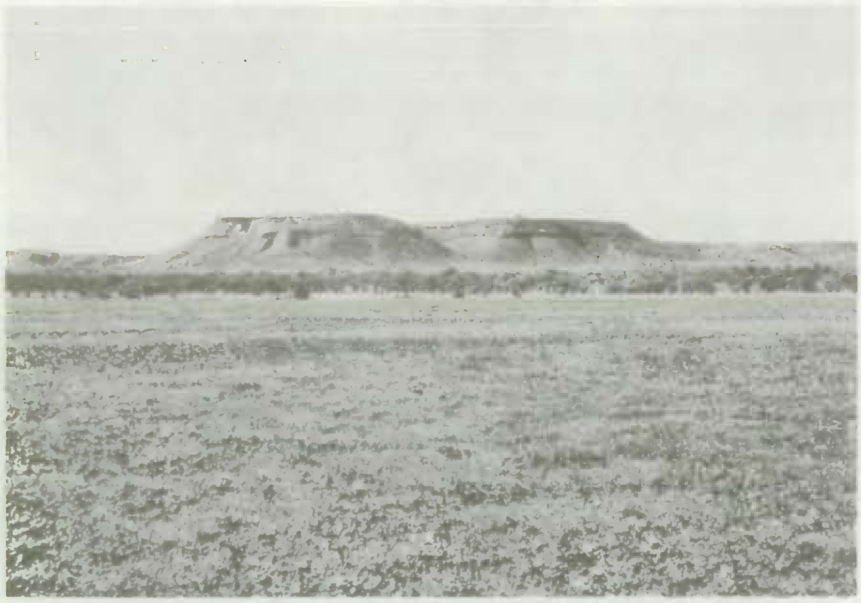
Sandy Limestone (Ql)

These are younger than the chalcedonic limestones and have a patchy distribution throughout the sand country of the western Sheet areas. A strip of this deposit occurs around the periphery of Lake Yamma Yamma.

The limestone varies from very fine grained, white, hard, nodular limestone, to soft friable calcified sand and silt. Some of the larger claypans have a hard pan of this unit. The calcium carbonate has probably been washed out of the surrounding dune sand and precipitated in these local evaporite environments.

The claypan limestones are probably less than one foot thick and are too small in area to be mapped. The limestones on the edge of Lake Yamma Yamma are probably up to 14 feet in thickness. Dowling's tank has been excavated exclusively in this material.

This unit is not silicified and in this respect is easily distinguished from the chalcedonic limestones.



4. Mesas within the central part of the Durham Downs Anticline, showing resistant beds within the chemically altered Winton Formation.

## CHEMICAL ALTERATION, SILICIFICATION AND OPALIZATION

### (1) CHEMICAL ALTERATION OF THE WINTON FORMATION

Deep weathering of the labile sandstone and siltstone beds, by leaching, followed by selective enrichment of selected beds has profoundly changed the lithology of the upper part of the Winton Formation.

These rocks form low hills or cuestas especially around the periphery of eroded and breached anticlines. The range of rock types includes:

(a) White kaolinitic argillaceous beds, replacing mudstone and siltstone.

(b) White, yellow and brown kaolinitic sandstone, replacing labile sandstone.

(c) A variety of sandstone and siltstone beds coloured pink, purple, yellow and brown, reflecting varying concentrations of iron hydroxides, some in the form of ochre.

(d) Indurated, highly fractured, very fine grained porcellanite, replacing mudstone.

(e) Concretionary or laminar 'ironstone' beds, usually 2 to 6 inches thick, occur throughout this chemically altered sequence. The iron oxide content in places is as high as 80% $Fe_2O_3$ (Jauncey, 1964). These oxides are in the form of boxworks, or in a sequence of vari-coloured multi-layered shells. Most 'ironstone' beds appear lenticular, or consist of a disconnected linear series of boulders. Prolific iron staining occurs along bedding laminae, and cross bedding interfaces. Some laminar iron beds have strange mosaic-like 'growth' patterns on their upper and lower surfaces.

Galloway and Ingram (1967), working on fresh core, found beds varying from almost pure siderite to finely disseminated and siderite free. They suggested that the iron in the siderite was the source of the iron in the weathered beds and thus the distribution of siderite in the fresh rock governed where the 'ironstone' beds and various coloured sandstones and siltstones are located in the weathered beds. Alternatively iron concentration could have formed by leaching from the surrounding sediments.

Drilling and direct observation show that the thickness of the chemically altered sediments is variable, but ranges up to 300 feet. It is about 60 feet in the centre of the Innamincka Dome (Durham Downs Sheet area), about 200 feet in the Durham Downs Anticline (Durham Downs and Barrolka Sheet areas), 250 feet at Mt. McIver (Eromanga 174737 ) and 2-300 feet at Mt.Canaway (Eromanga 170768 ). In contrast, B.M.R. Durham Downs No. 1 (Durham Downs 413577 ) encountered no weathered Winton Formation; the Tertiary sequence directly overlies the fresh Winton Formation. Near the base of this altered zone the sediments grade progressively into unaltered rock. The top of the altered sediments is truncated by erosion, and the original thickness is not known.

The deep leaching process destroyed the feldspars, calcite and pyrite, resulting in the formation of beds of kaolin, together with secondarily enriched beds of iron and silica. The white clay minerals are dominant and because of this the term pallid zone is sometimes used to describe these rocks.

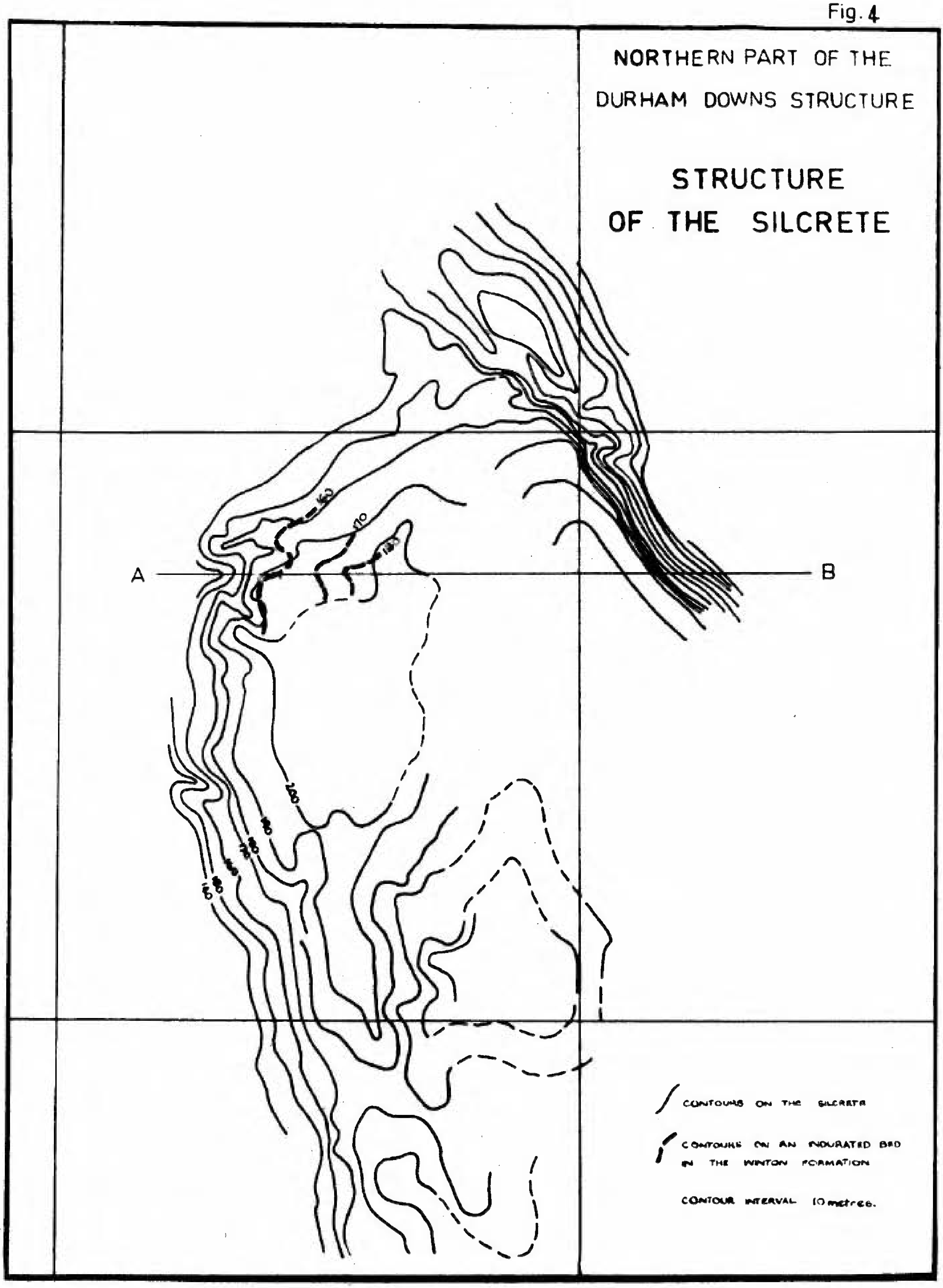
Analysis of the clay minerals show that kaolin is dominant, with subsidiary smectite (smectite is a British term for Montmorillonite group of clay minerals and minor illite-Gregory & Vine, 1968).

Secondary silica within the chemically altered Winton Formation has formed silicified mudstone and siltstone. These indurated beds are collectively described as 'porcellanites'. The porcellanites, together with nondescript iron and silica indurated beds, form prominent benches on the steep sided plateau and mesa escarpments (Photo 13). These beds are lenticular and this places a direct limitation on correlative use as marker beds. French Petroleum Company showed that in the northwest part of the Durham Downs Anticline, probable structural concordance occurs between the indurated beds within the Winton Formation and the silcrete in the overlying Glendower Formation (Cooper, 1966) (Fig. 4).

In many areas the arenitic Winton Formation beds are cemented in the granular interstices with opaline silica. In the vicinity of areas where precious opal occurs, all gradations of common to precious opal have been found.

Small flakes of cream-white coloured chalcedony were found on the scree slopes draping off prominent escarpments of Winton Formation. Chalcedony was found ramifying from Cainozoic chalcedonic limestone into the Winton

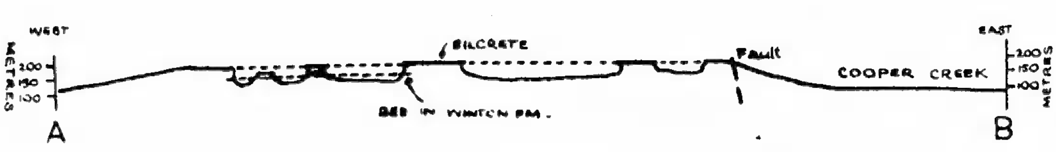
Fig. 4




NORTHERN PART OF THE DURHAM DOWNS STRUCTURE

STRUCTURE OF THE SILCRETE

AFTER R COOPER 1966, FRENCH PETROLEUM COMPANY (AUSTRALIA) PTY LTD.

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Q/A122

5. Steep sided residual of chemically altered Winton Formation, with a prominent kaolinitic sandstone capping. Note 'ironstone' gravel on bench to the left of the picture.

6. Detail of photo 5, showing alternating beds of mudstone and sandstone, some of which have flow structures resulting from vertical compression

Formation on Connemara Sheet area. This indicates that this mineral is a secondary feature of fairly recent origin (Gregory et al., 1967).

Precious opal is restricted to the chemically altered Winton Formation within the area investigated. The mode of formation is discussed under 'Precious Opal' in the chapter on Economic Geology.

(2) SILICIFICATION WITHIN THE GLENDOWER FORMATION

During the Tertiary and possibly continuing to Recent times, there were periods, or a period, of silicification that affected the Glendower Formation.

A very obvious feature of western Queensland are the silcrete-capped table-topped hills, and extensive flats covered by gibbers, formed by the breakdown of the silcrete. The table-topped hills also have a prolific cover of silcrete boulders and cobbles. The large area of outcrop and the resistant nature of this rock gives the impression of one vast silcrete sheet which formed as a result of surface or near surface silicification of quartzose sediments on a peneplain.

Woolnough (1926) was convinced that the hard cappings (including silcrete) were chemically formed rocks identical in mode of origin with other 'case hardened' or 'armour plate' surfaces throughout Australia. He used the term 'siliceous duricrust' to describe silcrete, and thought that its origin was ubiquitous with all other types of hard cappings. To describe the group collectively he coined the term "Duricrust". The duricrust he hypothesized was produced during an era of perfect peneplanation.

Numerous writers noticed that the silcrete has undertone tectonic disturbance. Woolnough observed monoclinal flexures in the duricrust in the Flinders Range area. Wopfner (1960) described several dome structures which are delineated by silcrete capped cuestas in the Cordillo-Betoota area.

Lithology

The rock term silcrete is described coloquially as 'grey billy', siliceous duricrust, quartzite or simply as 'duricrust'. Silcrete is here defined as " a predominantly pale grey, extremely indurated, highly siliceous rock with numerous angular quartz clasts distributed in an amorphous or cryptocrystalline matrix. Considerable variation exists in the ratio of quartz clasts to siliceous matrix, and in the size of the quartz fragments." These factors are controlled by the inherent variations in the host, which, in the area studied is the Glendower Formation.

Silcrete beds range in thickness from a few feet to thirty feet. They are usually fragmentary in the upper part, overlain by a variable thickness of loose boulders commonly called 'gibbers'. Bedding surfaces are often clearly preserved, and lines of quartz or agate pebbles are useful marker beds. Columnar and polygonal structures within the main body of the silcrete are common. In many places pillars of fragmentary material which have been resilicified, extend from the top of the bed down into the underlying sandstones.

Strong vertical joints normal to the bedding surfaces are numerous. These joints are attributed to changes in volume during the process of silicification. Some of the larger joints formed voids, which were later filled with fragmentary material. Much of this material appears to have been resilicified.

Complex concretionary structures indicating accumulation of silica around quartz nuclei are sometimes found on freshly broken silcrete boulders (Photo 9). Silcrete is extremely tough and has a sub-conchoidal fracture.

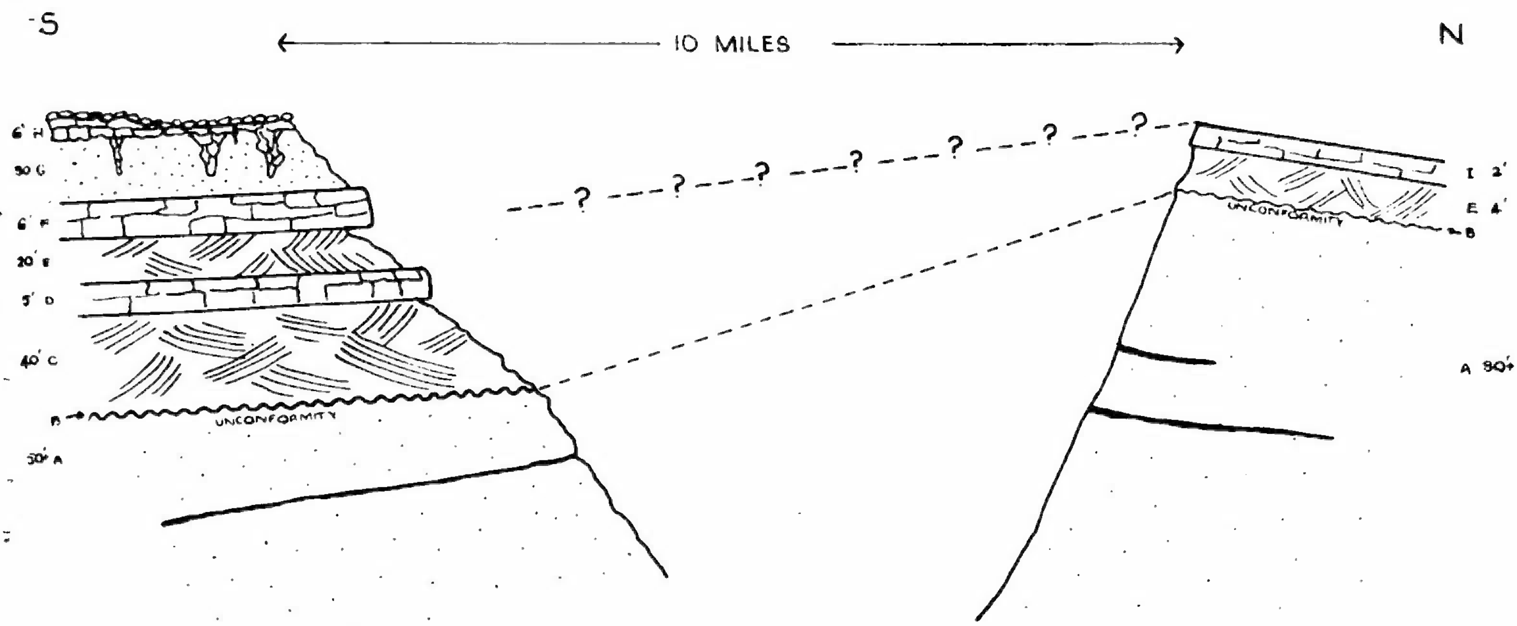
Evidence for Multiple Silcretes

During a field survey by the Bureau of Mineral Resources in 1966, extensive areas of silcrete were mapped. At this time the first indication was found that more than one silcrete might exist. On the western margin of the Thomson River (Jundah Sheet area) silcrete pebbles and cobbles were found incorporated in the Glendower Formation. This unit itself has an obvious silcrete capping. A shallow stratigraphic hole (B.M.R. Jundah Scout No. 3) encountered two silcrete beds (Gregory et al., 1967).

9. Concretionary structures on a broken surface of silcrete.

10. Massive spherical development of silcrete within a sandstone bed.

FIG. 5.




A MULTI-COLOURED, PALLID, FELDSPATHIC SANDSTONE AND SILTSTONE, MINOR 'IRONSTONE' BEDS
B CUT AND FILL UNCONFORMITY
C CROSS BEDDED, WELL SORTED, WHITE QUARTZ SANDSTONE
D SILCRETE $T_1$ HIGHLY SILICIFIED MEDIUM QUARTZ SANDSTONE AND CONGLOMERATE
E CROSS BEDDED QUARTZ SANDSTONE
F SILCRETE $T_2$ FINE GRAINED HIGHLY SILICIFIED QUARTZ SANDSTONE
G POORLY SORTED IRON-STAINED QUARTZ SANDSTONE WITH VERTICAL HONEYCOMB COLUMNAR SILICIFIED ZONES
H SILCRETE $T_3$ ERODED WITH A SUPERFICIAL LAYER OF 'GREY BILLY' SILCRETE BOULDERS
I SILCRETE $T_?$

DIAGRAMMATIC CROSS-SECTION OF A MULTIPLE SILCRETE PROFILE FROM THE SOUTHERN LIMB OF THE INNAMINCKA DOME AND A COMPARISON WITH A SECTION FROM THE NORTHERN LIMB.

TO ACCOMPANY RECORD 1968/35 Q/A123

The presence of two silcretes could be interpreted as two duricrusts representing breaks in sedimentation. Sprigg (1961) mentions that one, two or more duricrust levels are present locally in the Innamincka Dome; these duricrust levels are probably equivalent to the silcrete beds.

A fortuitous exposure along the south central limb of the Innamincka Dome has three silcretes. Each of the silcrete beds is separated by several feet of friable, unsilicified, quartz sandstones. There are no breaks in deposition within the sequence, and it is apparent that all three formed in situ. The lower two silcretes can be traced laterally where they are eroded to form a sequence of silcrete-capped benches.

Multiple silcretes were found at several other localities in southwestern Queensland, especially in the Grey Range area (Bulloo and Tickalara Sheet area, Banner and Wompah Anticlines and unnamed anticlines south of the Naranappa Anticline).

TABLE 1

MULTIPLE SILCRETE IN THE GREY RANGE
(Bulloo Sheet area, Grid Ref. 599517)

| | | |
|---|---|---|
| GLENDOWER FORMATION | 47' - 52' | Silcrete cobbles and large boulders. |
| | 37' - 47' | Quartz sandstone, fine grained, friable. |
| | 32' - 37' | Silcrete, lenticular bed. |
| | 7' - 32' | Cross-bedded quartz pebble conglomerate, quartz sandstone. Abundant redeposited clasts of Winton Formation mudstone. |
| | 2' - 7' | Silcrete, lenticular bed. |
| | 0' - 2' | Quartz sandstone, containing redeposited Winton Formation mudstone clasts. |
| ---------------------- | | Unconformity overlying kaolinitic sandstone and mudstone of Winton Formation. |

The occurrence of multiple silcrete is associated with greater than average thicknesses of host, quartz-rich arenaceous sediments. In places where the Glendower Formation is represented by only a few feet of sediments, the complete profile may be silicified to silcrete.

Stratigraphy of the Innamincka Dome Silcretes

The stratigraphic relationships of the silcrete beds are illustrated in Figure 5. Variable thicknesses of quartz sandstone separate the silcrete beds. The upper sandstone is rusty red brown in colour, and contains zones of honeycombed silicified sandstone, which extend vertically below the silcrete cap. These silicified zones contain a complex network of interconnected spaces, which may have acted as channels for migrating siliceous groundwater.

Close examination of the aerial photographs indicate that the middle silcrete persists for a large distance both laterally and down dip towards Cooper Creek. Silcrete capped benches are developed locally.

The upper and lower silcrete beds are lenticular. Migrating siliceous solutions appear to have been controlled to some extent by the lenticular nature of the beds. Solution was facilitated by the excellent porosity and permeability characteristics of the Glendower Formation sandstones.

Under favourable groundwater conditions one or more silcretes could form simultaneously. Silcretes forming during a specific time interval are in fact chrono-stratigraphic units and as such could transgress litho-stratigraphic boundaries. Photo 10 shows a silcrete bed whose undulatory lower surface is not obviously connected with the original sedimentary texture.

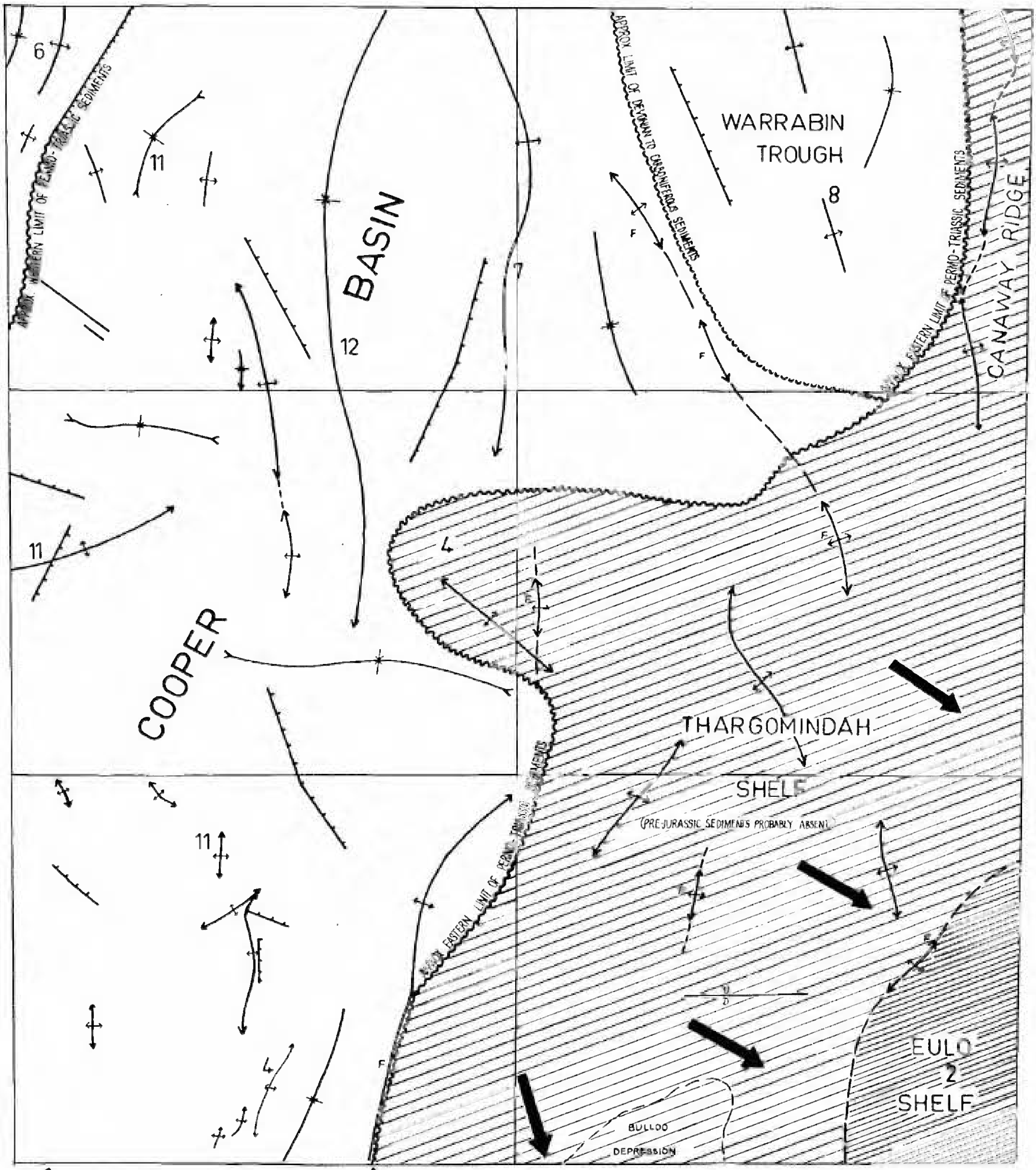
It would be inaccurate to place too much emphasis on silcrete as a regional structural marker, unless a particular silcrete can be traced continuously from one locality to another. However, because silcretes have formed within a very widespread veneer of a fluviatile sedimentary sequence, they can be used successfully on a regional scale as a marker of general structure. The danger is in regarding a sloping surface as a dip slope because it may be formed by more than one silcrete bed.

11. Remnant boulders of silcrete protecting a fossil soil hill capping.

12. Silcrete overlying Winton Formation. Top of the silcrete consists of re-silicified rubble.

FIG 6

## STRUCTURAL INTERPRETATION MAP




- FAULT CUTTING PRE-MESOZOIC SEDIMENTS
- FAULT CUTTING MESOZOIC SEDIMENTS
- INFERRED FAULT CUTTING POST-MESOZOIC SEDIMENTS
- FAULT GRADING TO A MONOCLINE AT THE SURFACE
- SYNCLINE AXIS WITH PLUNGE DIRECTION
- ANTICLINAL AXIS WITH PLUNGE DIRECTION
- TRUNCATED MARGINS OF PERMO-TRIASSIC SEDIMENTS
- 7 APPROX DEPTH TO BASEMENT IN THOUSANDS OF FEET
- THINNING OF MESOZOIC TOWARDS THE EULO SHELF

10 0 10 20 30 40 50
SCALE IN MILES

TO ACCOMPANY RECORD 1968/35

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Observations of multiple silcretes at widely spaced localities show that they can occur well below the present day land surface, and are separated by non silicified beds. If the lower silcretes did not form at a landsurface, then it is possible that the top one did not. Thus silcrete is not necessarily a duricrust.

Near Nappa Merry Homestead in the Cooper Creek valley is some curious 'banded' silcrete (Grid Ref. 414577). This banded silcrete occurs in slumped boulders, deriving from a horizontal silcrete bed, but the banding is horizontal whatever the attitude of the boulder. When the banded silcrete is broken the discolouration can be seen to continue internally. Although silcrete is almost totally impervious a change in the siliceous matrix is taking place at the present day, and might be the result of movement of silica during periodic flooding of Cooper Creek.

## STRUCTURE

### INTRODUCTION

Permian to Triassic sediments are probably confined to the Cooper Basin (Figure 6). The northeast part of this basin is within the mapped area. The Cooper Basin is concealed below a Jurassic to Cretaceous basin known as the Eromanga Basin. Devonian to Carboniferous sediments in the Cooper Basin are known only in the Warrabin Trough, which at this time was probably part of the Adavale Basin. The Warrabin Trough is now separated from the Adavale Basin by the Canaway Ridge.

The gross structures in the basement, in sedimentary basins older than the Great Artesian Basin, are summarized by Tanner, (1966).

Within the mapped area, the Cooper Basin is bounded by a Palaeozoic Basement high in the Arrabury to Curalle area (west Barrolka Sheet area) and in the east by an Ordovician (?) basement high in approximately the position of the present day Grey Range. East of the Grey Range, on the Thargomindah Shelf, pre-Mesozoic sediments are absent.

Thinning of Permo-Triassic sediments towards the Thargomindah Shelf forms a depositional edge to the eastern margin of the Cooper Basin. In contrast to this depositional edge, a structural edge is formed by the Canaway Ridge in the east, and the Curalle Ridge in the west.

Triassic and Permian sediments are probably not represented on the Thargomindah Shelf Area, and there is thinning of Jurassic sediments towards the east. On the Eulo Shelf Lower to Middle Jurassic sediments are absent and only Upper Jurassic and Cretaceous sediments were deposited. Water bore evidence suggests that the marine Cretaceous sediments thin across the Eulo Shelf.

Physiographically the axis of the Cooper Basin is reflected by the position of Cooper Creek.

SURFACE STRUCTURES

(a) Anticlines and Synclines. Over thirty large domes or anticlines were mapped within the six Sheet areas. These folds are evident at the surface by dips on the silcrete beds, with additional evidence from the distribution of chemically altered Winton Formation with respect to the relatively unweathered Winton Formation. By extrapolation, rises of silcrete on sand plain are the surface expression of anticlines, particularly on Tickalara Sheet area.

Seismic evidence confirms most anticlines, and indicates increasing dip with depth.

Many of the structures are on echelon and have northerly orientation. One important structure, the Innamincka Dome, has its axis trending east-west.

The structures can be divided into two groups on consideration of their symmetry. The majority of the structural highs are symmetrical, but a number of them are strongly assymetrical. The structures listed below are assymetrical based on dip measurement on Tertiary silcrete beds.

13. Part of the western limb of the Curalle Dome, showing silcrete capped, westward dipping cuestas.



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TABLE 2

| Name | Dip on Steep Limb | Dip on Shallow Limb | Axial Trend |
|---|---|---|---|
| Curalle Dome | 5-30° | 2-5° | N.N.E. |
| Innamincka Dome | 3-5° | 1-2° | E. |
| Woompah Anticline | 6-40° | 1-3° | N.N.E. |
| Kihee Anticline | 2-12° | 1-2° | N. |
| Constance Anticline | 1-12° | 1-2° | N. |
| Jackson Anticline | 1-5° | 1-2° | N.N.W. |
| Narranappa Anticline | 2-16° | 2° | N.N.W. |
| Yakara Anticline | 1-20° | 1-2° | N.N.E. |

At first sight the large anticlines and domes appear to have formed as a result of regional low amplitude compressional folding. In the Cordillo area (northwest South Australia), northeast-southwest transcurrent movements are suggested as a mechanism for forming the Mount Howie, Curalle and Morney Anticlines (Wopfner, 1961). Oil exploration wells and seismic show that there is evidence of thinning across structures within the Cooper Basin, and that some growth of the structures took place during deposition. Compressional folding probably plays an insignificant part in the evolution of these structures. Tectonic activity in the basement, together with differential compaction of sediments over basement highs, produce the obvious surface-expressed structures.

In areas where the sedimentary cover is relatively thin (less than 7000 feet) strong basement faults are expressed at the surface by strongly assymetric structures. Examples include the Curalle Dome (Photo 13), Kihee Anticline, and the Woompah Anticline.

The largest structure in the area is the Mount Howitt Anticline. This anticline is approximately 90 miles long by 30 miles wide. On seismic evidence the Mesozoic sediments appear as a broad simple fold. This structure probably formed due to differential compaction of sediments over a buried basement horst. Thick sequences of sediments occur in the marginal Cooper and Coonavalla Synclines. Dips on the peripheral escarpments of this structure range from ½ to 2 degrees. A series of trend lines parallel to the western escarpments is probably the surface expression of a basement fault. Seismic evidence indicates a fault upthrown to the east with over 1000 feet of displacement.

The Harkaway and Mount Margaret Anticlines, and possibly the Arcoba Anticline, are fault controlled. The surface expressed structure is a slightly assymetric anticline with a narrow stripped core zone which averages four miles in width. This structure is continuous from the northern extremity of the Mount Howitt Anticline, and strikes southeastward across Eromanga Sheet and possibly as far as the Arcoba Anticline on Thargomindah Sheet area.

The Durham Downs Anticline is a structural high with a smaller parallel anticline and a very shallow intervening syncline. The axes of this structure together with fault traces, trend in a north-north-westerly direction. The northeastern margin of the structure is faulted and Cooper Creek has eroded to the fault, thus spoiling the almost perfectly ovate topographic expression of the structure. The western limb dips gently below a sand covered sequence of near horizontal sediments.

The structure is breached in two places; these areas were the zones of maximum elevation caused by the fold movements and hence correspond to the anticlinal axis. The silcrete, Tertiary and chemically altered Cretaceous beds have been eroded on these axial zones. Fresh, or relatively unweathered Winton Formation sediments, occur below the layer of Quaternary gravels and alluvium in these zones.

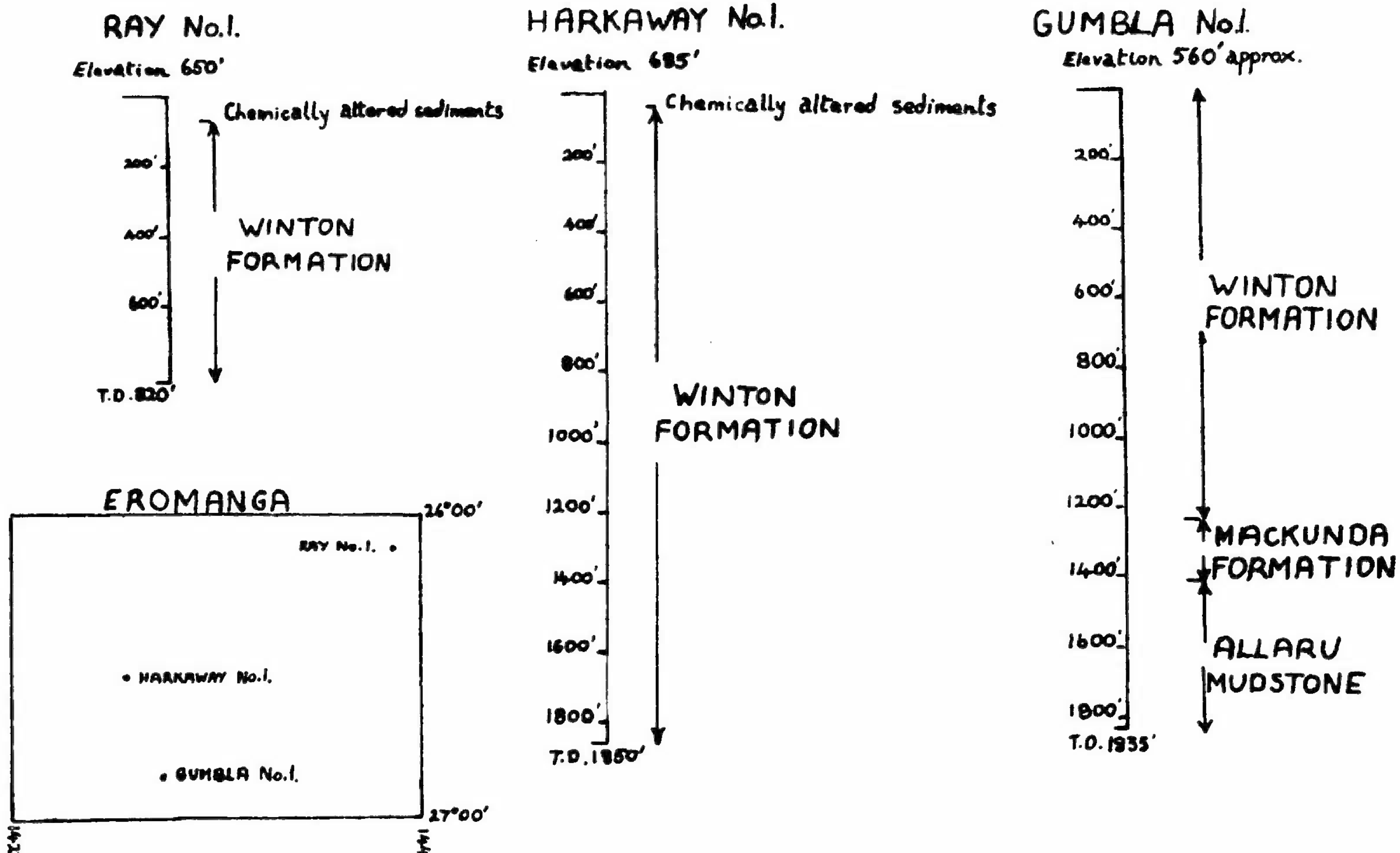
The entire structure may owe its origin to draping of sediments over a complexly faulted basement horst.

The periphery of the structure is marked by silcrete capped, shallow dipping cuestas. Some accurate levelling by French Petroleum Company (1966) shows that the silcrete reflects the structure (Fig. 5). Measurements were also made on an indurated bed within the Winton Formation, and contours on this horizon show structural concordance between the Cretaceous and Tertiary beds.

A sedimentary cover of approximately 4000 feet in thickness is indicated by aeromagnetic evidence for western Thargomindah Sheet area. In this area a north-trending basement fault is clearly defined at the surface as an assymetric anticline, here named the Kihee Anticline. The steeply dipping western limb is exceptionally straight, and persists as an intact silcrete capped cuesta for a distance of 14 miles.

FIG. 7.

# SMART OIL EXPLORATION SCOUT OIL BORES. FORMATIONS PENETRATED.




TO ACCOMPANY RECORD 1968/35

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Similar assymetric anticlines occur on Bulloo Sheet where geophysical evidence indicates less than 3000 feet of sedimentary cover. Fault controlled assymetric anticlines include the Constance and Yakara Anticlines.

On Tickalara Sheet area the Wompah and Narranappa Anticlines are also thought to be monoclines developed as a result of basement faults.

Deep areas of sedimentation occupy synclines between the major structural highs. The most prominent synclinal structure is the Cooper Syncline with its subsidiary offshoot the Yamma Yamma Depression. This syncline extends from Whitula Creek (Canterbury Sheet area) south to the Wilson Depression (Durham Downs Sheet area). The Wilson Depression is the confluence of several synclines. Thick sediments are indicated by geophysical methods along the synclinal axis.

Synclines are not obvious features on eastern Thargomindah and Bulloo Sheet areas. In this area structural highs are separated by flat-lying sediments. On the Bulloo Sheet area the Bulloo Depression is expressed at the surface as part of the Bulloo River drainage system. The Depression probably contains no more than 4500 feet of sediments above basement and these are probably of Jurassic, Cretaceous and Cainozoic age.

The distribution of the silcrete and Glendower Formation south of the Innamincka Dome and west of 142$^{\circ}$ E. Longitude does not reflect Mesozoic and Permian structure as accurately as it does further north. The Naryilco Anticline as expressed by the silcrete reflects the deeper structure only moderately. The Omicron, Epsilon and Roseneath Anticlines do not coincide with any structure as currently defined by seismic work (F.P.C., 1967). The Orientos Anticline as shown by Sprigg (1958b) based on the outcrop pattern of the Glendower Formation, is normal to the seismically defined axis (Delhi-Santos 1962b). On contouring the shot point elevation map that accompanies the Orientos Seismic report (Delhi-Santos 1962b) it was found that there is a topographic ridge parallel to and two to three miles north east of the axis of the Orientos Anticline.

An inlier of Winton and Glendower Formations south of Nappa Merrie was referred to by Sprigg (1958) as the Nappamerry structure and by Wilson and Fitzpatrick (1958b), in an unpublished report, as the Oontoo structure. This was in accord with the regional concept that inliers of Winton Formation coincided with structurally high areas. Wilson and Fitzpatrick described this area as a dome with a northeast-trending axis, a long gentle dip slope (1 degree) down to the northwest and a slope of $2^{o}$ down to the southeast..."the measurement of accurate dips is virtually impossible and skyline dips of the Tertiary Duricrust horizon were used" (Wilson and Fitzpatrick, 1958b). They recognized that in the larger creeks, where outcrops are best, the unconsolidated Tertiary sands below the Silcrete have been eroded, with resultant down-slumping and tilting of the silcrete surface. This was particularly evident along the southeast facing edge of the feature where all apparent southeast dip slopes are actually down-slumped areas. The only reliable dip is the gentle northwest dip down to Cooper Creek near Nappamerrie. Subsequent seismic work (Delhi-Santos 1962c) has shown that there is a uniform dip to the north-west across this area both in the Permian and Mesozoic reflectors. It is thought that erosion of the Glendower Formation and uppermost Winton Formation took place from the area between the hills south of Nappa Merrie and Orientos and the area was later partly filled with aeolian sand.

It is probable that similar combinations of erosion, in fill by dune sand and dune sand "drowning" of structures has led to the present apparently eroneous reflection of deeper structure by the Glendower Formation.

Gravity data (see Fig. 8) shows a minor gravity high corresponding to the feature which evidently reflects a change in the basement.

(b) Faults. Strong persistent lineaments observed on aerial photographs have been interpreted as faults. Most deep seated faults are expressed at the surface as monoclines or assymetric anticlines as described above. However, a few displace the sediments vertically, producing low ridges with no observed change in the regional dips of adjacent sediments.

On the east central part of the Durham Downs Anticline, three parallel lineaments occur which have been interpreted as faults. The most easterly is supported by seismic evidence. The remaining two faults have resulted in minor displacement and tilting of the silcrete. Omnagommera Creek is constricted where it has eroded through the faulted silcrete capped ridge.

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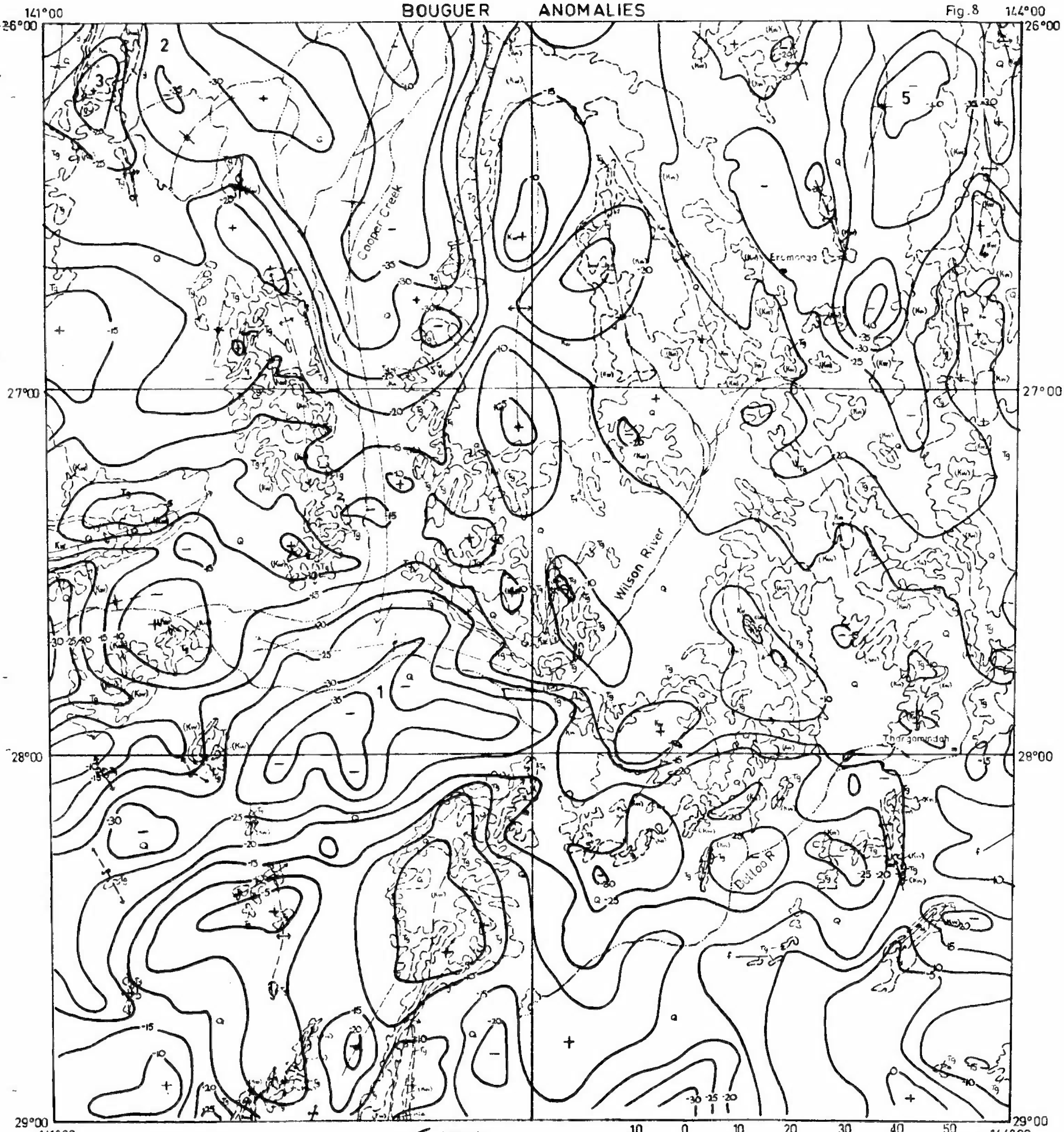
BOUGUER ANOMALIES Fig. 8




GEOLOGY

RESULTS OF SURFACE MAPPING

| | | | |
|---|---|---|---|
| Q | QUATERNARY | Kw | WINTON FORMATION |
| Tg | GLENDOWER FORMATION | Klm | MACKUNDA FORMATION |
| (Kw) | CHEMICALLY ALTERED WINTON FORMATION | Kla | ALLARU MUDSTONE |

ANTICLINE

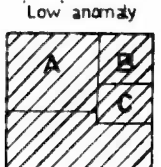
SYNCLINE

FAULT

-35 Isogals

\+ 'High' anomaly

\- 'Low' anomaly




/// B.M.R. Surveys

A Cooper Basin Survey

B Tallyabra Survey

C Conbar Survey

1 Cooper-Wilson Low

2 Barrolka Gravity Low

3 Curalle - Warbreccan High

4 Canaway-Pinkilla High

5 Warrabin Low

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To accompany record 1968/35

Q/A 126

A fault scarp near Quartpot homestead on Eromanga Sheet area is also indicated by geophysical evidence. This fault trends northwest and is on strike with a similar scarp on Thargomindah Sheet area. These fault scarps, although clearly delineated on aerial photographs, are very uninformative when visited on the ground as weathering and chemical alteration of sediments has destroyed all traces of the displacement.

## GEOPHYSICAL SURVEYS

### Introduction

Geophysical surveys undertaken on the six 1:250,000 sheet areas include gravity, aeromagnetic and seismic surveys. Three aeromagnetic surveys cover the entire area apart from the north-west corner. Regional seismic surveys cover most of Barrolka, Durham Downs and Eromanga while localized surveys have been undertaken on Thargomindah, Tickalara and Bulloo Sheet areas. Detailed seismic work following reconnaissance surveys has been undertaken over the Innamincka Dome, (Durham Downs Sheet area) and part of the Eromanga Sheet area. Semi-detailed work has been undertaken on parts of Durham Downs, Barrolka, Eromanga and Tickalara Sheet areas.

The majority of the geophysical work has been subsidized by the Commonwealth Oil search subsidy scheme.

### A. Gravity Surveys

Table 3 summarises the gravity work that has been carried out within the area. Gravity features have been discussed by Delhi-Santos (1967), Robertson and Davies (1966) and Lonsdale (1965). Most appear to be caused by changes in basement type and faults associated with such changes. The Warrabin Low appears to coincide with a Devonian infra-basin west of the Cannaway Arch and similar to but smaller than the Adavale Basin.

Summary of Gravity Surveys            Table 3

| Year of Survey | Abbreviated title | Sheet area covered by survey and remarks | Reference |
|---|---|---|---|
| 1959 | Regional survey Central and Northern Australia | scattered widely-spaced stations,none in area mapped. | Radeski,A.M. 1962 |
| 1957-61 | W.Qld reconnaissance | Eromanga | Gibb 1965. |
| 1961 | Eromanga survey | Eromanga | Smart 1961 |
| 1962-63 | Thargomindah-Noccundra | All sheet areas. | Davies and Robertson 1966 |
| 1963 | Conbar survey | Eromanga-Thargomindah | Smart 1963 |
| 1964 | S.W. Qld. helicopter survey | Barrolka,Eromanga, eastern Thargomindah | Lonsdale 1965 |
| 1965 | Strzelecki-Cooper | Durham Downs-Barrolka | Delhi-Santos 1965b |
| 1966 | Eromanga-Frome | Durham Downs, Barrolka | Delhi-Santos 1966b |
| 1966 | Windorah-Wolgalla | Barrolka, Durham Downs, Thargomindah. | F.P.C. 1966 |
| 1967 | Tickalara | Tickalara-Barrolka, Durham Downs. | F.P.C. 1967 |
| 1967 | Cooper Basin | Barrolka, Durham Downs | Delhi-Santos 1967. |

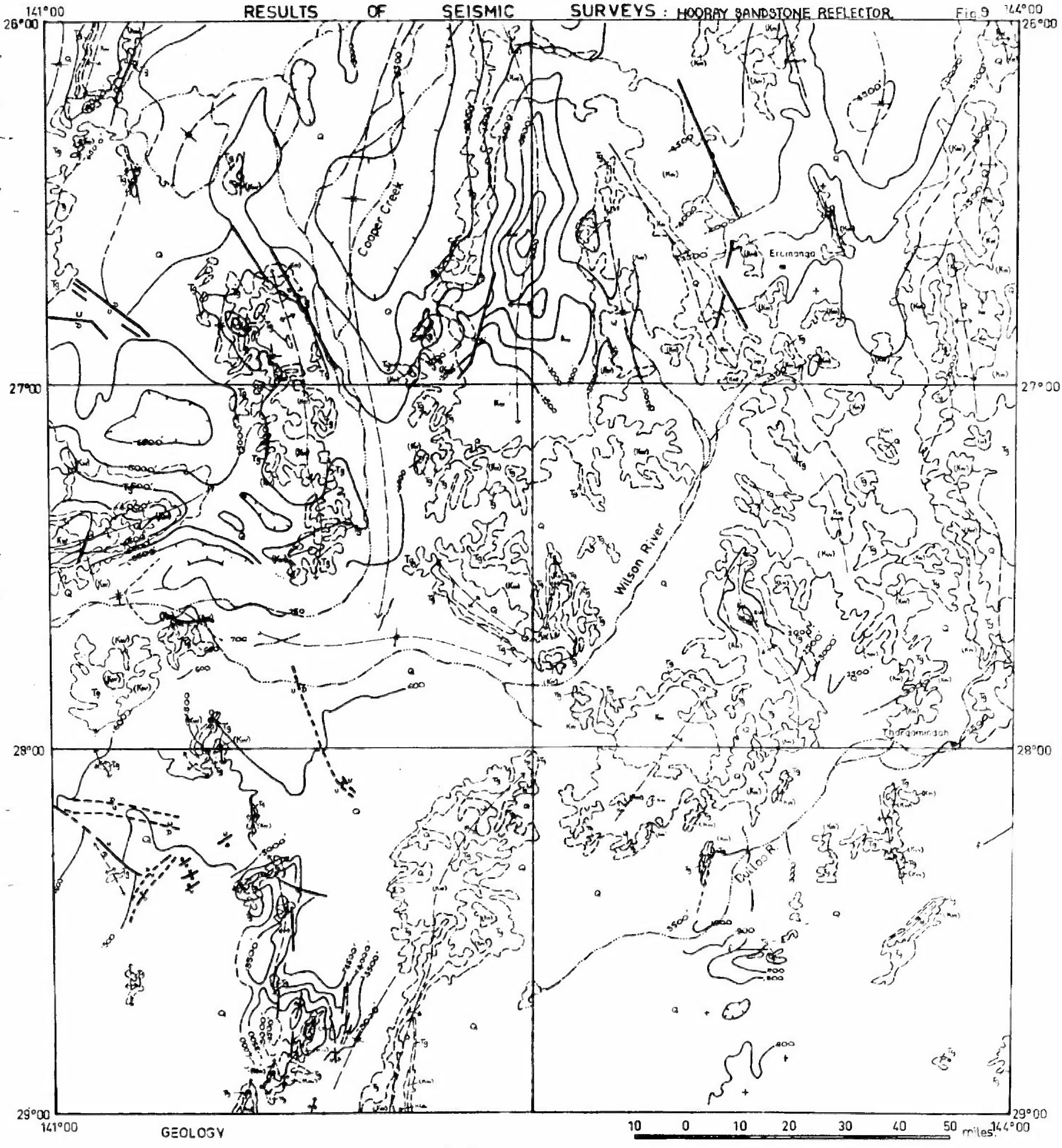
B. Seismic Surveys

Table 4 summarises the seismic surveys that have been carried out within the area.

Reconnaissance surveys have been carried out on Barrolka, Durham Downs, Eromanga and parts of Thargomindah, Bulloo and Tickalara. The Innamincka Dome on Durham Downs Sheet area has received very comprehensive seismic coverage, and seismic surveys are continuing in this area. The lack of pre-Mesozoic reflection east of the Grey Range has led to the concentration of seismic in the west of the area.

## RESULTS OF SEISMIC SURVEYS : HOORAY SANDSTONE REFLECTOR.

Fig 9




GEOLOGY

RESULTS OF SURFACE MAPPING

Q QUATERNARY

Tg GLENDOWER FORMATION

(Kw) CHEMICALLY ALTERED WINTON FORMATION

Kw WINTON FORMATION

Km MACKUNDA FORMATION

Kla ALLARU MUDSTONE

ANTICLINE

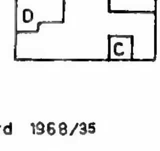
SYNCLINE

FAULT

Fault

High

Contour




A Contour interval 500 ft. Datum : mean sea level.

B Contour interval 500 ft. DATUM : GROUND LEVEL.

C Contour interval 0·1 secs. Datum: 600 ft. above sea level.

D Contour interval 0·1 secs (one way time) Datum : mean sea level.

To accompany record 1968/35

Q/A127

Fig. 10

# RESULTS OF SEISMIC SURVEYS : BASE MESOZOIC REFLECTOR

10 0 10 20 30 40 50 miles.

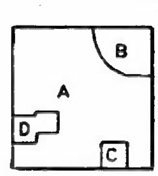
GEOLOGY

RESULTS OF SURFACE MAPPING

Fault

High

Contour




A Contour interval 500ft. Datum : mean sea level.

B Contour interval 0·1 secs. Datum : mean sea level.

C Contour interval 0·1 secs
Datum: 600ft. above sea level

D Contour interval 0·1 secs. (one way time). Datum : mean sea level.

To accompany record 1968/35

Q/A128

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Summary of Seismic Surveys Table 4

| Year of Survey | Abbreviated title | Sheet areas of survey | Reference |
|---|---|---|---|
| 1957 | Experimental seismic survey, Haddon Downs | Barrolka | Smith, and Lodwick, 1959 |
| 1959 | Quilpie-Eromanga reflection | Eromanga | Bigg-wither and Morton 1962 |
| 1961 | Quilpie-Charleville-Thargomindah | Bulloo, Thargomindah | Phillips-Sunray 1961 |
| 1962 | Innamincka-Mount Gason | Tickalara, Durham Downs | Delhi-Santos 1962c |
| 1962 | Orientos-Clifton Hills | Tickalara,Durham Downs | Delhi-Santos 1962b |
| 1962 | Thargomindah-Noccundra | Thargomindah, Tickalara, Durham Downs | Lodwick and Jones 1964 |
| 1962 | Grey Range | Eromanga, Thargomindah | Smart 1962 |
| 1962-63 | Thargomindah-Noccundra | Thargomindah, Tickalara, Durham Downs | Davies and Robertson 1966 |
| 1963 | Diamantine River-McGregor Range | Eromanga, Barrolka, Durham Downs | Delhi-Santos 1963c |
| 1963 | Eromanga | Eromanga | Smart 1963 |
| 1965 | Strzelecki-Cooper | Durham Downs, Barrolka | Delhi-Santos 1965a |
| 1965 | Cooper Creek | Durham Downs | Delhi-Santos 1965b |
| 1965 | Tinderry | Eromanga, Thargomindah | Smart 1965 |
| 1966 | Bulloo | Bulloo | Phillips-Sunray 1966 |
| 1966 | Eromanga-Frome | Durham Downs-Barrolka | Delhi-Santos 1966b |
| 1966 | Windorah-Wolgolla | Barrolka, Durham Downs, Thargomindah | F.P.C. 1966 |
| 1966 | Thylungra | Eromanga | B.P. 1966 |
| 1967 | Cooper Basin | Barrolka, Durham Downs | Delhi-Santos 1967 |
| 1967 | Tallyabra | Eromanga | B.P. 1967 |
| 1967 | Tickalara | Tickalara, Barrolka, Durham Downs. | F.P.C. 1967 |

Important reflector horizons, namely the top of the Hooray Sandstone and the base of the Mesozoic are illustrated on the contour maps (Figs. 9 and 10) which also allow comparison with the surface geology.

C. Aeromagnetic Surveys

Table 5 summarises the aeromagnetic surveys that have been carried out within the area.

Summary of Aeromagnetic Surveys          Table 5

| Year of Survey | Abbreviated title | Sheet areas covered by survey and remarks. | Reference |
|---|---|---|---|
| 1958 | G.A.B. Aeromagnetic reconnaissance | All | Jewell 1960 |
| 1961 | Innamincka-Betoota | Barrolka, Durham Downs, Tickalara, and extreme western edge of Eromanga, Thargomindah and Bulloo. | Delhi-Santos 1965F. |
| 1961 | Quilpie-Charleville-Thargomindah. | Thargomindah, Bulloo. | Phillips-Sunray 1961. |
| 1963 | Coopers Creek | Eastern Barrolka, Durham Downs; western Eromanga, Thargomindah, Bulloo; most of Tickalara. | Delhi-Santos 1963a |

The interpretation of the Cooper's Creek Aeromagnetic Survey indicates that the magnetic basement surface is generally coincident with the geological basement. In the central part of the area the basement rises, forming a ridge or arch reaching a height of 3000 feet or less below sea level and plunges northwesterly.

In the southwestern part of the area the basement plateau shape is that of a reversed "L" varying in depth between 6000 feet below sea level to the north and 4000 feet below sea level in the south.

Several small highs are indicated along the southwestern boundary of the area, reaching up to 3000 feet below sea level. One of these highs is the northernmost extent of the known basement ridge outcropping in the Tibooburra region (N.S.W.).

The older Delhi-Santos survey has picked out a number of anomalies, but few of these are of major importance and none corresponds in any simple way with the surface geology. They are therefore not shown on the accompanying sketch map (Fig. 11).

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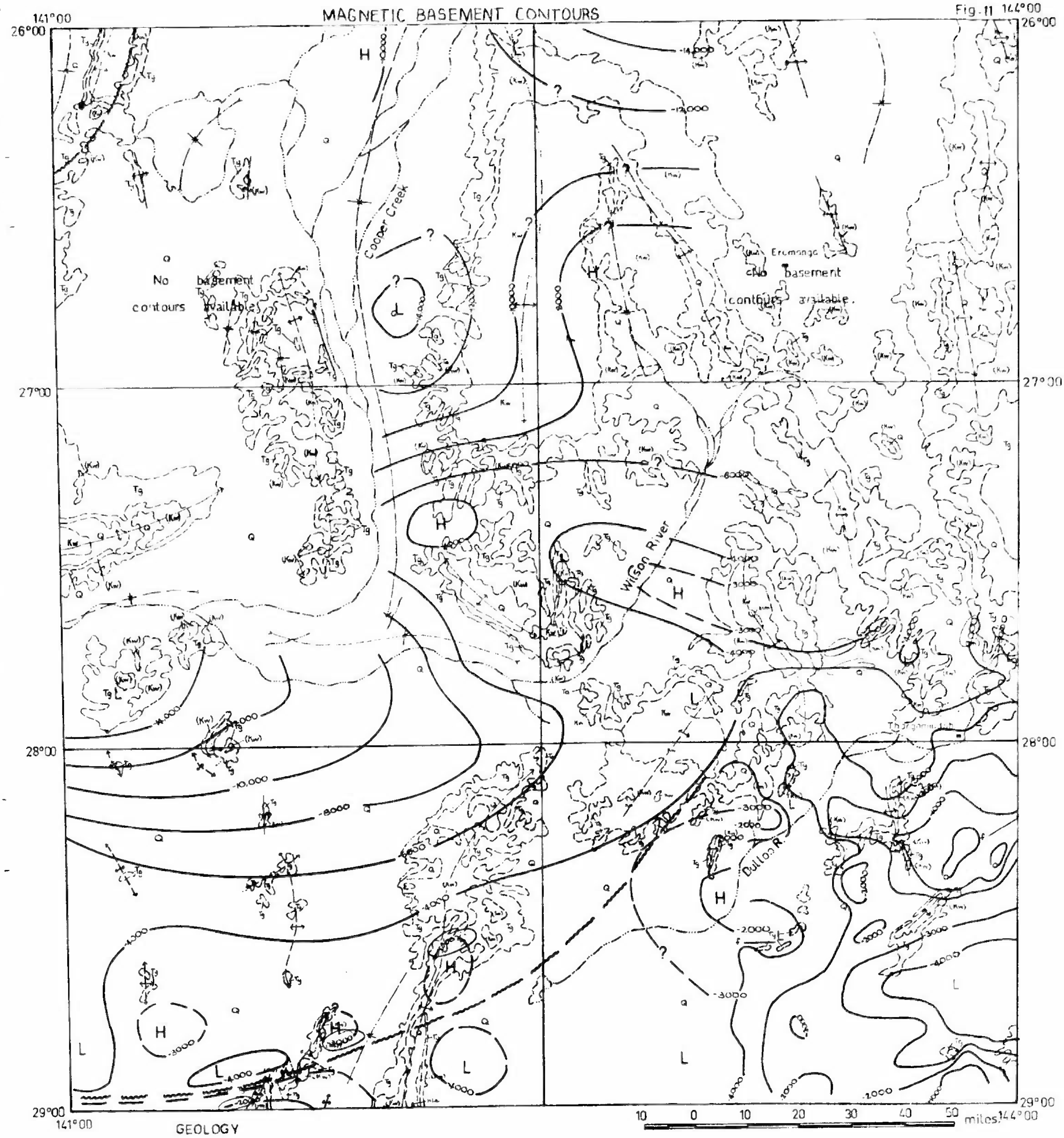
MAGNETIC BASEMENT CONTOURS

Fig. 11




GEOLOGY

RESULTS OF SURFACE MAPPING

| | |
|---|---|
| Q QUATERNARY | Kw WINTON FORMATION |
| Tg GLENDOWER FORMATION | Klm MACKUNDA FORMATION |
| (Kw) CHEMICALLY ALTERED WINTON FORMATION | Kla ALLARU MUDSTONE |

ANTICLINE

SYNCLINE

FAULT

| | |
|---|---|
| A | |
| B | C |

A. Innamincka Betoota.

Fault

B. Cooper's Creek.

H High

L Low

Magnetic Basement Elevation Contours in feet.

Datum: ground level.

C. Quilpie-Charleville-Thargomindah.

Datum: mean sea level.

To accompany record 1968/85

The Phillips-Sunray survey represented in the area is only part of a large survey in which the results indicate that a basement ridge extends northwards from the Eulo Shelf separating two areas, namely, the Cooper Basin in the west, and the Quilpie Trough to the northeast, which have very thick sedimentary sections.

The Thargomindah - Bulloo section of this survey shows a steepening of the basement contours as the eastern margin of the Cooper Basin is approached.

## GEOLOGICAL HISTORY

The basement over a large part of the area mapped, is probably of Upper Proterozoic, Cambrian and Ordovician age and the sediments are now fairly steeply folded and in parts have suffered low grade metamorphism. The orogeny which affected these sediments is probably of late Silurian - early Devonian age, contemporaneous with the Bowning Orogeny (Kapel, 1966).

In Middle Devonian times there was a marine transgression from the east. The Adavale Basin and its associated troughs are regarded as remnants of the western shelf of the Tasman geosyncline (Tanner, in press) and these shelf facies extended at least across the northeast part of the area mapped. The early Middle Devonian marine and shallow marine conditions were followed by uplift and erosion before the shallow marine carbonate conditions which produced the Cooladdi Dolomite Member of the Etonvale Formation. Deposition took place in an arid climate.

The shallow marine conditions were succeeded by late Middle Devonian to early Carboniferous (upper Etonvale and Buckabie Formations) continental conditions of low-lying arid fluvial flood plains and saline lakes (Tanner, in press). During the Upper Devonian the Eulo Granite was emplaced.

Epeirogenic movements in late Carboniferous times resulted in uplift and erosion along the Canaway Ridge and downwarping of the Warrabin Trough. Regional downwarping in the west and north of the area produced the Cooper Basin. Following these movements there was a marked drop in temperature and Permian sedimentation began with the deposition of glacigene material (Merrimelia Formation) on an eroded surface of Devonian sediments and older basement rocks.

Paludal conditions resulting in thick coal measures (Gidgealpa Formation) were dominant in Middle and Upper Permian times. The Triassic was a period of fluviatile and lacustrine sedimentation in the basin and the sediments follow the Permian without break.

Late Triassic movements resulted in the removal, at least from the structural highs, of any deposits of Middle and Upper Triassic age.

The Eromanga Basin sequence of Jurassic and Cretaceous rocks was deposited as a blanket of sediments over the whole area. The Jurassic sediments are continental, fluviatile and lacustrine. The Lower and Middle Jurassic sediments transgressed onto the Thargomindah Shelf and the Upper Jurassic Hooray Sandstone overlapped them onto the Eulo Shelf.

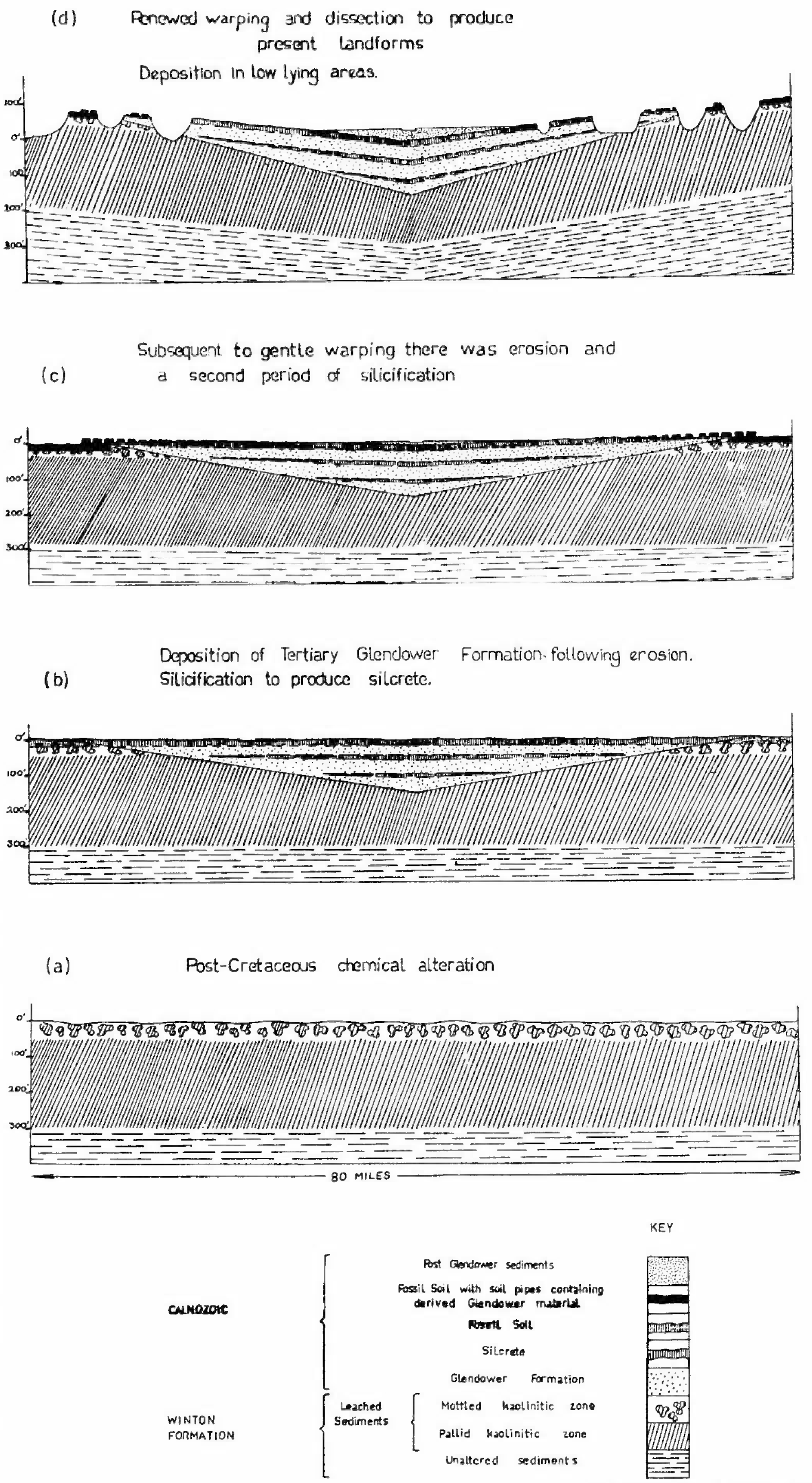
A change to marine conditions occurred in Lower Cretaceous times, which persisted until the deposition of the continental Winton Formation. During an interlude of clear water conditions in the Lower Cretaceous marine transgression the Toolebuc Limestone was deposited.

At the end of the Cretaceous, after gentle folding, there was erosion and peneplanation. Beneath this peneplain there was deep leaching and selective enrichment of the Cretaceous sediments.

The post Cretaceous geological history is summarized diagrammatically in Figure 12.

DIAGRAMMATIC REPRESENTATION OF POST CRETACEOUS GEOLOGICAL HISTORY

Fig. 12




To accompany Record 1968/93 Q/A130

# ECONOMIC GEOLOGY

## Groundwater

Water from artesian and sub-artesian bores and wells is a valuable commodity in this area which suffers from unreliable and inadequate rainfall.

Subartesian water is obtained from numerous bores and wells ranging in depth from 20 to 1000 feet. The water is very variable in quality and quantity. Field conductivity measurements gave a range from 3000 conductivity units (Fresh water) to 155,000 conductivity units * (Salt water) Iso - conductivity lines (Fig. 13) show that groundwater in the vicinity of Cooper Creek is normally saline. This is due to the residual salts accumulating in the sediments because of evaporitic conditions. There may also be structural control, for example meteroic water entering into the Glendower Formation at the catchment on the Mount Howitt Anticline accumulates soluble salts as it moves through the aquifers towards the Cooper Syncline. This observation suffers from the fact that the majority of bores in the area have no drillers log and there are inherent difficulties in establishing from which aquifer system the water is derived. Conductivity values for artesian bores are shown on the diagram for comparison (Figure 13).

Artesian groundwater is less variable than subartesian groundwater, ranging from 3000 to 53,000 conductivity units for water from Jurassic to Lower Cretaceous aquifers, and 8000 to 54,000 conductivity units for water from Winton and younger aquifers. Approximately 20 artesian bores give supplies to the area. These bores are listed in Table 6.

Artesian water can be obtained from any part of the area except possibly the elevated areas. The depth to the main aquifers in the Hooray Sandstone poses severe economic limitations to their utilization. This aquifer system lies at an average depth of 3,000 feet over most of the area. However along the central axis of the Cooper Syncline, depths in excess of 5,000 feet would be needed to tap these aquifers. On southeast Bulloo Sheet, artesian water is obtained between 1100 and 2000 feet below the ground surface.

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*Ten conductivity units are equivalent to one micro mho/cm at 20°C.

TABLE 6

SUMMARY OF ARTESIAN BORES

| Name | Sheet | Depth in feet | Field Conductivity at 20°C | Aquifer | QIWS Reg.No. |
|---|---|---|---|---|---|
| Town | Thargomindah | 2650 | 6,400 | Hooray Sd. St. | 401 |
| Orient No. 1+ | " | 3200 | 15,000 | " " " | 15239 |
| MacGregors | Durham Downs | 2968 | 3,000 | " " " | 2424 |
| Innamincka No. 2+ | " " | 6200 | 53,000 | Hutton Sd. St. | 16768 |
| Mount Howitt No.4* | Barrolka | 2270 | 45,000 | Winton or Mackunda Fms. | 5175 |
| Mount Howitt No.5* | Barrolka | 1156 | 52,000 | " " | 5269 |
| Waretha | Eromanga | 3250 | 7,500 | Hooray Sd. St. | 4022 |
| Whynot Trust | " | 3290 | 7,700 | " " " | 148 |
| Woolah | " | 2580 | - | Winton Fm. | 7311 |
| Mt. Margaret No.9 | " | 5088 | 17,000 | Hooray Sd. St. | 5092 |
| Eromanga No. 1 | " | 2612 | 54,000 | Winton Fm. | 357 |
| Eromanga No. 2 | " | 4270 | 24,000 | Hooray Sd. St. | 358 |
| Kilcoweres | Bulloo | 1207 | 9,000 | Jurassic Sd. St. | 15286 |
| Patoobin | " | 1734 | 8,000 | " " " | 12900 |
| Colenzo | " | 1600 | - | " " " | 7356 |
| Boodgheeree | " | 1474 | - | No information | 1615 |
| Clyde* | " | 2391 | - | Jurassic Sd. St. | 2072 |
| Moombidery No. 15* | " | 1170 | - | " " " | 9686 |
| Moombidery No. 16* | " | 1279 | - | " " " | 12046 |

---

* Denotes artesian bores ceased to flow

\+ Oil exploration wells converted to flowing bores.

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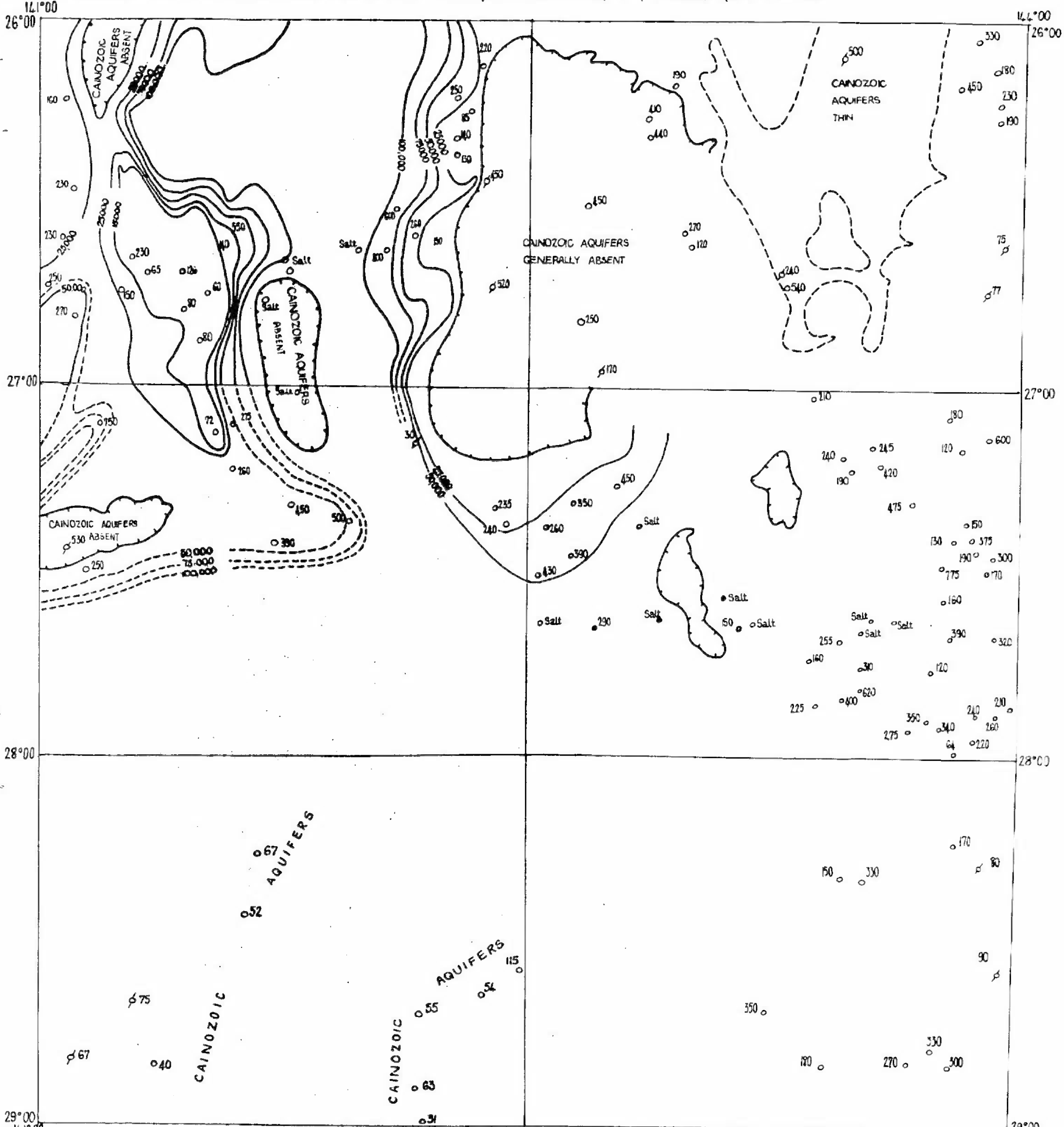
FIG. 13.

ISO-CONDUCTIVITY LINES FOR SHALLOW GROUNDWATER FROM THE WINTON FORMATION, GLENDOWER FORMATION, AND QUATERNARY AQUIFER SYSTEMS.




KEY

VALUES: HUNDREDS OF MICROMHOS/CM @ 20°C

o SHALLOW AQUIFERS < 200 ft.

ø DEEP AQUIFERS > 200 ft.

oSalt SALT WATER (USUALLY ABANDONED)

TO ACCOMPANY RECORD 1968/35

FIELD CONDUCTIVITY VALUES AT 20°C >100,000 MICROMHOS/CM AT 20°C } UNFIT FOR STOCK

75,000 - 100,000
50,000 - 75,000
25,000 - 50,000
} STOCK WATER

10,000 - 25,000
<10,000
} HUMAN + STOCK

Q/A131

A small flow of 500 gallons per hour was recorded from bore Registration No. 5175 which is situated on the west flank of the Mount Howitt Anticline. The aquifers for this bore are almost certainly in the Winton and Mackunda Formation.

Several hundred sub-artesian bores or wells in the area yield variable supplies of stock water. The aquifers are in the Winton and Glendower Formations. Many bores obtain water from both aquifer systems. Winton Formation aquifers are very variable and it is with a certain amount of luck that water of reasonable quality and qunatity is obtained.

Western Thargomindah Sheet area has few bores, and there is a concentration of successful bores to the east of the sheet . These bores obtain water from aquifers within both the Winton and Glendower Formations.

Wopfner, (1961) showed that groundwater at Nilpie Springs and Callamurra Springs, in the Cordillo area (north east South Australia) is derived from a pisolitic sandy 'laterite'. This 'laterite' overlies silcrete. Several wells on western Barrolka derive water from identical 'lateritic' material,which dips eastwards off the Cordillo uplift.

A sand covered silcrete bed exists to the west of the Durham Downs structure. Several bores and wells in the vicinity yield above average quality water. An aquifer above the silcrete at a depth of 27 feet, and another aquifer immediately below the silcrete, at a depth of 38 feet, were found whilst drilling BMR Barrolka Scout No. 3.

HYDROCARBONS

Thick sediments within the Cooper Basin occur to the west of the present day Grey Range. Commercial gas in the Permian is being obtained from the Gidgealpa and Moomba Gasfields in South Australia to the west of the mapped area. Private exploration companies have drilled test wells on all the mapped area with the exception of Bulloo Sheet. The results are largely disappointing but to date only seven deep wells have been drilled.

The number of wells is small when one considers the vast area that has to be evaluated. The results of these wells are described in Appendix 1 of this record.

Interest in the Eromanga Basin is generally lacking, because abundant fresh or brackish water in potential reservoirs probably indicates flushing by meteoric water. Minor shows from the Hutton Sandstone possibly indicate that the sequence cannot be ignored.

The Mackunda Formation (basal Winton Formation) has permeability and is suitably located to receive hydrocarbons originating in older marine Cretaceous sediments.

Preliminary geophysical surveys have covered large portions of the Sheet area (see chapter on geophysical results), and this is being followed up by systematic detailed seismic work.

So far three stratigraphic sequences have been considered as suitable reservoirs for petroleum, they are:

(a) The Devonian in the Warrabin Trough

(b) The Permian, which at Gidgealpa and Moomba in South Australia contains commercial accumulations of petroleum gas.

(c) The Triassic in which shows of oil and gas have been recorded from the mapped area.

Interest in the Devonian-Carboniferous sequence of the Warrabin Trough is due to major, but as yet, non-commercial supplies of gas in the Gilmore Field. The only oil exploration well, B.P. Bodalla No. 1 did not record any shows.

This present survey delineated a number of structural highs which had not previously been mapped. However many structures in the area are 'bald headed', (see chapter on structure) and it might be more useful to drill off structure test wells, rather than wells positioned on structural closures.

Bulloo and Thargomindah Sheet areas have received little attention from exploration companies. Preliminary geophysical work indicated that the Cretaceous-Jurassic sequence rests unconformably on the basement. Permian and older reflections appear to be absent from this area.

A sample of gas from bore 2424 which is located on the south west margin of the Mount Howitt anticline contained 69.9% methane, 28.7% inert, and 1.4% Carbon Dioxide (Geological Survey of Queensland, 1960). Field conductivity measurement of water from this flowing bore indicates the water is unusually fresh (3,000 Conductivity units @ 20°C).

Gas, mainly methane, inert and carbon dioxide were analysed from bores 357 and 358 at Eromanga Township (Geological Survey of Queensland, 1960-65).

PRECIOUS OPAL DEPOSITS

In the area mapped precious opal deposits are mainly restricted to the Eromanga Sheet area but a few prospects were mapped on the Thargomindah and Durham Downs Sheet areas. The majority of mines and prospects are abandoned but there was sporadic working at some of the more accessible mines. On the Eromanga Sheet area there are over forty mines and prospects, most of which were being worked in the last decade of the nineteenth century. However, severe drought conditions at the beginning of the century caused the abandonment of most of the mines.

Jackson, (1902) conducted a detailed survey of the mines in this area and also in the other Queensland fields, and Cribb (1948) examined the Hayricks Opal Mine. Results from the present mapping are presented in more detail elsewhere (Ingram, 1968).

The precious opal occurs in chemically altered Winton sediments, both in the pallid and mottled zones. In the area mapped the greatest depth below the Tertiary land surface that precious opal has been found is 120 feet at Hayricks Opal Mine (Photo 14). Nowhere in the area has precious opal been found in the Tertiary deposits themselves. This applies also to the other opalized areas mapped in Queensland, (Jauncey 1964; Vine 1963, 1964; Gregory et al., 1967) and to the main New South Wales and South Australian fields (Nixon, 1958; Whiting and Relph, 1958; Relph, 1959; Hiern, 1965; Jones & Segnit, 1966). In fact, in the mapped area of Queensland, precious opal has been found only in those Cretaceous sediments which are overlain by very thin (less than 25') Tertiary deposits or where there are no Tertiary sediments.

In the area mapped precious opal takes two main forms. These were first recognized by Jackson (1902).

(1) "Sandstone Opal"

This is used as a general term to cover an association of opal found at sandstone mudstone interfaces in the profile. At the boundary itself a thin iron seam is usually developed. This is usually no thicker than two inches and is commonly no more than a film. The overlying sandstone is commonly ferruginous, up to a thickness of one foot. Within this, the opal occurs as a matrix and also in cavities. Adjacent to the seam in the underlying argillaceous bed, opal occurs sporadically in cavities.

(2) "Boulder Opal"

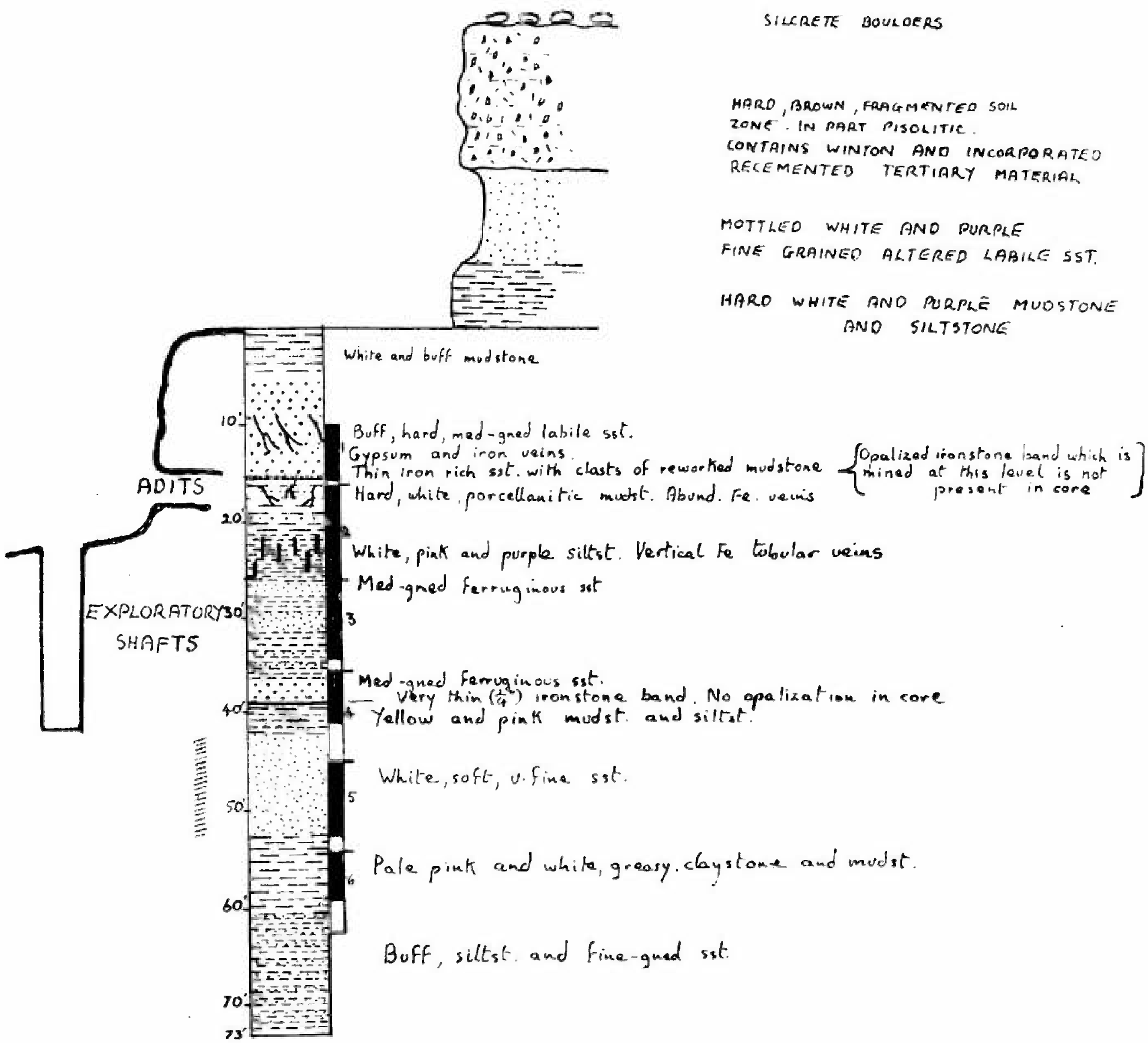
The opal occupies irregular veins, concentric veins, radial shrinkage cracks and "septarian-type" polygonal shrinkage cracks within iron concretions. Rarely, precious opal may form the core of the concretions.

Another, less common type, is pipe opal, where the opal fills thin, tubular, iron rimmed cavities or occurs as veins within solid iron oxide tubules. In some cases the tubules result from the replacement of woody tissue by iron oxide. Opal also occurs in irregular iron oxide veins, generally horizontal and commonly occurring in the same horizon as the boulders.

14. Hayricks Opal Mine
(North east Eromanga Sheet area)

Fig. 14

# B.M.R. EROMANGA No. 2 [LITTLE WONDER OPAL MINE]




CHEMICALLY ALTERED WINTON FORMATION ROCKS THROUGHOUT

Cored interval

Opalized iron concretions from this unit are being mined near the Little Wonder Mine



To accompany Record 1968/35 Q/A132

The usual method of prospecting involves searching for traces of "colour" on the surface. If fragments of ironstone containing traces of precious opal are found, then shafts are sunk in the hope of intersecting an opalized ironstone seam or concretionary horizon. The opal mines usually consist of a series of these shafts. However, where the opalized horizon crops out adits and drives have been dug into the hillside. The opal generally occurs at several levels in the profile (B.M.R. Eromanga Scout Hole No. 2 penetrated three opalized horizons, within 50 feet - see Fig. 14), but at any one mine usually only one level has worked.

The main conclusions about the formation of precious opal from field evidence in south western Queensland (Ingram, 1968) are as follows:-

(a) In the case of sandstone opal, the silica, which was probably released into solution by the breakdown during weathering of feldspar and/or clay minerals to kaolin in the labile Winton rocks, has apparently moved down the profile, been trapped above impervious barriers, and then concentrated and deposited as a silica gel. Possibly in this downward movement a certain amount of colloidal silica was trapped in the concretionary horizons.

(b) The rock profile during the formation of the opal was periodically wetted and dried. Shrinkage cracks formed in the concretions and cracks formed in opal which was already deposited. These cracks were filled by later opal after renewed rise of the water table.

(c) The reason for opal occurring where the Tertiary sediments were very thin may be due to the fact that percolating solutions in these areas were able to affect a thick section of Winton sediments below. Elsewhere, where relatively thick Tertiary sediments covered the Winton rocks, the solutions may have affected only the Tertiary which was possibly unsuitable for precious opalization.

It is suggested that future prospecting should concentrate on those areas of chemically altered Cretaceous sediments with thin, or no, Tertiary cover. It is possible that there is a structural control for opalization as at Andamooka (Nixon, 1958) where the opal is related to a very shallow basin structure, and this should be investigated.

Construction material

In such a remote area local materials, whether truly suitable or not, have to be used for many purposes. The main ones are:

1. silcrete boulders cemented to form causeways;
2. silcrete and quartz gravel as road surfacing in areas of thick clay soil or areas subjected to flooding;
3. fragmented material of chemically altered Winton Formation for road surfacing. This material has a low strength but forms a fairly smooth surface with fair drainage.

For main developmental roads, these materials are supplemented with bitumen to provide all weather roads.

Sand from sand dunes and loamy sand from sheet sand deposits is also available for road construction.

Gypsum

Gypsum occurs disseminated throughout both the chemically altered and unweathered profiles of the Winton Formation. Also drilling has shown the presence of small amounts of gypsum in Quaternary alluvium.

In widely spaced localities throughout the six sheet areas, gypsum occurs as reasonably thick beds in the Winton Formation, for example, northern Durham Downs Anticline (Barrolka Sheet area), where the lenticular beds of gypsum are up to 1½ feet thick.

Mining of the gypsum is not an economic proposition owing to the limited extent of the beds and the remoteness of the area.

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## APPENDIX I

### Summary of Results from Petroleum Wells on open file at The Bureau of Mineral Resources

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The following information has been extracted from oil exploration completion reports. All are available for inspection at the Bureau of Mineral Resources, Canberra. The nomenclature used is that of oil companies.

Innamincka No. 2

Company Delhi Australian Petroleum Limited and Santos Limited.

Completed 1-9-65

Tenement 66P and 67P Total depth 11,763 feet

Status Completed as a water bore.

Innamincka No. 2 was drilled on the flank of the Innamincka Dome. This well is located 8.7 miles east north east of Innamincka No. 1 (Innamincka Sheet area). Interest on this area at present is due to the presence of commercial quantities of gas at nearby Moomba and Gidgealpa.

The first indication of hydrocarbons in Innamincka No. 2 was from the Lower Triassic. Fluorescence was recorded the sandstones in the interval 6,830 to 6,850 feet, and from 7,130 to 7,160 feet. D. S.T. No. 1 across the sandstone recovered only drilling mud. Log analysis showed the sandstone to be 75% water saturated.

D.S.T. No. 2 (8,415 to 8,485 feet) and D.S.T. No. 3 (8,512-8,675 feet) in the Permian, both flowed gas to the surface, and recovered gas cut mud and formation water. Other gas shows occurred in the intervals 9,450 to 9,465 feet, and 10,827 to 10,950 feet.

Below 8,581 feet in the Permian and Permo-Carboniferous permeabilities are low. Traces of hydrocarbons were noted from these non-reservoir sediments.

Mount Howitt No. 1

Company Delhi Australian Petroleum Limited and Santos Limited.

Completed 18-10-66

Tenement 66P and 67P Total Depth 7,719 feet.

Status Dry and abandoned

Mount Howitt No. 1 was drilled on the crest of a large surface anticline. Weak hydrocarbon shows were recorded from Jurassic and Triassic sediments. There were no gas or oil shows recorded in the Permian. There were no pre-Permian hydrocarbon shows.

In the Jurassic sequence, hydrocarbon shows were recorded from the Birkhead Formation and the Hutton Sandstone. Yellow fluorescence was present in siltstones and tight sandstones from 4,660 to 4,747 feet in the Birkhead Formation. D.S.T. No. 1, tested across this interval, recovered 15 feet of mud. One hundred units of gas were recorded from the interval 5,505 to 5,535 feet in the Hutton Sandstone. D.S.T. No. 2, across the interval 5,474 to 5,535 feet flowed fresh water to the surface.

There were hydrocarbon shows in the Lower Triassic. Yellow fluorescence with an instant chlorothene cut, was recorded from a tight sandstone zone, in the interval 5,930 to 5,934 feet. D.S.T. No. 3, was conducted across this interval and recovered 31 feet of mud. Bright yellow fluorescence was present in all sandstone zones from 6,082 to 6,149 feet in the middle unit of the Lower Triassic.Gas and water flowed to the surface during D.S.T. No. 4 across this interval.

There were no hydrocarbon shows in the Gidgealpa Formation, Merrimelia Formation or the Ordovician (?) shale sequence.

Naryilco No. 1

Company Delhi Australian Petroleum Limited and Santos Limited.

Completed 19-2-62

Tenement 66P and 67P Total Depth 4,847 feet

Status dry and abandoned

Naryilco No. 1 was drilled on a subdued anticline which trends north-northeast to south-southwest. No shows of gas were recorded and the only evidence of hydrocarbons was detected by ultra violet light. A slight gold fluorescence from only 1% of the total sandstone from the interval 4,420 feet - 4,430 feet (possibly Walloon Formation equivalent) was recorded.

Permian sediments were absent from the well and the Walloon and Triassic beds rest unconformably on the basement. The age of the basement is in doubt but parts are similar lithologically to the Ordovician quartzites in Delhi-Santos Dullingari No. 1.

No formation tests were conducted. The Mooga Formation, and possibly the Walloon Formation and Triassic possessed fair to good reservoir qualities.

Orientos No. 1

Company Delhi Australian Petroleum Limited and Santos Limited

Completed 17-12-62 Total Depth 11,527 feet.

Tenement 66P and 67P

Status completed as a water bore.

Orientos No. 1 was drilled on the crest of a closed anticline. The Mesozoic section gave little encouragement regarding petroleum possibilities, aside from indicating excellent potential reservoir beds. The Permian shales and siltstone yielded traces of oil on extraction and may be regarded as possible source beds for petroleum. The marine Ordovician shales are also likely source beds for petroleum. No effective zones of porosity in association with these possible source beds were encountered in the well.

Porosities were low and permeabilities nil in sediments older than Lower Jurassic. No formation tests were made.

Bodalla No. 1

Company B.P. Petroleum Development Aust. Pty.Limited.

Completed 6-10-67

Tenement 99P Total Depth 8,809 feet.

Status Dry and abandoned.

Bodalla No. 1 was drilled on a flank of the Tallyabra anticline where seismic indicated a closed Permian structure on the downthrown side of a northwest-trending fault. It was drilled 45 miles south-southeast of Chandos No. 1. Chandos, drilled on the Chandos anticline, obtained free oil and gas shows from Lower Triassic and Permian sandstone. The Tallyabra and Kyabra Anticlines occur on a gravity high flanking the large Warrabin gravity low. Bodalla was drilled at a structurally higher elevation than Chandos.

No significant hydrocarbon shows were encountered. A weak pale yellow fluorescence was recorded from shales (core 3) of D4? age. The Triassic sandstones were porous with variable permeability, the Permian Sandstones were slightly permeable and the Devonian sandstones had low permeability. Reservoir sandstones encountered in the Cretaceous to Triassic section were fully saturated with fresh water.

Orient No. 1

Company L.H. Smart Petroleum Co. Limited

Completed 9-6-61

Tenement 85P Total Depth 3,195 feet.

Status Completed as a water well.

Orient No. 1 was located on the crest of a seismic and gravity determined anticline the Chesson Anticline (Thargomindah Sheet area). The scale of operations is considerably smaller than the exploration wells previously described and a 'Hydromaster' percussion boring plant was used.

Permission was obtained from the company to examine the cuttings from this well. The following stratigraphic divisions were made.

| Depth below ground surface in feet. | |
|---|---|
| 0' | Winton Formation |
| 45 | Mackunda Formation |
| 250 | Allaru Mudstone |
| 1400 | Toolebuc limestone |
| 1420 | Wallumbilla Formation |
| 2225 | Hooray Sandstone |
| 3195 | T.D. Hooray Sandstone |

Numerous gas shows were recorded, one analysis from 2,240 feet showed the composition to be entirely of hydrogen, inerts and methane. Gas at 2,910 feet consisted dominantly of methane and ethane (G.S.Q., 1961). The hole was completed in the Hooray Sandstone and completed as an artesian bore.

A second well Orient No. 2 was drilled $2\frac{1}{2}$ miles east of Orient No. 1. The well was spudded in the Mackunda Formation and encountered a very similar sequence to Orient No. 1. This well succeeded in penetrating the Hooray Sandstone and possibly completed at 3,535 feet in a calcareous green coloured sandstone, probably the Westbourne Formation (see Appendix 2 for Petrological Report).

Other exploration scout holes drilled by Smart Oil Company located on Eromanga Sheet area are illustrated diagramatically. (Fig. 7).

## APPENDIX 2

## Petrography of a Core Sample From a Depth of 3500 Feet in Smart Oil Orient No. 2

by

W.R. Morgan

The specimen (R12192) was submitted by Dr. G. Terpstra. Examination of the chips by hand lens shows that nearly all of them consist of a grey, very inequigranular but fine grained sandstone, the coarser grains being enclosed by a fine-grained, pale greenish-grey matrix. One chip was seen to be composed of a pale grey siltstone.

In thin section (slide number 9506) the sandstone noted in the chips is a fine-grained greywacke. The rock consists of inequigranular, angular to sub-angular grains embedded in a fine-grained matrix. The grains consist of quartz, subordinate sodic plagioclase, and rare chert, and ranges in size from 0.03 mm to 0.4 mm. The matrix consists of sericite, with a small amount of colourless to pale bluish-green chlorite; both of these minerals appear to have undergone some recrystallization, suggesting that the rock is a very low grade metamorphic. Rare calcite, accessory granules of leucoxene and opaque ore, and prismatic tourmaline are present. The tourmaline prisms have rounded edges, showing that they are detrital, and are pleochroic from pale to dark smoky, greenish-brown.

A chip of sericitic siltstone present in the section consists of quartz, sericite, and some chlorite; it has an average grain size of 0.02mm., although a few quartz grains measure up to 0.5 mm across. The rock has no lamination or cleavage. It is cut by rather irregular veins, at least 2.8 mm thick, that consist of quartz, chlorite, and calcite.

Reference.

Morgan, W.R., 1962 - The petrography of D.D.H. chips from L.H. Smart Oil exploration Orient No. 2 Bur.Miner. Resour. File No. 62/1085

## APPENDIX 3

## GEOMORPHOLOGY OF THE AREA

by

J.A. Mabbutt

### I - GENERAL PHYSIOGRAPHY

The survey area of approximately 90,000 $km^2$ forms part of the inland plains of the extreme southwest of Queensland, where the river systems of the Channel Country enter the dunefields of south-central Australia.

The drainage is dominated by Cooper Creek. This river follows a southward course in a broad floodplain which widens and attains 125 km in extent where it receives the Wilson River, its only major tributary in the survey area. The Cooper then swings westward in a constricted floodplain and enters South Australia. The other major river, the Bulloo River, heads southwestwards parallel with and east of the Grey Range and passes into a tract of floodouts and sand dunes which terminates in the Bulloo Lake system on the State border. The main river plains are between 60 and 120m. above sea level, with regional fall southwestwards towards Lake Eyre.

Between the river flats are large areas of windblown sand and extensive stony plains with a close branching pattern of tributary drainage channels. These lowlands are broken by north-south cuestas and chains of mesas and broader dissected uplands, with up to 120m. of relief and exceeding 300m. above sea level locally in the northern half of the area.

The mean annual rainfall at Thargomindah in the east is 22.2cm., and the amount decreases westwards across the area to less than 17cm. All local drainage is episodic. Cooper Creek, which has a catchment of some 150,000$km^2$, mainly north of the survey area, is subject to severe flooding in most years and the Bulloo, with a catchment of about 30,000$km^2$, is subject to smaller floods.

The area is made up of 7 main landscape types as shown in Figure 2:

1A. Silcrete-capped Uplands:

The flattish summits and prominent bounding escarpments of mesas and plateaux with sheer breakaways (Photo 4) are due to the resistant flat-lying silcrete (Photo 10) and indurated subjacent horizons in the weathering profile. The upland surfaces consist typically of an alternation of soil-covered tracts and silcrete outcrops, with sandplain locally. Silcrete dipping at moderate angles has given rise to narrow cuestas in some areas, as on the Curalle structure in the extreme northwest (Photos 1 and 13).

1B. Stripped Uplands:

Typically in the east of the area, a thin original silcrete cap has been largely stripped off, and these landforms owe their preservation to the indurated fragmented zone below. This capping breaks down into a fine-textured soil through which appear occasional rises of silcrete boulders let down in situ (photos 11 and 12). The escarpment zones are characterized by the detachment of large blocks of indurated material and by slumps parallel to the upland edge as a result of vertical partings within the upper weathered horizon.

2. Mesas and Plains:

This composite landscape has resulted from further dissection of the uplands and comprises groups or flat-topped hills in undulating lowlands, which are largely gravel strewn.

3. Rolling Downs:

Broadly rolling lowlands, generally with less than 10m. of relief and commonly with stony gilgaid surfaces (see foreground of Photo 4) extend along the main axes of uplift where erosion has proceeded furthest into relatively unweathered Cretaceous rock. These plains are characterized by closely branching drainage systems with alluvial floodplains along the main channels.

4. Gravel-Mantled Slopes and Plains:

Strongly undulating surfaces covered with coarse silcrete gravel, derived from the retreating duricrust, fringe the main escarpments. Similarly mantled gravel plains characterize lower dip slopes and synclinal tracts.

5. Floodplains:

Alluvial plains, mainly of silt and clay, with gradients of 1:5000 or less, characterize the larger rivers and attain their greatest extent in the Cooper-Wilson system. They are characterized by anastomating channels and shallower flood depressions, by many billabongs (Photo 2), by higher-lying more stable alluvial islands which are very rarely flooded, and by back plains with marginal swamp depressions and drainage sumps, of which Lake Yamma Yamma is the largest. They are subject to extensive flooding during the larger seasonal freshes. Islands of windblown sand are particularly extensive in the lower sectors.

6. Aeolian Sand Surfaces:

These cover almost one third of the survey area, extending from the western margins of river plains, particularly in the south and west. They include extensive fields of longitudinal dune ridges about 10m. high and mainly with a north and northeasterly trend. These attain their maximum development in the extreme southwest, whilst sandplain is relatively more extensive in the northwest and southeast.

In Figure 2 these landscape types are grouped into physiographic regions with constituent landscapes as follows:

| | |
|---|---|
| Mt. Margaret Dissected Tract: | An area of maximum tectonic disturbance and differential erosion, comprising extensive mesas and plains with rolling downs along major uplift axes and flanking uplands, locally with intact silcrete capping; apart from the periphery, the drainage is centripetal to an extensive alluvial basin. |
| Arrabury Lowlands: ) Orientos Lowlands: ) Moombidary Lowlands: ) | These are characterized by dunefields or sandplain broken by low anticlinal uplands commonly with intact silcrete capping fringing stony plains and, peripherally, by dissected uplands flanking the larger structures. |
| Cooper-Wilson Plains) Bulloo Plains: ) | Floodplains with included sandy tracts. |

## II - PATTERNS OF MAJOR RELIEF

As in the area further north (Mabbutt 1967), the distribution of high and low ground has resulted from warping of simple or compound silcrete-capped surfaces or horizons of small initial relief. The movement attained a structural amplitude of 150m., but this has been reduced in the present relief of the area by erosion along axial tracts of anticlines and by deposition in synclinal lowlands. Despite these modifications, the pattern of relief and of erosional and depositional landscapes depicts the main neo-tectonic units with remarkable fidelity.

This is well demonstrated in the details of the main alluvial plains, which have formed along a series of synclines: for instance, the sharp deflection of the Cooper channel to a little east of south and the separation of the lateral sump basin of Lake Yamma Yamma due to uplift of the Gillpeppee Dome across the drainage course, the characteristically straight-sided alluvial reach where it is confined between the Durham Downs and Mount Howitt anticlines; and the enlargement of the plains further south at the intersection of several synclinal axes. The line of the Cooper is prolonged southwards along a downwarp west of the Wompah Anticline, and a former outlet in this area may exist beneath the sand cover; however, barred by the series of uplifts extending SSE from the Innaminka Dome to the arch of the Grey Range, the channel now escapes westwards along what is obviously a youthful passage constricted south of the Innaminka Dome. The tributary plains of the Wilson River, broadly developed along the Wilson Syncline, connect with the Cooper Plains by a narrow passage between Jacksons and Banner Anticlines, a form of structural bottleneck common in the area.

An extensive alluvial plain of interior drainage, defined structurally by several bounding upwarps, occurs north of Eromanga, and the terminal floodout of the Bulloo River falls into the same category.

Periclinal upwarps equally determine the patterns of the erosional landscapes. Where uplift has brought the silcrete only a little above the present base level, the capping and the domal form may remain intact, as in the Gillpeppee Anticline. More commonly however, the structure has been breached on the anticlinal axis and the

Cretaceous rocks exposed in an inner lowland, with flanking uplands where the hard capping remains on the limbs of the structure. These latter are generally plateaux and mesas (Photo 4) or gently cuestiform reflecting the characteristic low dips of less than 5° but steeper dips may give rise to homoclinal ridges as on the western rim of the Curalle structure in the extreme northwest of the area (Photos 1 and 13).

Each upwarp forms a centre of dispersal for radial drainage which may be simply consequent on the initial structure, as on the Naryilco Anticline. More commonly however, advanced erosion results in migration of the secondary divide away from the more vigorous drainage basins; for instance, it has shifted westwards on the Durham Downs Anticline and eastwards on the Mount Howitt structure, in each case away from Cooper Creek.

The variety of upland forms results from a number of inter-related factors, including the form and intensity of uplift, the position of the resistant silcrete and other indurated horizons relative to local base level, and the stage of destruction achieved, which may itself reflect the energy of erosion locally or equally the age of the structure itself. Little-dissected domal uplands such as the Stokes Range clearly represent an early stage; structures with extensive central plateaux and with limited exposure of weathered rock of the Winton Formation, such as the Grey Range in the northeast corner of the Ticklara Sheet, have undergone a further stage of erosion; the Durham Downs Anticline, with a limited area of central upland and no exposure of fresh Winton rock, represents a further advance, and erosion has progressed still more in the Mount Howitt Anticline, where fresh Winton rock is exposed over a wide axial belt.

In general, the level of the deformed silcrete surface falls south-westwards more rapidly than do the present valley plains, and this is reflected in an increasing dominance of alluviated synclinal lowland westwards, and conversely an increasing inversion of relief northwards and eastwards across the area.

Alluviated synclinal lowlands and intact or moderately dissected anticlinal uplands dominate in the extreme southwest; breached anticlines with flanking uplands occur next to the northeast; synclinal uplands of limited extent occur still further east, as in the McGregor Range between the Mount Howitt and Harkaway structures, and complete reversal of relief is established in the east of the Thargomindah Sheet area, where Dewalla Creek occupies a narrow anticlinal lowland with an extensive synclinal plateau on the east. This transition is only a general trend, and variations in the amplitude of individual folds determine local conditions.

Consistent with this trend, it must be anticipated that the silcrete capping will have been stripped beneath parts of synclinal lowlands in the centre of the area prior to alluviation, for instance in the Wilson and Coonawalla Synclines.

## III - EROSIONAL LANDFORMS

Upland forms reflect the protective role of a flat or slightly tilted duricrust above soft underlying strata further weakened by weathering. These forms have been described in a general way for the area to the north (Mabbutt 1967), and this report merely discusses variations in this survey area. They result mainly from regional differences in the nature and complexity of the hardened horizons.

### (a) Thin Silcrete Cappings in the East of the Survey Area

In general, silcrete cappings thin towards the east of the area as the Tertiary cover diminishes, and here the main role as duricrust is played by the underlying "fragmented zone" (Wopfner and Twidale 1967), which commonly exceeds 10m. thick, up to 5 times as massive as the silcrete cover locally. In the east of the Eromanga Sheet area it is this fragmented horizon which preserves some of the most prominent relief in the survey area, for instance Mount Canaway (Photo 12). Logically, the term "duricrust" should embrace such geomorphically significant surface-related horizons.

Such thin silcrete, only one or two blocks thick, may be stripped from large areas. Some tributary catchments on the east limb of the Harkaway structure are entirely lacking in silcrete whilst in others nearby the horizon survives only as talus boulders or as ruiniform remnants on a few mesa tops. However, there can be no doubt of the former continuity of the silcrete, even where now removed, since the upper part of the fragmented horizon is commonly penetrated by pipe-like structures up to 1m. in diameter, with loosely re-cemented nodules and blocks of silcrete.

Where the fragmented horizon dominates, its massiveness combined with vertical jointing results in the detachment of successive zones parallel with the breakaway edge, as a result of basal sapping accelerated by piping. The outermost fallen blocks may be separated from the main capping by deep clefts several metres wide, whilst the displacement of the innermost zone is normally evident only as slight steps, surface cracks, or a related banding of trees and shrubs. Airphotos of such features commonly show a multiple zonation parallel with the escarpment rim.

Plateau summits and dip slopes maintained by the fragmented zone commonly have remnant areas of silcrete which range from tabular cappings to slightly separated and largely buried rounded boulders and which represent varying degrees of disturbance and removal of the original silcrete. In certain areas (for instance on the Coonawalla Syncline and elsewhere in the Eromanga Sheet area) it was claimed during field discussions that silcrete cappings had been "let down" bodily in the landscape. Arguments against this having occurred on a large scale are -

(a) the survival of the fragmented zone which normally underlies the silcrete;

(b) the survival of "pipes" with hardened silicified linings and fillings of silcrete nodules and clasts; these rarely penetrate more than a few metres beneath a silcrete surface;

(c) intact flaggy or laminar structures in silcrete remnants.

However, the possibility must be considered that a reformed silcrete mantle might be mistaken for an original duricrust in an area in which the latter is known to have been thin. Recognition of this is essential where the silcrete capping is used as a "surface marker" and a structural indicator; hence the importance of determining the original profile position of weathered rock beneath any doubtful silcrete capping.

Extensive outcrop of the fragmented zone in the Eromanga Sheet area has given rise to large areas of powdery red earth soils, both on the intact duricrust and on derived slope materials at lower levels. The fine sand fraction of these soils points to admixture of Tertiary material.

(b) Multiple Silicified Horizons in the Southwest of the Area

Although the occurrence of silcrete cobbles in the Glendower Formation on Jundah Sheet area demonstrated that silicification was in progress both before and after this episode of Tertiary deposition, the silcrete duricrust in the area to the north could be interpreted as a unit, albeit showing signs of penecontemporaneous reworking. However, multiple silcrete horizons are developed in the southwest of this area, particularly on the south limb of the Innamincka Dome.

Here a silicified horizon about 2m. thick and 15m. below the base of the Tertiary Glendower Formation forms a discontinuous bench on the main escarpment. It recalls the claim by Whitehouse (1940a) and others (e.g. Connah and Hubble 1960) that silicification, although characteristic of the mottled zone, may occur at all levels in the profile. It also raises the possibility that silcrete cappings elsewhere may not mark a deeply weathered land surface but have been formed at depth and stripped of an overburden, again a matter of importance where duricrusted surfaces have been accepted as structural markers. Related profile characteristics will help; for instance the layer described showed none of the mottling characteristic of the silcrete above, which was further identified by the subjacent fragmentary horizon with its evidence of deformation following near-surface weathering.

Limited geomorphic observation indicated that this horizon was either localized or not prominent in relief beyond the main escarpment.

In the same escarpment, sandstone of the overlying Glendower Formation was silicified to silcrete at the top, midway through the section, and also in the base pebble bed which rested unconformably on the weathered and previously duricrusted Winton beds.

The silicification in the sandstone was less massive than in the Winton and older Tertiary beds and there was associated ferruginization, locally with pisolitic ironstone.

Although these silicified younger deposits are localised, they raise questions concerning the duration of silicification in the area and the range of diachronism of the silcrete, and the possibility that silicified deposits at low levels in the landscape may represent younger episodes of induration rather than the tectonic deformation of an older land surface. This latter possibility is further indicated by the occurrence of conglomeratic silcrete within a few metres of the level of Prouts Creek in the southeast corner of the Eromanga Sheet area.

I was not convinced that the Prouts Creek section was a silicified river terrace, as suggested during field discussion. Given the structural setting, the main silcrete should in any case occur at a low level here; the gravels include quartz as well as silcrete clasts, and could represent a local facet of the Glendower Formation. There is no widespread silicification of post-deformation sediments in this area as, for instance, in Western Australia (Litchfield and Mabbutt 1962) to support a hypothesis of continuing silicification on a general scale. Riverine environments can be exceptional, as with the creek laterites formed within an otherwise arid environment in central Australia, but the weathering environment in the later stages of relief evolution in this area has been conducive to calcification rather than to thorough weathering.

### (c) Ferruginous Pisolitic Mantles

At several localities, sandstone with iron pisolites and showing some silicification were observed above more indurated siliceous horizons, for instance the uppermost horizon of the Tertiary sandstones already described on the south flank of the Innamincka Dome. In the Kihee Anticline a mantle of lightly indurated sands about 2m. thick and with pisolites rests with apparent disconformity on the dip slope of the small homoclinal ridge on the south flank. Attention is drawn to the note by Wopfner (1960) on the occurrence further west of a "sandy pisolite" of bauxitic nature resting disconformably or unconformably on duricrust or kaolinized zone, but itself affected by later earth movements.

## IV - DEPOSITIONAL LAND SURFACES

### (a) Older Alluvial Surfaces

Stages in the dissection of the land surface below the silcrete cappings are expressed as terraces and benches within some of the structures and may indicate subsequent earth movements. The most striking seen on my visit were in the Innamincka Dome, in drainage systems tributary to Cooper Creek. These were terraces up to 15m. above the present river channels, with an unconsolidated mantle up to 2m. thick of silcrete clasts on a surface planed in pallid Winton rocks, the whole showing a reddish soil profile.

(b) Chalcedonic Limestones

Calcreted valley fills and lacustrine deposits with chalcedonic replacement in layers and pockets typify many parts of arid Australia. They are younger than the duricrust, and although closely related to the present drainage lines they often extend beyond them, thus affording testimony to a restriction of surface drainage with progressive desiccation. The low platform fringing Lake Yamma Yamma on the west represents a composite alluvial flat linking points of former drainage entry and is very similar to the surfaces around the inlets of "river lakes" in Western Australia, described as land units in the Wiluna-Meekatharra area (Mabbutt et al. 1963). Like their Western Australian equivalents, they stand a metre or so above the present lake bed, indicating higher lake levels in the past or deflative lowering of the lake floor since their formation. Similar surfaces extend beneath the dunefields to the south of Lake Yamma Yamma and the chalcedonic limestones are certainly older than the aeolian phase of dune building.

Under the present climate, and in the calcareous environment offered by the Winton Formation, pan limestones are expectable phenomena, and it is possible that some rather clinkery calcrete rubble surfaces between dunes and in small claypans are younger, forming part of a continuing series. However, chalcedony may be present at depth below such surfaces. In both the Wiluna and Alice Springs areas, where these tracts are known as "opaline country", the main chalcedonic horizons lie at some depth, associated with present or former groundwater tables. In the somewhat similar Alcoota Beds, the chalcedony occurs in horizons probably marking finer-textured traps.

Attention is drawn to the possibility that chalcedonic limestone formations may well range back into the Upper Tertiary, as in central Australia (Woodburne 1967).

(c) Active Alluvial Forms

The main features of the active alluvial plains and their drainage lines resemble those previously described for the area further north (Mabbutt 1967). In general, the relative extent of alluvia increases southwestwards towards the regional drainage terminals; for instance, alluvial plains constitute almost one third of the Durham Downs Sheet area. The structural accordance of the depositional patterns and the great thicknesses of alluvia together indicate that differential subsidence has been a major factor controlling deposition in the main river systems.

The river plains show the same combination of higher, less frequently flooded tracts, levee-fringed channelled zones, and backplains with sump basins as does the area to the north. The more stable, higher floodplains are relatively less important here, perhaps as a result of greater burial by aeolian sand, whilst the sump basins are more extensive. The largest sump areas are associated with tectonically-determined extensions of the plains, what Whitehouse (1940) has termed "inland deltas", as at the Wilson-Cooper confluence. Lake Yamma Yamma is a lateral basin, the largest of its kind, now rarely flooded and apparently never to its former extent as indicated by the relict gravel beach ridge which fringes it in the northwest. It is noteworthy that Lake Yamma Yamma lies in direct continuation of the course of the Cooper above its deflection at the Gillpeppee structure, and is possible that the main drainage may formerly have continued southwestwards, north of the Innamincka Dome. The great thickness of sediments in the lake basin indicates prolonged subsidence, perhaps with transition from a fluvial to a lacustrine environment. The present connection with the Cooper is partly sand-blocked, and in part the feeder channels traverse a rather high-lying floodplain tract which is presumably flooded only infrequently. It is suggested that this may reflect a tendency towards abandonment of the lake basin, a possible continuation of an eastward displacement of the main drainage at this point as a result of subsidence along the Cooper Syncline.

The drainage lines comprise deep channels of suspended-load type (Schumm 1963) and shallower floodways. The former include sinuous "trunk" sectors up to 200m. wide containing the main waterholes. These commonly terminate in distributary systems of smaller channels of similarly deep cross-section but which show remarkable reticulate anastomosing patterns, particularly where they feed into sump basins. The distributary channels are commonly tightly meandering. The trunk channels are discontinuous, and generally less than 15 km. long, and arise from the confluence of reticulate feeder channels similar to the distributaries in which they terminate.

The floodways are more sinuous than the distributaries and interlace in systems which may be superposed on the channel systems, or which may feed into them, or which may be fed by them via small distributaries which may occasionally occupy the depression of the floodway itself.

These two channel types are closely associated and together occupy the higher parts of the active floodplains, commonly with flanking levees. The airphotos show many abandoned channels and indicate changes of course are common. The channel patterns reflect the highly irregular discharge regime, the generally fine nature of the alluvia transported, and the prevailing low gradients, of the order of 1 in 5000. The term "anabranching" has been applied to the channel patterns, and Dury (1968) has suggested that "braiding" may be inappropriate where the diffluence does not arise from a split around a midstream island but represents a more angular channel parting.

An explanation of this channel habit may perhaps be found in another local linear drainage form, namely the reticulated linear gilgai systems which characterize the sump basins proper and which connect with the distributary channels in transitional forms (Photo 2). It is suggested that the distributary channel traces may be affected by those same fracture patterns which develop in the periodically flooded, expansive clays of the floodplain sumps.

(d) Aeolian Sand Surfaces

Aeolian sand surfaces are closely associated with zones of present and prior river deposition and are therefore particularly extensive in the southwest of the survey area, towards the drainage terminals and the areas in which major shifts of course have occurred. They tend to extend north and west, i.e. downwind from the main floodplains, particularly of the Cooper, and may cover former alluvial tracts since abandoned by the river systems, as south of Lake Yamma Yamma. The alluvial origins of the sand are attested by this distribution.

The reddish colour of the sands contrasts with the lighter-coloured sand fractions in or immediately derived from alluvial deposits locally, for instance the white dunes which cap the beach ridge at Lake Yamma Yamma. Whitehouse (1940a) and others have suggested that this indicates a sand source in Tertiary beds forming part of lateritic profiles, presumably north and east of the present area. The heavy mineral content of the sands (Gregory et al. 1967) supports a northern origin, although this is not inconsistent with recycling via local Tertiary deposits. Although Tertiary cappings in the area constitute a possible source of the sands, it should be pointed out that there is remarkably little aeolian sand surface away from the main floodplains, so that it is in the deposits of the major rivers rather than those of minor drainage that the immediate source of the large sand spreads must be sought.

Dune islands occur in the floodplains, commonly between anabranches, and have dune forms adjusted to the shape of the "island" as delimited by the river systems; hence it is a question of dune growth in situ rather than the isolation of fragments of former dunefields by river invasion; it is the dunes, rather than the alluvial plains, which have expanded in the area generally. Since the sands here are also reddish, albeit somewhat lighter-coloured than aeolian sands away from the river plains, the iron-coatings may well develop in situ, perhaps by admixture of dust of local origin, and sand bleached during fluvial transport may eventually resume a reddish colour.

The main distribution in the aeolian surfaces is between sandplain and dunefields. Sandplain occupies two types of situation; areas in which a thin sand cover mantles Tertiary land surface relicts at low elevation, suggesting an origin in former sandy latosols, and areas on the margins of dunefields where time or location have inhibited dune growth.

The dunes are of three main types: dune ridges in open situations in larger dunefields, reticulate dunes in areas receiving run-on (Photo 3), and linked crescentic dunes in floodplain islands. The first attain their best development in the Tickalara Sheet area, where they approach the continuity and regularity of spacing (4 or 5 per mile) of ridges in the Simpson Desert proper, further west. They trend northeast, and in the south of the area they have many convergences pointing northeast, i.e. down the direction of the inferred formative wind. With the entry of higher ground and drainage further northeast, there is a transition to reticulate dunes studded with many small claypans. The dune ridges further north, for instance on the southern margins of Lake Yamma Yamma, are single ridges, here aligned more northerly and with a tendency to extend northwards as indicated by incursions into alluvial areas. These attain their best development towards the north (downwind) margins of dunefields. All the ridges exhibit the usual contrast between stable, vegetated flanks and more mobile, loose sand crests. Lateral slip faces and serrate profiles may occur along the latter, with blowouts oblique to the main ridge trend. Clay cores were not observed in the dunes in this area on the same scale as in the area further north.

The reticulate dunes range from parallel ridges with transverse, slightly crescentic links enclosing elongate pans to rhomboidal networks where run-on is into sand plain-type environments (Photo 3), particularly near the margins of river plains or lakes. There is an unexplained relationship here between the pan and its dune fringe.

The floodplain islands are characterized by linked dunes which resemble reticulate dunes on the upwind side but which show a linked series of prominent transverse crescentic dunes fronting the river plain on downwind margins.

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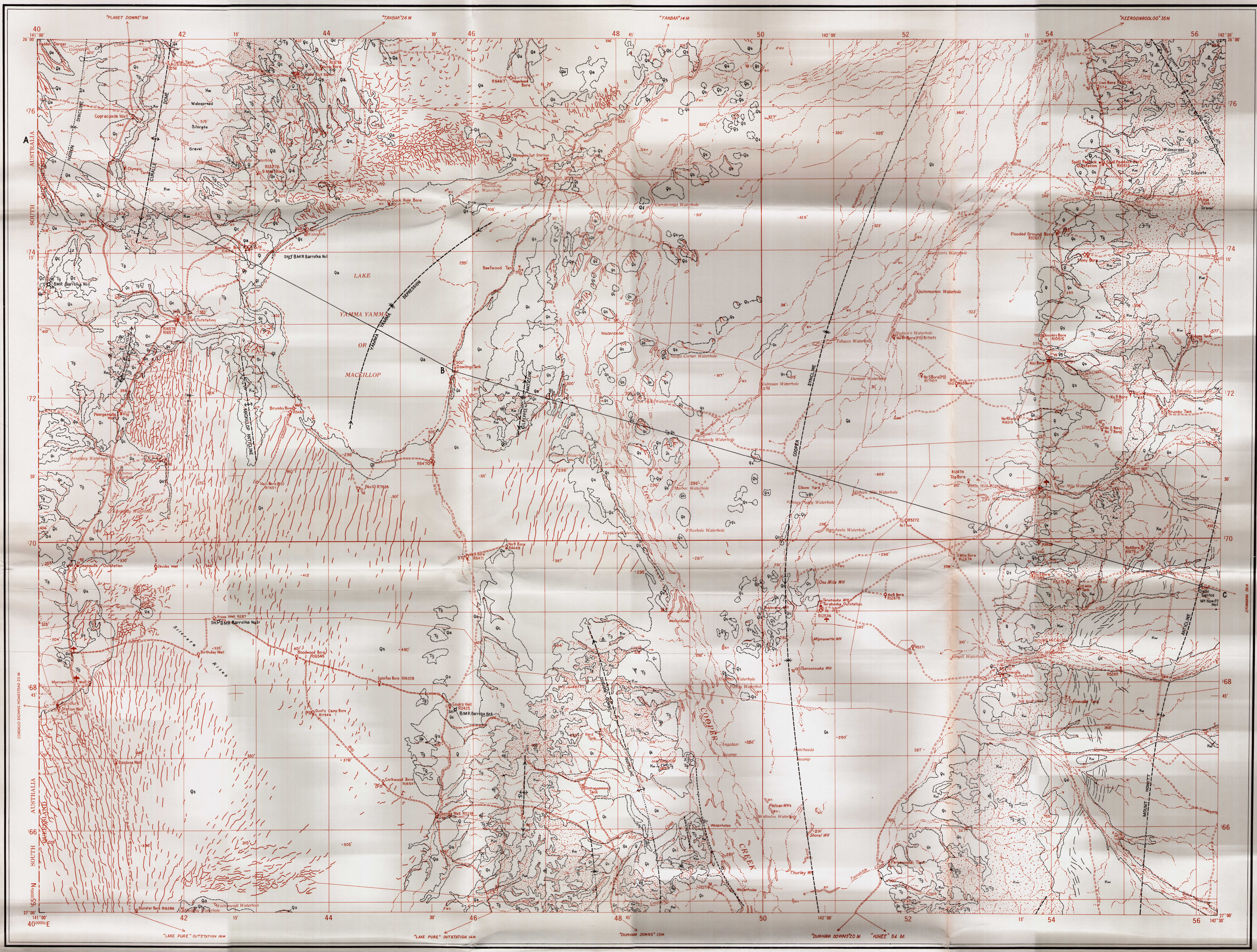


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|---|---|---|---|---|
| CAINOZOIC | QUATERNARY | | Q | Undifferentiated |
| | | | Qa | Alluvium: sand, silt, clay, minor gravel |
| | | | Qs | Dune and sheet sand |
| | | | Qc | Silcrete gravel |
| | | | Ql | Calcareous sandstone |
| | | | Qp | Limestone, chalcedony |
| | TERTIARY | Glendower Formation | Tg | Quartz sandstone, sandy conglomerate, minor siltstone, silcrete |
| MESOZOIC | LOWER TO UPPER CRETACEOUS | Winton Formation | | Chemically altered, (leached, silicified and ferruginized) sediments |
| | | | Kw | Labile sandstone, siltstone, mudstone, in part calcareous, minor coal |
| | LOWER CRETACEOUS | Rolling Downs Group: Mackunda Formation | Klm | Labile sandstone, calcareous labile sandstone, mudstone, coquinite |
| | | Allaru Mudstone | Kla | Mudstone, calcareous lithic sandstone |
| | | Toolebuc Limestone | Klo | Coquina limestone, calcareous shale |
| | | Wallumbilla Formation | Klu | Mudstone, siltstone, minor sandstone, in part calcareous |
| | UPPER JURASSIC TO LOWER CRETACEOUS | Hooray Sandstone | J-Kh | Sublabile sandstone, quartz sandstone, conglomerate |
| | MIDDLE TO UPPER JURASSIC | Injune Creek Group: Undifferentiated | Ji | |
| | UPPER JURASSIC | Westbourne Formation | Juw | Siltstone, shale, quartz sandstone |
| | MIDDLE JURASSIC | Adori Sandstone | Ja | Labile sandstone, siltstone, claystone |
| | | Birkhead Formation | Jmb | Calcareous sublabile sandstone, siltstone |
| | LOWER JURASSIC | Hutton Sandstone | Jlh | Quartz sandstone, minor siltstone, shale |
| | LOWER TRIASSIC | Undifferentiated | R | Interbedded sandstone, shale, siltstone |
| PALAEOZOIC | PERMIAN | Gidgealpa and Merrimelia Formations | P | Sandstone, siltstone, coal, conglomerate (Tillite?) |
| | UNDIFFERENTIATED | Undifferentiated | Pz | Strongly folded clastics |

Klm to Pz: Section only

Geological boundary

Anticline, Syncline: Showing plunge

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

Strike and dip of strata

Dip < 5°, Trend lines: Air-photo interpretation

B.M.R. scout hole

Abandoned dry oil exploration well

Sub artesian water bore or well

Artesian water bore

Artesian water bore, ceased to flow

Abandoned water bore or well

(R5269 refers to bore registration number of the Queensland Irrigation and Water Supply Commission records)

Earth tank or dam

Waterhole

Windpump

Sand dunes

Road

Vehicle track

Fence

"Malagarga" Homestead

Building

Landing ground

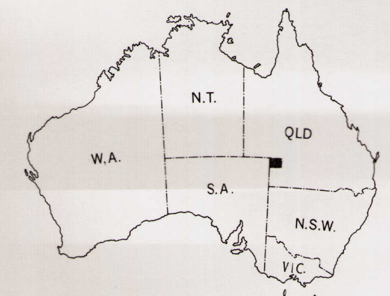
Yard

Astronomical station

•372' Height in feet; datum: mean sea level

(PD) Position doubtful


Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. David Fairbairn Minister for National Development. Base map compiled by the Division of National Mapping, Department of National Development. Commonwealth aerial photography; complete aerial coverage at 1:50,000
Transverse Mercator Projection

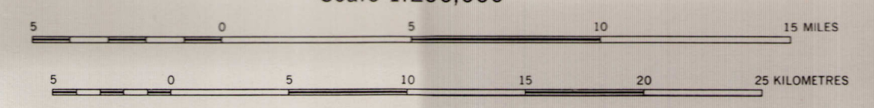

## INDEX TO ADJOINING SHEETS
Showing Magnetic Declination

| | | | | |
|---|---|---|---|---|
| BEDOURIE SG 54-1 | MACHATTIE SG 54-2 | CONNEMARA SG 54-3 | JUNDAH SG 54-4 | BLACKALL SG 55-1 |
| BIRDSVILLE SG 54-5 | BETOOTA SG 54-6 | CANTERBURY SG 54-7 | WINDORAH SG 54-8 | ADAVALE SG 55-5 |
| PANDIE PANDIE SG 54-9 | CORDILLO SG 54-10 | BARROLKA SG 54-11 | EROMANGA SG 54-12 | QUILPIE SG 55-9 |
| GASON SG 54-13 | INNAMINCKA SG 54-14 | DURHAM DOWNS SG 54-15 | THARGOMINDAH SG 54-16 | TOOMPINE SG 55-13 |
| KOPPERAMANNA SH 54-1 | STRZELECKI SH 54-2 | TICKALARA SH 54-3 | BULLOO SH 54-4 | EULO SH 55-1 |

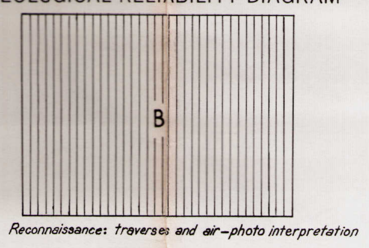
7°E, 7°30'E, 8°E, 6°30'E

ANNUAL CHANGE 2'30"E

Scale 1:250,000




## GEOLOGICAL RELIABILITY DIAGRAM

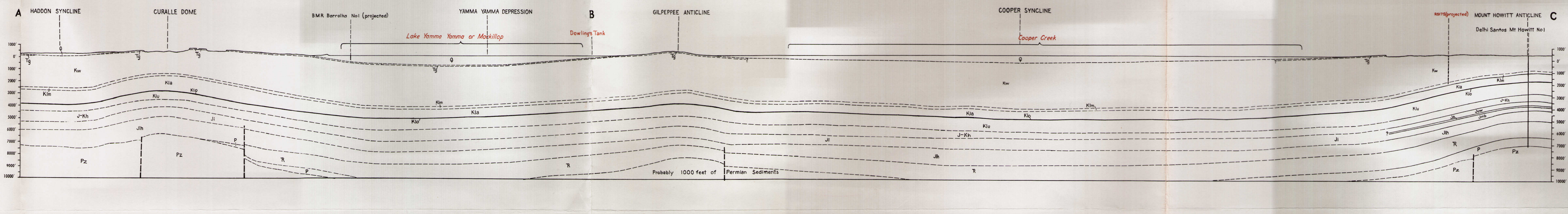



B Reconnaissance: traverses and air-photo interpretation


Geology, 1968, by: B.R. and D. Senior
Compiled, 1968, by: B.R. and D. Senior and R.D. Cooper
Drawn by: R.D. Cooper



## Section
Superficial Quaternary sediments omitted from section
Scale: $\frac{V}{H} = 4$




PRELIMINARY EDITION, 1968

SUBJECT TO AMENDMENT



BARROLKA

SHEET SG 54-11

*Complimentary*

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

# EROMANGA

QUEENSLAND

SHEET SG 54-12


## Reference

| | | | | |
|---|---|---|---|---|
| CAINOZOIC | QUATERNARY | | Q | Undifferentiated |
| | | | Qa | Alluvium: sand, silt, clay, gravel |
| | | | Qr | Sandy red earth |
| | | | Qs | Sand, minor silt |
| | | | Qc | Silcrete gravel |
| | TERTIARY | Glendower Formation | Tg | Quartz sandstone, quartz conglomerate, siltstone, mudstone, silcrete (silicified sandstone) |
| MESOZOIC | LOWER TO UPPER CRETACEOUS | Winton Formation | | Chemically alterered (Leached, silicified and ferruginized) sediments. Fossil soil |
| | | | Kw | Labile sandstone, siltstone, mudstone, in part calcareous. Minor coal |
| | LOWER CRETACEOUS | Mackunda Formation | Klm | Labile sandstone, siltstone, mudstone, in part calcareous, coquinite |
| | | Allaru Mudstone | Kla | Mudstone, minor calcareous sandstone and siltstone |
| | | Toolebuc Limestone | Klo | Limestone, calcareous shale |
| | | Wallumbilla Formation | Klu | Mudstone, siltstone, minor sandstone, in part calcareous |
| | UPPER JURASSIC TO LOWER CRETACEOUS | Hooray Sandstone | J-Kh | Sublabile sandstone. Polymitic conglomerate |
| | MIDDLE TO UPPER JURASSIC | Injune Creek Group | Ji | Siltstone, quartzose and labile sandstone, mudstone |
| | LOWER JURASSIC | Hutton Sandstone | Jlh | Quartz sandstone, minor siltstone and mudstone |
| | LOWER TRIASSIC | | Ꞧ | Sandstone; micaceous, carbonaceous shale; shale |
| PALAEOZOIC | LOWER TO UPPER PERMIAN | Gidgealpa Formation | Pg | Sandstone, micaceous and carbonaceous siltstone and shale, coal |
| | LOWER PERMIAN | Merrimelia Formation | Plm | Sandstone, shale, siltstone, conglomerate |
| | MIDDLE DEVONIAN TO LOWER CARBONIFEROUS | | D-C | Argillaceous sandstone; shale, siltstone, dolomitic shale and siltstone, dolomite |
| | MIDDLE DEVONIAN | Log Creek Formation | Dml | Siltstone, sandstone, shale |
| | LOWER PALAEOZOIC | | Pz | Steeply dipping indurated shale, siltstone and sandstone |

Section only (Klm to Pz)

Geological boundary

Anticline

Syncline

Fault (D,U indicate relative movement down, up)

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

Strike and dip of strata

Dip <5° ; air-photo interpretation

Abandoned mine

Mineral prospect

Op Opal

SH Scout hole

Abandoned dry oil exploration well

Artesian water bore } From post Allaru aquifer system

Sub-artesian water bore or well } From post Allaru aquifer system

Artesian water bore; from pre-Wallumbilla aquifer system

Abandoned water bore or well

R4022 refers to bore registered number of Queensland Irrigation and Water Supply Commission Records

Windpump

WH Waterhole

E Earth tank or dam

Dam

Road

Vehicle track

Fence

"Ray" Homestead

Building

Landing ground

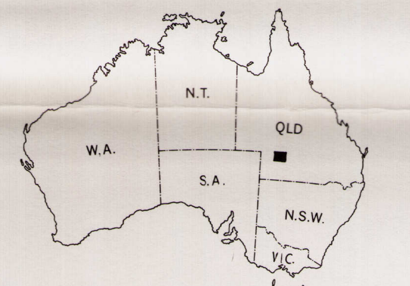
Yd Yard

•794' Height in feet; datum; mean sea level

Astronomical station

(PD) Position doubtful


Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Division of National Mapping, Department of National Development. Commonwealth Aerial Photography; Complete vertical coverage at 1:50,000 scale Transverse Mercator Projection


### INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

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|---|---|---|---|---|
| MACHATTIE SG 54-2 | CONNEMARA SG 54-3 | JUNDAH SG 54-4 | BLACKALL SG 55-1 | TAMBO SG 55-2 |
| BETOOTA SG 54-6 | CANTERBURY SG 54-7 | WINDORAH SG 54-8 | ADAVALE SG 55-5 | AUGATHELLA SG 55-6 |
| CORDILLO SG 54-10 | BARROLKA SG 54-11 | EROMANGA SG 54-12 | Q[illegible]LPIE SG 55-9 | CHARLEVILLE SG 55-10 |
| INNAMINCKA SG 54-14 | DURHAM DOWNS SG 54-15 | THARGOMINDAH SG 54-16 | TOOMPINE SG 55-13 | WYANDRA SG 55-14 |
| STRZELECKI SH 54-2 | TICKALARA SH 54-3 | BULLOO SH 54-4 | EULO SH 55-1 | CUNNAMULLA SH 55-2 |

6°30'E, 7°E, 7°30'E, 8°E, 8°30'E

ANNUAL CHANGE 2'30"E

Scale 1:250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

### GEOLOGICAL RELIABILITY DIAGRAM

B Reconnaissance – traverses and air-photo interpretation

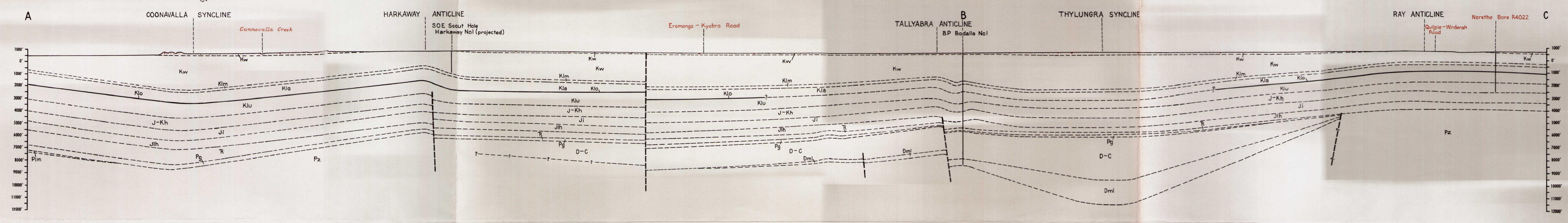

Geology, 1967, by: J.A. Ingram
Compiled, 1967, by: J.A. Ingram and R.D. Cooper
Cartography by: Geological Branch, B M R
Drawn by R.D. Cooper



### Section

Cainozoic sediments omitted from section

Scale: V/H = 4





PRELIMINARY EDITION, 1968

SUBJECT TO AMENDMENT




EROMANGA

SHEET SG54-12

*Complimentary*

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

# DURHAM DOWNS

QUEENSLAND

SHEET SG 54-15

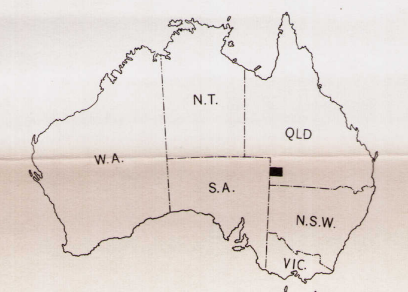
## Reference

| | | | | |
|---|---|---|---|---|
| CAINOZOIC | QUATERNARY | | Q | Undifferentiated |
| | | | Qa | Alluvium; clay, sand, silt, soil, minor gravel |
| | | | Qs | Dune and sheet sand |
| | | | Qr | Red sandy earth, minor gravel |
| | | | Qc | Silcrete gravel |
| | TERTIARY | Glendower Formation | Tg | Quartz sandstone, conglomerate, sandy conglomerate, breccia, siltstone, silcrete |
| MESOZOIC | LOWER TO UPPER CRETACEOUS | Winton Formation | | Chemically altered (leached, ferruginized and silicified) sediments |
| | | | Kw | Labile sandstone, siltstone and mudstone, in part calcareous; minor coal |
| | LOWER CRETACEOUS | Rolling Downs Group: Mackunda Formation | Klm | Labile sandstone, siltstone and mudstone, in part calcareous; minor coquinite |
| | | Allaru Mudstone | Kla | Mudstone, calcareous labile sandstone |
| | | Toolebuc Limestone | Klo | Limestone, calcareous shale, coquinite |
| | | Wallumbilla Formation | Klu | Mudstone, siltstone, minor sandstone, in part calcareous |
| | UPPER JURASSIC TO LOWER CRETACEOUS | Hooray Sandstone | J-Kl | Sublabile sandstone, quartz sandstone, conglomerate, in part calcareous, micaceous; kaolinitic siltstone |
| | MIDDLE TO UPPER JURASSIC | Injune Creek Group: Westbourne Formation, Adori Sandstone, Birkhead Formation | Ji | Siltstone, mudstone, micaceous sandstone; minor lignite and coal |
| | LOWER JURASSIC | Hutton Sandstone | Jlh | Quartz sandstone, minor siltstone and mudstone, in part calcareous or dolomitic; minor coal |
| | LOWER TRIASSIC | | ℞ | Sandstone, shale and siltstone, micaceous |
| PALAEOZOIC | LOWER TO UPPER PERMIAN | Gidgealpa Formation | Pg | Sandstone, micaceous and carbonaceous siltstone and shale, coal |
| | LOWER PERMIAN | Merrimelia Formation | Plm | Sandstone, shale, siltstone |
| | ORDOVICIAN ? | | O | Strongly folded clastics |
| | CAMBRIAN ? | | € | Red beds: sandstone, siltstone, mudstone |
| PRECAMBRIAN | PROTEROZOIC | | p€ | Sandstone, dolomitic limestone. Minor shale (red bed unit). Red-brown very fine grained micaceous and iron-stained quartzite. |

Klm to p€: Section only

- Geological boundary
- Syncline, Anticline — Showing plunge
- Fault (D, U indicate relative movement down or up)
- Where location of boundaries, folds and faults is approximate, line is broken; where concealed, folds are dotted, faults are shown by short dashes
- Strike and dip of strata
- Dip < 5°; air-photo interpretation
- • Op — Minor mineral occurence; Op - opal
- Dry abandoned oil exploration well
- SH — BMR scout hole
- Artesian water bore
- Sub-artesian water bore or well
- Abandoned water bore or well
  (R5735 refers to bore registration number in the Queensland Irrigation and Water Supply Commission records)
- E — Earth tank or dam
- Windpump
- Waterhole
- Sand dunes
- Road
- Vehicle track
- Fence
- "Karmona" — Homestead
- Yd — Yard
- Landing ground
- •230' — Height in feet, datum: mean sea level
- Astronomical station

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Division of National Mapping, Department of National Development. Commonwealth aerial photography: complete vertical coverage at 1:50,000 scale. Transverse Mercator Projection




### INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

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|---|---|---|---|---|
| BIRDSVILLE SG 54-5 | BETOOTA SG 54-6 | CANTERBURY SG 54-7 | WINDORAH SG 54-8 | ADAVALE SG 55-5 |
| PANDIE PANDIE SG 54-9 | CORDILLO SG 54-10 | BARROLKA SG 54-11 | EROMANGA SG 54-12 | QUILPIE SG 55-9 |
| GASON SG 54-13 | INNAMINCKA SG 54-14 | DURHAM DOWNS SG 54-15 | THARGOMINDAH SG 54-16 | TOOMPINE SG 55-13 |
| KOPPERAMANNA SH 54-1 | STRZELECKI SH 54-2 | TICKALARA SH 54-3 | BULLOO SH 54-4 | EULO SH 55-1 |
| MARREE SH 54-5 | CALLABONNA SH 54-6 | MILPARINKA SH 54-7 | URISINO SH 54-8 | YANTABULLA SH 55-5 |

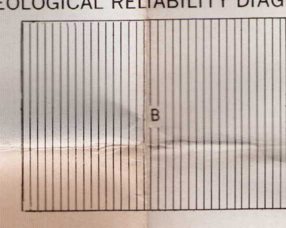
ANNUAL CHANGE 2'30"E

Scale 1:250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

### GEOLOGICAL RELIABILITY DIAGRAM



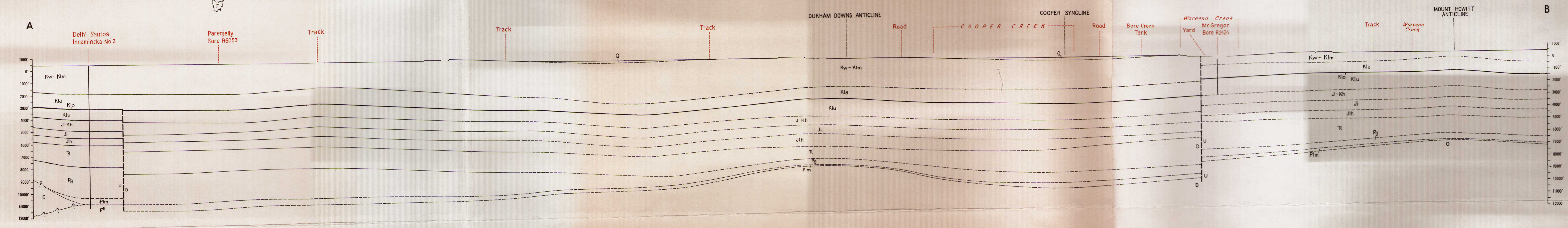

B Reconnaissance: Traverses and air-photo interpretation

Geology, 1967, by: D.A. Senior, B.R. Senior and M.C. Galloway
Compiled, 1967, by: D.A. Senior, B.R. Senior, M.C. Galloway and R. Cooper
Drawn by: R. Cooper


### Section

(Superficial Cainozoic sediments omited from section)

Scale: $\frac{V}{H} = 4$




PRELIMINARY EDITION, 1968

SUBJECT TO AMENDMENT



DURHAM DOWNS

SHEET SC 54-15

*Complimentary*

AUSTRALIA 1:250,000

# THARGOMINDAH

QUEENSLAND

SHEET SG 54-16


## Reference

| | | | | |
|---|---|---|---|---|
| CAINOZOIC – QUATERNARY | | Q | Undifferentiated | |
| | | Qa | Alluvium clay, sand, silt, soil, minor gravel | |
| | | Qs | Quartz sand, mostly iron-stained | |
| | | Qr | Red sandy earth, minor gravel | |
| | | Qc | Gravel, mainly silcrete | |
| | | Qg | Gravel, mixed clasts | |
| | | Qp | Limestone, chalcedony | |
| CAINOZOIC – TERTIARY | Glendower Formation | Tg | Quartz sandstone, conglomerate, sandy conglomerate, breccia, siltstone; silcrete | |
| MESOZOIC – LOWER TO UPPER CRETACEOUS | Rolling Downs Group – Winton Formation | | Chemically altered (leached, ferruginized and silicified) sediments | |
| | | Kw | Labile sandstone, siltstone and mudstone, in part calcareous; minor coal | |
| MESOZOIC – LOWER CRETACEOUS | Rolling Downs Group – Mackunda Formation | Klm | Labile sandstone, siltstone and mudstone, in part calcareous minor coquinite | |
| | Rolling Downs Group – Allaru Mudstone | Kla | Mudstone, minor calcareous labile sandstone | Section only |
| | Rolling Downs Group – Toolebuc Limestone | Klo | Limestone, calcareous shale, coquinite | Section only |
| | Rolling Downs Group – Wallumbilla Formation | Klu | Mudstone, siltstone, minor sandstone, in part calcareous | Section only |
| MESOZOIC – UPPER JURASSIC TO LOWER CRETACEOUS | Hooray Sandstone | J-Kh | Sublabile sandstone, quartz sandstone, conglomerate in part calcareous, micaceous; kaolinitic siltstone | Section only |
| PALAEOZOIC – LOWER PALAEOZOIC | | Pz | Folded clastics, low grade metamorphics | Section only |

- Geological boundary
- Anticline showing plunge
- Syncline showing plunge
- Fault (U, D indicate relative movement up or down)
- 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
- Strike and dip of strata
- Dip < 5°; air-photo interpretation
- •Op Minor mineral occurrence Op–Opal
- Dry abandoned oil exploration well
- Abandoned water bore or well
- Sub-artesian water bore or well; from post Wallumbilla aquifer system
- Artesian water bore; from pre-Wallumbilla aquifer system

R401 refers to bore registration number in the Queensland Irrigation and Water Supply Commission records

- E Earth tank or dam
- Windpump
- Waterhole
- Dam on stream
- Sand dunes
- Road
- Vehicle track
- Fence
- "Kihee" Homestead
- Yd Yard
- Landing ground
- ·495' Height in feet, datum: mean sea level
- Astronomical station
- PD Position doubtful

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Division of National Mapping, Department of National Development. Commonwealth aerial photography; complete vertical coverage at 1:50,000 scale. Transverse Mercator Projection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| CORDILLO SG 54-10 | BARROLKA SG 54-11 | ERONANGA SG 54-12 | QUILPIE SG 55-9 | CHARLEVILLE SG 55-10 |
| INNAMINCKA SG 54-14 | DURHAM DOWNS SG 54-15 | THARGOMINDAH SG 54-16 | TOOMPINE SG 55-13 | WYANDRA SG 55-14 |
| STRZELECKI SH 54-2 | TICKALARA SH 54-3 | BULLOO SH 54-4 | EULO SH 55-1 | CUNNAMULLA SH 55-2 |
| CALLABONNA SH 54-6 | MILPARINKA SH 54-7 | URISINO SH 54-8 | YANTABULLA SH 55-5 | ENNGONIA SH 55-6 |

Scale 1:250,000

5 0 5 10 15 MILES

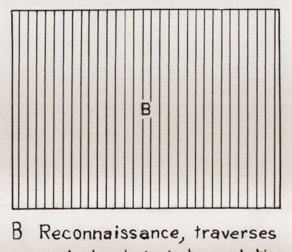
5 0 5 10 15 20 25 KILOMETRES

Section

Chemically altered Cretaceous and superficial Quaternary sediments not shown

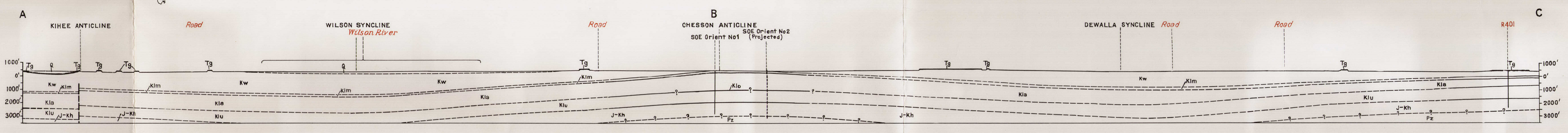
Scale : $\frac{V}{H} = 4$

GEOLOGICAL RELIABILITY DIAGRAM




B Reconnaissance, traverses and air-photo interpretation

Geology, 1967, by: B.R. Senior and D.A. Senior
Compiled, 1967, by: B.R. Senior, D.A. Senior and A. Tatarow
Cartography by: Geological Branch B.M.R.
Drawn by: A. Tatarow


PRELIMINARY EDITION, 1968

SUBJECT TO AMENDMENT



THARGOMINDAH

SHEET SG 54-16

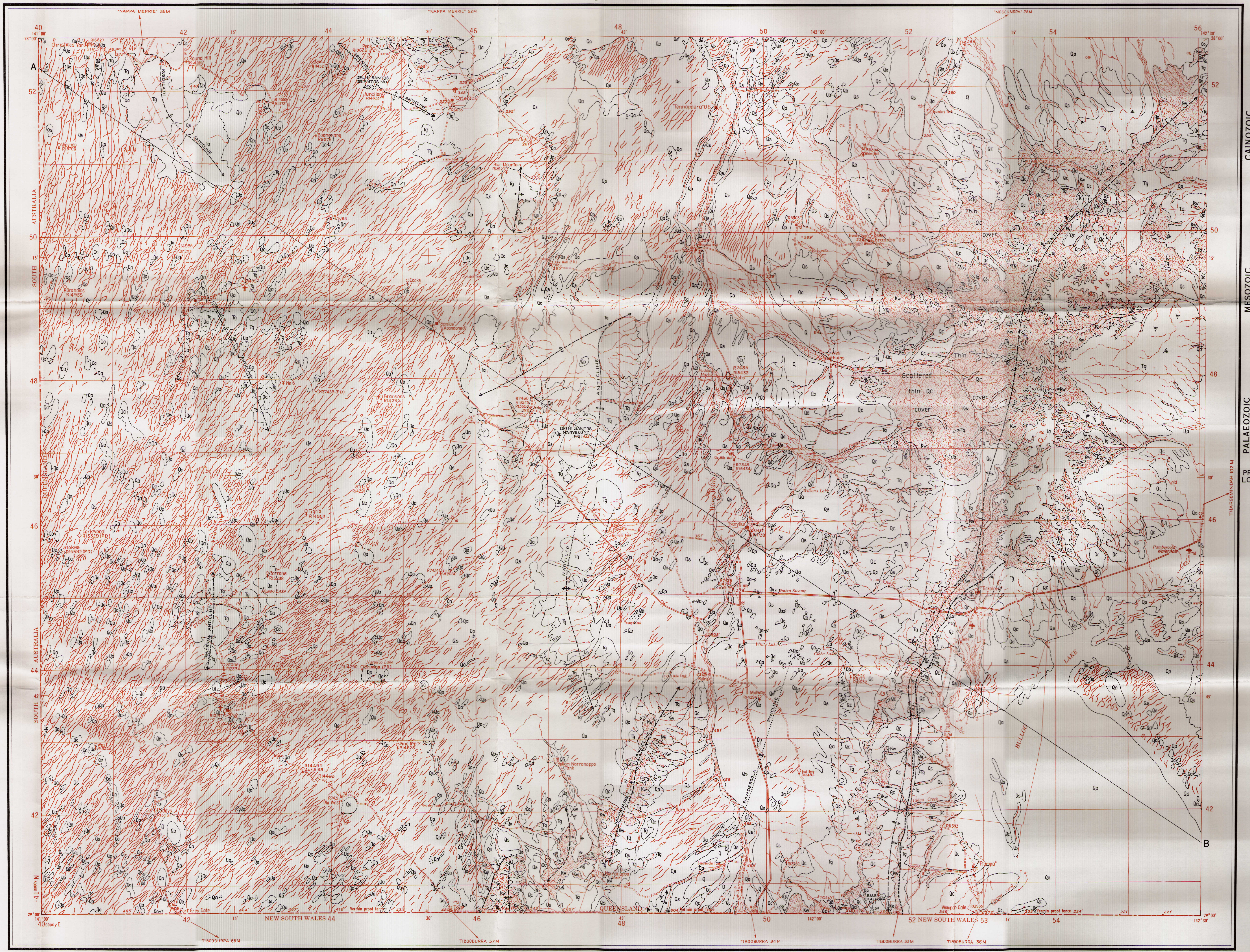
*Complimentary*

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

# TICKALARA

QUEENSLAND

SHEET SH 54-3




## Reference

| | | | | |
|---|---|---|---|---|
| CAINOZOIC | QUATERNARY | | Q | Undifferentiated |
| | | | Qa | Alluvium |
| | | | Qs | Sheet sand, some poorly consolidated silty sandstone |
| | | | Qc | Pebbles and cobbles, mostly silcrete |
| | | | Ql | Sandy limestone, limey sandstone, limestone |
| | TERTIARY | Glendower Formation | Tg | Quartz sandstone, quartz pebble conglomerate, sandy conglomerate, silcrete, siltstone and mudstone |
| MESOZOIC | LOWER TO UPPER CRETACEOUS | Winton Formation (Rolling Downs Group) | | Chemically altered, (leached, silicified and ferruginised), sediments |
| | | | Kw | Labile sandstone, siltstone and mudstone in part calcareous, minor coal, locally abundant silicified wood (Section only) |
| | LOWER CRETACEOUS | Mackunda Formation (Rolling Downs Group) | Klm | Labile sandstone, siltstone and mudstone in part calcareous, coquinite (Section only) |
| | | Allaru Mudstone (Rolling Downs Group) | Kla | Mudstone, minor siltstone in part calcareous, minor limestone |
| | | Wallumbilla Formation (Rolling Downs Group) | Klu | Mudstone, labile siltstone, fine labile sandstone (Section only) |
| | JURASSIC TO LOWER CRETACEOUS | Hooray Sandstone | J-Kh | Sublabile sandstone siltstone, conglomerate (Section only) |
| | UPPER JURASSIC | Westbourne Formation (Injune Creek Group) | Juw | Siltstone, mudstone, fine grained quartzose sandstone (Section only) |
| | MIDDLE TO UPPER JURASSIC | Adori Sandstone (Injune Creek Group) | Ja | Labile to sublabile sandstone, pebbly in part; siltstone (Section only) |
| | MIDDLE JURASSIC | Birkhead Formation (Injune Creek Group) | Jmb | Sublabile to labile sandstone, in part calcareous; carbonaceous siltstone and mudstone; minor coal (Section only) |
| | LOWER TRIASSIC | | Rl | Sublabile to labile sandstone, some shaley siltstone, minor carbonaceous material throughout (Section only) |
| PALAEOZOIC | LOWER TO UPPER PERMIAN | Gidgealpa Formation | Pg | Quartz sandstone, carbonaceous siltstone and shale, coal (Section only) |
| | LOWER PERMIAN | Merrimelia Formation | Plm | Polymictic conglomerate, sandstone, minor shale and siltstone (Section only) |
| | ORDOVICIAN | | O | Shale, dolomitic to calcareous, quartz veined, dolomitic siltstone, fine grained sandstone, steeply dipping (Section only) |
| PROTEROZOIC TO LOWER PALAEOZOIC | | | Ꝑ-Pz | Quartzite. Minor slate or phyllite, steeply dipping (Section only) |

Geological boundary
Syncline, showing direction of plunge
Anticline
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

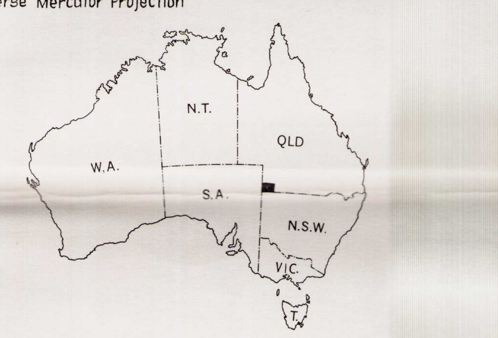
15 Strike and dip of strata
Dip < 5° } air-photo interpretation
Dip < 15° } air-photo interpretation

Dry hole, abandoned
SH BMR Scout hole

R14957 Abandoned bore or well
Sub-artesian bore or well
(R14957 refers to bore registration number of the Queensland Irrigation and Water Supply records)
E Earth tank
Dam on stream
WH Waterhole on stream
Sand dunes

Road
Vehicle track
Landing ground
"Orientos" Homestead; OS, outstation
Building
Yd Yard
Fence
Astronomical station
.272' Height in feet, datum: mean sea level
(PD) Position doubtful

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Division of National Mapping, Department of National Development. Commonwealth aerial photography; complete vertical coverage at 1:50,000 and 1:85,000 scales
Transverse Mercator Projection




### INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

| | | | | |
|---|---|---|---|---|
| PANDIE PANDIE SG 54-9 | CORDILLO SG 54-10 | BARROLKA SG 54-11 | EROMANGA SG 54-12 | QUILPIE SG 55-9 |
| GASON SG 54-13 | INNAMINCKA SG 54-14 | DURHAM DOWNS SG 54-15 | THARGO-MINDAH SG 54-16 | TOOMPINE SG 55-13 |
| KOPPERA-MANNA SH 54-1 | STRZELECKI SH 54-2 | TICKALARA SH 54-3 | BULLOO SH 54-4 | EULO SH 55-1 |
| MARREE SH 54-5 | CALLABONNA SH 54-6 | MILPARINKA SH 54-7 | URISINO SH 54-8 | YANTABULLA SH 55-5 |
| COPLEY SH 54-9 | FROME SH 54-10 | COBHAM LAKE SH 54-11 | WHITE CLIFFS SH 54-12 | LOUTH SH 55-9 |

(Isogonic lines: 6°30'E, 7°E, 7°30'E, 8°E)

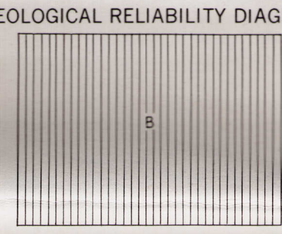
ANNUAL CHANGE 2' 45"E

Scale 1:250,000

5 0 5 10 15 MILES

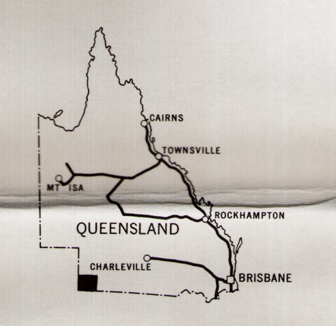
5 0 5 10 15 20 25 KILOMETRES

### GEOLOGICAL RELIABILITY DIAGRAM




B Reconnaissance – traverses and air-photo interpretation

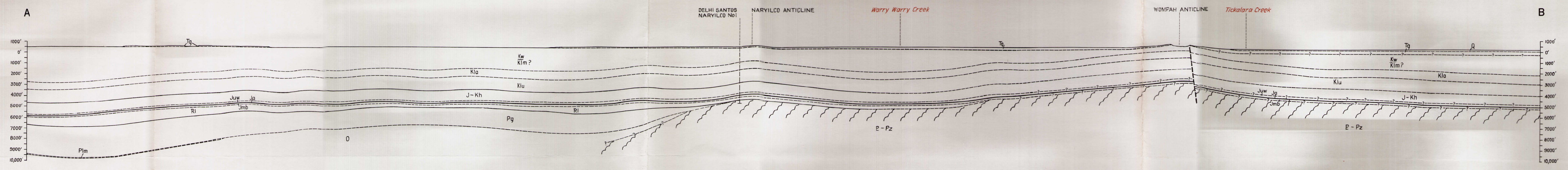
Geology, 1967, by: M.C. Galloway
Compiled, 1967, by: M.C. Galloway, D.A. Senior and R.D. Cooper
Cartography by: Geological Branch BMR
Drawn by: D.M. Pillinger




### Section

(Superficial sediments omitted from section)

Scale: V/H = 4




PRELIMINARY EDITION, 1968

SUBJECT TO AMENDMENT



TICKALARA

SHEET SH 54-3

*Complimentary*

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

# BULLOO

QUEENSLAND

SHEET SH 54-4

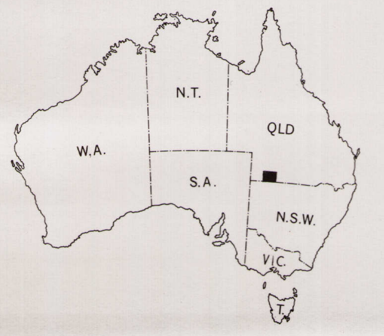

## Reference

| | | | | |
|---|---|---|---|---|
| CAINOZOIC | QUATERNARY | | Q | Undifferentiated |
| | | | Qa | Alluvium: sand, silt, clay, gravel |
| | | | Qs | Sand, minor silt |
| | | | Qc | Silcrete gravel |
| | TERTIARY | Glendower Formation | Tg | Quartz sandstone, quartz conglomerate, siltstone, mudstone. Silicified sandstone (silcrete) |
| MESOZOIC | LOWER TO UPPER CRETACEOUS | Winton Formation (Rolling Downs Group) | | Chemically altered (leached, silicified and ferruginized) sediments. Fossil soil |
| | | | Kw | Labile sandstone, siltstone, mudstone, in part calcareous; minor coal |
| | LOWER CRETACEOUS | Mackunda Formation (Rolling Downs Group) | Klm | Labile sandstone, siltstone, mudstone, in part calcareous; coquinite |
| | | Allaru Mudstone (Rolling Downs Group) | Kla | Mudstone, minor calcareous sandstone and siltstone |
| | | Wallumbilla Formation (Rolling Downs Group) | Klu | Mudstone, siltstone, minor sandstone, in part calcareous |
| | UPPER JURASSIC TO LOWER CRETACEOUS | Hooray Sandstone | J-Kh | Sublabile sandstone, conglomerate, siltstone |
| PALAEOZOIC | | | Pz | Steeply dipping indurated sediments, metasediments, granite |

Klm, Kla, Klu, J-Kh, Pz: Section only

Geological boundary
Anticline
Syncline
Fault (D,U indicate relative movement down, up)
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
Strike and dip of strata
Dip < 5° (Air photo interpretation)
Dip < 15° (Air photo interpretation)
Scout hole
Abandoned bore or well
Sub-artesian bore or well
Artesian bore, flowing
Artesian bore, ceased to flow
R12567 refers to bore registration number of the Queensland Irrigation and Water Supply records
Windpump
Earth tank
Dam on stream
Waterhole on stream
Sand dunes
Road
Vehicle track
Landing ground
Homestead, O.S.: outstation
Building
Yard
Fence
Astronomical station
Height in feet, datum: mean sea level
Position doubtful

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Divison of National Mapping, Department of National Development. Commonwealth aerial photography; complete vertical coverage at 1:50,000 and 1:80,000 scales
Transverse Mercator Projection



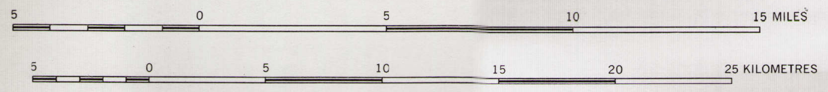

### INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

| | | | | |
|---|---|---|---|---|
| CORDILLO SG 54-10 | BARROLKA SG 54-11 | EROMANGA SG 54-12 | QUILPIE SG 55-9 | CHARLEVILLE SG 55-10 |
| INNAMINCKA SG 54-14 | DURHAM DOWNS SG 54-15 | THARGO-MINDAH SG 54-16 | TOOMPINE SG 55-13 | WYANDRA SG 55-14 |
| STRZELECKI SH 54-2 | TICKALARA SH 54-3 | BULLOO SH 54-4 | EULO SH 55-1 | CUNNAMULLA SH 55-2 |
| CALLABONNA SH 54-6 | MILPARINKA SH 54-7 | URISINO SH 54-8 | YANTABULLA SH 55-5 | ENNGONIA SH 55-6 |
| FROME SH 54-10 | COBHAM LAKE SH 54-11 | WHITE CLIFFS SH 54-12 | LOUTH SH 55-9 | BOURKE SH 55-10 |

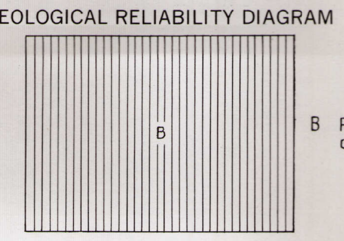
ANNUAL CHANGE 2′ 30″E

Scale 1:250,000




Section
(Quaternary sediments omitted from section)
Scale: $\frac{V}{H}$ = 4

### GEOLOGICAL RELIABILITY DIAGRAM



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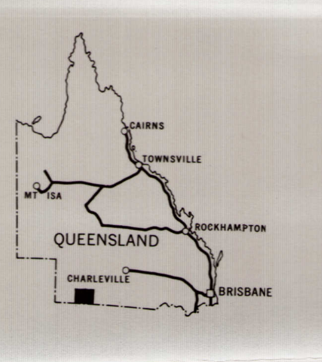
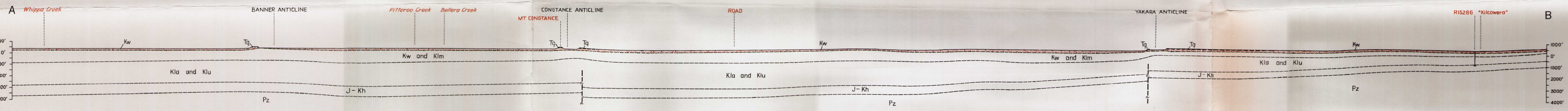



Geology, 1967, by: J. A. Ingram
Compiled, 1967, by: J. A. Ingram and D. A. Senior
Cartography by: Geological Branch BMR
Drawn by: Miss D.M. Pillinger




**PRELIMINARY EDITION, 1968**

SUBJECT TO AMENDMENT



BULLOO

SHEET SH 54-4

*Complimentary*

# CORRELATION DIAGRAM OF OIL EXPLORATION WELLS

PLATE 1.


TO ACCOMPANY RECORD 1968/35 Q/A135