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DEPARTMENT OF NATIONAL DEVELOPMENT

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PROGRESS REPORT ON THE GEOLOGY OF THE SOUTHERN CARPENTARIA BASIN

by

H.F. Doutch, J.A. Ingram, J. Smart (BMR)
and K.G. Grimes (GSQ).

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SUMMARY

Regional mapping of the Carpentaria Basin was started in 1969 by a combined party from the Bureau of Mineral Resources and the Geological Survey of Queensland. This Report deals with Burketown, Donors Hill, Millungera and parts of Dobbyn, Cloncurry, Gilberton and Croydon 1:250,000 sheet areas, which cover most of the southern Carpentaria Basin.

The maximum known thickness of Jurassic and Cretaceous rocks in this area is about 700 metres near Burketown, where mid and late Jurassic and early Cretaceous terrestrial quartzose sandstone is overlain conformably by early Cretaceous marine mudstone, limestone, and labile sandstone. Further south, over the Euroka Arch, where the labile sandstone is missing, the preserved Cretaceous sequence is a little over 300 metres thick. The southern Carpentaria Basin sequence is an unchanged northwards continuation of the northern Eromanga Basin sequence.

The Jurassic sandstone is confined to three depressions in the basement. The Canobie and Millungera Depressions are lobes of the depositional Eromanga Basin which in Jurassic times extended well to the north of its present day structural boundary along the Euroka Arch. The Burketown Depression was the beginning of the depositional Carpentaria Basin. The Euroka Arch is the result of sags away from it towards the centres of the Eromanga and Carpentaria Basins during early Cretaceous deposition.

After marine deposition ceased in the Cretaceous there were erosional and continental depositional episodes both before and after culmination of a period of deep weathering with laterite, siliceous duricrust and ferricrete, in that sequence. At present, Plio-Pleistocene continental deposits such as the Wyaaba, Wondoola and Armraynald Beds, which are up to 40 metres thick in the Report area, are being eroded. The Pliocene was also a time of faulting, tilting and uplift on the eastern margin of the basin. Pleistocene and Holocene eustasy produced a series of beach ridges.

In the southern half of the area artesian water is extensively used for stock purposes. The aquifers in which water bores are most often completed are in the quartzose sandstone sequence. So far the search for petroleum has been unsuccessful, although oil shale associated with the Toolebuc Limestone may be exploited in the near future.

INTRODUCTION

This report summarises results of a regional geological survey of the southern Carpentaria Basin, carried out by a combined part from the Bureau of Mineral Resources, Geology and Geophysics (BMR) and the Geological Survey of Queensland (GSQ) in 1969, which was supplemented by shallow stratigraphic drilling by BMR in 1970 and 1971.

It was prepared concurrently with:

1. BMR Explanatory Notes on the 1:250,000 sheet areas -

Burketown	1st edition	(Ingram, in press b)
Croydon	1st edition	(Doutch, in prep)
Dobbyn	2nd edition	(Smart, in press b)
Donors Hill	1st edition	(Ingram, in press a)
Gilberton	2nd edition	(Smart, in press a)
Millungera	1st edition	(Grimes, in press)
Normanton	1st edition	(Simpson, in press)

2. BMR Records -

   on the Mesozoic and Cainozoic geology of Cloncurry (Grimes, 1972) and Georgetown (Needham, 1972). These Records update the Explanatory Notes already published.

   on BMR shallow stratigraphic drilling (Grimes & Smart, 1970; Needham et al., 1971).

   on the geology of the central Carpentaria Basin, a continuation of the regional survey in 1970 (Doutch et al., in press).

3. Systematization of stratigraphic nomenclature for the Carpentaria Basin (Smart et al., 1971, and in press; Smart, 1972).

Hence this report concentrates on discussions not appropriate to the other publications: physiography is treated only in geological terms, stratigraphy concentrates on basin wide features, and structure deals with regional development.

Previous Investigations

The first reports on the geology of the Carpentaria basin are in the journal of the explorer Leichhardt (1847) who travelled along the southern margins of the gulf on his journey from the Darling Downs to Port Essington (near Darwin). Later on, surveys were made of the mineral deposits of the areas adjacent to the basin, but the first detailed survey of the Mesozoic rocks was by Maitland (1898) who mapped the Great Artesian Basin between Hughenden and Croydon. Other early reports on the basin and the adjoining areas were by Cameron (1901), Jackson (1902), and Dunstan (1920). Whitehouse (1940, 1941, 1944) studied the geology of the area, and the first comprehensive reports on the geology and hydrology of the Carpentaria Basin were given by Whitehouse (1954) and Ogilvie (1954).

Laing & Power (1959) defined a number of formations in the Carpentaria Basin. They later discussed them in Hill & Denmead (eds., 1960, pp 302-303, 324-328), in which Cainozoic deposits of the basin were also discussed by a number of authors (pp 345, 381, 388). Reynolds (1960) mapped the Mesozoic and younger sediments of GEORGETOWN and GILBERTON on the eastern margin of the basin, and the Mesozoic geology of White's report (1965) is largely based on Reynolds' work. Skwarko (1963) examined Mesozoic outliers on the western margin of the basin. A summary of the basin geology appeared in Reynolds et al. (1963).

Perry et al. (1964) compiled a report on the lands of the Leichhardt-Gilbert area, which included a summary of the geology of the area by C.E. Prichard (B.M.R.). Twidale has published a number of papers on the physiography of the area (1956 a,b,c; 1966 a,b). Grant (1968b) presented a terrain classification of BURKETOWN and DONORS HILL based on geology. Meyers (1969) reviewed the available published and unpublished reports of the area and re-examined the cores and cuttings from the petroleum wells in the area.

Mapping in the adjoining part of the Eromanga Basin is described in Vine (1964, 1970), Vine et al. (1964) and Casey (1970). The stratigraphic nomenclature of that area is discussed by Vine & Day (1965), Vine (1966), and Vine et al. (1967). The nomenclature has been extended in part into the Carpentaria basin, with some modifications (Smart et al., 1971).

The geology of the adjacent basement areas were described in detail by Carter et al. (1961) for the Mt Isa Block, and White (1965) for the Georgetown Inlier.

Petroleum companies have been working in the Carpentaria Basin intermittently since 1954 and a number of oil exploration wells have been drilled within the Report area (Table 1). Geological and geophysical surveys carried out by these companies are listed in Table 2.

The Bureau of Mineral Resources has carried out seismic surveys, (Robertson & Moss, 1959) and gravity surveys (Flavelle 1965, Neumann 1964) in the area. Bouguer Anomaly maps are available for all of the sheet areas mapped in 1969.

Photogeological maps of CROYDON, MILLUNGERA, BURKETOWN and DONORS HILL were made by the Photogeological section of the B.M.R. (Rivereau 1966 a,b,c; Perry 1967).

TABLE ONE

PETROLEUM EXPLORATION WELLS DRILLED IN THE SOUTHERN CARPENTARIA BASIN

DATE	COMPANY	NAME OF WELL	LOCATION	REFERENCES
1958	Associated Aust. Oilfields	No. 8 (Karumba)	17° 25'S 140° 52'E	Laing (1960)
1961	Delhi - Santos	Mornington Is No. 1	16° 33'S 139° 15'E	Harrison et al. (1961)
1961	Delhi - Santos	Mornington Is No. 2	16° 29'S 139° 31'E	Harrison et al. (1961)
1964	Mid-Wood Exploration	Burketown No. 1	18° 04'S 139° 32'E	Perryman (1964)

PHYSIOGRAPHY AND GEOMORPHOLOGY

The physiography and geomorphology of the southern Carpentaria Basin have been dealt with in detail in Explanatory Notes by Ingram (in press, a & b), Smart (in press, a & b), and Grimes (in press) who all base their descriptions and analyses on Twidale (1956a, 1966b), and report such departures as were felt necessary from his 'physiographic regions'. Grimes introduced a completely new physiographic unit, the Millungera Plain, which is described in this report under Stratigraphy. We discuss here only the ancient drainage system remnants in the Gregory Range and the origins of the Claraville and Wondoola Plains (the nature of their sediments is discussed in Stratigraphy).

1. Ancient drainage

North of the Gilberton Plateau, in the Gregory Range, at least three stages of river valley history are clearly preserved and all post-date the deep weathering profile on the Gilberton Plateau. Figure 1 is of part of an area at the northwestern end of the plateau. Three main valley stages are present; at least two other stages could be interpreted, but these extra stages are not discernible anywhere else.

The earliest stage consists of two meandering river systems entrenched in the Hampstead Sandstone (q.v.), about 100 m below the plateau top. These rivers were part of the Gilbert River system of their times. Meanders have not been developed by younger streams in the same sandstone, so it is possible that the earliest rivers developed on the surface that the plateau is a relic of, and that their incision reflects a battle against uplift preceding second stage development.

The second stage streams were smaller and did not meander except where they occurred as valley-in-valley rejuvenations in the earliest river systems (Fig. 1). Some of them flowed west rather than into the Gilbert system, and made up the ancestral Norman and Clara Rivers, eroding the valleys the Wyaaba Beds ('Lynd Formation') eventually filled. Further uplift seems probable just before, and during, second stage development. This stage was terminated by block faulting and tilting, widespread, but of little magnitude locally (Fig. 43).

Regionally the effects are pronounced. All of the tilting and faulting which helped form the Gregory Range is due to uplift along the eastern margins of the Carpentaria Basin. The Gilberton Plateau, which now slopes about 1° to the northwest, west and south from a maximum elevation of over 1 000 m, was probably once part of a duricrusted plain about 200 m above sea level, perhaps continuous with the Donors Plateau (Twidale, 1956a, 1966b; see also Ingram, in press a & b; but see below). The structural implications of the raising of the Gilberton Plateau are discussed further in structure in this report, and by Smart (in press, a).

It is for the moment an unexplainable coincidence that where some faults can be observed on air photos cutting the old drainage system, there too can be observed what appear to be unconsolidated sediments completely filling the old valleys. The simplest interpretation is earthquake or fault movement debris, but such an interpretation cannot explain the choking of both ends of the old north-south valley in Fig. 1; similar choking occurs wherever old valleys encounter the margins of the plateau.

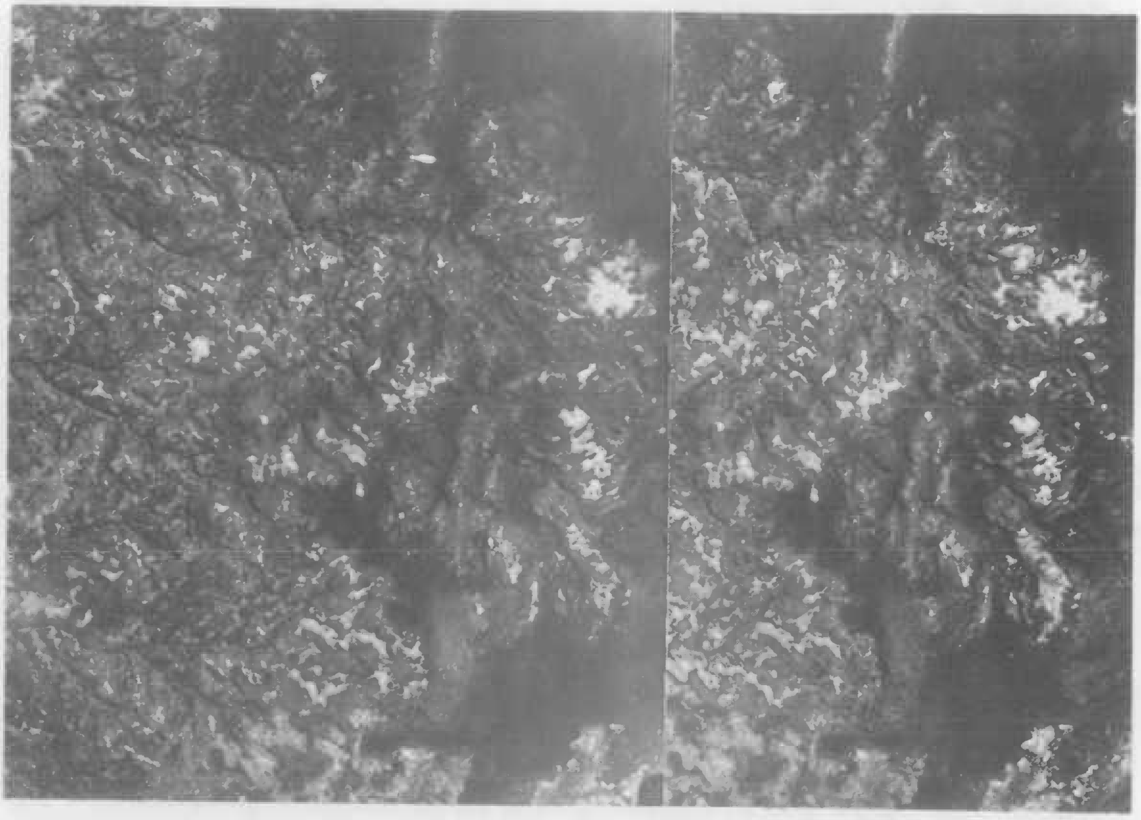


Fig. 1 -Stereo pair, GILBERTON RC-9 Run 4, Photos 93 and 94. Valley-in-valley development in entrenched meanders of pre-faulting drainage stage, Gregory Range.

TABLE TWO

PETROLEUM EXPLORATION COMPANY SURVEYS IN THE SOUTHERN CARPENTARIA BASIN

COMPANY	NATURE OF SURVEY	REFERENCES (all unpublished)
Frome - Broken Hill Co.	Geological	Reed (1954), Dixon (1956, 1957)
Frome - Broken Hill Co.	Gravity	Richards (1957)
Frome - Broken Hill Co.	Aeromagnetic	Sauve (1955)
Associated Aust. Oilfields	Geological	Laing et al., (1956)
Associated Aust. Oilfields	Gravity	Laing et al., (1956)
Delhi - Santos	Geological	Delhi Petroleum (1959, 1960, 1962, 1963) Warner (1960a, b)
Delhi - Santos	Aeromagnetic	Hartman (1962)
Delhi - Santos	Seismic	Andrews (1961)
Carpentaria Oils	Geological	Swindon (1959)
Mid - Wood Exploration	Geological	Boutakoff (1963), Rade (1963a, b)
Mid - Wood Exploration	Aeromagnetic	Hartman (1963)
Mid - Wood Exploration	Seismic	Warner (1963)
Australian Oil Corporation	Geological	Grasso (1963)
Northern Gulf Oil	Geological	Stone & Assoc. (1966)

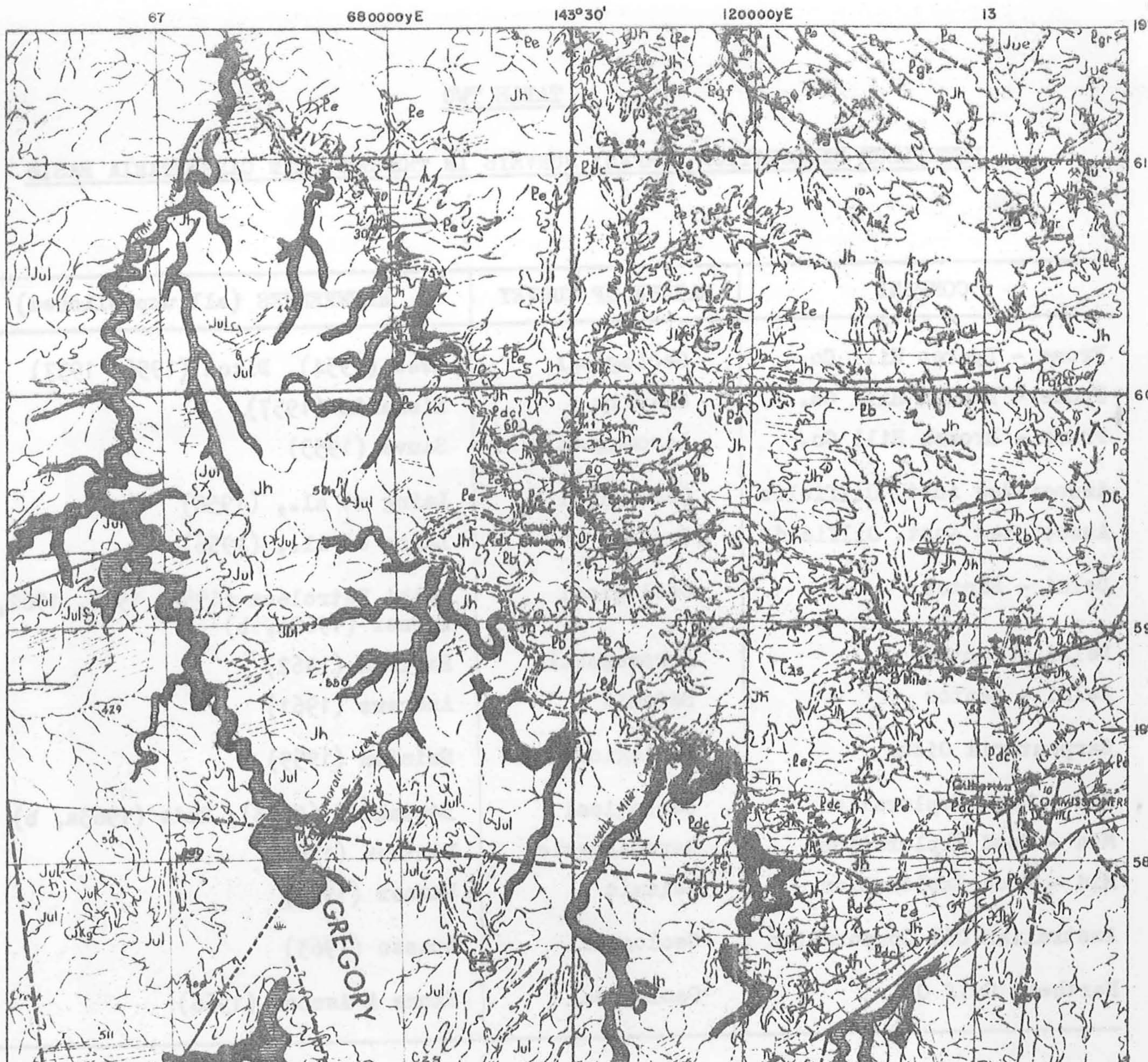


Fig 2 Ancient drainage system, Gregory Range

The third stage of erosion proceeded for a while, and then Chudleigh Basalt flowed into the upper reaches of the Stawell River, immediately southeast of the Gilberton Plateau. The Chudleigh Basalt is probably the same age as the Nulla Basalt in Clarke River and Townsville, and a series of Nulla Basalt flows has been radiometrically dated as ranging between 1 and 4.5 m.y. (Wyatt & Webb, 1970), i.e. they are of Pliocene age. Since this event the third stage of erosion has continued uninterrupted to the present day.

The basalt ages require the faulting, tilting and uplift to be early or pre-Pliocene. The ancient drainage system is so well preserved that a young age for it is likely, and both it and the Gilberton Plateau were probably created early in the Pliocene. The Wyaaba Beds of the Claraville Plain are mostly younger than this.

2. Origins of the Depositional Plains

The erosion by the ancestral Norman-Clara system, initiated by the uplift of the Gregory Range, apparently occurred at the same time as ancestral Flinders and Leichhardt Valleys were being eroded further west. A pre-requisite to the latter is a change of climate from that in which the deep weathering profile was produced (the deep weathering profile is also discussed in this Record in Stratigraphy). Between the ancestral systems of the Flinders and Norman-Clara lay the Savannah Downs Ridge (see Stratigraphy, this report, Figs. 25) with a backbone of Toolebuc Limestone (Fig. 27; Grimes, in press). This bespeaks either a relatively arid climate, and/or a seasonal one such as exists now to the northeast in the Chillagoe district, noted for its limestone hills.

The formation of the ancestral systems may have involved the preferential erosion of the Allaru Mudstone and Wallumbilla Formation with respect to the sandier, 'duricrusted' Normanton Formation now cropping out as the Donors Plateau, depositional plains sediments being generally thicker where mudstone formations are bedrock. The places of occurrence of the Floraville Formation to the west, with respect to the Leichhardt River system and Armraynald Plains (see also Stratigraphy) suggests such differential erosion may have started even before 'duricrusting' occurred.

The absence of any remnants of duricrust from the Allaru Mudstone in outcrop or subcrop in the Carpentaria Basin is rather puzzling as it is present in MCKINLAY in the Eromanga Basin on both the Allaru Mudstone and the Mackunda Formation (the Mackunda Formation is similar to and in the same stratigraphic position as the Normanton Formation). As the Allaru Mudstone seems to be more susceptible to present-day weathering than the sandstones of the Normanton and Mackunda Formations (the two latter are characterised by rubbly outcrop, whereas soil completely conceals the Allaru Mudstone) then perhaps the Allaru Mudstone has always floored lowlands or suffered relatively fast erosion; for the most part it may never have acquired a duricrust, and this of course would have made erosion by the ancestral Flinders (and Leichhardt) very much easier. A similar case could be made out for the Wallumbilla Formation and its erosion by the ancestral Norman-Clara. Ferricrete in the headwater basins of the Saxby River and its tributaries is confined to the Hampstead Sandstone, and has not been seen on nearby Wallumbilla Formation mudstone exposures.

Despite claims above for preferential erosion of the Allaru Mudstone, the depositional plains begin in the south where the erosional Julia Plain ends, and the Julia Plain consists almost entirely of Allaru Mudstone (Twidale, 1966b). The apparent resistance to erosion shown by the Allaru Mudstone in the south contrasts sharply with the old valleys carved in it in the north before the alluvia of the depositional plains filled them. The reason for the contrast may be that headward erosion by both ancestral and present day rivers flowing to the gulf as a result of original tectonic and Mesozoic sediment slopes has only recently advanced south of the Euroka Arch (see Structure), and headwaters are only now cutting back into outcrop along the northern margins of the Eromanga Basin. The Selwyn Upwarp (Twidale, 1966a) may have accentuated the erosion.

In the Wondoola Plain a possible by-product of this situation may be that the direction and vigour of river flow, oriented and energised basically by the geological structures along its southern and eastern margins, could be responsible for the bite taken out of the eastern side of the Donors Plateau, which is made up of 'duricrusted' Normanton Formation.

With respect to palaeo-climate during accumulation of the depositional plains, the scarp country of the Donors Plateau between the Wondoola and Armraynald Plains invites use of the terms pediment, pedimentation, pediplanation and scarp retreat. The first three have strong connotations of arid climate processes, for which the only independent data are sandhills in the Millungera Plain (see Stratigraphy).

The mesas that make up the Donors 'Plateau' are a recent development post-dating accumulation of the depositional plains. Their formation involved scarp retreat, this being the only response a valley side below a protective hill capping can make in most climates. Arid climates do not need to be imagined in this area during and after the formation of the depositional plains, except for the time of sand dune formation.

The outcrops of Normanton Formation along the south coast of the Gulf of Carpentaria (excluding those of the Wellesley Islands) need not necessarily be interpreted on geomorphological grounds as upwarped, resulting in constraints to the accumulation of the depositional plains (Twidale, 1966b). Although its drainage suggests the Donors Plateau is tilted to the west (Ingram, in press a & b), computer plotted topographical form lines based on BMR gravity station elevations suggest the surface 'duricrusted' was a dome-shaped area which might have originated as a result of either tectonism or erosion or both. Lacustrine deposition of the Wondoola Plains sediments remains unproven (Twidale, op. cit.).

In brief, depositional settings for the Claraville and Wondoola Plains are the valleys in the mudstone formations which were eroded differentially with respect to the harder rocks of older and younger Mesozoic formations and rocks of the Georgetown Inlier. Tectonism to the south and west affected stream energies. Palaeoclimates are uncertain but changes must have occurred between the periods of duricrusting and erosion, and also possibly between erosion and deposition.

The Armraynald Plains were formed in a similar setting, that of the ancestral Leichhardt River system. Ante- and post-duricrust valleys were differentially eroded into Allaru Mudstone, with respect to the Normanton Formation to the east and the rocks of the Mt Isa Block to the west. The valleys were in due course filled by the Armraynald Beds. The effects of Pliocent tectonism are unknown but probably slight.

TABLE 3 - MESOZOIC AND CAINOZOIC STRATIGRAPHY

ERA	PERIOD	ROCK UNIT	MAP SYMBOL	THICKNESS (metres)	LITHOLOGY	DEPOSITIONAL ENVIRONMENT & PROCESS	STRATIGRAPHIC RELATIONS: CORRELATIONS	ECONOMIC GEOLOGY	PRINCIPLE REFERENCES
CAINOZOIC	QUATERNARY (Qrp, Qro, Qre, Qrc, Qrs & Qra Holocene)	coastal alluvium	Qac	< 10	Silty clay, silt, quartzose sand	Coastal (Karumba) Plain - paludal, littoral, paralic	Qac part underlies, is part contemporaneous with, Qrp, Qa; Qac probably contemporaneous with younger Qa, and rests on Czy, Qw, Qn, and Kln		Twidale, 1956a, 1966b) Valentine (1961) Whitehouse (1963) Doutch et al. (in press) Ingram (in press b)
		salt pan deposits	Qrp (Qcp)	< 2	Silty clay, salt			Minor salt	
		beach and sand ridges	Qm	< 5	Coquina, calcarenite, shelly quartzose sand			lime from shells; building sand; minor perched aquifers	
		meander belt point bar deposits	Qre	< 5	sand, mud	Coastal Plain - Fluvial	Contemporaneous with Qac		
		Secondary limestone	Qt	< 2 ?	Travertine, caliche	pedological ?	associated with Precambrian rocks		
		flood plain alluvium and floodout deposits	Qa	< 10	Sand, silt, clay	alluvial plain (undivided)	)Qa contemporaneous with)most Qac, Qw, Qn, Qre,)Qro, Qra, Qrs, Qro contemporaneous with youngest Qa		
		stream bed sediments	Qra	< 5	Quartzose sand, silt, clay	stream beds - fluvial	)	minor	
		floodout deposits	Qro	< 5	Quartzose sand	distributary floodout areas - fluvial	)		
		floodout deposits	Qrs	5 ?	Quartzose sand	Millungera Plain - fluvial	)	perched	
		flood plain alluvium	Qrc	< 10 ?	Silty clay	Armraynald Plain (newer part) - fluvial	Overlies youngest Mesozoic units unconformably		
		Armraynald and Wondoola Beds	Qn, Qw (Qf)	< 60 +	Silt, clay, sand	Armraynald and Wondoola Plains - fluvial	)Overlie younger)Mesozoic units unconformably; contem-		
		alluvial plain	Czr	< 20	Sand, silt, clay	Wondoola Plain (older) - fluvial	)poraneous with most)of Czy	aquifers	
		Wyaaba Beds	Czy	up to 60	Poorly sorted grey clayey quartzose sand, sandstone and granule conglomerate, commonly pebbly	Claraville Plain - outwash alluvium - fluvial	Overlie all Mesozoic units unconformably ('Lynd Formation' of Laing & Power (1959)	aquifers usually saline	Warner (1968); Smart et al (in press)
		soil, colluvium	Cza (Ql)	< 5	Clay, quartzose sand	Fill in ancient valleys - colluvial	Overlies Td; probably contemporaneous with older Czs		

TABLE 3 - MESOZOIC AND CAINOZOIC STRATIGRAPHY (Cont'd)

ERA	PERIOD	ROCK UNIT	MAP SYMBOL	THICKNESS (metres)	LITHOLOGY	DEPOSITIONAL ENVIRONMENT & PROCESS	STRATIGRAPHIC RELATIONS; CORRELATIONS	ECONOMIC GEOLOGY	PRINCIPLE REFERENCES
CAINOZOIC	TERTIARY (?)	colluvium and outwash deposits	Czs	<10	Quartzose sand and gravel	coluvium: outwash alluvium - fluvial	Overlies most Mesozoic units; probably contemporaneous in part with Qw, Qn, Czr, Cza and Czy		
		high level gravels	Czg (Tg)	< 10	Quartzose cobbles and pebbles				
		Chudleigh Basalt	Czc	About 20		valley fill lava flows	post-dates Czd; correlates with Pliocene Nulla Basalt (?)		White (1965)
		'Ferricrete'	Tf (Czf)	2 ±	Iron cemented gravel and colluvium		Developed on JKg, Czd (and Esmeralda Granite)		
		'Duricrust'	Td (Czd)	Up to 12	Hard fossil soil and colluvium; brecciated, ferruginous, siliceous, Rocks beneath are mottled, kaolinized, silicified.	continental - deep weathering	Developed on Kln deep weathering zone, on KTf, and on Jue & JKg of Gilberton Plateau		
	LATE CRETACEOUS OR EARLY TERTIARY	Floraville Formation	KTf	12	clayey quartzose sandstone & conglomerate	Continental - fluvial	Overlies younger Mesozoic units unconformably		Smart et al. (1971)
MESOZOIC	EARLY CRETACEOUS; Albian; Rolling Downs Group	Normanton Formation	Kln	250 +	Labile sandstone, minor silty mudstone, limestone and siltstone	shallow marine and paralic	Conformably overlies Kla; offlaps to north? Correlates with Mackunda Formation, Eromanga Basin		Smart et al. (1971)
		Allaru Mudstone	Kla	170-200	Shale, mudstone, some siltstone, minor limestone		Conformably overlies Klo; offlaps to north? Part of Normanton Formation of Meyers (1969)		Vine et al. (1967) Smart et al. (1971)
		Toolebuc (Kamileroi) Limestone	Klo (Klk)	6-21	Calcareous shale, limestone, oil shale	marine	Conformably overlies Klu Kamileroi Formation of Meyers (1969)	possible uranium, vanadium, shale oil	Vine and Day (1965) Vine et al. (1967) Smart (1972)
		Wallumbilla (Blackdown) Formation	Klu (Klb)	120-210	Mudstone, some siltstone, minor limestone		Conformably overlies JKg. Blackdown Formation of Meyers (1969)	possible aquifers	Laing & Bower (1959) Vine et al. (1967) Smart et al. (in press)

TABLE 3 - MESOZOIC AND CAINOZOIC STRATIGRAPHY (Cont'd)

ERA	PERIOD	ROCK UNIT	MAP SYMBOL	THICKNESS (metres)	LITHOLOGY	DEPOSITIONAL ENVIRONMENT & PROCESS	STRATIGRAPHIC RELATIONS: CORRELATIONS	ECONOMIC GEOLOGY	PRINCIPLE REFERENCES
MESOZOIC	LATE JURASSIC AND EARLY CRETACEOUS	Gilbert River Formation	JKg	45-61	Clayey quartzose sandstone, glauconitic in upper part	shallow marine, following fluvial	Unconformable on basement rocks in places; conformable on Eulo Queen Group elsewhere	excellent aquifers in water bores	Meyers (1969) Smart et al. (1971)
	Aptian	Coffin Hill Member	Klf	12 ±	Clayey quartzose sandstone, minor siltstone, shale. Glauconitic in upper part.	near shore marine	together make up Gilbert River Formation		
		Yapper Member	JKy	15 ±	Quartzose sandstone and conglomerate, minor shale	fluvial			
	MID. TO LATE JURASSIC	Eulo Queen Group	Jue	30-100+	Coarse to fine-grained quartzose sandstone, commonly clayey, siltstone, conglomerate	continental - fluvial	Overlies basin basement unconformably in places and older Jurassic (?) rocks elsewhere conformably	excellent aquifers	Smart et al. (1971)
		Loth Formation	Jul	30-90	Clayey quartzose coarse to fine-grained sandstone, siltstone, mudstone	continental - fluvial	Overlies Hampstead Sandstone conformably; correlates with Westbourne Formation of Eromanga Basin		Smart et al. (1971) Vine e al. (1967)
		Hampstead Sandstone	Jh	30-45	Coarse and medium-grained quartzose sandstone, conglomerate, minor fine-grained sandstone and siltstone	continental - fluvial	Overlies basement unconformably or older Jurassic rocks conformably; correlates with Birkhead Formation of Eromanga Basin		Smart et al. (1971) Vine e al. (1967)

STRATIGRAPHY

Summary

Although the survey was primarily of the Carpentaria Basin some areas of basement rocks in GILBERTON, CLARKE RIVER and MILLUNGERA were remapped. They included metamorphic rocks of Archaean (?), Proterozoic and early Palaeozoic age, sedimentary rocks of Upper Devonian to Lower Carboniferous age and Upper Silurian to Lower Devonian granite.

The first Carpentaria Basin sediments were deposited in the Jurassic in the Burketown Depression. At the same time similar sediments were deposited further south in the Millungera and Canobie Depressions, which at that time formed the northern limits of the Eromanga Basin. The northern ends of the last two depressions are now within the structural limits of the Carpentaria Basin. These first Jurassic sediments do not crop out and are known in only a few bores.

The oldest rocks of the Carpentaria Basin cropping out in the survey area are the Jurassic continental quartzose sandstone sequences of the Eulo Queen Group. In outcrop the group can be divided into the lower Hampstead Sandstone and the upper Loth Formation.

These two formations cannot generally be recognised in bores by their lithologies, but gamma ray logs show differences at appropriate depths which are assumed to differentiate the two units from each other and from older and younger units. The same general gamma ray log pattern is used by Vine et al., (1967) in the northern Eromanga Basin to pick out the Birkhead and Westbourne Formations of the Injune Creek Group.

Above these units in the Eromanga Basin lies the Hooray Sandstone, and in the Carpentaria Basin the quartzose Gilbert River Formation. The Gilbert River Formation began as a Jurassic continental deposit and ended as a shallow marine deposit in earliest Cretaceous times. It blanketed the whole basin; its present limits of preservation are also the furthest known limits of the Lower Cretaceous sea.

Shortly after the sea covered the two basins mud began to be deposited, with accumulations of labile sand and various calcareous materials from time to time. This sequence makes up the Rolling Downs Group of both basins. In both, the Toolebuc Limestone separates older muddy beds, the Wallumbilla Formation, from younger muddy beds, the Allaru Mudstone. Above this in the Carpentaria Basin lies the sandy Normanton Formation, which is correlated with the Mackunda Formation (and possibly part of the Winton Formation) of the Eromanga Basin.

The Normanton Formation represents the retreat of the Cretaceous sea. There are no dated Upper Cretaceous rocks in the area. The Floraville Formation, which rests unconformably on most Lower Cretaceous units, is continental and was probably deposited by an ancestral Leichhardt River in late Cretaceous or early Tertiary times.

In mid-Tertiary times all outcrops of the Carpentaria Basin except perhaps the mudstones of the Rolling Downs Group, were altered by deep weathering processes. After another period of erosion, the valleys so excavated were filled by the continental Wyaaba, Wondoola and Armraynald Beds. To some extent these were consequent on tectonism, which was strongest along the eastern margins of the basin, and could be said to mark the beginnings of a new sedimentary basin.

Table 3 systematically lists the Mesozoic and Cainozoic stratigraphy of the Southern Carpentaria Basin.

BASEMENT ROCKS

General

The southern part of the Carpentaria Basin is flanked by Precambrian blocks, part of a craton now largely covered by the Mesozoic sediments of the basin. The Mount Isa block to the west (Carter et al., 1961) is composed mainly of mid-Proterozoic rocks of the Carpentaria System. These vary from unaltered sediments and volcanics to high grade metamorphics and are intruded by numerous granites. There is extensive mineralisation.

The geological history of the Georgetown Inlier to the east is less well known. It consists of a central granite batholith which intruded moderate to high grade metamorphics of possible Archaean age (White, 1965), flanked (particularly in the west) by a thick sequence of unfossiliferous, largely unmetamorphosed, sediments which have been assigned to the Proterozoic (Needham, 1971; Smart, in press a). The history of the block is, however, complicated by tectonic events associated with the Palaeozoic Tasman Geosyncline which formed to the east and southeast. These events were accompanied by granite intrusion of Siluro-Devonian age (Richards et al., 1966 a, b). Permo-Carboniferous acid volcanism and granite intrusion is a feature of the late Pàlaeozoic tectonism (Branch, 1966 a, b).

Between these two blocks the only outcrops of 'basement' occur in MILLUNGERA as small inliers at Mount Fort Bowen and Mount Brown. The rocks at Mount Fort Bowen consists of unmetamorphosed conglomerate and sandstone and those at Mount Brown consist of mica schist and sheared coarse-grained sediments. The metamorphism is in the greenschist facies. Carter et al. (1961) believed the rocks to be Proterozoic in age although Mount Brown was considered to be the older. They may, however, be the same age. A Palaeozoic age for the inliers cannot be discounted. New data on these inliers appear below.

This report also includes descriptions of a number of the Precambrian inliers south of the Georgetown Inlier.

Information on the basement rocks below the southern Carpentaria Basin is scarce. The information contained in the drillers' logs of water bores is generally unreliable. Granite is commonly reported and most of the other basement rocks reported appear to be metamorphics. Reliable information is, however, available for petroleum exploration wells AAO 8 (Karumba), (Laing, 1960) and Mid-Eastern Burketown No. 1 (Perryman, 1964). In the former the basement is quartzite and in the latter dolomite overlies quartzite. It is probable that these rocks are of Proterozoic age. Midwood Normanton Scout No. 2 penetrated 183 m of quartzite of unknown age dipping consistently at 45°.

Fig. 3 -Conglomerate at Mt Fort Bowen. Iron-coated pebbles at junction with sandstone may indicate a period of weathering. (Neg. 2895)

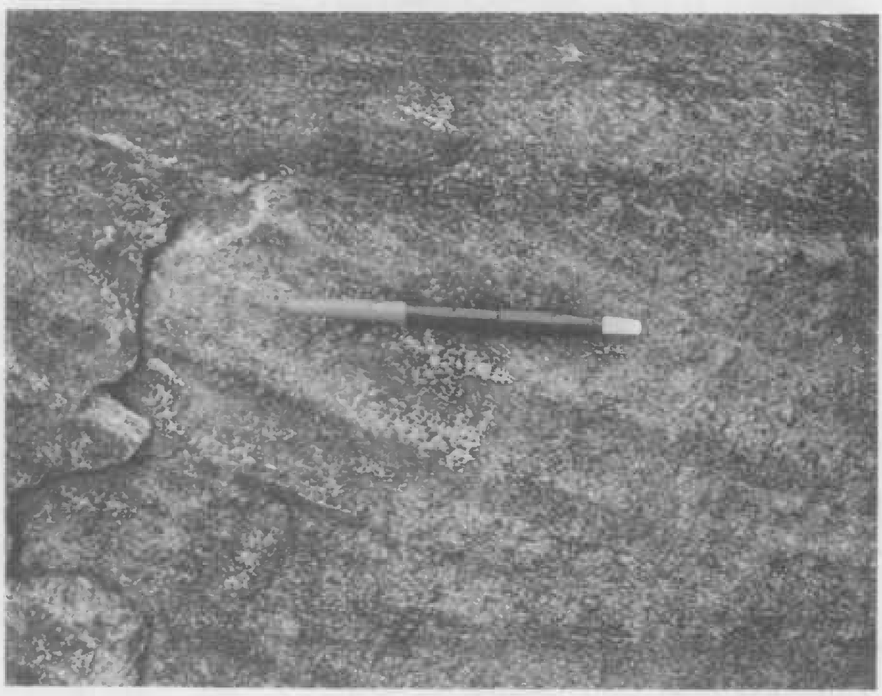


Fig. 4 -Metamorphosed cross bedded sandstone, Mt Brown. (Neg. 2874)

Mount Fort Bowen and Mount Brown

Mount Fort Bowen and Mount Brown in MILLUNGERA represent culminations of the Fort Bowen Ridge, which is thought to be an erosional ridge formed on a pre-Mesozoic fault block, and which has been buried beneath the Mesozoic and Cainozoic sediments of the basin.

These notes should be read in conjunction with Carter et al. (1961), and Grimes (in press).

Mount Fort Bowen is composed of a sequence of pebble conglomerate and hard, red-brown and purple, coarse to fine, micaceous, feldspathic, quartz sandstone, all of it ferruginized and silicified. The conglomerates are composed of rounded pebbles of quartz, quartzite, silicified sandstone, jasper, chert, and slate (Fig. 3). The sandstone has a silty matrix and is angular and poorly sorted. Small scale cross beds and ripple laminae are common and indicate a direction of sedimentation from the south and southwest (Carter et al., 1961). The beds dip at 20° - 40° ENE. There are two sets of joints; a major vertical set striking at 350°, and a minor flat-lying set that dips 10° east. Movement has occurred along some of the vertical joints, resulting in slickensides, and some of the fractures are filled by quartz veins and crystalline haematite.

Mount Brown is composed of mica schist together with sandstone similar to that at Mount Fort Bowen. Conglomerate beds are absent. The mica schist has a foliation with a north-northwest strike and which dips vertically, and steeply to the east. Carter et al. (1961) described the schist as quartz-feldspar-mica-schist containing epidote and garnet as accessory minerals. There are some irregular quartz veins and north to northwest-striking joints. At the northern end of the mountain vertically foliated schist is overlain by hard silicoous sandstone dipping 20° - 35° ENE. These sandstones show relic crossbedding in places (Fig. 4).

No fossils are present and the rocks are regarded as Precambrian on the basis of their metamorphic character, and general similarity to some of the less strongly metamorphosed rocks of the Precambrian block to the west. Carter et al. (1961) thought that the Mount Fort Bowen beds were correlatable with the Quamby Conglomerate to the west, which they dated tentatively as Upper Proterozoic. They considered that the mica schist at Mount Brown is Lower Proterozoic on the basis of its apparent higher degree of metamorphism. If this were so then the contact between the sandstones and the schist at the northern end of Mount Brown must be faulted or unconformable. Examination in the field showed no evidence for faulting.

The beds of both inliers may be of the same age. The sandstone overlying the schist shows lineations parallel with the schistosity of the underlying rock. The presence of epidote in the schist suggests that the grade of metamorphism is not greater than the greenschist facies.

Undifferentiated Precambrian rocks south of the Georgetown Inlier

During the course of the survey inliers of igneous and metamorphic rocks were examined in the southern part of GILBERTON and CLARKE RIVER. Of these, two inliers in the extreme southeast of GILBERTON in the Stawell River area had previously been mapped as undifferentiated granite and metamorphics (White, 1962 b) and to the west of these the inlier at the Woolgar Goldfield had been mapped as ?Archaean metamorphics (White, 1962 b, 1965). These inliers are surrounded by Jurassic and Cretaceous sandstones of the Gilbert River Formation and Eulo Queen Group.

Stawell River Inlier

An inlier exposed along the Stawell River and its tributaries consists mainly of granite and granite gneiss. The granite varies from grey and pink medium to coarse biotite adamellite and granodiorite to a pink coarse garnetiferous adamellite. The granite is foliated in places. The granite gneiss varies from slightly sheared to coarsely banded with separate quartz-feldspar and mafic bands. Orthogneiss has not been differentiated from granite on the 1970 preliminary to the second edition of the Gilberton 1:250,000 geological map. Rhyolite and rhyolite porphyry dykes trending northnorthwest, parallel to the gneissic foliation, are common and in the north they form larger bosses.

Overlying the granite in the east are unmetamorphosed sediments. These sediments dip to the east between 13° and 20°. Measured on the air photograph (scale, 1:84,000) they crop out over nearly 1 km, with an average dip of 15°, making the sediments about 260 m thick. The sequence is composed dominantly of sandstone and conglomerate. It consists of red-brown, purple, and green poorly sorted arkose, lithic sandstone and conglomerate. The sandstone is commonly cross bedded. Interbedded with these are finer grained sandstone and micaceous siltstone. No fossils were found.

The sediments unconformably underlie the Middle to Upper Jurassic Eulo Queen Group. They are similar lithological to the Upper Devonian-Lower Carboniferous Bundock Creek Formation which was deposited in a basin at the southwestern end of the Broken River Embayment, part of the Tasman Geosyncline (White, 1965). The Bundock Creek Formation is up to 7,000 m thick and the main outcrop area is 110 km northeast of the Stawell River; only Jurassic - Cretaceous sandstone and Cainozoic basalt crops out in between. It is possible the Bundock Creek Formation continues below these rocks into GILBERTON.

Glenloth Inlier

Between the Stawell River and Hampstead Creek further west is the Glenloth Inlier. The rocks consist of granite and orthogneiss, and other metamorphics. The granite includes a coarse-grained and porphyritic pink adamellite; orthogneiss, including biotite-augen-gneiss, has not been differentiated from granite on the map. The boundary between the granitic rocks and the metamorphics is faulted.

The metamorphics include quartz-muscovite-biotite-garnet-schist and gneiss, quartz-muscovite-haematite-schist, and amphibolite. The foliation strikes east-west. Pegmatite veins and dykes are abundant and in places there are aplites. Some of the pegmatites contain garnet.

Between this inlier and the Woolgar River Inlier there are outcrops of metamorphics at the base of the Mesozoic sandstones. Rock types include quartz-muscovite-biotite schist and quartz-feldspar-biotite-garnet gneiss.

Structure of the metamorphics, southern GILBERTON

The metamorphics are isoclinally folded and the foliation dips are greater than 70°. The mica schist commonly exhibits microfolds with a strain-slip cleavage developed. Elsewhere in GILBERTON the Precambrian metamorphics (Robertson River Metamorphics and Einasleigh Metamorphics of White, 1965) have structures indicative of several periods of folding.

Granites of southern GILBERTON

The granites described in the Stawell River and Glenloth Inliers appear to be similar to the Dumbano Granite (Paine et al., 1965) in HUGHENDEN and CLARKE RIVER. They also appear to have affinities with both the Lolworth Complex and the Ravenswood Granodiorite in HUGHENDEN. All these granitic bodies are Lower Palaeozoic. In southern GILBERTON no attempt has been made to subdivide the granitic rocks. They are included with the Dumbano Granite on broad lithologic grounds. The Dumbano Granite to the north has been dated as Upper Silurian - Lower Devonian (Richards et al., 1966 a, b).

Woolgar River Inlier

The metamorphics of the Woolgar River Inlier were included by White (1965) with the Einasleigh Metamorphics, which he regarded as Archaean. The rocks include quartzite, quartz-muscovite-garnet-schist, quartz-muscovite-biotite-garnet-schist and gneiss, quartz-feldspar-biotite-epidote-gneiss. The foliation strikes about 90° and the dips are generally greater than 70°. Amphibolite dykes are common and there are abundant large pegmatite dykes, some garnetiferous. There are also some small pods of biotite-granite. Large rhyolite dykes intruding the inlier may be Permian; they are not shown on the map.

In thin section the garnets in the schists are commonly replaced by chlorite along cracks. In one schist large porphyroblasts of orthoclase and muscovite are largely broken down and replaced by sericite. Some of the gneisses have sericitic shear zones.

The gold of the Woolgar Goldfield is generally associated with shears along the margins of pegmatite and amphibolite dykes.

In the gorge of Ten Mile Creek, at lat. 19°63'S, long. 143°28'E, there are about 60 m of unmetamorphosed sediments unconformably overlying the metamorphics and unconformable beneath the Jurassic Eulo Queen Group. The sediments dip at 20° east and consist of purple and green very poorly sorted micaceous feldspathic conglomerate and sandstone. The lower beds contain blocks of gneiss up to 0.7 m across. These sediments are more like the rocks of the Upper Devonian - Lower Carboniferous Bundock Creek and Gilberton Formations than any others, and are tentatively assigned to the Bundock Creek Formation.

CLARKE RIVER

In southern CLARKE RIVER metamorphics occur as roof pendants within the Upper Silurian - Lower Devonian Dumbano Granite. These include quartz-feldspar-biotite-schist, quartz-muscovite-biotite-garnet-schist, quartz-andalusite-muscovite-biotite-schist, epidote-actinolite-schist, and amphibolite. Pegmatites and quartz veins are abundant.

South of Gregory Springs Homestead there are some low grade metamorphics. Sericite-filled shears traverse the rocks which have a fine-grained groundmass of quartz and mica and, in places, of quartz, feldspar and mica. The quartz grains are strained. These rocks appear to be sheared sediments (Quartzose and arkosic) and are of a lower grade than the rest of the metamorphics.

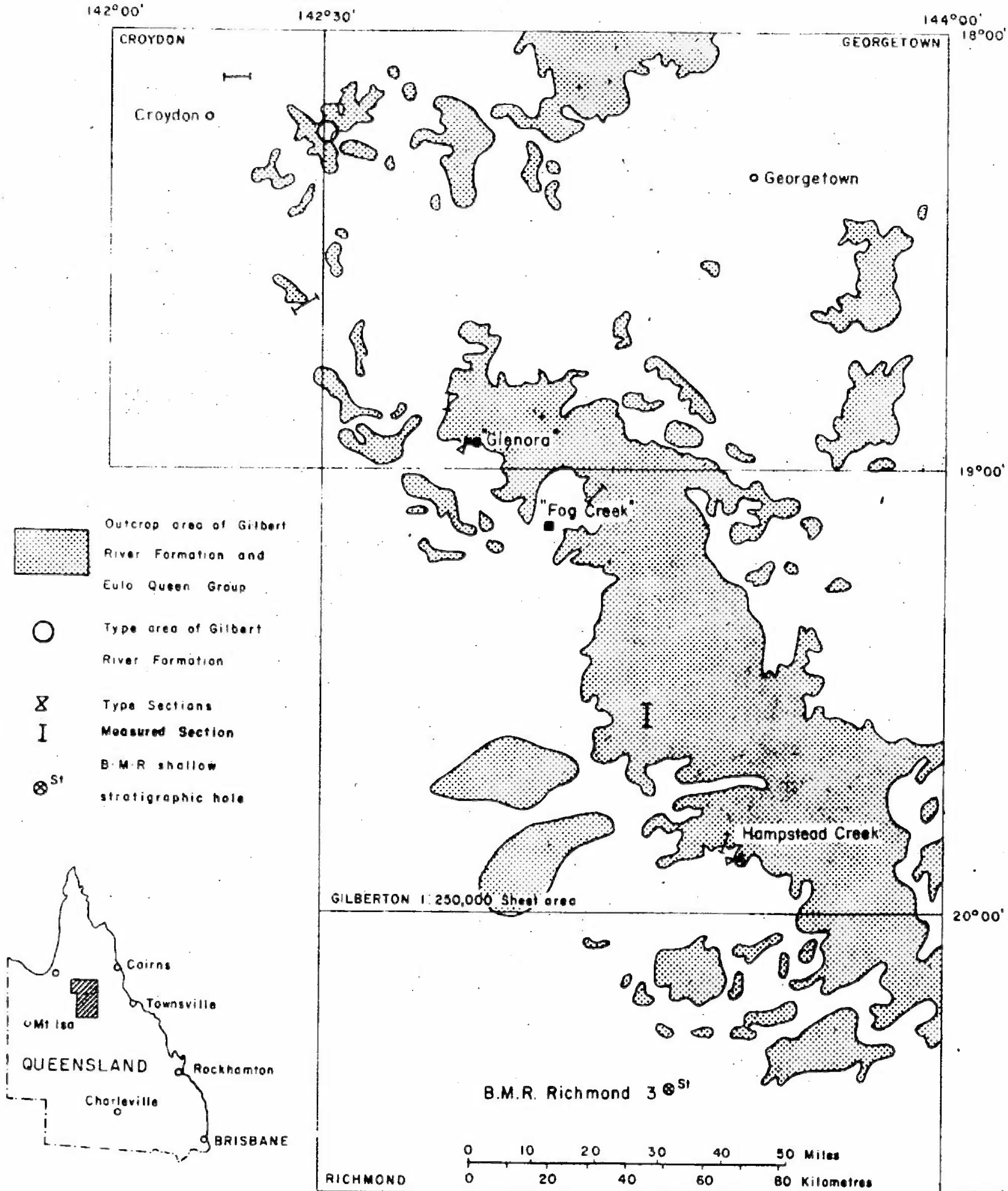
<u>TABLE 4</u>

History of Nomenclature, Jurassic-Cretaceous quartzose sandstone units, southern Carpentaria Basin

CROYDON-GEORGETOWN Laing & Power (1959)	GEORGETOWN-GILBERTON Reynolds (1960)	RICHMOND (outcrop) Vine (1970)	GEORGETOWN-GILBERTON Smart et al., (1971)		RICHMOND (subsurface Vine (1966) Tentative wireline log identifications
Gilbert River Formation (Lower Cretaceous)	Gilbert	Gilbert River Formation (Lower Cretaceous)	Gilbert River Formation	Coffin Hill Member (Lower Cretaceous)	Hooray Sandstone
		regional unconformity		Yapper Member (Upper Jurassic? to Lower Cretaceous)	
- - - - - - - - - - - - -	River	Unit B (Jurassic)	Eulo Queen Group	Loth Formation (Middle? to Upper Jurassic)	Westbourne Formation
	Formation (Lower Cretaceous)	Unit A (Jurassic)		Hampstead Sandstone (Jurassic)	Adori Sandstone Birkhead Formation

Fig. 5

MESOZOIC QUARTZOSE SANDSTONE OUTCROPS



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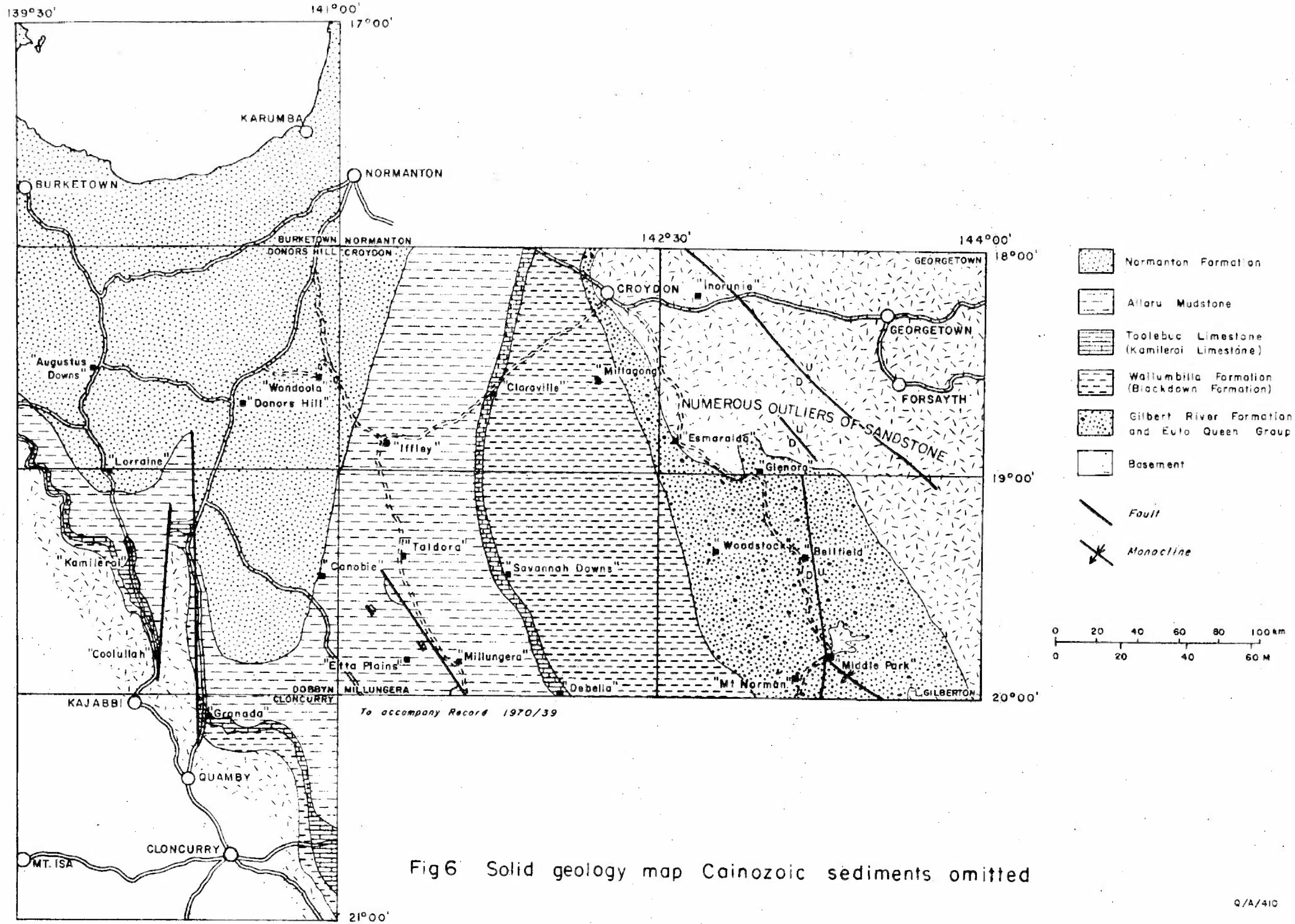


Fig 6 Solid geology map Cainozoic sediments omitted

Metamorphism, and age of the metamorphics in southern GILBERTON and CLARKE RIVER

The metamorphism in these areas is mainly in the almandine amphibolite facies and upper greenschist facies. Retrogression of almandine amphibolite facies to upper greenschist facies appears to have occurred. This is possibly related to dynamo-thermal metamorphism associated with emplacement of the Upper Silurian - Lower Devonian Dumbano Granite. This possibly also produced the low grade metamorphics (lower greenschist facies) in CLARKE RIVER. Paine et al. (1965) recorded rocks of low grade (metamorphosed feldspathic greywacke) within the higher grade metamorphics of the Cape River Beds in HUGHENDEN, and suggested that there is a weakly metamorphosed sequence infolded with the Cape River Beds. Paine et al. (Ibid.) regarded the Cape River Beds as early Palaeozoic. It is quite possible, however, that the higher grade metamorphics in southern GILBERTON (and also possibly those in CLARKE RIVER and HUGHENDEN) are Precambrian. As they are similar to the Einasleigh Metamorphics, which also exhibit retrograde metamorphism, the metamorphics in southern GILBERTON have been included with these. However, the Archaean age attributed to these rocks by White (1965) is unnecessarily old.

JURASSIC AND CRETACEOUS QUARTZOSE SANDSTONE UNITS

The sandstone sequence cropping out in the east of the Eromanga and Carpentaria Basins was first formally defined as Gilbert River Formation in the Croydon - Georgetown area by Laing & Power (1959). Use of the term was extended by Reynolds (1960) to cover the sandstone of the Gregory Range to the south. The nomenclature of the sandstone in the outcrop area has been revised by Smart et al. (1971), and is summarised in table 4.

1: Outcrop Areas

The sandstones of the Gilbert River Formation and the Eulo Queen Group (Tables 3, 4) form the dissected plateau of the Gregory Range, including the Gilberton Plateau, and numerous mesas to the north and northwest of it, in GILBERTON, GEORGETOWN and CROYDON (Fig. 5). Five units have been recognised and formally defined (Tables 3 & 4; Smart et al., 1971). Some measured sections and proposed correlations are shown in Plate 7.

(a) Hampstead Sandstone (Jh). The Hampstead Sandstone is very extensive in the southern Gregory Range and in outliers on the Precambrian and Palaeozoic basement further east. In the northern Gregory Range it is absent, apparently due to onlap (Plate 7).

The name is derived from Hampstead Homestead, 45 km east of Mt Norman Homestead, and the type section is at Hampstead Creek (Fig. 8, Plate 7).

In the vicinity of the type section the formation is 30-45 m thick, and remains of that order throughout the area (Plate 7). The unit unconformably overlies an irregular basement surface of Precambrian and Palaeozoic rocks; a basal conglomerate is usually present. There is relief on the basement of up to 60 m. The Hampstead Sandstone is the older part of the Eulo Queen Group.

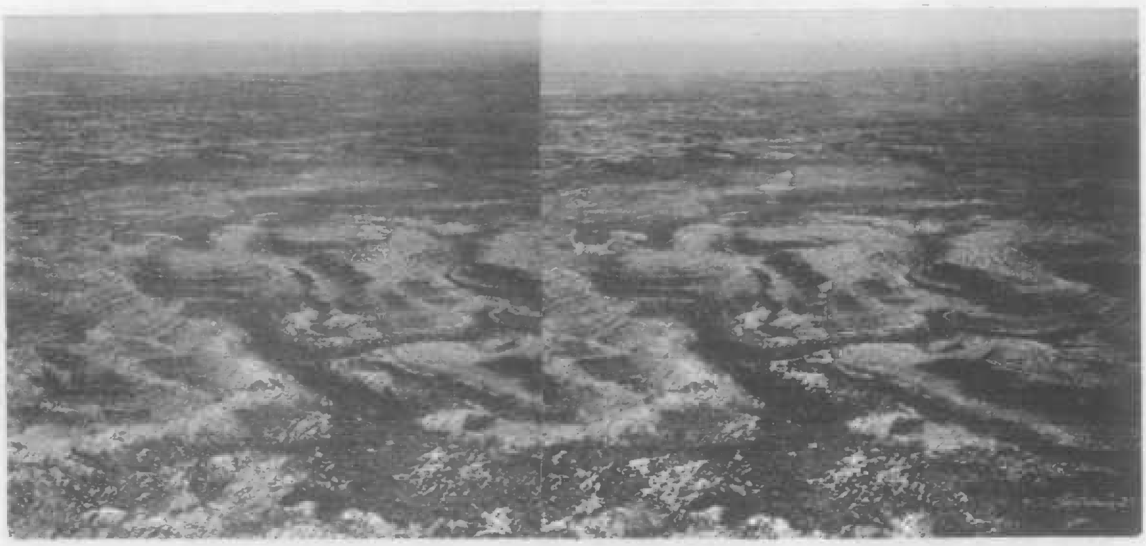


Fig. 7 -Stereo pair, Wallumbilla (Blackdown) Formation caps hills behind Glenora Homestead, GEORGETOWN, and overlies Gilbert River Formation members, beneath which the Eulo Queen Group rests on ?Precambrian in the main gorge. Type section for members is nearby.

(Negs. 2486, 2487)

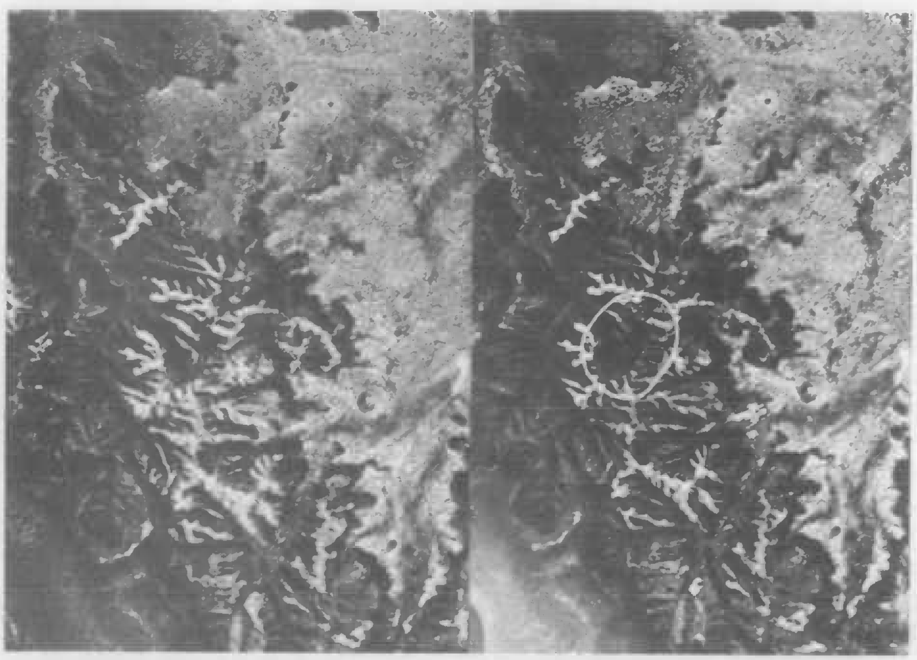


Fig. 8 -Stereo pair, Hampstead Creek. Type section for Loth and Hampstead Formations marked. (GILBERTON air photos, RC9, Run 8).

Fig. 9 -Large scale cross-bedding in the Hampstead Sandstone, north of Ortona, GILBERTON.
(Neg. 2916)

Fig. 10 -Pebble bands and minor channeling in the Hampstead Sandstone, north of Ortona, GILBERTON.
(Neg. 2918)

The formation consists of coarse and medium-grained sandstone, with conglomerate, and minor fine-grained sandstone and siltstone. The sandstone is grey to brown, rarely white, and is generally coarse to very coarse-grained, quartzose, with a varied, but generally low, clay content. Some feldspar fragments are present. It is commonly pebbly (Fig. 10) and some polymict conglomerate bands are present, with clasts of quartzite, rhyolite and metamorphics. The fine-grained sandstone and siltstone are also grey to brown, clayey and quartzose.

The sequence is characteristically cross-bedded, with large scale planar and trough cross beds up to 2 m in the coarser units, and mostly 45-60 cm in the finer units (Fig. 9). Some of the fine-grained sandstones and siltstones show ripple marks or ripple drift bedding. Cross bed directions are varied; easterly is the most common. Channelling is locally present, but channels larger than about 6 m wide have not been observed, possibly due to their large scale.

A strong joint system (ENE - WSW) is developed in this unit. This was considered by Reynolds (1960) to be a reflection of basement structure. Joints are best developed close to faults and at the eastern end of the Euroka Arch; in many places they seem to result from Pliocene tectonics.

The conditions of deposition were probably fluviatile, as evidenced by cross bedding and other structures. The distribution of conglomerate beds suggests deposition from a river system draining adjacent high areas. All large clasts are of rock types common in the surrounding basement, but the generally sandy character of the unit led Reynolds (1960, p. 7) to suggest derivation from pre-existing sandstones, possibly the Inoruni Sandstone. Clasts in the conglomeratic portion are fairly well rounded, and the sandstones contain some subrounded grains, but any conclusions as to source must await more detailed work.

(b) Loth Formation (Jul). The Loth Formation is widespread in the southern Gilberton Plateau, decreasing in thickness and extent northwards (Plate 7). The name is derived from Loth Creek, 129 km NW of Hughenden, but the type section is at Hampstead Creek (Figs 7 & 8, Plate 7).

In the type section, the formation is 90 m thick but thins northwards to 30 m at Glenora (Fig. 5, Plate 7). The formation overlies the Hampstead Sandstone without apparent discontinuity. There is a distinct topographic bench between them. The Loth Formation is the younger part of the Eulo Queen Group.

Two lithological groupings are present:

The middle unit (30 m thick in type section, 10 m thick east of Fog Creek) consists of ferruginized and micaceous siltstone and fine-grained sandstone, and cross bedded, fine-grained clayey quartzose sandstone, with minor coarse pebbly sandstone in thin bands. Locally, fossil wood fragments and ?worm tubes are present.

The upper and lower units (each 30 m thick in type locality and 24 m thick east of Fog Creek) consist of sandstone, siltstone (with fine-grained sandstone), and mudstone. The sandstone is white or grey, medium to coarse-grained, quartzose and clayey, with rare feldspar grains, and is commonly cross-bedded. A few pebble bands are present.

The siltstone and fine-grained sandstone are white, grey, or rarely purple, quartzose, clayey, partly micaceous, commonly ripple drift bedded, and usually form thick units of massive appearance. The mudstone is white and porcellaneous, with a varied silt content, usually having a blocky fracture, but rarely fissile.

Conditions of deposition for the formation appear to be fluviatile, but there is a much greater proportion of fine material than in the Hampstead Sandstone. The clay content of the sandstones, much of which is degraded feldspar, suggests a different source rock from the Hampstead Sandstone, although not necessarily a different source area; Reynolds (1960) suggests that the younger sandstones in the Gregory Range were derived from Palaeozoic igneous and metamorphic rocks, exposed after erosion of the Inoruni Sandstone (which provided detritus for the pre-Loth Hampstead Sandstone). Current directions indicated by cross beds and other structures are variable and no conclusions regarding transport direction can be made.

The Hampstead Sandstone and the Loth Formation have been grouped together as the Eulo Queen Group (Jue), as they are distinct from the overlying Gilbert River Formation (Smart et al., 1971). The latter has a conglomeratic base, in sharp contrast to the Loth Formation, and transgresses widely on basement, thus representing an important change in palaeogeography.

(c) Gilbert River Formation (JKg). In the northern part of the Gregory Range the Gilbert River Formation consists of two members:

(i) Yappar Member (Juy). The Yappar Member occurs in mesas, buttes and plateaux areas in the northern Gregory Range, but is much more extensive in the southern Gregory Range where it probably makes up the greater part of the Gilbert River Formation shown on the 2nd edition of the 1:250,000 geological map GILBERTON. The name is derived from the Yappar River south of the type section and area near Glenora Homestead in the northern part of the Range.

In the type area, the member is just over 15 m thick and this order of thickness continues to the north. In the south of the Gregory Range, there is about 30 m of rock above the Loth Formation, the top layers of which are altered by a deep weathering zone up to 15 m thick. The Yappar Member is present, but the presence or absence of the Coffin Hill Member above it cannot be ascertained; it could be present in either the unweathered sequence and/or in the deep weathering zone. However, the two criteria for distinguishing between the members in the north - the topographic bench between them, and the marine pelecypods of the Coffin Hill Member - are absent in the south.

The Yappar Member overlies the Loth Formation without apparent discontinuity, but with a prominent 'topographic' bench. Near Croydon the Yappar Member is the lowest Mesozoic unit and overlies Precambrian basement rocks (Plate 7).

The lower portion of the member is coarse to medium-grained quartzose sandstone with a clayey matrix, and a varying degree of ferruginisation. The sandstone is commonly pebbly, and some conglomerate bands are present with clasts of rhyolite, quartzite, and some schist and slate.

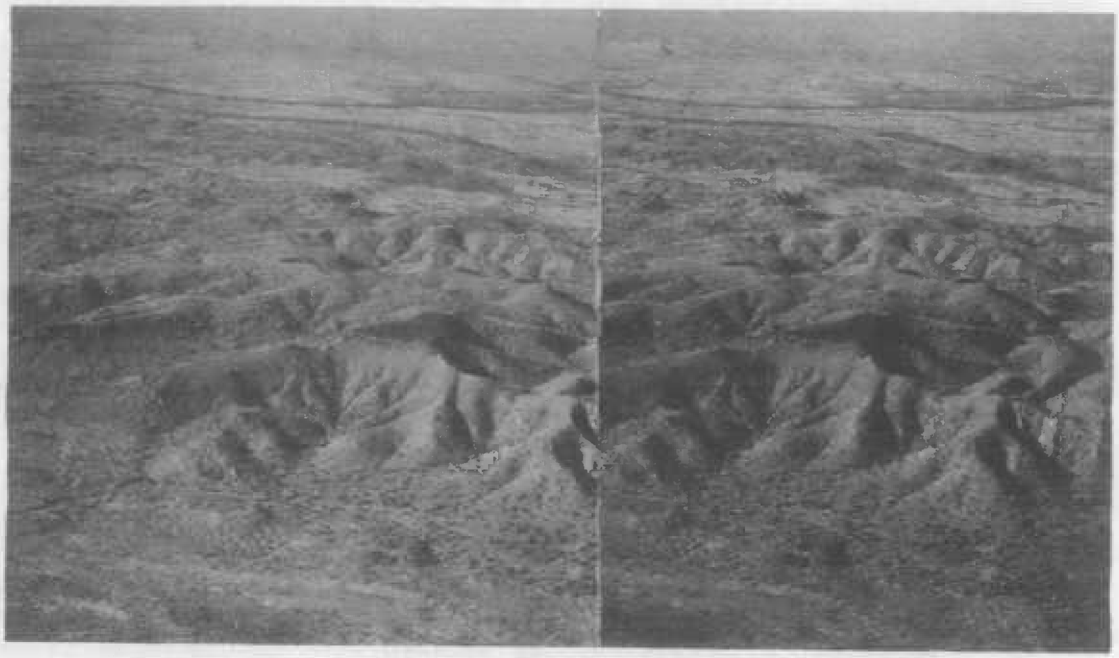


Fig. 11 -Stereo pair south of Roxmere, CLONCURRY, showing capping of Mesozoic sandstone resting on Precambrian.
(Negs. 2912, 2913)

Fig. 12 -Capping of Mesozoic sandstone on Precambrian. Flat Top Mountain, CLONCURRY.
(Neg. 2488)

The upper part is medium to fine-grained quartzose, clayey sandstone and minor siltstone in thin irregular beds, with a few ripple-marks and worm tubes.

The lowest part of the member is lithologically and probably also environmentally similar to the Hampstead Formation. Plant fossils from a mesa in the headwaters of the Near Carron River, CROYDON, give a Jurassic, or possibly Lower Cretaceous age (White, 1972). The abrupt change from the finer grained Loth Formation could indicate uplift in the source areas, the emergence of a new source, or a climatic change. Subsequently, there was a fairly rapid transgression and the upper portion, with worm tubes, is probably estuarine or even shallow marine.

No data are available for interpreting transport direction.

(ii) Coffin Hill Member (Klf). The Coffin Hill Member is a mappable unit only in the area from Glenora (Fig. 5) northwards, but may be present in the south (see remarks on Yappar Member).

The name is derived from Coffin Hill Creek, 20 miles NW of Esmeralda Homestead, while the type locality, the same as that of the Yappar Member, is near Glenora Homestead.

At the Type Section locality, the member is 12 m thick, and appears to thicken slightly towards Croydon (Plate 7). The unit overlies the Yappar Member without apparent discontinuity; there is a narrow topographic bench between them. In many places it is overlain conformably by Wallumbilla Formation clayey sandstone.

Lithologically, the member is a sequence of medium to fine-grained, clayey, quartzose sandstones and siltstones, in thin, irregular beds. Worm tubes are common in the upper part and pelecypods occur in the middle portion. The fossils are of Lower Aptian Age (Laing & Power, 1959; and see Appendices 1 & 2, and CR localities in Table 5).

Sedimentary structures are few and no evidence of transport direction has been obtained.

The depositional conditions appear similar to those of the uppermost Yappar Member, with an increasing marine influence. A shallow marine - estuarine environment seems likely. The overlying Wallumbilla Formation ('Blackdown Formation') represents wholly marine conditions, as it contains glauconitic sandstones (in boreholes: e.g. AAO 8 (Karumba); see Laing, 1960).

The ages of the Gilbert River Formation and Eulo Queen Group cannot be accurately established from the outcrop areas on present evidence. The fossiliferous Coffin Hill member provides a convenient, but possibly diachronous bed for correlation. The formations of the Gregory Range are correlated with surface and subsurface units of the Eromanga Basin in Table 4 and by Smart et al. (1971). Burger (in press) for the Eromanga Basin units, gives ages which may be tentatively extrapolated north (and see Grimes & Smart, 1970).

TABLE 5

Fossils from the Southern Carpentaria Basin

determined by S.K. Skwarko - see Appendices 1 & 2

	APTIAN							Undiff. APT-ALB			ALBIAN											
CR Croydon; CL Cloncurry; Gi Gilberton; M Millungera	CR 105	CR 108	CR 109, 700, 701, 702	CR 113	CR 114	CR 703	CR 704	Gi 13	Gi 17	M 1	CL 5	CL 55	CL 73 73A	M 96	M 10	M 116	M 120	M 124	M 127	M 129	M 130	M 131
"Phaenodesmia" elongata			X																			
? Eyrena linguloides			X																			
Inoceramus etheridgei										X												
Inoceramus sp.indet											X	X	X	X	X	X		X		X	X	
Maccoyella barklyi var, mariaeburiensis							X															
Maccoyella cf. reflecta	X			X																		
Maccoyella aff. reflecta		X																				
Maccoyella aff. subangularis			X																			
Maccoyella sp.indet aff. barklyi						X																
Maccoyella sp. nov.					X																	
Maccoyella sp.			X	X																		
Entolium sp. nov?			X																			
Entolium sp.							X															
Camptonectes sp. nov.?								X														
Aucellina hughendenensis											X		X	X			X	X				
Nototrigenia cinctuta		X																				
Austrotrigonia prima			X																			
Trigonia sp.indet.						X																
? Tancretella plana		X																				
Onestia sp. nov.				X																		
Thracia wilsoni			X																			
? Thracia primula		X																				
Yoldia sp.			X																			
Grammatodon (Indogrammatoden) robusta			X																			
Ostraidae indet.							X															
Vulsells ? sp. nov.							X															
Mytilus ? sp.							X															
Bivalves indet.		X	X	X		X	X															
? Labeceras (L.) laqueum													X									

TABLE 5 (Cont'd)

Fossils from the Southern Carpentaria Basin

determined by S.K. Skwarko - see Appendices 1 & 2

	APTIAN							Undiff. APT-ALB			ALBIAN											
CR Croydon; CL Cloncurry; Gi Gilberton; M Millungera	CR 105	CR 108	CR 109, 700, 701, 702	CR 113	CR 114	CR 703	CR 704	Gi 13	Gi 17	M 1	CL 5	CL 55	CL 73, 73A	M 96	M 10	M 116	M 120	M 124	M 127	M 129	M 130	M 131
Siphonaria stanwelli							X															
Natica variabilis		X					X															
Peratobelus cf. australis					X																	
Belemnites indet.																X						
"Rhynconella" croydonensis					X		X															
Rhizocorallium Sp.								X														
Fish bones, scales											X	X			X				X			X

Table 6 Approximate ages of quartzose sandstone units

Formation	Age	Environment from Fossils
Coffin Hill Member	Lower Aptian	marine
Yappar Member	U. Jur. - L. Cret.	continental; top marine?
Loth Formation	U. Jur.	continental
Hampstead Sandstone	M. - U. Jur.	continental

In the west of the Carpentaria Basin the Gilbert River Formation is overlapped by the succeeding formations and does not crop out. However, on the Precambrian basement areas of the Mt Isa Block mesas of sandstone and conglomerate occur in which Jurassic plants have been found (Carter et al., 1961). These deposits could represent lateral equivalents of any of the younger quartzose sandstone units of the eastern Carpentaria Basin and northern Eromanga Basin.

2: Subsurface

A sandstone sequence underlies the Wallumbilla Formation ('Blackdown Formation') throughout the Carpentaria Basin, except in the west where the Wallumbilla Formation overlaps the sandstones and rests on basement.

The first petroleum exploration well in the area AAO 8 (Karumba) penetrated 25 m of quartzose sandstone, with siltstone and shale containing marine macrofossils, resting on basement, and overlain by lithic glauconitic sandstone and shale. The sequence was correlated with the Wrotham Park Sandstone by Laing (1960). The Wrotham Park Sandstone was considered equivalent to the Gilbert River Formation by Laing & Power (1960), Reynolds (1960) and Smart et al. (in press), and the term is not used by us.

Burketown No. 1 (Perryman, 1964) encountered a sandstone and shale sequence over 180 m thick. The top 36 m was described as coarse quartzose sandstone, often pebbly or conglomeratic, with grey shaley interbeds. All of the sandstone sequence and the 137 m of underlying shale were referred to the Jurassic Blythesdale Formation of the Surat Basin. Exon & Vine (1970) recommended that the term Blythesdale be dropped; the top part in Burketown No. 1 is called Gilbert River Formation by Ingram (in press, a).

The present study of the pre-Wallumbilla Formation sandstone sequence in the subsurface is dependent on wire line logs of water bores and petroleum exploration wells, with lithological control better in the latter than the former. BMR Richmond 3 (Grimes & Smart, 1970) gave good lithological results. Gamma ray logs of water bores made under contract for the Bureau of Mineral Resources have been most valuable in this respect.

Examination of gamma ray and electrical logs shows the sandy lower portion of the Wallumbilla Formation to be underlain by a sandy unit up to 61 m thick but generally less than 45 m. Where this unit does not rest on basement it is underlain by a more argillaceous sequence.

A selection of gamma ray logs of water bores and resistivity logs of oil wells is shown in Plate 9. This figure suggests fairly constant lithologies. A correlation across the basin on gamma ray logs of water bores is shown in Plate 8.

The sandy unit below the Wallumbilla Formation can be traced all over the basin on the evidence of wire line logs (Plates 8, 9) and is considered to be the Gilbert River Formation; the unit underlying this is then equivalent to the Eulo Queen Group.

The Gilbert River Formation is present throughout the basin except in a few places where the Wallumbilla Formation rests on basement, as along the western margin and over certain basement highs, e.g. at Kamileroi Station (DOBBYN) where the Wallumbilla Formation rests on schist, on parts of the Boomarra Horst, and west of Croydon (Midwood Normanton Scouts 1 & 2: see Table 7).

Structural contours on the top of the Gilbert River Formation are shown in Figure 40.

Over most structural highs—e.g. Boomarra Horst, Croydon-Smithburne High, Claraville Shelf, Fort Bowen Ridge (Fig. 42) the Gilbert River Formation (equivalent) rests on basement. In the hollows between the basement highs the Gilbert River Formation is underlain by a variable thickness of sediments. Some bores show 30 m or less of sediment (e.g. R. 3028 on Plate 9), while others have a few hundred metres - e.g. Burketown No. 1, Plate 9, R. 1945, Plate 8.

On wireline logs, the rocks underlying the Gilbert River Formation can be subdivided as shown on Plate 9, into an upper argillaceous unit and a lower sandy unit; these may correlate with the Loth Formation and Hampstead Sandstone. In some bores, the latter is underlain by a varied sequence of sandy and argillaceous rocks, which may correlate with the Jurassic sandstone units of the Eromanga Basin (Table 4).

In many bores in the southwest of GILBERTON, thin coal seams are reported from levels within the Eulo Queen Group equivalents, apparently within the Hampstead Sandstone. Coal is also reported from many bores on Richmond and Hughenden Sheets. Equivalent beds to the north and west do not contain coal, suggesting that the coal is restricted to the SE part of the area, where formations are continuous with those of the Eromanga Basin.

Possible correlations of the subsurface units with outcrop areas and with the subsurface units of the Eromanga Basin are shown in Plate 10.

Burketown No. 1 and some water bores penetrate a sequence below the suggested equivalent of the Eulo Queen Group (Plate 9). In Burketown No. 1, sandstone, siltstone and mudstone overlie a shaley sequence which becomes conglomeratic downwards. The conglomerate is coarse, with a clay matrix and was described as a mud flow by Perryman (1964). Myers (1969) considered the sequence to be of probable glacial origin. The nearest outcropping Permian glacigene deposits occur in HUGHENDEN (Vine et al., 1964).

3: Palaeography and Sedimentation

Whitehouse (1954) considered the pre-Cretaceous units west of the Gregory Range to have been deposited in a northern extension of the Eromanga Basin, limited to the west by a fault scarp, and in essence this is correct.

Table 7

LOGS OF MIDWOOD NORMANTON SCOUTS 1 & 2

Location 17°39' south, 141°32' east.
Hole No. 2 is 15 feet west of hole No. 1.

Combined log of the two holes
Drillers log to 864'; core description by K.G. Grimes below that depth.

0' - 20'	Surface alluvium and loose sand.
20' - 130'	Siltstone and loose sand; sand fine grained, subrounded to angular, little cement. Lost circulation at 115'.
130' - 160'	Hard shale, with minor sand.
160' - 165'	Loose fine grained sand.
165' - 304'	Loose fine grained sand, and siltstone with minor shale.
304' - 390'	Loose sand and siltstone.
390' - 424'	Mainly mudstone and shale, minor siltstone.
424' - 542'	Grey blue calcareous mudstone, traces of calcite and pyrite.
542' - 552'	Blue grey mudstone.
552' - 573'	Blue grey calcareous mudstone.
573' - 602'	Blue grey mudstone.
602' - 725'	Blue grey micaceous mudstone, minor bands of siltstone.
725' - 798'	Blue grey calcareous mudstone.
798' - 825'	Blue grey mudstone, calcareous in part, some minor pyrite, small beds of siltstone.
825' - 864'	Blue grey mudstone, with some patchey beds of siltstone.
864' - 916'	Grey claystone with bands of micaceous siltstone, interbedded with pale green-grey, slightly micaceous, glauconitic, ?sublabile, very fine sandstone. Flat bedded. The sandstone contains slivers of mudstone. There is a thin (2-4 mm) vertical sedimentary dyke of v.f. sandstone in claystone at 888'.
916' - 1523'	Quartzite. Light grey, medium to coarse grained; bedding when visible is graded and beds are 3-4 cm thick, with a consistent 45° dip throughout the section. The grains are dominantly quartz or quartzite, with some finer grains of a dull red mineral, and some pale green ?lithic grains. High angle (70°) fractures with a few thin (2 in) breccia zones. The lithology is consistent throughout the 500' of section.

Interpretation (K.G.G.)

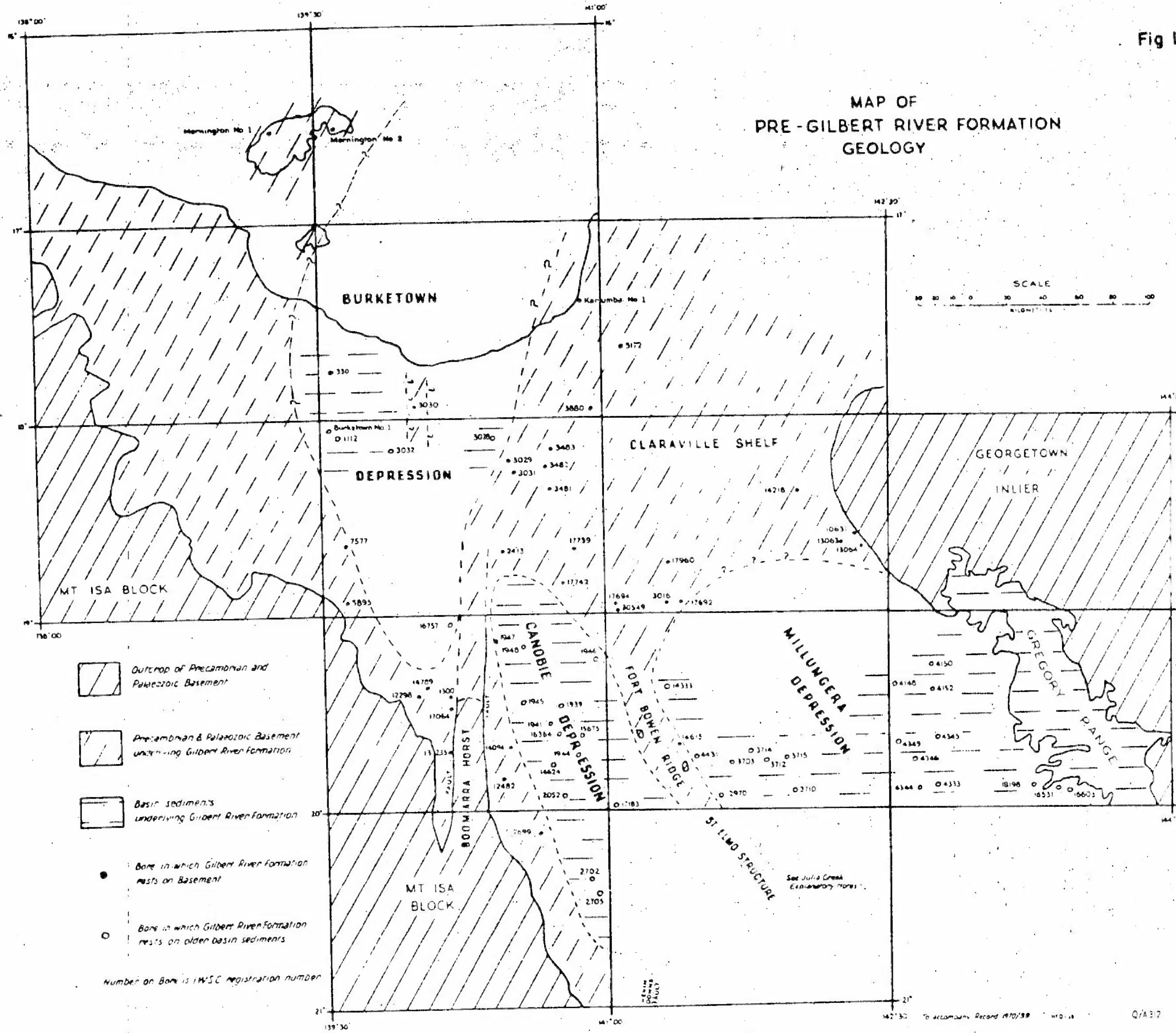
0' - 20'	Surface alluvial deposits.
20' - 390'	Wyaaba Beds.
390' - 916'	Wallumbilla (Blackdown) Formation*.
916' - T.D.	Basement.

The Gilbert River and the Eulo Queen sandstones are absent and the Wallumbilla (Blackdown) Formation is lying directly on the quartzite basement.

* The Toolebuc Limestone should be present at about 425' (Simpson, in press).

Fig 13

MAP OF
PRE-GILBERT RIVER FORMATION
GEOLOGY



Water bore data suggest three pre-Cretaceous hollows in the area (Fig. 13). The Millungera and Canobie Depressions represent northward extensions of the Eromanga Basin. The Burketown Depression is separated from these by the Boomarra Horst, which may have formed the drainage divide between northward and southward flowing river systems.

Although the sequence in the Burketown Depression is separated from those in the Canobie and Millungera Depressions, the sediments are very similar in character and appear to be approximate time equivalents, deposited in similar sedimentary environments.

The formations of the Eulo Queen Group and equivalents were probably deposited in a fluviatile environment. These sediments might have been deposited over the whole area, and subsequently eroded off the ridges following uplift immediately before the Gilbert River Formation was deposited, or merely have filled up the hollows. However, although in outcrop the conglomerates and sandstones of the lower part of the Gilbert River Formation are in marked contrast to the underlying Loth Formation, they are thin and do not seem indicative of a major change in conditions, at least in the areas where the Eulo Queen Group was deposited; there is no evidence in the area for a regional unconformity between the Loth and Gilbert River Formations.

The Gilbert River Formation blankets both rocks in the Depressions and the ridges between them, and indicates a sharp change in conditions traceable throughout the Carpentaria Basin and the northern Eromanga Basin. The upper portion of the formation (Coffin Hill Member) represents the first appearance in the area of the Cretaceous Sea. It is suggested that much of the Gilbert River Formation represents fluvial sands and gravels, at first deposited in relation to, and later reworked by, a fairly rapidly advancing sea. This would explain the widespread occurrence of the unit and its uniform lithology.

Wallumbilla Formation (Blackdown Formation) (Klu)

The Blackdown Formation was defined by Laing & Power (1959), from the Wrotham Park area in southern Cape York Peninsula. It was described (ibid, p. 36) as black, silty or sandy shale, with discoidal concretions up to 3 feet in diameter, and said to overlie the Wrotham Park Sandstone conformably. In the completion report of AAO 8 (Karumba) (Laing, 1960) the rocks between the Wrotham Park Sandstone and the Kamileroi Limestone were called Blackdown Formation.

The Blackdown Formation has generally been considered equivalent to Whitehouse's (1954) Roma Formation (Reynolds, 1960; Day, 1964; White, 1965). Vine (1964) compared the Blackdown Formation with the lower portion of the Wilgunya Formation, and later the name Wallumbilla Formation was re-introduced for this portion (Vine et al., 1967). The term Wallumbilla Formation is now used in Carpentaria Basin (Smart et al., in press), although Blackdown Formation appears (as Klb) on the Preliminary maps with this Report. The Wallumbilla Formation is the oldest unit of the Rolling Downs Group, a form used in both the Eromanga and Carpentaria Basins.

Distribution The Wallumbilla Formation is present throughout the Carpentaria Basin, although it crops out in few places. Its probable distribution is shown on Figure 6. It crops out only along the basin margins and in structurally high areas, such as near Kamileroi Homestead and the Boomarra Horst.

Lithology. Surface exposure of the Wallumbilla Formation is poor and fresh material is rarely seen. However, sub-surface data is available from water bores, petroleum exploration wells and BMR shallow stratigraphic holes (Grimes & Smart, 1970; Needham et al., 1971).

The formation consists of dark grey laminated mudstone, with a blocky fracture, and is generally silty, and locally quite clayey. Pyrite is commonly present. In the lowest portion there are numerous thin bands of sandy shale and glauconitic labile sandstone, up to a few metres thick. Water bores often produce subartesian supplies from this level.

Bands of fossiliferous, grey impure limestone showing cone-in-cone structure are common and vary from a few mm to 1.5 m thick. These provide zones of harder drilling than the mudstones and are often noted on drillers' logs. Associated with the limestone bands are discoidal concretions up to 1 m in diameter, some of which show septarian structure. Petrographic studies of some concretions from the Wrotham Park area by Houston (in Woods, 1961) show that they vary from argillaceous limestones to highly calcareous labile sandstone, but all contain glauconite. The limestone bands do not appear to be concentrated in any particular part of the formation.

The mudstone weathers olive-green and buff-yellow and the limestone is bleached grey-white. Blocks of weathered cone-in-cone limestone are generally the only surface expression of the unit. When wet, the mudstone swells considerably owing to its montmorillonite content and is often slow to drill for this reason.

The formation is generally about 180 m thick, varying from 120 m on the western margin of the basin, to 210 m in the centre.

Palaeontology. The formation is fossiliferous throughout and the fauna includes belemmites, ammonites, pelecypods and a variety of foraminifera. Species mentioned by Laing & Power (1959) gave a Lower Aptian age. Woods (1961) carried out more detailed palaeontological studies in the type area of the Blackdown Formation. He made no definite zonal subdivisions, but considered the formation to be equivalent to the lower part of the 'Roma Formation' (now Wallumbilla Formation) and to be of Aptian age.

Cores from BMR stratigraphic drilling yielded only one determinable macrofossil of no value for dating (Appendix 3).

Origin. A marine unit, deposited in a low energy environment, probably in shallow water. The lability of the unit and occurrence of limestone could point to aridity, and to an igneous provenance which would have been available in basement outcrops. Scheibnerova (1970) suggests a high palaeolatitude for this area in the Cretaceous.

Subsurface Identification. In drillers' logs, the Wallumbilla Formation cannot normally be separated from the Allaru Mudstone as the intervening Toolebuc (Kamileroi) Limestone is rarely distinguished in these logs. The top of the underlying Gilbert River Formation can usually be inferred from the presence of water, but local aquifers in the lowermost Wallumbilla Formation may confuse this slightly. Gamma-ray and resistivity logs generally give an accurate indication of the bottom of the unit, and of the Toolebuc Limestone immediately above it (Plates 8, 9). Resistivity logs also show small peaks within the Wallumbilla Formation which appears to correspond to limestone bands, and to the sandstone bands of the lower portion. The formation is difficult to distinguish on spontaneous potential logs. All five BMR shallow stratigraphic holes drilled in the southern Carpentaria Basin in 1969 penetrated the Wallumbilla Formation (Grimes & Smart, 1970).

Toolebuc (Kamileroi) Limestone Klo (Klk)

The Kamileroi Limestone was defined by Laing & Power (1959) from a type locality at Kamileroi Homestead in DOBBYN. It was described as fine, grey to pink limestone, with abundant fossil remains, and the thickness was given as 6 m on the evidence of the driller's log of Bore Reg. No. 12298. A band of white, crystalline limestone in AAO 8 (Karumba) bore was tentatively correlated with this formation, but later work interpreted the Kamileroi horizon at a different depth (Reynolds, 1960; Laing, 1960; Myers, 1969).

Stratigraphic Relations. In the Eromanga Basin the Toolebuc Limestone occupies a similar stratigraphic position between the Wallumbilla Formation and Allaru Mudstone (Vine et al., 1967) as does the Kamileroi Limestone in the Carpentaria Basin. The Toolebuc Limestone is very similar to the Kamileroi Limestone and subsurface information indicates that the two make up a continuous rock body. Smart (1972) argues for the replacement of the term Kamileroi Limestone by Toolebuc Limestone. The latter is now used in the Carpentaria Basin although it appears as Kamileroi Limestone (Klk) on some Preliminary maps. It is the second oldest unit of the Rolling Downs Group.

Distribution. The distribution of the Toolebuc Limestone is shown in Figures 6, 41.

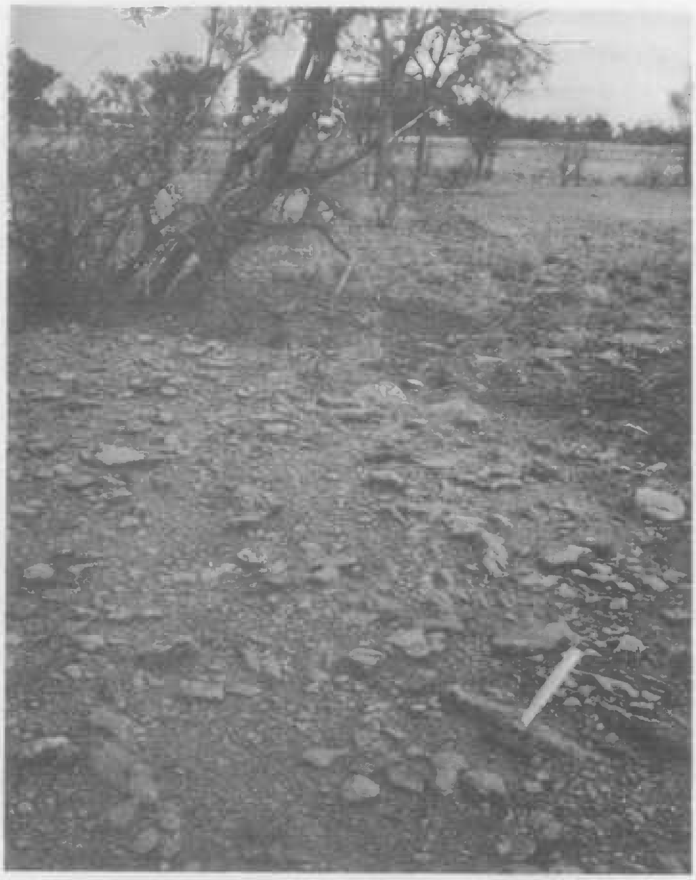


Fig. 14 -Characteristic outcrop of platey limestone fragments of Toolebuc Limestone, Courtenay Creek, CLONCURRY.
(Neg. 2911)

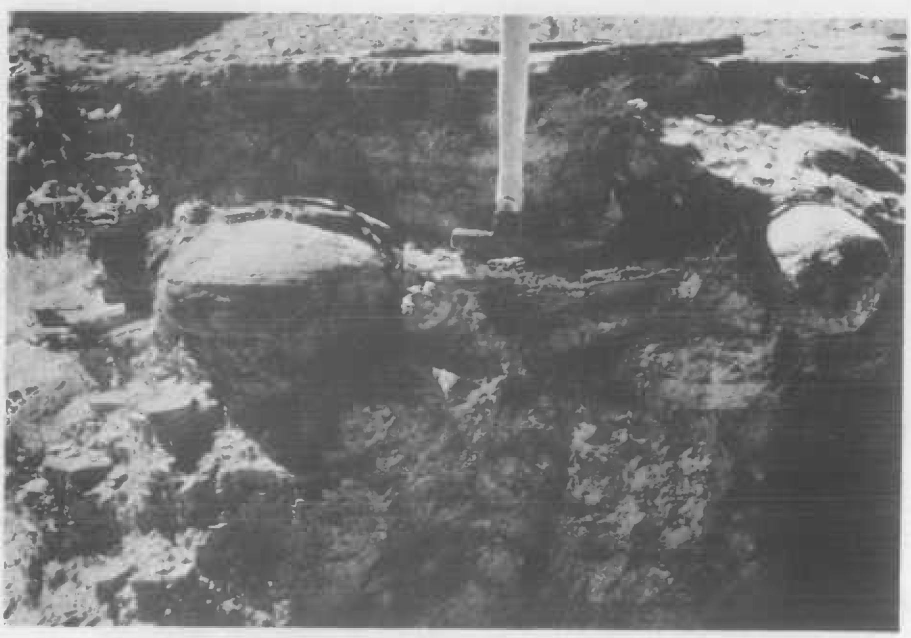


Fig. 15 -Toolebuc Limestone exposed in Dugald River, north of Granada, CLONCURRY. Note distortion of shale around concretions.

(Neg. 2492)

Apparently the formation does not crop out north of Savannah Downs on the eastern side of the basin because of erosion preceeding deposition of the Wyaaba Beds. Gamma-ray logs suggest that the formation increases from 6-8 m thick in the southern portion end near the basin edges, to 19-21 m in the northern and central part of the basin (see Plate 9), where it has been identified as far north as the Wellesley Islands and FBH Wyaaba No. 1 (see Meyers, 1969).

Lithology. Surface exposures in the southern Carpentaria Basin are of grey to pink, crystalline limestone, in thin, flaggy units from 2 to 30 cm thick. Some exposures include blocks of massive, vuggy limestone. A complete section of the formation occurs in the Dugald River (Fig. 15), north of Granada, CLONCURRY. It consists of:

White - grey limestone	122 cm
black, calcareous shale	213 cm
white-grey limestone, weathering to nodules	23 cm
black, calcareous shale	90 cm+

In general, the formation appears at the surface as a float of platey limestone fragments, and the thickness of the formation is usually indeterminate (Fig. 14). Only by means of subsurface samples can the formation be properly described (Smart, 1972). Core from BMR Scout Hole Dobbyn No. 2 shows the following section:-

grey-white, crystalline limestone with thin carbonaceous streaks	122 cm
black, calcareous shale	221 cm
grey-white, crystalline limestone ('nodule band')	23 cm
black, calcareous shale, at the top of an oil shale sequence	305 cm (+)

The top limestone band has a flaggy structure and breaks readily into thin plates, while the lower is more massive and weathers into large nodules.

The shales are black, laminated and silty, with fossils. The lamination is emphasized by thin, irregular bands of calcite, up to 2 mm thick.

The position and number of limestone bands varies throughout the southern Carpentaria Basin and the possibility exists that the limestone occurs as discontinuous lenses within the calcareous shale.

In thin section, the top band is a coarse-grained crystalline limestone. Inoceramus prisms are usually abundant (see Table 5), and show a rough parallelism to bedding, and there is a variable content of faecal pellets and carbonaceous material. Thin, irregular bedding is usually apparent.

The nodule band is a fine-grained crystalline limestone, with some fine clastic material, and a few carbonaceous specks. Bioclastic material is not generally present.

Investigations by Kennecott Exploration (Williamson, 1967) suggested that the formation consists of three zones. The uppermost bed which is discontinuous in nature, is composed of vuggy limestone. Williamson (op. cit.) suggested that these were formed by a species of calcareous hydrozoan and considered that this upper horizon was of biohermal origin. Below the vuggy limestone is a unit composed of coquinite and crystalline limestone interbedded with calcareous shale, which Williamson considers to be of biostromal origin. These units overlie calcareous shale with concretions of limestone. The shale is generally brown and yellow in the surface outcrops, but is black in the subsurface. It contains only a few macrofossils but a thin section from the shale at Granada contains numerous globigerinid foraminifera.

The concretions are possibly of diagenetic origin and must have formed before significant compaction had occurred, as the surrounding shale is distorted about them (Fig. 15). The term concretion may be inappropriate as there are no concentric structures present in nodules and the original bedding and contained fossils are well preserved. A thin section of one of these nodules contains oolites and pellets in a matrix of micrite.

Surface floats of limestone commonly have veins and coatings of secondary limestone. These coatings are composed of ferruginous microcrystalline calcite which contains angular to well rounded quartz grains. They are thought to have formed as a part of the recent weathering processes, the quartz grains being derived from the adjacent Cainozoic deposits.

Oil shale occurs in the Toolebuc Limestone north of Julia Creek. It is discussed briefly under Economic Geology.

<u>Chemical Composition</u>. Ten samples of limestone from surface exposures and cores were analysed. Variation in composition was slight, and the mean values are:

Residue insol. in 10% HCI	Iron	Calcium	Magnesium
1.44%	0.79%	40.63%	0.13%

These figures indicate a very pure limestone, with a low content of clastics and very low magnesium content. The calcium content is abnormally high. Insufficient data is available to establish significant differences between the upper band and the nodule band; the nodule band cored in BMR Scout Hole Dobbyn No. 2 had a clastic content double, and a magnesium content three times, the mean of other samples analysed, but the proportions are still very low.

Examination of the formation to the south as a possible source of phosphates (Williamson, 1967) showed that phosphate distribution was irregular and difficult to predict. Portions of the limestone rich in faecal pellets showed a high phosphate content.

Fossils. Both the limestone and the shale are rich in fossils. Fragments and tests of Inoceramus spp. and belemnites are particularly characteristic, and the typical fauna includes Aucellina hughendenesis. Specimens were collected from outcrops and were also identified in BMR Dobbyn 1 (Appendix 3); no particularly diagnostic species are present and the closest age possible is Upper Albian (Skwarko, pers. comm; and Table 5 - all the Albian fossils are from this formation).

Radioactivity. The Toolebuc Limestone displays relatively high radioactivity, and forms a prominent marker on gamma-ray logs throughout the area (Plates 8, 9, 10). Some analyses have shown the presence of uranium oxide (Down Under Well Services, pers. comm.), but testing of a large number of surface and sub-surface samples by one of the authors (Smart) with a scintillometer gave counts barely above background for both limestone and shale.

Origin. The origin of the formation poses problems, the unit being thin but continuous over a very large area. It must have been formed by some abnormal event that interrupted the deposition of the otherwise monotonous mudstone sequences which are found above and below it; the absence of terrigenous detritus suggests an arid climatic phase. The fossil assemblage indicates that the unit is marine and suggests a shallow water environment. Krumbein & Sloss (1963, pp 567-569) consider that blanket carbonate deposits of this nature are generally associated with transgressions and regressions of the sea. Thus it is possible that the Toolebuc Limestone was formed as biostromal banks in a marine transgression during an arid climatic phase, possibly following regression of the shallow continental sea. The origins of the oil shale and radioactive material are unknown.

The blotchy airphoto patterns in the outcrop areas of the unit are very similar to those of present reef areas and it is possible that the patterns represent the original distribution of biohermal mounds which stand above the level of the main beds.

Allaru Mudstone (Kla)

The Allaru Mudstone conformably overlies the Toolebuc Limestone and crops out (or subcrops beneath the Cainozoic sediments) in a belt of plains country around the southwestern margin of the Carpentaria Basin (Fig. 6). The outcrop is continuous with the Allaru Mudstone in the northern Eromanga Basin (Vine et al., 1967). It was called the lower Normanton Formation in the Carpentaria Basin by Meyers (1969); this was changed to Allaru Mudstone by Smart et al., (1971). It is a unit of the Rolling Downs Group.

Because the formation is argillaceous it is easily weathered and eroded and outcrops are rare. Most of the outcrop area is covered by Cainozoic alluvium. Where the formation does crop out it consists of calcareous mudstone and siltstone, with cone-in-cone limestone and rare calcareous fine-grained labile sandstone; the mudstone is non-fissile and has a blocky fracture. In drillers' logs of water bores the formation is generally reported as blue-grey shale. Mid-Eastern Burketown No. 1 and AAO 8 (Karumba) penetrated grey, fossiliferous, carbonaceous shale, siltstone, lithic sandstone and argillaceous limestone at depths appropriate to the formation. BMR shallow stratigraphic holes Dobbyn 1 and 2 commenced in Allaru Mudstone, which proved to be weathered to a depth of 30 m (Grimes & Smart, 1970).

Fig. 16 -Normanton Formation sandstone, Saxby River; road crossing north east of Wondoola Homestead, DONORS HILL.
(Neg. 2917)

Fig. 17 -<u>Rhizocorallium</u> in Normanton Formation sandstone, Walkers Bend, Flinders River, DONORS HILL.

The only fossil identified from outcrop (in MILLUNGERA) was Inoceramus etheridgei, of Lower Cretaceous age (Table 5 and Appendix 1). Skwarko reported at least one species of Inoceramus from Core 4, BMR Dobbyn 2 (Appendix 3). However, in the northern Eromanga Basin the formation contains marine macrofossils which are specifically of Albian age (Vine & Day, 1965). Lower Cretaceous foraminifera were described from the formation in the AAO 8 (Karumba) (Crespin, App. in Laing, 1960) and indicate shallow marine conditions.

The formation has a fairly constant thickness of between 170 and 200 m throughout most of the area. It is very similar to the preceeding Wallumbilla Formation and presumably was deposited under similar conditions.

Normanton Formation (Kln)

The Normanton Formation is the youngest Cretaceous formation in the southern Carpentaria Basin. It is the youngest unit of the Rolling Downs Group preserved in the Carpentaria Basin. Outcrop, and subcrop below Cainozoic sediments, occurs over the whole of BURKETOWN and most of DONORS HILL, together with parts of DOBBYN and CROYDON (Fig. 6). Outcrops consist both of rocks in deep weathering zones ('lateritized rocks') and little-weathered rocks. The most extensive exposures are of the deep weathering zone (see 'Weathering' below) which occur in uplands consisting of the dissected Donors Plateau, 30 to 45 m above the level of the surrounding plains (see 'Physiography,' above). The little-weathered rock is found in plains where the deep weathering zone has been stripped, and occurs as rubbly outcrops surrounded by cracking clay soil; this is typical of the Rolling Downs Group throughout the Great Artesian Basin. The best outcrops of the Normanton Formation are in the beds of the Flinders, Bynoe and Saxby Rivers, where it occurs as inliers in alluvium (Fig. 16).

The Normanton Formation was named by Laing & Power (1959). The type area is in the Little Bynoe River at the Burketown road crossing, about 40 km southwest of Normanton township. The rocks were described as 'grey, fine, lithic sandstone and dark grey siltstone and shale with hard calcareous concretionary bands, mainly in sandstone'. This is broadly true of the whole outcrop area of the unweathered rocks. The dominant lithology is a fine-grained calcareous labile sandstone with minor mudstone, siltstone and cone-in-cone limestone. Bedding is thin and the beds are commonly disrupted. The sandstone is cross-bedded.

Laing & Power (op. cit.) included within the Normanton Formation all the Cretaceous sediments overlying the Kamileroi Limestone. However, Meyers (1969) divided the formation into upper and lower units, which mapping during this survey supports. The name Normanton Formation has been restricted to the upper unit, and the lower unit is called the Allaru Mudstone by Smart et al (1971). In AAO 8 (Karumba) the spontaneous potential log suggests that the boundary between the sandy Normanton Formation and the underlying Allaru Mudstone is at 283 m (cf Meyers, 1969).

Marine fossils are fairly common in the unweathered rocks. The sediments at the type area contain marine fossils (ammonites, pelecypods and belemnites) of Albian age (Laing & Power, op. cit.). The rocks commonly exhibit extensive worm burrowing (including Rhizocorallium: Fig. 17). Calcified wood fragments also occur. These indicate a paralic environment; provenance and climate were probably the same as during Allaru times. The thickest preserved section of the formation occurs in the central part of BURKETOWN and DONORS HILL, where it is about 250 m.

The Normanton Formation is equivalent to the Mackunda Formation and perhaps part of the Winton Formation, of the Eromanga Basin. The Normanton and Mackunda Formations both overlie the Allaru Mudstone, are lithologically similar, and contain similar faunas. There is no direct evidence that the two formations were once a thick continuous rock body. If they were then it is necessary to postulate uplift of the Euroka Arch after sedimentation ceased (see Structure in this Report), followed by considerable erosion. It is simpler to regard them both as having been deposited in a regressing sea, either as separate bodies, or as one which was very thin over the Euroka Arch.

Floraville Formation

The Floraville Formation (Smart et al., 1971) crops out on western DONORS HILL and DOBBYN and is exposed in the valley of the Leichhardt River (Fig. 18). The type section is at the Leichhardt Falls, at the Burketown-Normanton road crossing of the Leichhardt River, DONORS HILL. It unconformably overlies all the Cretaceous sediments and is unconformably overlain by Quaternary alluvium. It is everywhere deeply weathered.

The formation consists mainly of fluviatile cross bedded clayey quartzose sandstone and conglomerate (Fig. 18). Large scour and fill structures are common. Pebble conglomerates are common in the south but absent at the type section at the Leichhardt Falls.

The formation at the type section is 12 m thick, which is the thickest section measured. The deposits were possibly laid down by an ancestral Leichhardt River. Isolated outcrops of similar sediments on the Donors Plateau to the east possibly represent the deposits of contemporary tributary streams draining the plateau.

The precise age of the formation is not known as it contains no age diagnostic fossils but only silicified wood, in fragments up to a few metres long. The formation overlies sediments of Lower Cretaceous age and is overlain by the Armraynald Beds (Smart et al., in press), which contain Pleistocene vertebrates bones (Bryan & Jones, 1946). It has been altered by deep weathering processes ('lateritized'). This deep weathering is usually considered to be Miocene or Pliocene in age (Woolnough, 1927; Whitehouse, 1940).

The Floraville Formation is very similar lithologically to sediments elsewhere in the Artesian Basin which have been assigned an early Tertiary age, but it could be as old as late Cretaceous.

CAINOZOIC STRATIGRAPHY

General

In the southern Carpentaria Basin Cainozoic sediments are clay, silt, sand and gravel, the younger units are unconsolidated and are generally modified by soil formation, and a few of the older units are lithified. Stratigraphic units are detailed in Table 8, and the soils developed on them are discussed briefly later.

Fig. 18 -Cross bedded sandstone, Floraville Formation KTf. Leichhardt River near Augustus Downs Homestead, DONORS HILL.
(Neg. 2825)

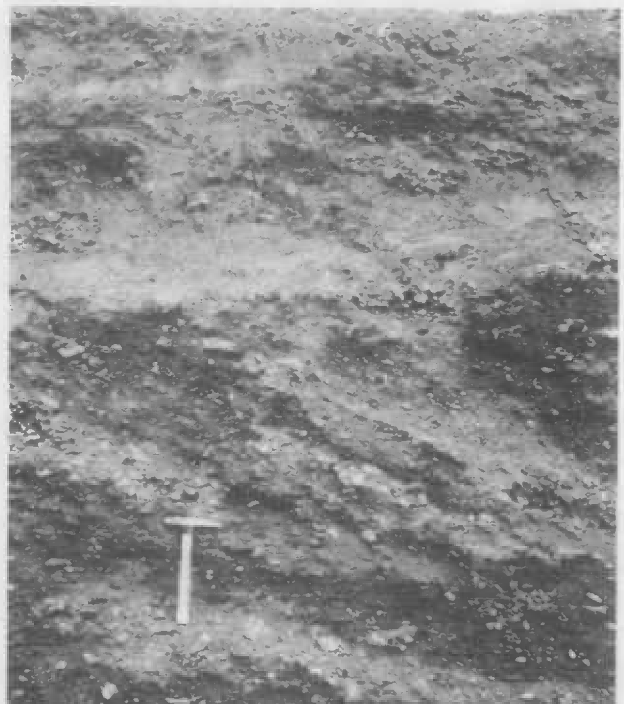


Fig. 19 -Red cross bedded sand and gravel deposits (Czr) in earth tank east of Fort Constantine Homestead, CLONCURRY.
(Neg. 2491)

TABLE 8

CAINOZOIC UNITS, SOUTHERN CARPENTARIA BASIN

(A) LITHOLOGY AND STRATIGRAPHIC RELATIONSHIPS

Age	Unit	Lithology	Unit	Lithology	Unit	Lithology	Unit	Lithology	Unit	Lithology
HOLOCENE	Qra	quartzose sand	Qa	clay, silt, sand	Qrc	clay, silt	Qre	sand, mud	Qrp	mud, salt
	Qro	quartzose sand			Qrs	quartzose sand	Qt	travertine	Qac	sand & silt
PLEISTOCENE	Qw (Qn)	silt, clay, sand			Czr	sand, silt & clay			Qm	calcareous sand
PLIOCENE	Czy	quartzose sand & sandstone, conglomerate			Cza	soil, sand			Czc	olivine basalt
					Tg	gravel				
	Czs	sand, gravel, pebbles								
? EARLY	Tf	lithified ferruginised gravel (ferricrete)								
TERTIARY	Td	lithified soil and colluvium ('duricrust')								
TO LATE	∴∴	mottled horizons (laterite?)								
? CRETACEOUS	KTf	sandstone, conglomerate								

(B) ENVIRONMENTS (letter symbols in brackets are those used on Preliminary maps)

ORIGINAL SEDIMENTARY ENVIRONMENT OF UNIT	Processes	PRESENT DAY ENVIRONMENTAL REGIME IN WHICH UNIT OCCURS: EROSIONAL	DEPOSITIONAL	
COASTAL	estuarine, tidal coastal currents	Qm - beach ridges	Qrp (Qop) - salt pans, tidal flats Qac - coastal deposits	
				Qre - meander belt point bar deposits
RIVERINE PLAINS	fluvial (aeolian?)	Qw (including Czr) and Qn (both Qf) - Wondoola and Armraynald Beds alluvia Tg (Czg) - high level gravel KTf (Tfl) - Floraville Formation ancient river gravels	Qrs - outwash sand Czy - Wyaaba Beds outwash sand	Qra - present day river channel deposits Qro - flood out deposits Qrc - flood plain deposits Qa - alluvia
PIEDMONT RIVERINE	fluvial, colluvial weathering	Qt 'travertine'	Czs - colluvial sand and gravel	
OLD LAND SURFACE	colluvial & deep weathering	Cza (Ql) - duricrust drainage sediments Tf (Czf) - 'ferricrete' Td (Czd) - 'duricrust' ∴∴ - 'laterite'		

In erecting some of the Cainozoic units additional or alternative criteria to the usual ones of lithology, superposition, structural relations and fossils had to be considered, but the end result is the same - the recognition of discrete bodies of rock or unconsolidated sediment.

Units which can be erected on the criterion of lithology alone are Qrp (Qcp)* and Tg (Czg) which are unconsolidated, Qm, which is consolidated in some places, Qt, Tf (Czf) and Td (Czd), which have been lithified in different ways, and basalt (Czc). Czr is separated from Qw by the criterion of superposition. The additional, or alternative, criteria of morphology of the body of sediment plus its position in the landscape permit separation of : Qac, which is a coastal deposit (so are Qrp and Qm); Cza (Ql), alluvium and colluvium of old valleys on the top of Donors Plateau; Czs, piedmont and high level sands; Qro and Qrc, bodies of sand and clay respectively, where distributaries flood out; Qa, Qra, sands etc., in and flanking river channels; and Qre, point bar deposits in river meander belts. The major riverine plains deposits cannot be subdivided properly without interpreting drillers' bore logs, when it becomes possible to separate Czy, Qw & Qn (both Qf), and Qrs.

Air photo interpretation and physiographic analysis are essential aids to recognition of all these units as discrete depositional bodies. Geomorphological analysis provides most of the relative ages of the units and ideas about their genesis. Table 8 is the end product of this exercise, not the beginning of it.

Riverine Plains Deposits

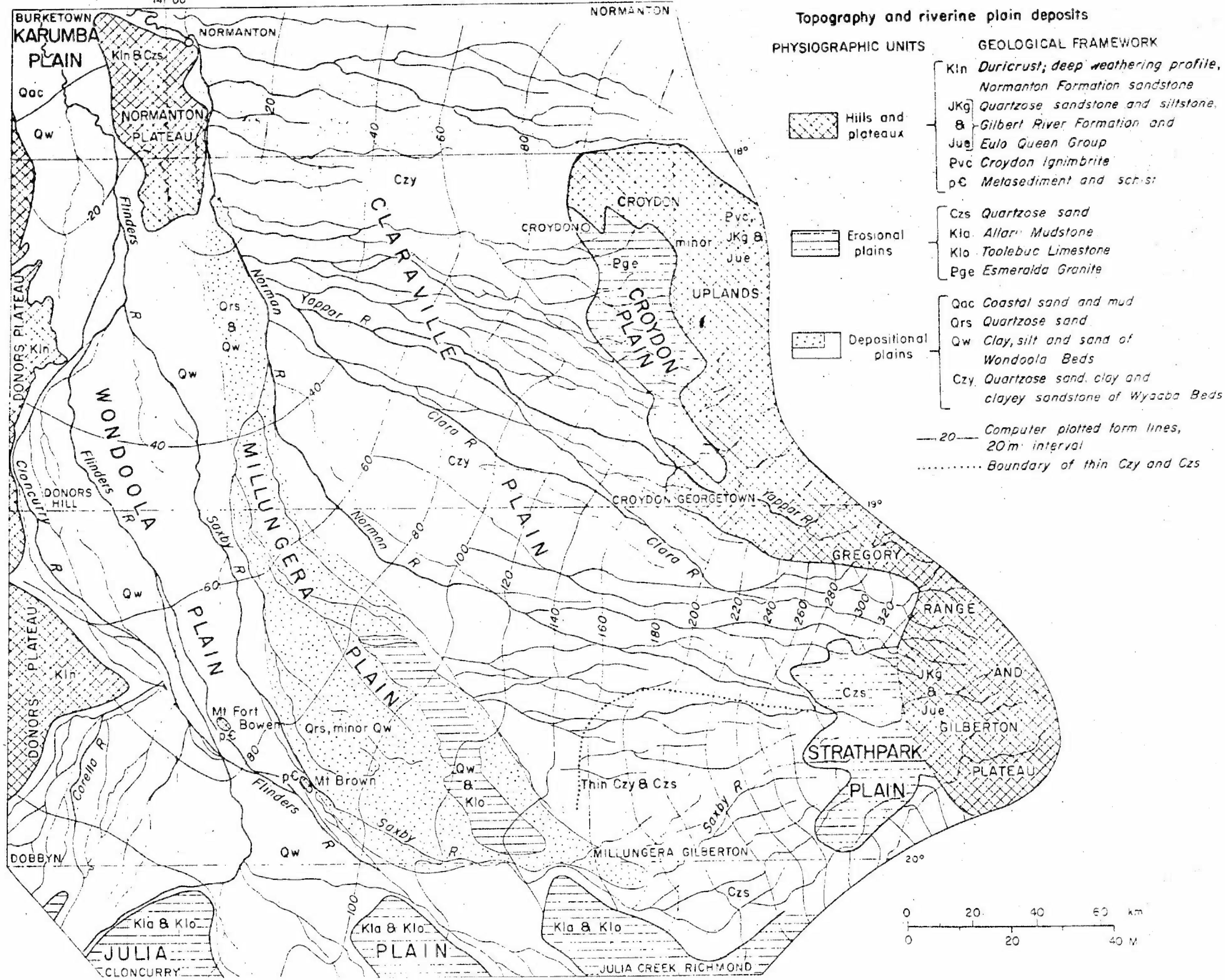
General. The alluvial deposits of the grassy Wondoola and Armraynald Plains consist of silty clay ('black soil') at the surface, which contrasts sharply with the yellow and red sandy soils and loose sands of the 'forest country' of the Millungera and Claraville Plains. Physiographic aspects of the origins of the Plains have been discussed already. The Armraynald Beds beneath the Armraynald Plain appear to be sandier than the Wondoola Beds which underlie the Wondoola Plain (Smart et al., in press).

The Plates and Figures mentioned below illustrate facies and thickness distributions which together with surface morphology and sediment types provide a basis for differentiating geological units.

Because they cover such a large area of the Gulf Country, are fundamental to the pastoral industry, and may be the beginning of a new sedimentary basin, the plains deposits warrant discussion in some detail; for lack of bores the Armraynald Beds cannot be discussed at any length, but they are, in general, very like the Wondoola Beds.

* Letter symbols in brackets are those used on Preliminary Editions of 1:250,000 geological sheets of the area before revision.

Fi



Topography and riverine plain deposits
PHYSIOGRAPHIC UNITS
GEOLOGICAL FRAMEWORK
Hills and plateaux
Kln Duricrust; deep weathering profile, Normanton Formation sandstone
JKg Quartzose sandstone and siltstone.
& Gilbert River Formation and
Jue Eulo Queen Group
Pvc Croydon Ignimbrite
pC Metasediment and schist
Erosional plains
Czs Quartzose sand
Kla Allaru Mudstone
Klo Toolebuc Limestone
Pge Esmeralda Granite
Depositional plains
Qac Coastal sand and mud
Qrs Quartzose sand
Qw Clay, silt and sand of Wondoola Beds
Czy Quartzose sand, clay and clayey sandstone of Wyaaba Beds
20 Computer plotted form lines, 20 m interval
Boundary of thin Czy and Czs
0 20 40 60 km
0 20 40 M
141°00'
142°30'
18°
19°
20°
BURKETOWN
KARUMBA PLAIN
NORMANTON
NORMANTON PLATEAU
Kln & Czs
CLARAVILLE
CROYDON
CROYDON PLAIN
Pvc, minor JKg & Jue
UPLANDS
Pge
Flinders
Norman R
Yappar R
Clara R
Czy
DONORS PLATEAU
DONORS HILL
Cloncurry R
WONDOOLA PLAIN
MILLUNGERA PLAIN
Qrs & Qw
Saxby R
CROYDON GEORGETOWN
GREGORY RANGE AND GILBERTON PLATEAU
JKg & Jue
Czs
STRATHPARK PLAIN
Thin Czy & Czs
Mt Fort Bowen
Mt Brown
Qrs, minor Qw
Qw & Klo
Corella R
DOBBYN
MILLUNGERA GILBERTON
Kla & Klo
JULIA PLAIN
CLONCURRY
JULIA CREEK RICHMOND

The area covered by the Wondoola and Claraville Plains is shown on Figure 20. The topographic contours depict a surface which probably represents a stillstand in deposition, if not the end of it, as soils have developed on both plains, and they are at present in an erosional environment. Figures 21, 22 give some idea of the Wondoola Plain. Assuming all the deposits are fluviatile, the top surfaces of the Wondoola and Wyaaba Beds also probably represent the equilibrium reached when the rivers of the Wondoola and Claraville Plains became graded, base level then possibly being sea level during the maximum of the Holocene transgression; recent regression brought about the present day erosional regime. Base level for Wondoola Beds deposition is also related to Normanton Formation outcrop along the coast of the Gulf of Carpentaria the present surface of the Wondoola Plain may be in a state of equilibrium with respect to the outcrop barrier.

Qro floodout deposits on the Claraville Plain (Fig. 24) suggest how the Wyaaba Beds accumulated; they also suggest that modern rivers are less energetic than those which deposited the plain's sediments. In contrast Qrc floodout deposits from the Leichhardt River show that part of the Armraynald Plain and Beds are still building up.

Most of these interpretations support the contention that the Wondoola and Claraville Plains could be regarded as the almost unmodified top surface of a complete body of continental sediments.

The surface on which the Wondoola and Wyaaba Beds were deposited is shown on Figure 26; the contours were drawn by using data from water bore logs. It is difficult to decide whether yellow clay above fresh sandstone recorded in drillers' logs should be regarded as part of bedrock or of plains sediments (see Fig. 20). Despite this Figs 27 and 28 (which are derived from Fig. 26) suggest that the plains sediments were deposited in valleys eroded into the old duricrusted land surface and its Mesozoic rocks during a regression of the sea (see 'Physiography').

This erosion exhumed the basement hills of Mt Fort Bowen and Mt Brown but, more importantly, created a Savannah Downs Ridge which formed a barrier until recently between the sand coming from the east and the silt and clay from the south. Regionally, erosion differentially removed the Allaru Mudstone and Wallumbilla Formation rather than Normanton or Gilbert River Formations and thus set limits on the eventual deposition of the Wondoola and Wyaaba Beds to the west and east. To the east Wondoola Beds deposition was prevented by piedmont deposition of the sands of the Wyaaba Beds (Czy).

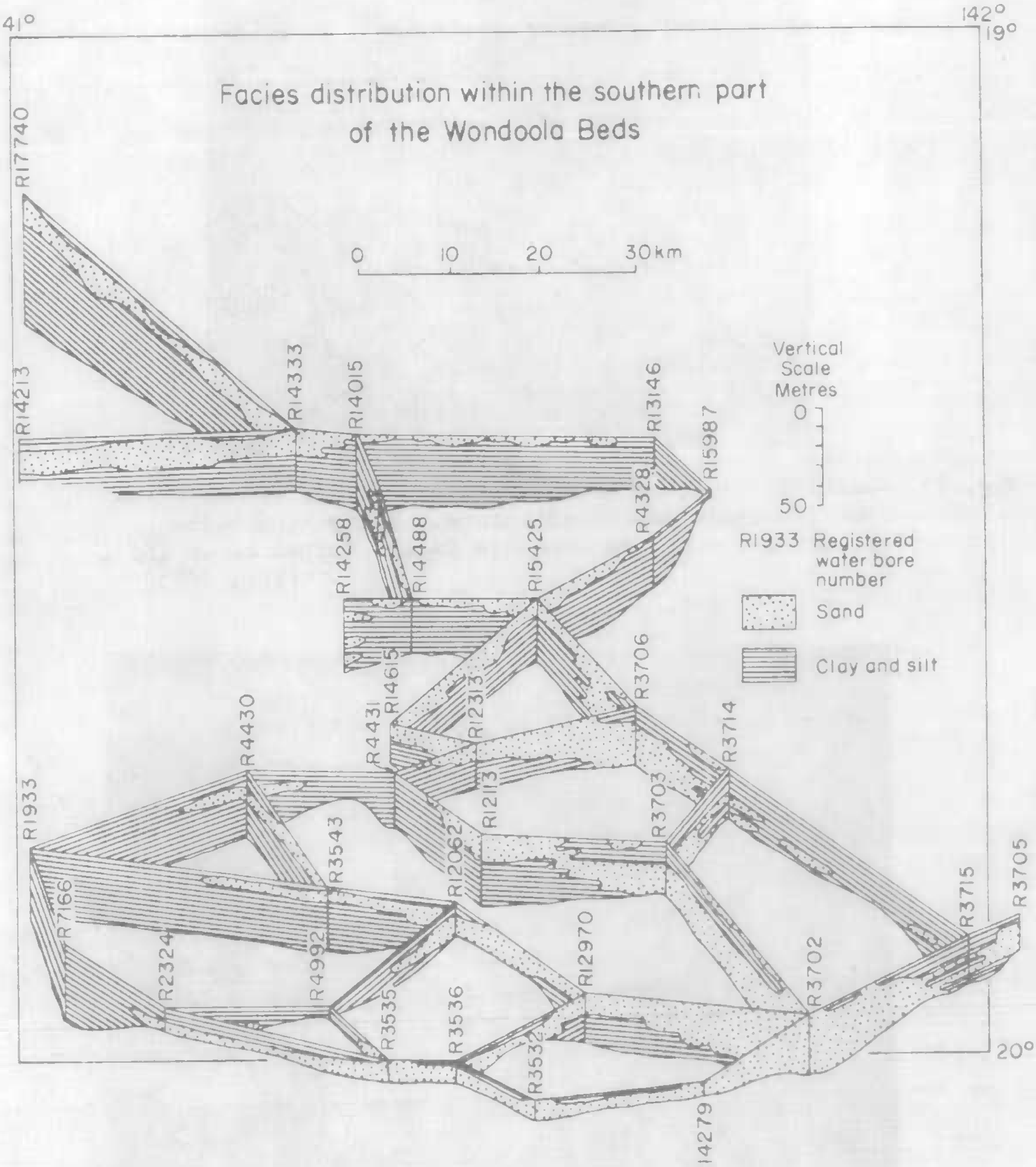
Erosion notwithstanding, the margins of the deposits are fundamentally structurally controlled blocks of Precambrian or Mesozoic rocks (see 'Structure') which provide provenances which are siliceous and arenaceous to the east and west and labile and lutitic to the south.

The Wondoola Beds thin out over and against Normanton Formation along the Gulf coast; the Wyaaba Beds continue north along the western side of Cape York Peninsula.

Fig. 21 -Saxby River, east of Wondoola Homestead, DONORS HILL. Erosion dominates at all times. White sand below 'black soil' may be Wondoola Beds. Mapped as Qw (Qf).
(Neg. 2871)

Fig. 22 Cloncurry River (right) and Flinders River (left) flowing from south towards observer. Canobie Homestead, DOBBYN, top centre. Local deposition during floods, erosion at other times. Mapped as Qw (Qf).

(Neg. 2873)



To accompany Record 1970/39

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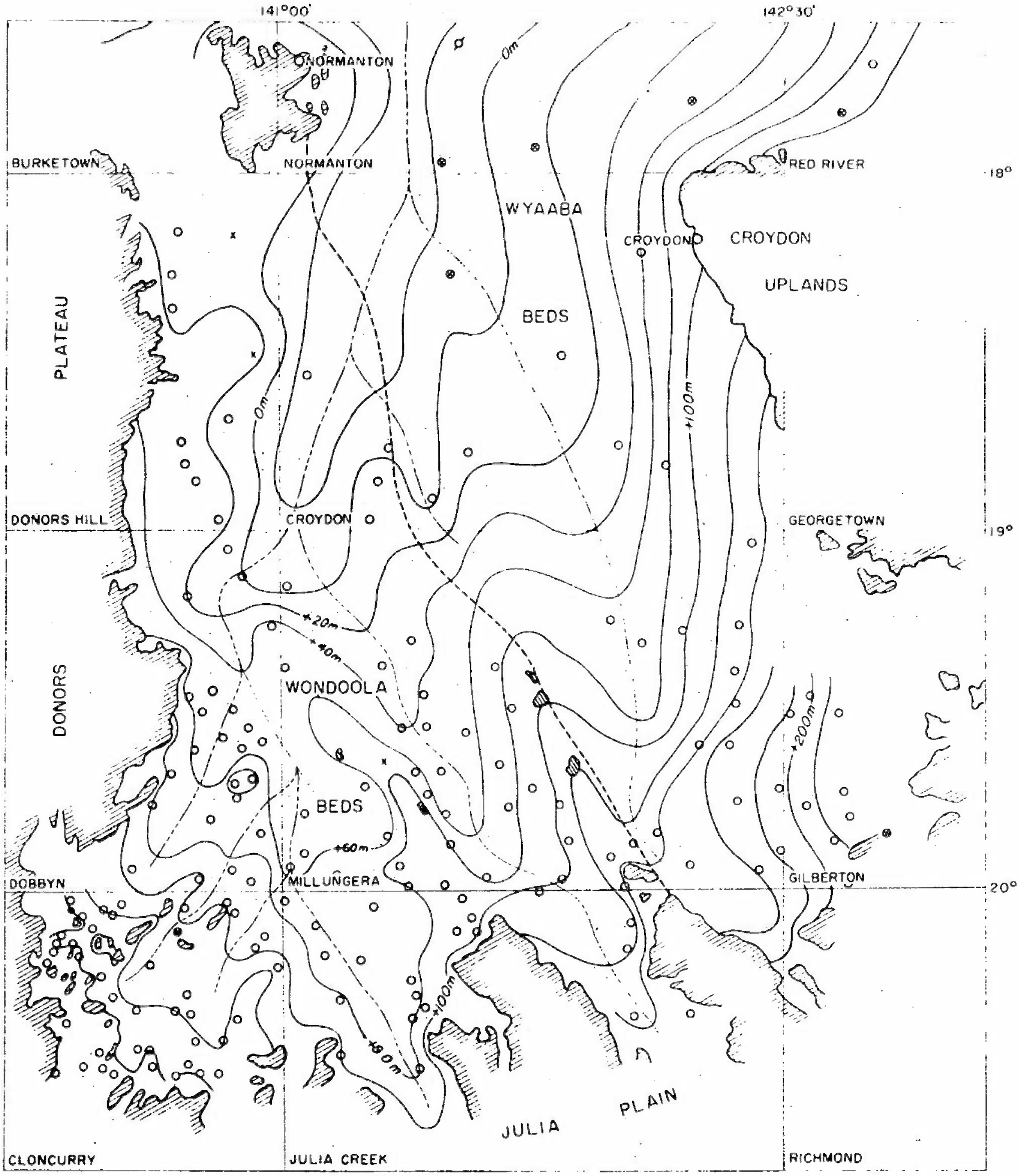
Fig. 24 -Norman River. Qra in channel area, scattered Qro on Wyaaba Beds (Czy) elsewhere. 'Forest country', Claraville Plain, GILBERTON.

(Neg. 2876)

Fig. 25 -North towards Savannah Downs, MILLUNGERA. Gidyea forest (black) and grassland (light grey) on 'black soil' - Qw (Qf) - with Toolebuc Formation outcrops. Paperbark and eucalypt forest (dark grey) on Qrs sand of Millungera Plain.

(Neg. 2889)



20m intervals wrt MSL

Water bore drillers log

BMR stratigraphic hole

Petroleum company hole

Outcrop data in stream channels

Geological boundary

Hypothetical drainage of old valley system

pЄ inlier

0 20 40 60 80 100km

0 20 40 60M

Fig 26 Structural contours on base of Wondoola and Wyaaba Beds

To accompany Record 1970/39

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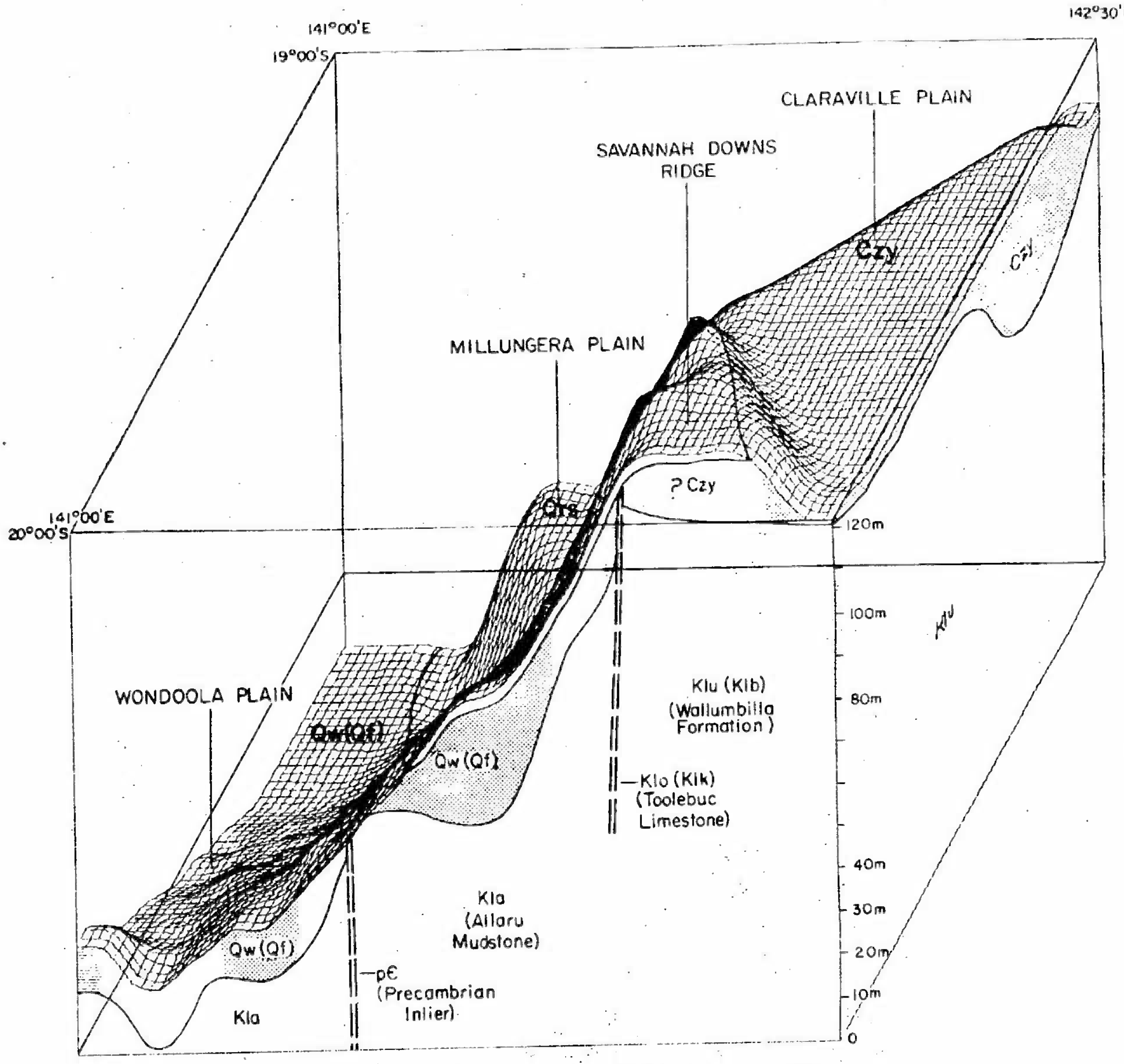

>90% sand >90% clay/silt

Qrs red and yellow quartzose sand

Qw(Qf) Wondoola Beds grey and brown clay, silt and sand

Czy Wyaaba Beds clayey quartzose sand

Computer drawn isometric view of the Millungera 1:250,000 area topography

Fig 27 RIVERINE PLAINS, MILLUNGERA

To accompany Record 1970/39

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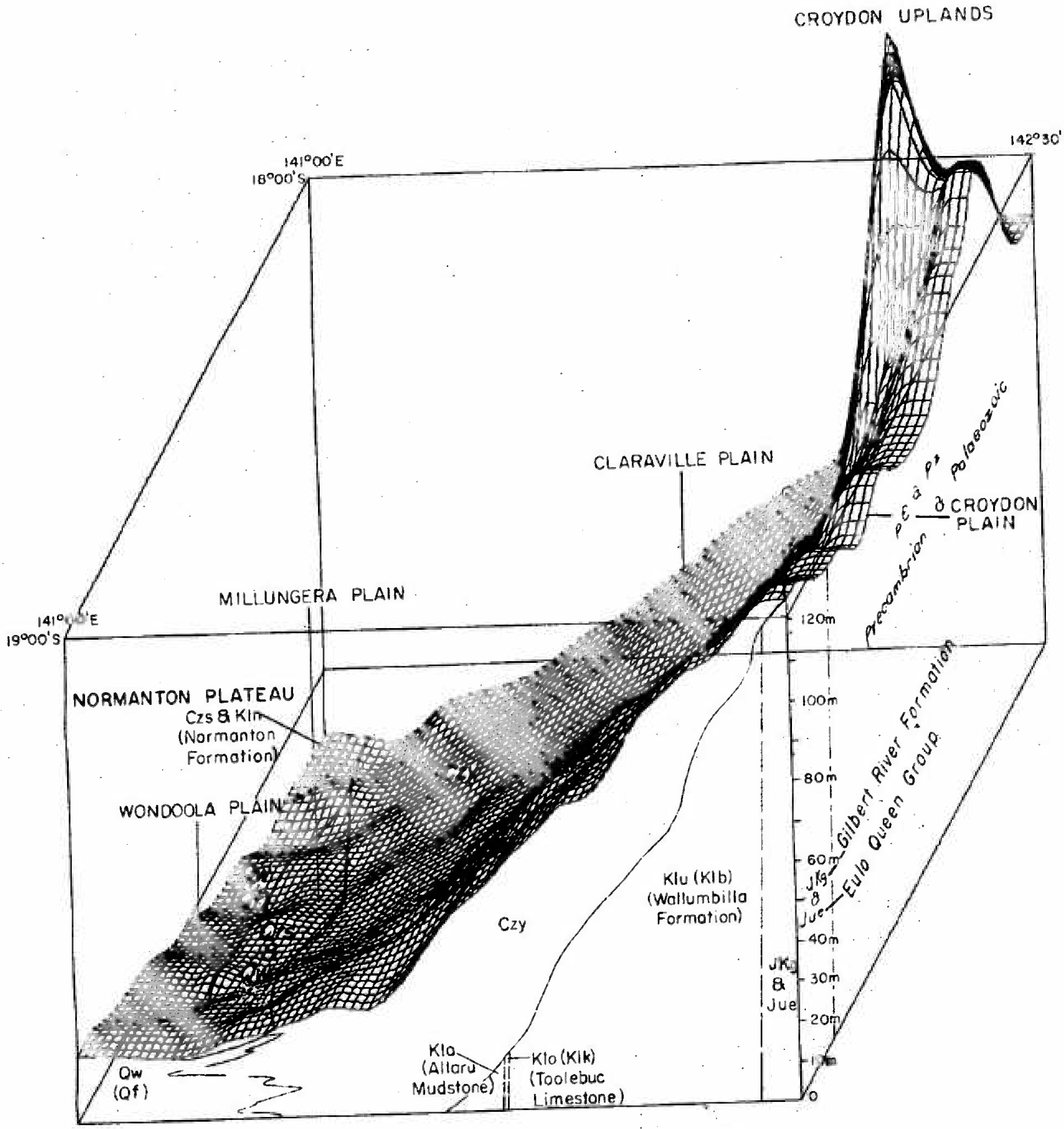

Qrs red and yellow quartzose sand

Qw(Qf) Wondoola Beds grey and brown clay, silt and sand

Czy Wyaaba Beds clayey quartzose sand

Computer drawn isometric view of the Croydon 1:250,000 area topography

Fig 28 RIVERINE PLAINS CROYDON

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To accompany Record 1970/39

In MILLUNGERA (Grimes, in press) the Wondoola Beds Qw (Qf) are composed of two facies, dark grey silt with a granule faction (cf. Twidale, 1966), and a quartzose poorly sorted clayey sand with minor gravel beds. Sand predominates in the southeast part of the plain: it is relatively thin and is probably in part floodout deposition from the Flinders River as its gradient flattens (Figs 20, 23). The percentage and volume of clay and silt increase to the north at least as far as the end of the Savannah Downs Ridge, where the deposit may be greater than 60 metres thick. Further north in DONORS HILL (Ingram, in press a) the Sarby River has eroded through only 3 m of 'black soil' into white clayey sand, perhaps a tongue of the Wyaaba Beds, (q.v.) which directly overlies the Normanton Formation (Fig. 21). In the south the sand comes mainly from the Gregory Range and the Mt Isa Block, and the clay and silt from the erosion and production of the Julia Plains (Grimes, 1972), in which Cretaceous mudstones are exposed. The sand was probably deposited in migrating channels and the clay and silt on flood plains.

'Black soil' occurs in windows in the Millungera Plain, particularly over the Savannah Downs Ridge, where in many places the Wondoola Beds are absent, the soil being produced directly from the Toolebuc Limestone (Fig. 25).

Red sand along the Cloncurry River in CLONCURRY has been mapped as Czr (Fig. 19); it underlies grey silts of the Wondoola Beds (Grimes, op. cit.). Physiographically the unit is included in the Wondoola Plain as a matter of convenience; although its surface was probably produced by erosion, it is a depositional unit in the same sense as the Wondoola Beds and could represent a basal member of them (Fig. 20).

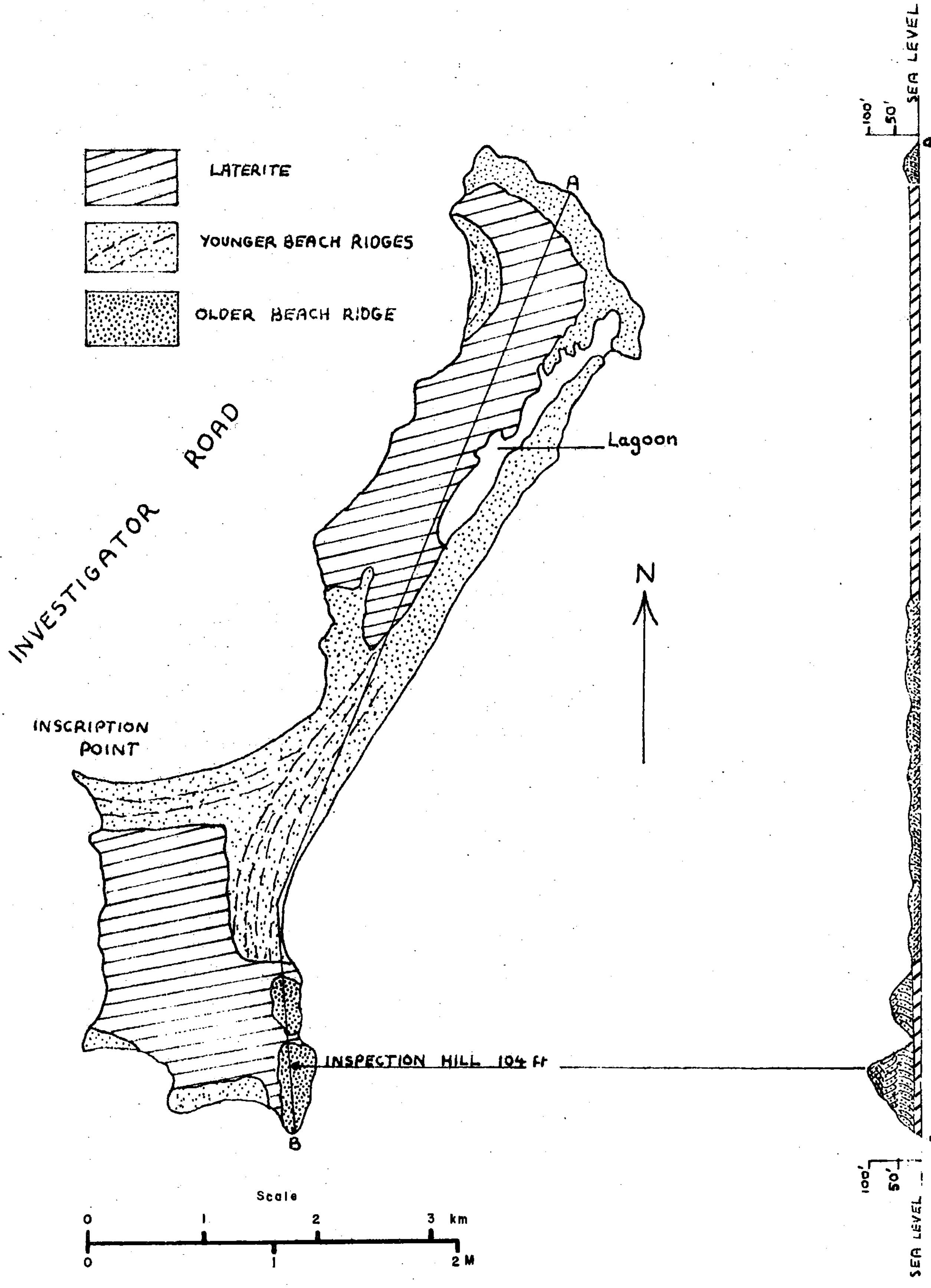
The Wyaaba Beds, Czy, of the Claraville Plain are composed of clayey, poorly sorted quartzose sand, with some pebbles, poorly consolidated in most places and very friable. In the southern Carpentaria Basin they are derived from the Gregory Range and are in effect a gigantic piedmont outwash body. North of Normanton and Croydon the Wyaaba Beds are up to 150 m thick in the tectonic Gilbert-Mitchell Trough (Doutch et al., in press) in bores drilled by Warner (1968), but in the Report area they apparently thicken from southeast to northwest as a result of filling up old valleys east of the Savannah Downs Ridge (Figs 27, 28), and vary from 5 to 60 m thick. At the surface the beds commonly shows mottling and a pisolitic iron horizon, but this is part of a soil profile (this is dealt with under Weathering in this Report).

The Millungera Plain is underlain by a thin sheet of quartzose sand, Qrs, less than 10 m thick, originally alluvial, but now partly aeolian. The sand may have come from the east, overtopping the Savannah Downs Ridge, as Fig. 27 suggests. But Figure 20 shows that the Flinders River is also a source of sand, and depressions and streams in the Millungera Plain parallel it. They also parallel the prevailing winter wind. To the north the sand of the plain is present only in scattered outliers, which sit like islands on the Wondoola Beds in the northern half of CROYDON; at its southern end in JULIA CREEK there is a well preserved set of stabilised sand dunes (Vine, 1964). The Qrs is apparently younger than the surface of the Wyaaba Beds, as the mottled yellow and grey earths on the latter are not present in the Millungera Plain.

The age of all the plains deposits is probably Plio-Pleistocene, because:

Fig 29

Laterite and beach ridge relationships on Sweers Island



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(1) they post-date duricrusts which themselves probably post-date a laterite younger than an early Tertiary spore in the Wellesley Islands (Hill & Denmead, 1960).

(2) The Wyaaba Beds were deposited in valleys eroded as a consequence of the uplift that created the southern part of the Gregory Range (see Structure, this report) and the highlands of Cape York Peninsula. This uplift ante-dated the Chudleigh Basalt, which is probably of the same age as the Nulla Basalt, that is, its oldest flows are Pliocene. The same structural event may also have created the Gilbert-Mitchell Trough north of Normanton and Croydon (Doutch et al., in press), which provided a local base level for the Wyaaba Beds deposition in the southern Carpentaria Basin.

(3) The Wyaaba Beds appear to interfinger with the Wondoola Beds (Figs 28), which are similar to the Armraynald Beds, in which Pleistocene vertebrate fossils were found at Floraville on the Leichhardt River.

(4) Pleistocene to Recent eustatic events and climatic changes more likely caused oscillation between erosion and deposition than accumulation of thick deposits in the area.

In all geological settings in the area Qa denotes flood plains and Qrs areas in river beds where sediment in transport rests temporarily. Qre denotes areas of point bar deposits in river meander belts, most of which develop where rivers cross the coastal plains. (Qa is a recent revision, and appears only on CROYDON Preliminary map; there is no Qre on any of the Preliminaries).

Coastal Deposits

Beach ridges Qm

Quaternary beach deposits occur in BURKETOWN, both on the mainland and islands, as ridges more or less parallel to the coast (Fig. 32). These deposits were described by Jackson (1902). They consist of coquina, calcarenite and shelly sandstone. Some deposits are lithified by calcite; most are not lithified; they commonly exhibit cross stratification (Fig. 31). Pebbles of ironstone and iron cemented quartzose sandstone eroded from ferricrete are commonly included in the deposits. Both pelecypods and foraminifera are fairly common and on the islands abundant coral fragments are present in the deposits. Where the sediments are lithified they have been weathered by solution into a honeycomb appearance. Vertical solution pipes occur in the beach limestone of Sweers Island, one of the Wellesley Islands, and create a very rugged surface.

The ridges commonly rise 6 to 8 m above sea level but exceed this in places, and on Sweers Island an old ridge rises to 31.7 m above sea level (Fig. 30). On the mainland there appears to be very little difference in height between the tops of ridges near the coast and those furthest from it; the tops of the ridges at Karumba were measured with a barometer as 4.5 to 6 metres above sea level, and a ridge 13 km from the coast is 7.5 m above sea level. Twidale (1966b), however, states that there is a difference of 20 feet (6 m) in elevation between the ridges near the coast and those furthest from it. On Sweers Island the old ridge at its southern end is 21 m thick and rests on a laterite bench which is 8-9 m above sea level (Fig. 29). The younger ridges are just above sea level.

Fig. 30 -Older beach ridge deposits, Qm, on raised 'laterite' platform. Blocky boulders from deposits rest on modern platform cut into mottled zone. South end of Sweers Island, BURKETOWN. (Neg. 2829)

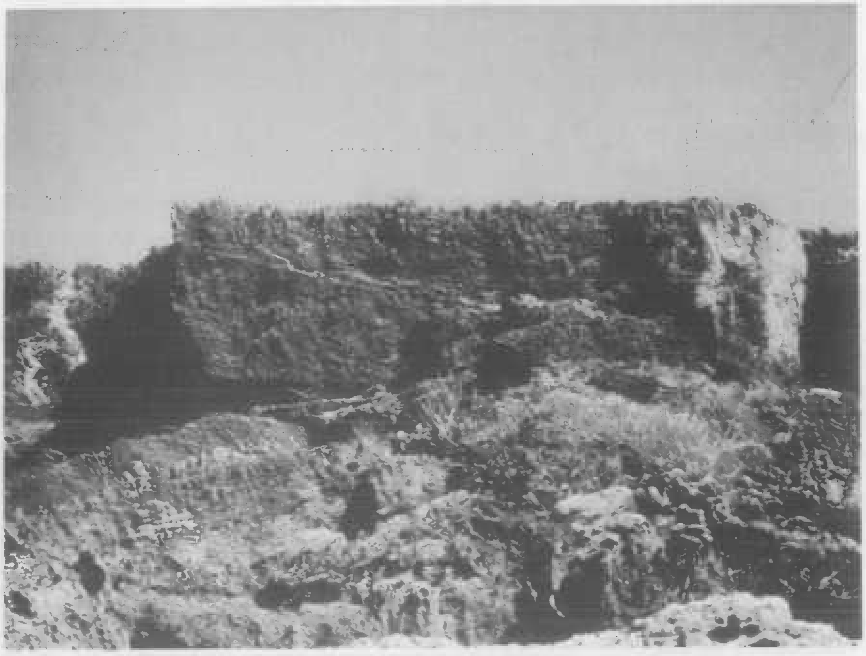

Fig. 31 -Large scale cross bedding in calcarenite of older beach ridge, Qm. South end of Sweers Island, BURKETOWN. (Neg. 2831)

Fig. 32 -Tidal stream flooding out inland into a salt pan in Qrp behind beach ridge remnants, Qm, between Flinders River and Spring Creek, BURKETOWN.

(Neg. 2888)

Fig. 33 -Abandoned meander with 'gutters' (Whitehouse 1944). Qrp. Bynoe River, BURKETOWN.

(Neg. 2909)

Phipps (1966, 1970) found in cores taken in the Gulf that the earliest marine sediments were about 20,000 years old. There was a marine period in the Gulf from about 20,000 to 16,000 years b.p., followed by a mainly non-marine period until 6,500 years b.p. Since then the sea has always been present. This last marine period represents the Holocene transgression which was worldwide (Guilcher, 1969). The younger beach deposits were formed during and after this recent transgression.

The older beach ridge in Sweers Island may be related to the 20,000-16,000 years b.p. marine period or to an even earlier marine episode for which no evidence has so far been found in the cores. It is possible that the Wellesley Islands were uplifted and the older deposits preserved from marine erosion at the same time as the area to the east was downwarped allowing older beach deposits there to be destroyed later during the last rise in sea level. Abundant small scale faults and folds, which affect the laterite, are common on the Wellesley Islands, supporting the notion of uplift.

Younger alluvium and coastal deposits Qac

These coastal deposits consist of quartzose sand and some silt between beach ridges. The deposits are commonly at a slightly lower level than the adjoining margins of the riverine plains. Deposition is probably controlled by slackening river velocity when floods are ponded back by high tides.

Tidal flats Qrp (Qcp)

The tidal flats (Fig. 32) are mud and salt flats inundated only by the highest tides and seem to be an excellent environment for evaporites. They have not been drilled, so their economic potential is unknown. Fig. 32 shows 'levee' deposits in the tidal flat belt; apparently the levees are built up only on the low velocity side of rivers during flood times; simultaneously finer materials may be widely, but probably thinly, deposited over the flats.

High level gravel Tg (Czg)

Conspicuous beds of unconsolidated pebbles and cobbles crop out along the Julia Creek-Normanton road north of the Dugald River, in DOBBYN. They may have been deposited by an ancestral Dugald River, and may predate erosion of the valleys later filled by the Woondola Beds. They could therefore be equivalents of the Floraville Formation.

Old soil and sand Cza (Ql)

This unit has not been studied. It consists of white to grey sand, silt, clay and soil in broad shallow valleys on the tops of duricrusted mesas and the Donors Plateau. Soil may have formed on its parent material (probably of colluvial origin) before deposition of the riverine plains sediments.

Chudleigh Basalt Czc

The Chudleigh Basalt occurs in GILBERTON and is described by White (1965). Its importance in the history of the southern Carpentaria Basin is discussed under 'Physiography', 'Structure' and 'Geological History'.

Fig. 34 -Ferricrete overlying lithified colluvium, Bang Bang, DONORS HILL.

(Neg. 2833)

Fig. 35 Duricrust remnants (Td (Czd) - lithified soil), Bang Bang, DONORS HILL.

(Neg. 2885)

Old colluvium and residual sand Czs

This unit comprises piedmont sand around the basin margins, and residual sand between the Flinders and Leichhardt Rivers. The residual sand may be in part old river deposits. The piedmont sand along the western margin of the Basin is possibly detritus produced by scarp retreat. Along the eastern margin of the basin the sand may be partly floodout alluvium deposited near the Gregory Range during early uplift phases. In most places some of the sand is produced in situ by weathering of bedrock. As aeolian sand is present in the Millungera Plain, it is likely that Czs deposits have an aeolian component too, as they were initiated when erosion of the duricrust commenced and are still accumulating.

Travertine or caliche Qt

Travertine is found only along the eastern margin of the Boomarra Horst where basic Precambrian rocks occur. It is in the form of platy fragments and lumps in the soil and may represent a broken up hardpan.

Weathering and Soils

Two types of chemical alteration of rock and unconsolidated detritus since the end of Cretaceous deposition need to be considered when defining Cainozoic units in the Report area. The first is the deep weathering which altered Cretaceous and early Tertiary(?) rocks, producing 'laterite', 'duricrust' and 'ferricrete'. The second is the pedological process; we have mapped Cainozoic units as lithological units, of which the soils developed thereon are a part.

Deep Weathering

Weathering during the Cainozoic (or possibly the Upper Cretaceous) produced a lateritic profile (as of Hays, in Jennings & Mabbutt, 1967) which probably formed over the whole area except on Cretaceous mudstone outcrop. However, much of this profile and modifications of it have since either been removed by erosion or covered by later sediments. The thickest relics of the profile are preserved in BURKETOWN, DONORS HILL and NORMANTON in the central west of the southern Carpentaria Basin, where they occur as alterations to the Normanton and Floraville Formations and where, in places, they are over 30 m thick. The profile on the Gilberton Plateau, in GILBERTON, at the eastern margin of the basin, is less well known, and is not discussed here.

The preserved part of the profile in the west (stippled areas on Preliminary maps) consists only of a mottled zone; apparently no underlying pallid zone developed. The mottled zone, which is described below, has a hard capping ('duricrust', Td (Czd)) - which is commonly overlain by a thin ironstone gravel ('ferricrete', Tf (Czf); Fig. 34). The duricrust appears to be the result of prolonged weathering, including silicification, of the previously lateritised landsurface; the ferricrete in turn formed by the weathering and colluvial disintegration of the duricrust and mottled zone, and involved iron enrichment and cementation.

The mottled zone consists of white and reddish purple patches in which the clay and feldspar have broken down to kaolin with release of silica. Locally the patches form a rectangular grid pattern (Fig. 36). Mobilization and redistribution of silica and iron oxides has occurred within the zone. The silica occurs as opal and chalcedony, in porcellanite, and as discrete segregations within the mottled zone. The iron oxides occur within the

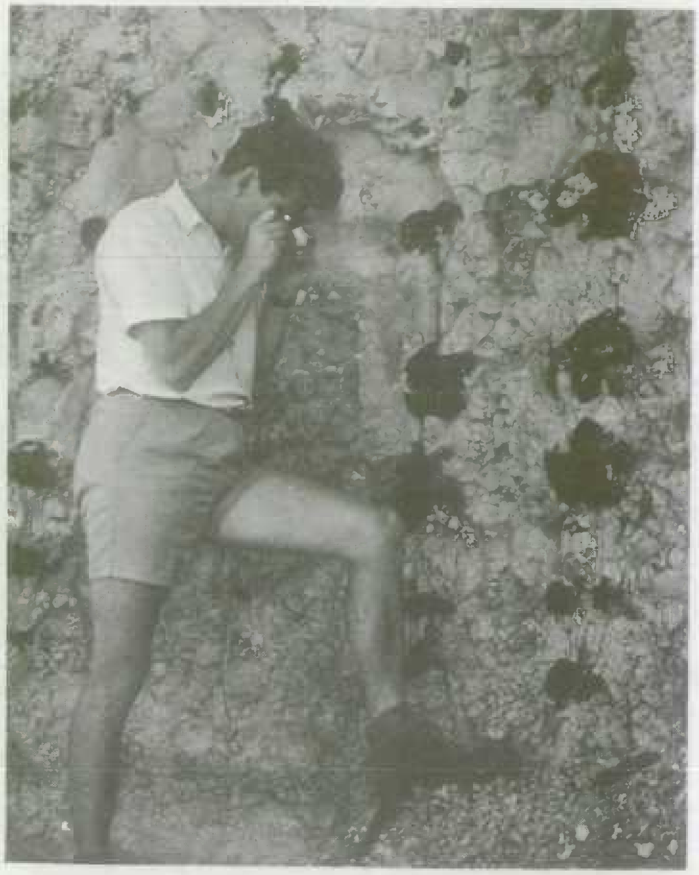

Fig. 36 -Grid pattern in mottled zone of deep weathering profile. Burketown-Normanton road at crossing of Flinders River, BURKETOWN.

(Neg. 2883)

Fig. 37 -Mottled yellow earth with pisolitic horizon:- 'lateritised' Wyaaba Beds Claraville-Prospect road at crossing of Borer River, CROYDON.

(Neg. 2890)

reddish patches and as concretions, particularly at the base of the zone immediately above the unaltered rock, where there is also a layer of ochrous yellow iron-enriched rock. This layer and the concretions may be a recent development associated with the present day water table; springs occur in this zone north of Donors Hill Homestead.

Throughout most of the mottled zone the original bedding is largely undisturbed. Bedding becomes less distinct and finally disappears as the mottled rock grades up into a zone of hardening and thorough brecciation - the duricrust. Mottling continues up through the duricrust but soil structures, including soil pipes and brecciation, are so abundant as to obliterate the bedding. Silica and iron oxides occur as cements in the breccia. There is, however, no overall iron-enrichment and a chemical analysis showed that the Fe content is only about 2%. The duricrust, which is as much as 12 m thick, is harder than the underlying mottled zone and forms hill cappings. Around the scarp edges there are commonly large blocks which have broken away along joints (Fig. 35).

On the top of the duricrust there is generally an ironstone gravel which varies in thickness from a few cm up to a metre (Fig. 34). The pebbles vary from angular to round (in places giving 'buckshot' gravel) and consist of ironstone, iron-cemented quartzose sandstone and quartz. The gravel is loose, or cemented by concretionary iron oxides to form a ferricrete (Tf (Czf) on GILBERTON). Samples of ferricrete analysed vary from 14 - 30% Fe (about 20-50% Fe_2O_3) and 5-8% Al. Cemented iron gravel also occurs on the piedmont slopes around some of the mesas. This colluvial gravel is derived from the duricrust capping and probably also from concretions in the mottled zone.

In general therefore, the weathered profile is not a simple lateritic profile with in situ laterite on top (Fig. 38). Practically everywhere the iron gravel is reworked and secondary iron enrichment has taken place as the profile has been altered by overall lowering of the surface. Conditions conducive to leaching and iron enrichment therefore did not occur during one simple deep weathering episode.

Further evidence for this is that the Wyaaba Beds, which unconformably overlie the 'lateritized' Cretaceous and early Tertiary? units in the Gilbert-Mitchell Trough (Doutch et al., in press), are themselves mottled and iron-enriched at the top. Laing & Power (1960) described it as 'slightly lateritised'; Isbell et al (1968) mention mottling and ironstone nodules as properties of the mottled gray earths which have developed in the area (see Fig. 37). It is possible that all ferricretes in the southern Carpentaria Basin formed at the time of formation of the ferruginous soil horizons on the Wyaaba Beds.

The reasons that similar alterations to those of the Wyaaba Beds did not develop contemporaneously in the Wondoola and Armraynald Beds may be the particular nature of groundwater movement in the Wyaaba Beds, both lateral and vertical, a function of the formation top's position in the catena, and of the sandy nature of the parent material. Analogously, preferential formation of 'duricrust' on sandy Normanton Formation rather than on Allaru Mudstone or muddy Wallumbulla Formation is suggested in 'Physiography'.

The mottled and nodular earths modifying the Wyaaba Beds (Table 9) bear a family resemblance to the profiles described by Prescott & Pendleton (1952), to the 'standard laterite profile' of Hays (op. cit.), and to the deep weathering profiles, 'laterite', duricrust and ferricrete discussed in this report and by many other authors. All these resemblances and coincidences could be interpreted as stages and variations in pedologically initiated processes, culminating in the lithification of the alteration products.

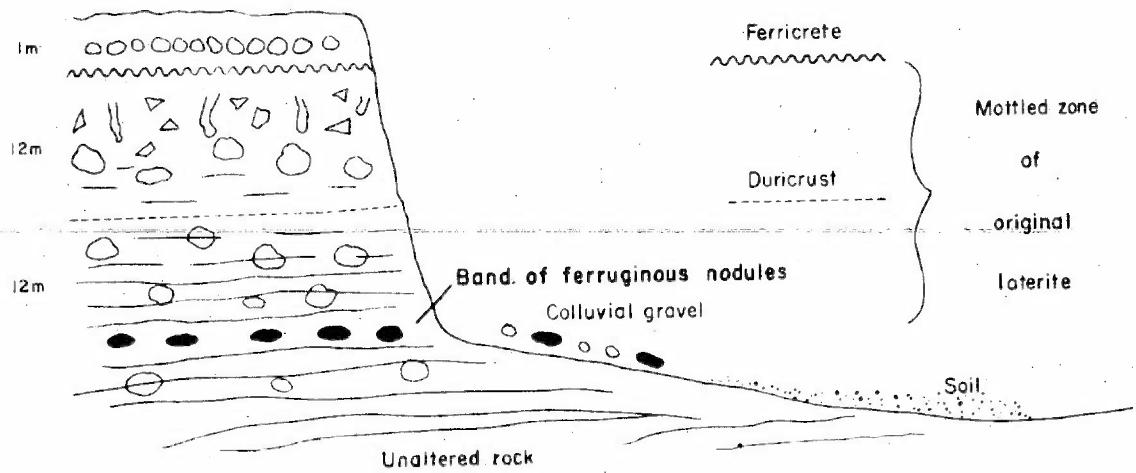

Fig 38 Diagrammatic cross section of deep weathering profile

To accompany Record 1970/39

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As with the formation of soils, the processes may not go to completion if interrupted by climatic or tectonic changes. Similarly, they may be initiated every time structural changes or landscape alteration by erosion or deposition present fresh parent material in the right position in the catena in an appropriate climatic regime.

If this is so, then the present day climate in the area is apparently not appropriate for the formation of laterite, etc. Perhaps the land forms are unsuitable, but the type of parent material which was affected by ancient deep weathering phenomena is currently available in a fresh state in piedmont and plateau environments, where some of it is weathering to soils other than lateritic ones.

Lateritic processes (sensu lato) could conceivably have operated either during several episodes in the Cainozoic or continuously during the era. But apart from the lateritic(?) soil developed on the Wyaaba Beds, and equivalent alterations, the end products of the deep weathering processes in this area seem to have formed in a period when nothing much else was happening geologically, between the time of deposition of the Floraville Formation and the beginning of the erosion event that ante-dated riverine plain deposition (Wondoola Beds etc.) in the Pleistocene(?), and outpouring of the Chudleigh Basalt in the Pliocene. The sequence of laterite profile/duricrust/ferricrete suggests the processes were episodic during the time span in which they were operative.

Soils

Sheet 7 of the Atlas of Australian Soils, covering Cape York Peninsula and the Gulf Country, was prepared by Isbell et al., in 1968. In the Explanatory Data accompanying the sheet the mapping units are said to be associations of soils delineated by landscapes, and parent material lithology is stated to be of great importance in the determination of soil character. In our report a close relationship is shown to exist between landscape and geology. Thus soils, landscape and geology in the area are directly related, and the relationships are emphasized in various ways by the different authors by the classificatory systems they adopt. Therefore it is not surprising to find soil boundaries on the Soils Atlas map nearly identical with geological boundaries. Sleeman (in Perry et al., 1964) makes a similar statement about soils/lithology relationships, and his soils map also resembles the geological map, but less closely than does the Soils Atlas map.

Table 9 details relations between the physiographic and geological units of this report and the soil units of Isbell et al (1968). Some of the soil unit descriptions could be used as part of the definitions of the Cainozoic geological units which provide their parent material. However, in some cases similar soils have developed on a variety of geological units, which therefore cannot be defined using soil as a critical criterion. Nevertheless a number of soils in the area are highly characteristic of the rock bodies they modify (see Table 9).

Table 9 Main Soils developed on Mesozoic and Cainozoic units in the southern Carpentaria Basin

GEOLOGICAL UNIT	DOMINANT SOIL (from Isbell et al., 1968)				PHYSIOGRAPHIC UNIT (this Report)	
	CLAYS	SANDS	EARTHS	OTHER		
Qw, Qn, Czr	cracking grey and brown self mulching clays (some gilgais) (1)				Wondoola and Armraynald Plains	DEPOSITIONAL PLAINS (mostly in erosional environment)
Qrp	saline, dense, plastic grey clay soils (1)				Coastal (Karumba) Plain	
Qac	grey cracking clays (gilgais) (1)					
Qm		calcareous sand soil of minimal development (1)				
Qrs		yellow earthy sand (1)			Millungera Plain	
Czs & Czy		yellow and some red earthy sands and earths (1)			South Claraville Plain	
Czy			grey loamy earth with mottling and ironstone nodules, and mottled sandy yellow earth (11)		North	
Czd			red and yellow earths, nodular loamy (11)		'duricrust' (see p.30)	HILLS
Cza			grey earths (11)		shallow drainage in duricrust	
				hard setting soil with yellow clayey subsoil (111)	deeply weathered Cretaceous rocks in north	
JKg, Jue		stony sands (1)			Gregory Range Mesozoic plateau	

Table 9 Main Soils developed on Mesozoic and Cainozoic units in the southern Carpentaria Basin (Cont'd)

GEOLOGICAL UNIT	DOMINANT SOIL (from Isbell et al., 1968)				PHYSIOGRAPHIC UNIT (this Report)	
	CLAYS	SANDS	EARTHS	OTHER		
Kln	Some cracking and grey-brown self mulching clays (1)			mainly loamy soils, gravelly or nodular (1)	piedmont slopes	EROSIONAL PLAINS

(1) Soils with uniform texture profiles (youngest?)

(11) Soils with gradational texture profiles

(111) Soils with contrasting texture profiles (oldest?)

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Soil ages could be useful in helping to date Cainozoic geological units but the ages of the soils in the area are unknown from their own attributes, either absolutely or relatively. As profiles are rarely well differentiated, we do not have this guide to relative ages; in addition profile development in cracking self mulching clay soils is not clearly understood. So rather than soils helping to clarify the ages of geological units in the area, the reverse is the case: the geomorphological analysis that helps with the ages of geological units also helps provide the ages of soils. Soil ages in the area vary from post-ferricrete to historical.

Possible climatic and tectonic changes in the Plio-Pleistocene must be taken into account as initiating or stopping both parent material deposition and soil formation and as modifying existing soils. For example the Wyaaba Beds deposition was initiated by early Pliocene tectonics. It could be claimed that their deposition is still continuing, but modern flood-out sediments (Qro) on the Claraville Plain probably postdate the mottled grey and yellow earths (developed in a Pleistocene climate ?) which modify the Wyaaba Beds: the soils set an upper age limit for the Wyaaba Beds.

Some of the Wyaaba Beds are derived from Czs outwash and piedmont sands flanking the Gregory Range, and on these sands have developed red and yellow earthy sand soils. Whether or not these soils predate Wyaaba Bed deposition is unknown. Many other soil-geological unit age relations are even less clear.

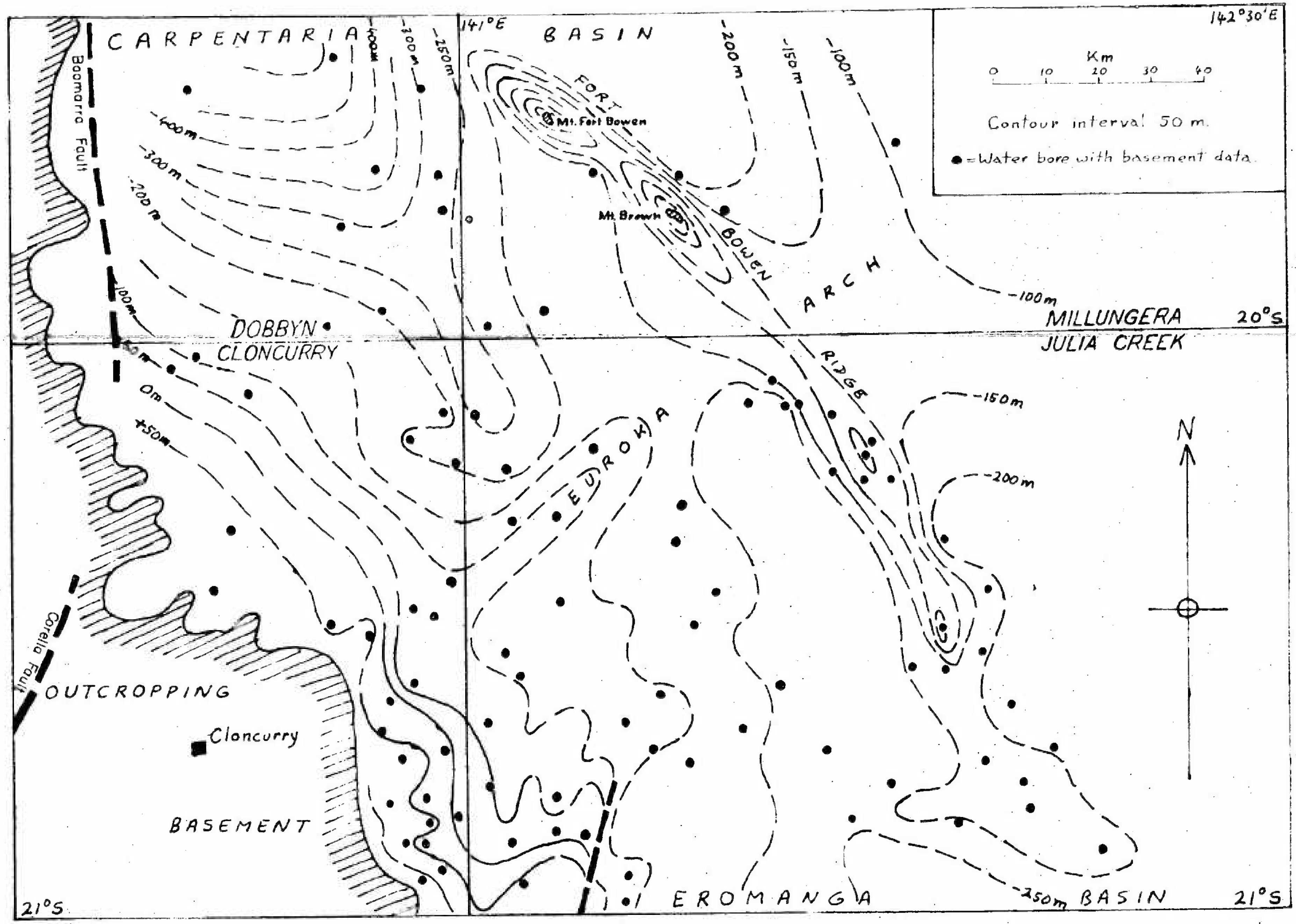
Probably the most important and unstudied geological aspect of soils is their role in the origin of sedimentary rocks. Two different origins of continental formations are illustrated by the Wyaaba Beds and Qm, both of which are partly consolidated and both of which have soils on them. This suggests that continental deposits can be modified by soil formation during lithification (cf. 'laterite' as a possible end result of a soil being modified by consolidation and lithification).

Marine and paralic formations may derive from a combination of provenance detritus and soils. The most striking coincidence in the report area is the co-existence of outcropping Cretaceous mudstone (in part calcareous), grey-brown cracking clay pedocal soils, and modern Gulf of Carpentaria calcareous muds, which contrast strongly with coastal plain sands. This mudstone/clay/mud group may add up to a straightforward bedrock/weathering detritus/soil/erosion/deposition sequence, but as copious sandy soil and sand is also available for transport to the Gulf, the sequence should perhaps not be so simple. However, river transport (and the pattern of rainfall involved) is probably a key factor, such sands as are transported being deposited on the coastal plain, where summer tides pond back summer floods, and the river meander belt suggests a decrease in river velocity and a pro-grading coast - only mud and clay can be carried out to sea.

The mineralogy of the clays of the provence rocks and soils and in the depositional area is unknown, and could throw much more light on the part played by soils in this area in the formation of sedimentary rocks. Tables 8 and 9 taken together indicate what provenance detritus is available at the present time for future sedimentary rock units, both terrestrial and marine.

Fig 39

BASEMENT STRUCTURE - CLONCURRY AND ADJACENT SHEETS



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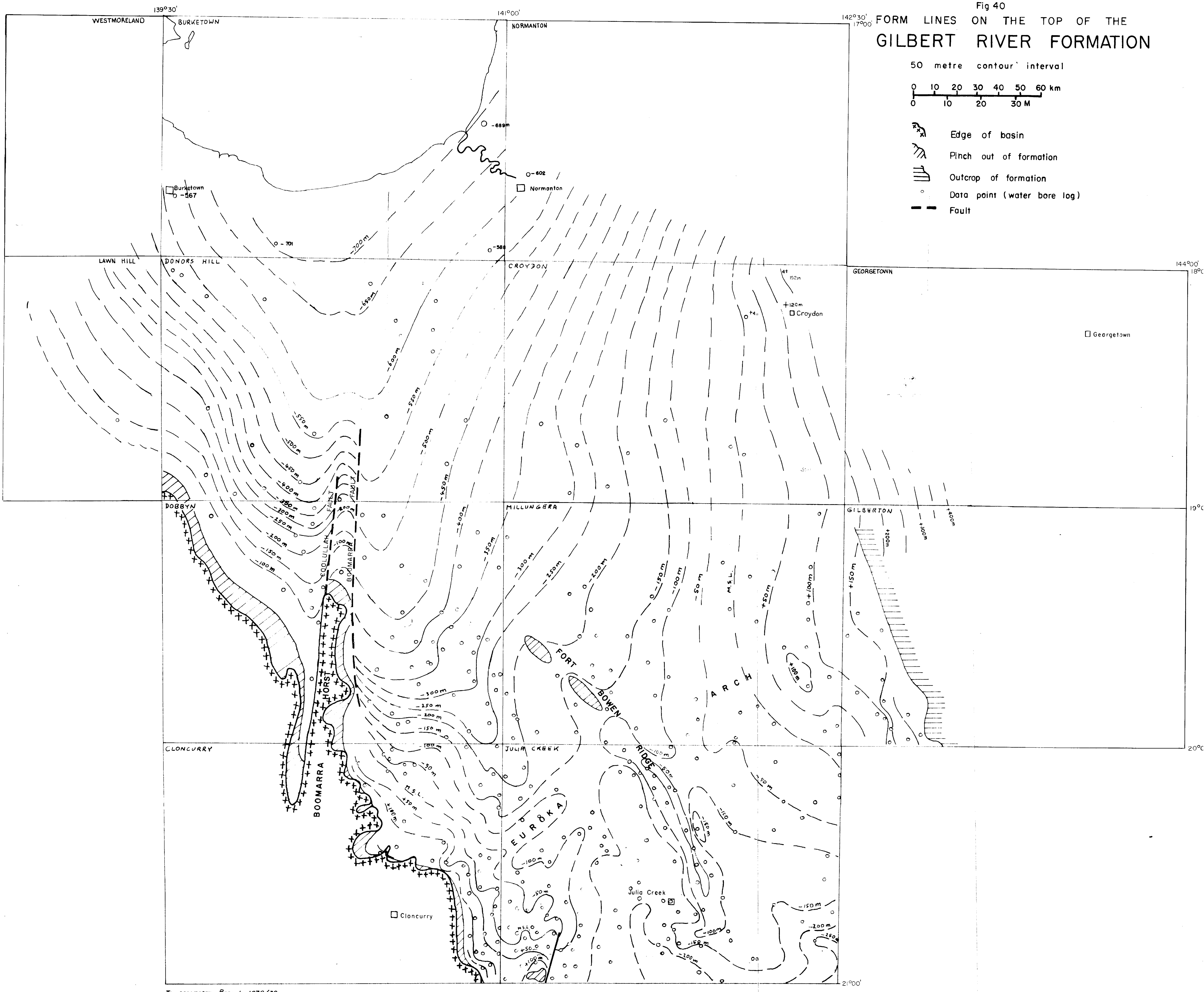


Fig 40

FORM LINES ON THE TOP OF THE GILBERT RIVER FORMATION

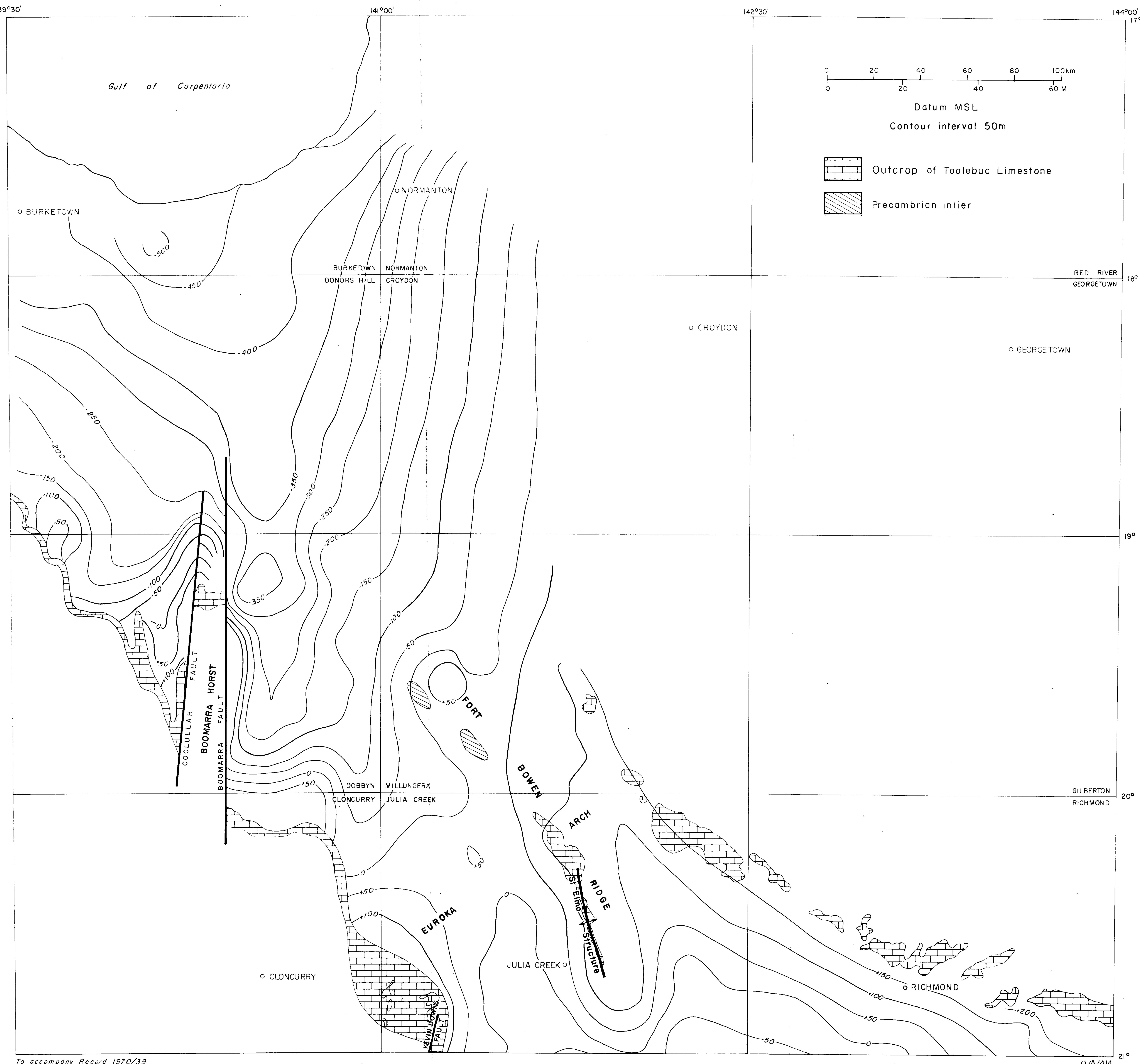


Fig 41 Structural contours on top of Toolebuc Limestone

STRUCTURE AND TECTONICS

General Structures of the southern Carpentaria Basin are detailed in Explanatory Notes by Ingram (in press a & b), Smart (in press a & b), Grimes (in press) and Doutch (in prep.).

The structural Carpentaria Basin is separated from the structural Eromanga Basin to the south by the complex Euroka Arch. North from the arch the Carpentaria Basin sediments have, in broad terms, the form of a syncline pitching to the north, modified by the Boomarra Horst and the basement monadnock inliers of the Fort Bowen Ridge. Tectonic folding on a local scale is not found in the basins. The western margin of the basin may be faulted in places; the eastern margin was uplifted and block faulted in the Pliocene.

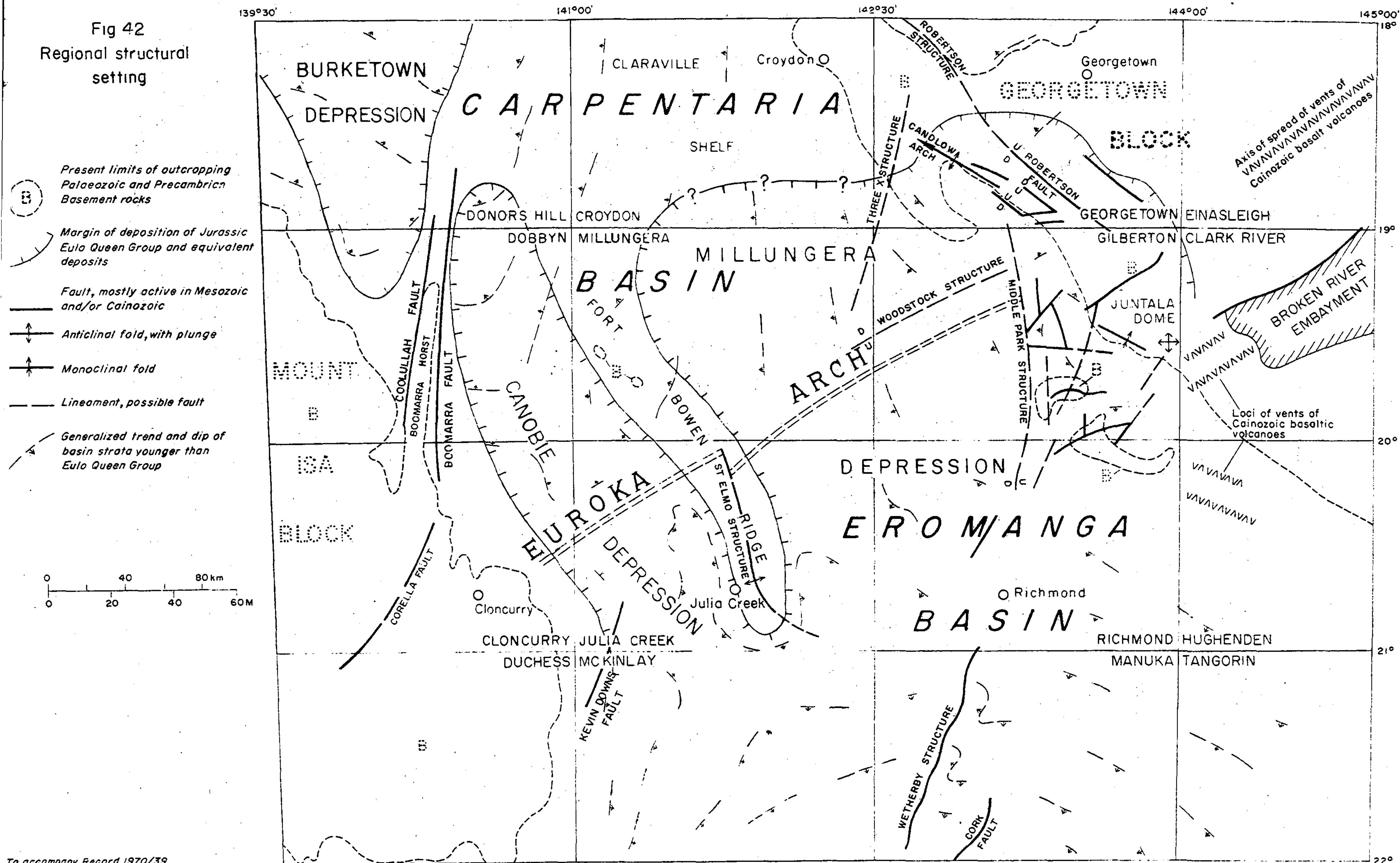
The Euroka Arch and the western margin of the basin: The term Euroka Arch is used to replace the 'Euroka Ridge' of Hill (1951), Mott (1952) Hill & Denmead (1960), Twidale (1956a, 1966b) and others. When using Euroka Ridge these authors usually relate the present day structural boundary between the Carpentaria and Eromanga Basins to a ridge or swell in the basement. We have already shown that no ridge existed during Jurassic times, when the Canobie and Millungera Depressions extended well to the north of the present structural boundary (Fig. 42). These depressions are flanked by faults which strike at right angles to the Euroka Arch (Fig. 42). No basement structures parallel the Euroka Ridge or its components. The basement connotations of the Euroka Ridge concept now needs modifying to such a degree that doing so would be pointless - there is little value in identifying a Euroka Ridge on Fig. 39.

The Euroka Arch is one specifically in terms of the regional dip of basin sediments away from it towards the centres of maximum sagging of the two basins. There is no evidence that the arch is the result of a simple localized uplift. On the contrary the trends on Figure 42 could be most readily interpreted as sags to the north and south of a hinge area between Cloncurry and the headwaters of the Clara River.

From this point of view the Boomarra Horst and the Fort Bowen Ridge are stable basement slices left upstanding while the rest of the basement sagged intermittently, deforming the Jurassic depressions. The St Elmo Structure (JULIA CREEK) formed by sagging on either side of the Fort Bowen Ridge during deposition of the Wallumbilla Formation (Vine, pers. comm.). There was sagging along the Boomarra Horst between Normanton and Floraville Formations times. Similarly the Cork Fault , the Wetherby Structure (Vine, 1966) and the lineaments extending north from them such as the Middle Park Structure (Fig. 42) could be the result of differential sagging of eastern and western parts of the Eromanga Basin, perhaps controlled in part by the suture between the Precambrian and Palaeozoic basements to the basin.

This interpretation of the origins of the Euroka Arch is oversimplified, implying that there were few if any structural movements during and before deposition of Carpentaria or Eromanga Basin sediments. The structural contours of Figures 40 and 41 suggest the implication is correct in terms of dislocations. However the isopachs that can be derived from these two figures show that the Wallumbilla (Blackdown) Formation is 50 m or more thicker over the Millungera Depression than elsewhere, and the little we know about the thickness of the Gilbert River Formation suggests much the same thing. So for this area sagging during deposition is possible, at a time when the same Cretaceous sediments were blanketing the stable areas of the Canobie and Burketown Depressions. The structural contours then must needs be interpreted as representing in part uplift and tilting of the Millungera Depression to the southwest after sedimentation.

Fig 42
Regional structural setting



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The Euroka Arch, then, is a structural and tectonic complex which was perhaps initiated by sagging during sedimentation in the basins, but which was not completed until after sedimentation ceased. Its completion by uplift in the north-east may have been in the Pliocene when the eastern margin of the Carpentaria Basin was uplifted.

The eastern margin of the basin: The Pliocene uplift of the eastern margin of the Carpentaria Basin has been outlined in 'Physiography' and 'Stratigraphy'. Regionally the uplift is a combination of tilting and block faulting. Fault displacement of Mesozoic rocks is small and vertical (Fig. 6). There is no deformation of Cainozoic units.

There are three groups of faults and lineaments which all converge in GILBERTON (Fig. 42). The first group is that to which belong both the northeast-trending northern extensions of the Wetherby Structure, such as the Middle Part Structure, and the northwest-trending faults and lineaments in GEORGETOWN, such as the Robertson Structure. These two sets of structures intersect in the vicinity of the Agate Creek Volcanics. The angle made by the intersection of these lineaments is bisected by the axis of the Euroka Arch. All these structures and lineaments may relate to the arch's creation by sagging before later uplift at its eastern end.

The second group consists of structures related to uplift and tilting of the Gilberton Plateau. Several faults and lineaments radiate south and west from the Juntala Dome just east of the Plateau (Fig. 42) and bedding dips are in the same directions. The dome predates Chudleigh Basalt extruded on its eastern flanks and may have been formed by initial upward movement of the basalt magma before eruption (cf King, 1949, on the Napak Area in Uganda).

The third group of lineaments is inferred from the northeasterly and northwesterly trends of vents in the McBride, Chudleigh, Nulla and Sturgeon Basalts in EINASLEIGH, CLARK RIVER and HUGHENDEN. These lineaments converge in the area of the Gilberton Plateau. The northeast-trending set parallels the fault boundary between the Palaeozoic Broken River Embayment and the Precambrian Georgetown Inlier. The volcanics post-date uplift, but the drainage history of the Gilbert River outlined in Physiography suggests that little time separated the two events, which may be genetically related.

The meaning of the lineament directions and convergences is not clear. The lineaments and faults are all roughly the same age, and are the result of basement movements; sagging in the sedimentary basins caused some faults, uplift along the eastern margin of the Carpentaria Basin caused others. Tectonic style is epeirogenic and tectonism is contemporaneous with orogenic uplift in New Guinea. It seems likely that some lineament directions are related to fundamental crustal structures such as the junction between Palaeozoic and Precambrian rocks.

Tectonically the southern Carpentaria Basin can be classified as a Platform, consisting of basin sediments as platform cover on a downwarped cratonic basement which probably consists of Precambrian rocks. The craton crops out flanking the basin, i.e., the platform cover, as the shield areas of the Mt Isa Block and Georgetown Inlier (strictly speaking the Euroka Arch area may not be covered by these definitions as it is not a downwarped area). These classifications are not intended to embody any implications about processes of origin.

Fig. 43 -Norman River Fault, GILBERTON, looking north east. On left, disrupted meandering drainage only partly occupied by modern creek.

(Neg. 1023)

Fig. 44 -'Exploding springs', north of Malpas Homestead, MILLUNGERA.

(Neg. 2914)

GEOLOGICAL HISTORY

The Carpentaria Basin apparently began to form in Jurassic times, when equivalents of the continental quartzose Eulo Queen Group of the northern Eromanga Basin were deposited in the ill-defined Burketown Depression.

This was followed by the blanketing of the Southern Carpentaria and northern Eromanga Basins by the quartzose Gilbert River Formation, which began as continental in late Jurassic times and finished as shallow marine in earliest Cretaceous times.

The muddy Wallumbilla Formation, Toolebuc Limestone and Allaru Mudstone were successively laid down in this early Cretaceous sea, which started to recede by the time the sandier Normanton Formation was deposited. Basin sagging accompanied marine sedimentation but apparently ceased soon afterwards.

A period of erosion and weathering, perhaps starting in late Cretaceous times, was responsible for the deposition of the Floraville Formation by the ancestral Leichhardt River, and culminated in alteration of it, and of Mesozoic rock outcrop, by deep weathering processes. Deep weathering occurred episodically in mid-Tertiary times, first producing laterite, then, after a period of weathering, and perhaps erosion, a duricrust. Ferricretes overlying the duricrust may have also been formed at this time.

Another period of erosion carved valleys which were eventually filled by alluvia of the late Cainozoic Wyaaba, Wondoola and Armraynald Beds. In the area covered by the Wyaaba Beds, erosion and subsequent deposition were in part hastened by uplift in Pliocene times on the eastern margins of the Eromanga and Carpentaria Basins. The uplift raised the basal sandstones by as much as 1000 m, and later erosion produced the Gilberton Plateau and Georgetown Inlier. Basalt was extruded along the eastern margins of the basins shortly after uplift ceased.

The late Cainozoic beds were mainly laid down during the Pleistocene. As sea level fluctuated erosion and deposition must have alternated. Only the latest of these fluctuations between 20,000 and 6,000 years ago, is readily recognizable, by the series of beach ridges running parallel to the present coast.

Erosion continued in some areas during deposition of the late Cainozoic beds, and the Donors Plateau is its most important result. Erosion continues there today and is also mildly affecting the late Cainozoic beds. Deposition at the moment is mainly along the coast.

ECONOMIC GEOLOGY

Groundwater

The hydrology of the Carpentaria Basin has been discussed by Ogilvie (1955).

The main aquifers are in the Gilbert River Formation, and in the Hampstead Sandstone of the underlying Eulo Queen Group. Smaller supplies are obtained from the Loth Formation, the basal sandstone beds of the Wallumbilla Formation, some of the Cainozoic alluvial deposits, and from ?Proterozoic dolomites.

Fig 45

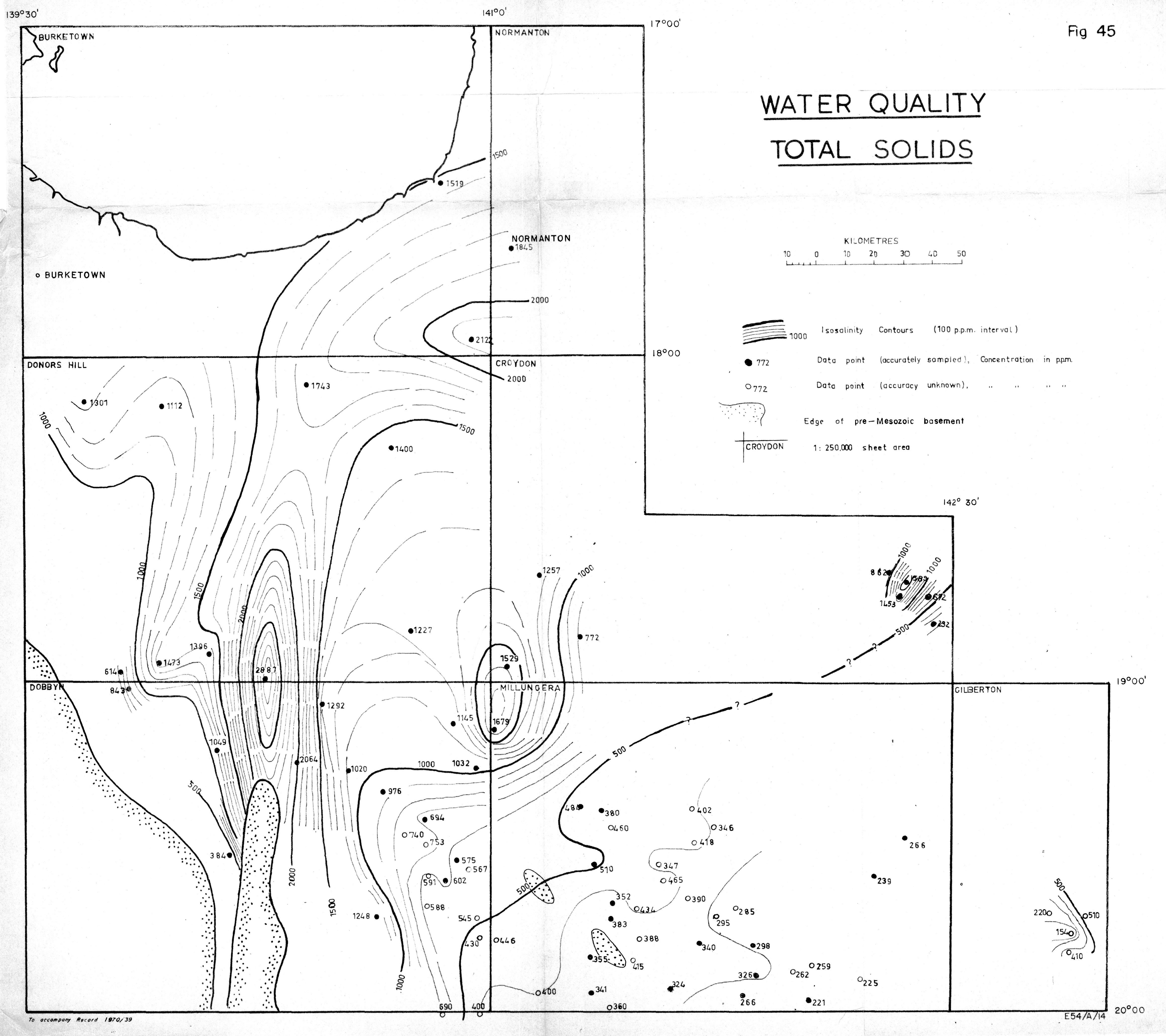
WATER QUALITY
TOTAL SOLIDS
KILOMETRES
10 0 10 20 30 40 50
1000 Isosalinity Contours (100 p.p.m. interval)
772 Data point (accurately sampled), Concentration in p.p.m.
772 Data point (accuracy unknown), " " " "
Edge of pre-Mesozoic basement
CROYDON 1:250,000 sheet area
139°30'
141°0'
17°00'
18°00
19°00'
20°00
142° 30'
BURKETOWN
NORMANTON
DONORS HILL
CROYDON
DOBBYN
MILLUNGERA
GILBERTON
To accompany Record 1970/39
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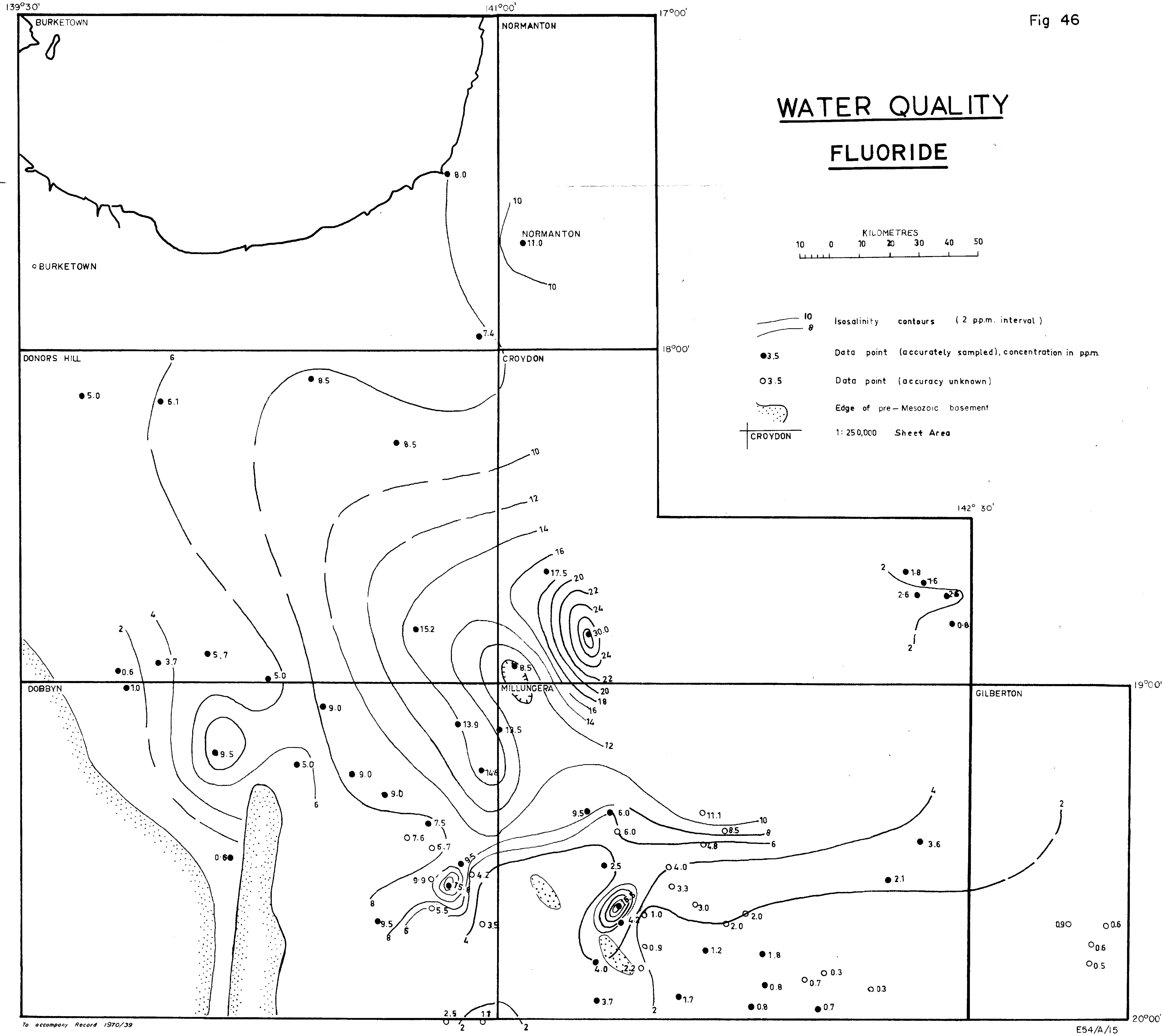
Fig 46



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Water is present in the Gilbert River Formation aquifer throughout the basin with the exception of the extreme western margin and a small area adjacent to the Precambrian inliers in Millungera. In these areas the sandstones pinch out against basement rocks. The formation crops out along the eastern margin of the basin, in a recharge zone. It has an average thickness of 45 m and reaches a maximum depth Ogilvie (1955) of 760 m in the northern part of the survey area. Figure 40 shows structural contours on the upper surface of the formation. The Eulo Queen Group which contains the Hampstead Sandstone aquifer is restricted to the Millungera Depression; there are equivalents of it in the Canobie and Burketown Depressions, beneath the Gilbert River Formation (Fig. 42). Its thickness varies from 0 to 150 m. The deposits in the Millungera depression crop out to the east below the Gilbert River Formation, in the same recharge zone. The deposits in the Burketown Depression do not crop out at the surface and the water in them is probably derived from the overlying sandstones of the Gilbert River Formation.

Water supplies are subartesian around the edge of the basin, but artesian in the central part. Flows as high as 3,000,000 gallons per day have been recorded, but most of the bores give supplies of less than 1,000,000 gallons per day.

The salinity of the waters from these aquifers is low in the southern part of the basin and on its western margin, but is greater than 1,000 p.p.m. of total solids over the rest of the area (see Fig. 45). No samples have been collected from the eastern margin of the basin. There is a marked area of higher salinity over the Boomarra Horst which is probably due to salts derived from its basement rocks.

Fluoride content is illustrated in Figure 46. Concentrations are generally higher than 4 p.p.m., the recommended safe limit for human consumption, and reach 30 p.p.m. in a few places. Fluoride content is notably higher in the Croydon area, where bedrock contains fluorine minerals (Ogilvie, 1955). High concentrations in other areas are probably also due to local concentrations of fluorides in the basement rocks underlying the sandstones.

Small supplies of generally saline water have been obtained from sandstone beds within the Rolling Downs Group. The Mid-Wood Burketown No. 1 well, which was converted to a water well, obtains its supplies from ?Proterozoic dolomite which underlies the Mesozoic sequence.

Cainozoic alluvial deposits on either side of the Donors Plateau are a potential source of water. Many wells passing through these deposits report soaks, and a supply of 21,600 gallons per day is recorded from Cainozoic deposits in Bore Reg. No. 14213 in MILLUNGERRA.

Mound springs occur in the Claraville plain in MILLUNGERA and GILBERTON (Fig. 44). These appear to be the result of water in the Gilbert River Formation breaking through the thin mudstone cover of the Wallumbilla Formation in this area. Pliocene block faulting may be responsible for their existence. Many of the springs have ceased flowing since pressure in the aquifer was reduced as it was tapped by bores, and others only flow intermittently.

TABLE 10 OIL WELLS AND WATER BORES WITH HYDROCARBON SHOWS

WELL/BORE	LOCATION	TOTAL DEPTH	TYPE OF SHOW	FORMATION	REFERENCE
F.B.H. 1 (Wyaaba)	19 29 30 141 37 22	2822 ft.	Nil		Derrington (195
A.A.O. 8 (Karumba)	17 24 36 140 52 22	2364 ft.	Slight brown oil staining and yellow fluorescence.	Gilbert River	Laing (1960)
D.S. Mornington Is. 1	16 32 44 139 15 27	2764 ft.	Tarry odour	Toolebuc	Harrison et.al. (1961)
D.S. Mornington Is. 2	16 29 13 139 31 11	3000 ft.	Dead oil staining Tarry odour, bituminous shales	Gilbert River Toolebuc	Harrison et.al. (1961)
M.W. Burketown 1	18 03 43 139 32 16	3323 ft.	Petroliferous odour, dead oil	Toolebuc	Perriman (1964)
Inverleigh West	18 10 139 32	2240 ft.	"oil and gas reported"	?	G.S.Q. (1960)
Inverleigh	17 55 00 140 05 10	2451 ft.	"Oil show"	Gilbert River	Delhi (1963)
Normanton	17 40 15 141 04 44	2330 ft.	"methane"	?	G.S.Q. (1960)
Vanrook	16 56 141 56	1612 ft.	"oil and gas"	?	G.S.Q. (1960)

Fresh water springs are present along part of the northern edge of the Donors Plateau on DONORS HILL where they occur at the junction of the deep weathered zone and the underlying unweathered Cretaceous rocks, which form an impermeable barrier to downwards movement of water in the plateau rocks.

Surface Water

Most of the rivers in the area flow only during the summer wet season. For the rest of the year surface water supplies are restricted to waterholes, some permanent, in the channels of the major rivers. The major rivers are salty or brackish up to 100 km inland. On MILLUNGERA surface water is provided away from the artesian bore heads by a network of bore drains. Small supplies can be obtained from spears sunk in the sandy beds of some of the rivers.

Petroleum

Table 10 is a list of the petroleum exploration wells in the area and of water bores from which petroleum shows were reported. No petroleum production has been achieved. Petroleum potential was discussed by Meyers (1969) and summarised by Allen & Hoogetorn (1970).

The shows are restricted to the Gilbert River Formation and the Toolebuc Limestone. The Gilbert River Formation is permeable, and is capped by mudstones over a wide area. Wherever penetrated by bores it yields fresh water, and petroleum shows are rare. Fault trap structures probably exist onshore; prospects may be better offshore where the formation is likely to be thicker.

Where known from bores and outcrop the Toolebuc Limestone is mainly shaly and its limestone beds, the most permeable rocks in the formation, total only a metre or so in thickness (see 'Stratigraphy'). The formation may be thicker and contain oil beneath the Gulf of Carpentaria.

The Limestones of the Toolebuc Limestone overlie high grade oil shale in the Julia Creek area. In BMR shallow stratigraphic holes Croydon 1 and Dobbyn 2 approximately 65 m of oil shale occurs below the limestone; its grade has not yet been established. This oil shale may be the source of the petroleum shows in the Toolebuc Limestone.

Limestone

Limestone beds in the Toolebuc Limestone contain 40% Ca and are suitable for use as a flux in smelting or for cement production. However the limestone beds are too thin to be economically workable.

The beach ridges on the margins of the gulf are in places formed almost entirely of shells and shell fragments. The deposits could be used as a smelting flux or for cement production. The unconsolidated nature of many of the deposits would facilitate extraction. There is an abandoned limestone quarry and kiln in a beach ridge on the southern end of Sweers Island.

Coal

Dunstan (1920) reports a seam of fair quality, non-coking coal in a seam of few centimetres thick in the Mesozoic beds of the Cabbage Tree Creek area in Cloncurry. Coal has also been reported in several bores in GILBERTON and RICHMOND where it occurs in the Jurassic sandstones. Drilling by the BMR (Grimes & Smart, 1970) and by Carpentaria Exploration Company (D. Crabb, pers. comm.) has shown that these seams are less than 2 centimetres thick.

Strontium

Veins of strontianite or celesite were found in excavations for an earth tank on Lorraine Station on DOBBYN in 'Tambo' Formation. The exact location is not known.

Gypsum

Needles, veins, and nodules of gypsum are common in the Rolling Downs Group in some areas. But no economic deposits have been found to date.

Salt

Deposits of salt occur in slight depressions on the mudflats at the margin of the gulf (in unit Qrp), where they are formed by evaporation of sea waters. They have been discussed by Jackson (1902) and Dunstan (1920). The deposits near Burketown are used locally for stock. Commercial production of salt is possible, but summer floods would create access and construction difficulties.

Road Materials

The gravel and ferricrete forming a thin cover over the duricrust is commonly used for surfacing dirt roads. The shelly sands of the beach deposits are also used for road surfacing. Flagstones of the Toolebuc Limestone are used locally to pave creek crossings and to protect earth tanks and bore heads from damage. There are large deposits of loose sand on the Millungera and Claraville Plains and elsewhere in the area.

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APPENDIX 1

REPORT ON COLLECTIONS OF MACROFOSSILS FROM THE CARPENTARIA BASIN SUBMITTED BY H.F. DOUTCH FOR INDENTIFICATION AND DATING

by S.K. Skwarko

Of the 22 collections of macrofossils of the Great Artesian Basin type collected during the 1969 field season by the Carpentaria Basin field party, and submitted subsequently for identification and dating, thirteen are of Albian age and belong to the Toolebuc Limestone, five are of Aptian age and may indeed represent the Gilbert River Formation as suggested by the field geologist, while of the remaining four, two are of undifferentiated Aptian-Albian age, while a Rhizocorallium may be of Aptian age, and one is an inorganic structure.

Although a few hitherto unknown fossils are present in the collections, there is no evidence of faunas older than Aptian or younger than Albian age.

CLONCURRY 1:250,000

CL 5: 332485 Cloncurry - 2 miles east of Granada Homestead. Photo Ref. Cloncurry RC-9 Run 1, Ph.67, Pt. Cl 5, Toolebuc Limestone, Lower Cretaceous. Collected by K.G. Grimes, June, 1969.

Aucellina Hughendensis (Etheridge Snr. 1872)
Inoceramus sp. indet
Fish vertebrae

Age: Albian
Suggested Toolebuc Limestone verified.

CL 55: 385433 Cloncurry - Courtenay Creek area, 6 miles west of Kennedys Hut. Photo Ref. Cloncurry RC-9, Run 4, Ph. 65, Pt. CL 55. Toolebuc Limestone, Lower Cretaceous. Collected by K.G. Grimes, June, 1969.

Inoceramus sp. indet
Vertebrae (Fish?) indet

Age: Albian
Suggested Toolebuc Limestone verified.

CL 73; 73A: 327485 Cloncurry, at Granada Hs. Photo Ref. Cloncurry RC-9, Run 1, Ph. 67, Pt. CL 73 Toolebuc Limestone, Lower Cretaceous. Collected by K.G. Grimes, June, 1969.

73: Aucellina hughendensis
Inoceramus sp. indet prisms

73A: Aucellina hughendensis
Inoceramus sp. indet prisms
?Labeceras (L.) laqueum (Etheridge Jnr. 1892)

Age: Albian
Suggested Toolebuc Limestone verified.

CROYDON 1:250,000

CR 105: 564697 Croydon, 14 miles ESE of Croydon on old Esmeralda Road, Photo Ref. Croydon RC-9, Run 3, Ph. 22, Pt. CR 105, Gilbert River Formation, Lower Cretaceous. Collected by H.F. Doutch, August, 1969.

Maccoyella cf. reflecta (Moore, 1870).

Age: Aptian
Suggested Gilbert River Formation verified on age only.

CR 108: 572680 Croydon, (Coffin (?) Hill), 25 miles SE of Croydon, on old Esmeralda Rd; 2 miles SW of Stanhill Battery. Photo Ref. Croydon RC-9, Run 4 Ph. 112 Pt. CR 108, Gilbert River Formation, Lower Cretaceous. Collected by H.F. Doutch, August, 1969.

Maccoyella aff. reflecta
Nototrigonia cinctuta (Etheridge Jnr. 1902)
?Tancretella plana (Moore, 1870)
?Thracia primula Hudleston, 1890
Astartid indet
Bivalve frags. indet
Natica variabilis Moore, 1870

Age: Aptian
Suggested Gilbert River Formation, verified on age only.

CR 109: 546733 Croydon, (Briden Hills), 10 miles north of Croydon - string of isolated mesas trending N.E. Photo Ref. Croydon RC-9, Run 1, Ph. 28, Pt. CR 109, Gilbert River Formation, Lower Cretaceous. Collected by H.F. Doutch and R.R. Vine, August, 1969.

"Phaenodesmia" elongata (Etheridge Snr. 1872)
Entolium sp. nov. ?
Maccoyella sp. (large)
?Eyrena linguloides (Hudlestone, 1884)
Maccoyella aff. subangularis Etheridge Jnr. 1892

Age: Aptian
Suggested Gilbert River Formation, verified on age only.

CR 113: 542717 Croydon, 3 miles N.W. of Croydon, NE (other side of road from) True Blue Hills, Photo Ref. Croydon RC-9, Run 2, Ph. 108, Pt. CR 113, Gilbert River Formation, Lower Cretaceous. Collected by H.F. Doutch and R.R. Vine, August, 1969.

Maccoyella cf. reflecta
Maccoyella sp.
Astartid indet
Bivalve frag. indet

Age: Aptian
Suggested Gilbert River Formation, verified on age only.

CR 114: 547714 Croydon, Mount Angus, 2 miles east of Croydon, Photo Ref. Croydon RC-9, Run 2, Ph. 106, Pt. CR 114, Gilbert River Formation, Lower Cretaceous. Collected by H.F. Doutch and R.R. Vine, August, 1969.

Maccoyella sp. nov. (imprint of a right valve, unusual because of smoothness)
Peratobelus cf. australia Phillips
"Rhynchonella" croydonensis Etheridge Jnr. 1892

Age: Aptian
Suggested Gilbert River Formation, verified on age only.

GEORGETOWN 1:250,000

GE 523: 648713 Georgetown, 28 miles WNW of Georgetown, Photo Ref. Georgetown RC-9, Run 2, Ph. 122, Pt. GE 523, Gilbert River Formation, Lower Cretaceous. Collected by H.F. Doutch, September, 1969.

Inorganic structure only.

GILBERTON 1:250,000

Gi 13: 606501 Gilberton, 1 mile north of Billican Bore, 6 miles SW of Etheldale, Photo Ref. Gilberton RC-9, Run 9, Ph. 28, Pt. Gi 13, Wallumbilla Formation, Lower Cretaceous. Collected by K.G. Grimes, August, 1969.

Rhizocorallium sp.

Age: ?Aptian.

Gi 17: 611502 Gilberton, 4 miles SW of Etheldale, Photo Ref. Gilberton RC-9, Run 9, Ph. 28, Pt. Gi 17, Wallumbilla Formation, Lower Cretaceous. Collected by K.G. Grimes, August, 1969.

Camptonectes sp. nov.

No dating available.

MILLUNGERRA 1:250,000

M 1: 459507 Millungera, Dalgonally Road, Flinders River, near Washpool Lagoon, ?Allaru Mudstone, Lower Cretaceous. Collected by H.F. Doutch, June, 1969.

Inoceramus etheridgei Etheridge Jnr. 1901.

M 9b: 488560 Millungera, 1 mile SW of Savannah Downs Hs., Photo Ref. Millungera Rc-9, Run 4, Ph. 156, Pt. M 9b, Toolebuc Limestone, Lower Cretaceous. Collected by K.G. Grimes, July, 1969.

Aucellina Hughendenensis
Inoceramus sp. indet.

Age: Albian
Suggested Toolebuc Limestone verified.

M 10: 488560 Millungera, 1 mile SW of Savannah Downs Hs., Photo Ref. Millungera RC-9, Run 4, Ph. 156, Pt. M 10, Toolebuc Limestone, Lower Cretaceous. Collected by K.G. Grimes, July, 1969.

Fish Scale
Inoceramus indet

Age: Albian
Suggested Toolebuc Limestone verified.

M 116: 436539 Millungera, Springs Waterhole, 6 miles WNW of Numil Hs., Photo Ref. Millungera RC-9, Run 6, Ph. 192, Pt. M 116, Collected by K.G. Grimes, July, 1969.

Several bememnites too badly eroded for identification. Some Inoceramus laths; probably Toolebuc Limestone.

Age: Albian.

M 120: 519502 Millungera, 3 miles NNE of Debella Hs., Photo Ref. Millungera RC-9, Run 8, Ph. 134, Pt. M 120, Toolebuc Limestone, Lower Cretaceous. Collected by K.G. Grimes, July, 1969.

Aucellina hugendenensis

Numerous fossil fragments not individually identifiable. Suggested Toolebuc Limestone probably correct.

M 124: 498536 Millungera, 4 miles E of Savanna Downs No. 1 Bore, Photo Ref. Millungera RC-9, Run 6, Ph. 178, Pt. M 124, Toolebuc Limestone, Lower Cretaceous. Collected by K.G. Grimes, July, 1969.

Aucellina hughendenensis
Inoceramus sp. indet

Age: Albian
Suggested Toolebuc Limestone verified.

M 127: 490558 Millungera, 1½ miles south of Savannah Downs Hs., Photo Ref. Millungera RC-9, Run 9, Ph. 156, Pt. M 127, Toolebuc Limestone. Lower Cretaceous. Collected by K.G. Grimes, July, 1969.

Numerous bone fragments. Probably Toolebuc Limestone as suggested.

M 129: 487567 Millungera, 4 miles NNW of Savannah Downs Hs., Photo Ref. Millungera RC-9, Run 4, Ph. 156, Pt. M 129, Toolebuc Limestone, Lower Cretaceous. Collected by K.G. Grimes, July, 1969.

Inoceramus sp. indet
Bivalve indet

Age: Albian
Suggested Toolebuc Limestone verified.

M 130: 485569 Millungera, 5 miles NNW of Savannah Downs Hs., Photo Ref. Millungera RC-9, Run 4, Ph. 156, Pt. M 130, Toolebuc Limestone, Lower Cretaceous. Collected by K.G. Grimes, July, 1969.

Shell bed made up of Inoceramus sp.

Age: Albian
Suggested Toolebuc Limestone verified.

M 131: 488560 Millungera, 1 mile SW of Savannah Downs Hs., Photo Ref. Millungera RC-9, Run 4, Ph. 156, Pt. M 131, Toolebuc Limestone, Lower Cretaceous. Collected by K.G. Grimes July, 1969.

Organic fragments numerous but individually not discernible, except for bone fragments. Sample has overall appearance of Toolebuc Limestone.

APPENDIX 2

PRELIMINARY REPORT ON MACROFOSSILS COLLECTED FROM THE COFFIN HILL MEMBER, GILBERT RIVER FORMATION DURING THE 1970 FIELD SEASON BY MEMBERS OF THE CARPENTARIA GULF GEOLOGICAL PARTY

by S.K. Skwarko

CROYDON 1:250,000 Sheet area

Photo points

Cr 700: Briden Hills, about 10 miles N of Croydon.
RC-9,
Run 1,
Photo 28

Grammatodon (Indogrammatodon) robusta Etheridge Snr.
Austrotrigonia prima Skwarko, 1963 subsp. nov:
Bivalvia indet.
Gastropod

Suggested age: Aptian

Cr 701: As above, but stratigraphically below Cr 700, in the same mesa.
RC-9,
Run 1,
Photo 28

Bivalvia indet.

Suggested age: Aptian (on stratigraphical evidence).

Cr 702: As above, but stratigraphically below Cr 701, in the same mesa.
RC-9,
Run 1,
Photo 28

Yoldia sp.
Thracia wilsoni Moore, 1870

Suggested age: Aptian

Cr 703: Mesa north of Normanton-Croydon Rd, about 2 miles N of Croydon.

Maccoyella sp. indet. aff. barklyi (Moore, 1870)
Trigonia sp. indet. (?Nototrigonia)
Bivalve indet.

Suggested age: ?Aptian

Cr 704: Mesa just south of the Normanton - Croydon road, about 2.1 miles north of Croydon.

Maccoyella barklyi var. mariaeburiensis Etheridge Jnr, 1892
Entolium sp.
Ostreidae indet.
Vulsella? sp. nov.
Mytilus? sp.
Austrotrigonia prima Skwarko, 1963 subsp. nov.
Bivalvia indet.
Siphonaria stanwelli Etheridge Jnr., 1892
Natica variabilis Moore, 1870
Rhynchonella croydonensis Etheridge Jnr., 1892

Suggested age: classically regarded as Aptian, but individual species are not known outside this area, and their age has never been checked against key Aptian fossils.

APPENDIX 3

MACROPALAEONTOLOGICAL REPORT ON CLONCURRY (B.M.R.) NO. 1 CORES 2 & 5, DOBBYN (B.M.R.) NO. 1 CORES 3 & 7 AND DOBBYN (B.M.R.) NO. 2 CORES 4, 6, and 7.

by S.K. Skwarko

CLONCURRY NO. 1: Core 2 (190'00" - 198'10") (Wallumbilla Formation)
Small and indeterminate shell fragments at 193'00" and 195'10", and a *Dentalium* sp. at 198'10". No dating closer than Cretaceous for the *Dentalium* sp. is possible.

Core 3 (280'00" - 288'6") (Wallumbilla Formation)
Some fragments of bivalves and a small fragment of a belemnite guard at 282'5". No dating closer than Lower Cretaceous is possible on the basis of the fragment of belmnite.

Core 5 (490'00" - 499'00") (Wallumbilla Formation)
A number of shell fragments too incomplete for identification at 493'10" - 495'9" interval, and a few more fragments at 495'5" - 499'00" interval. No dating possible.

DOBBYN NO. 1: Core 3 (240'00" - 250'00") (Toolebuc (Kamileroi) Limestone)
Numerous fragments and tests of *Inoceramus* spp. and *Aucellina hughendenensis*. Age: Upper Albian.

Core 7 (490'00" - 500'00") (Wallumbilla (Blackdown) Formation)
No definite organic remains observed. Inorganic structures simulating concentric organic structures.

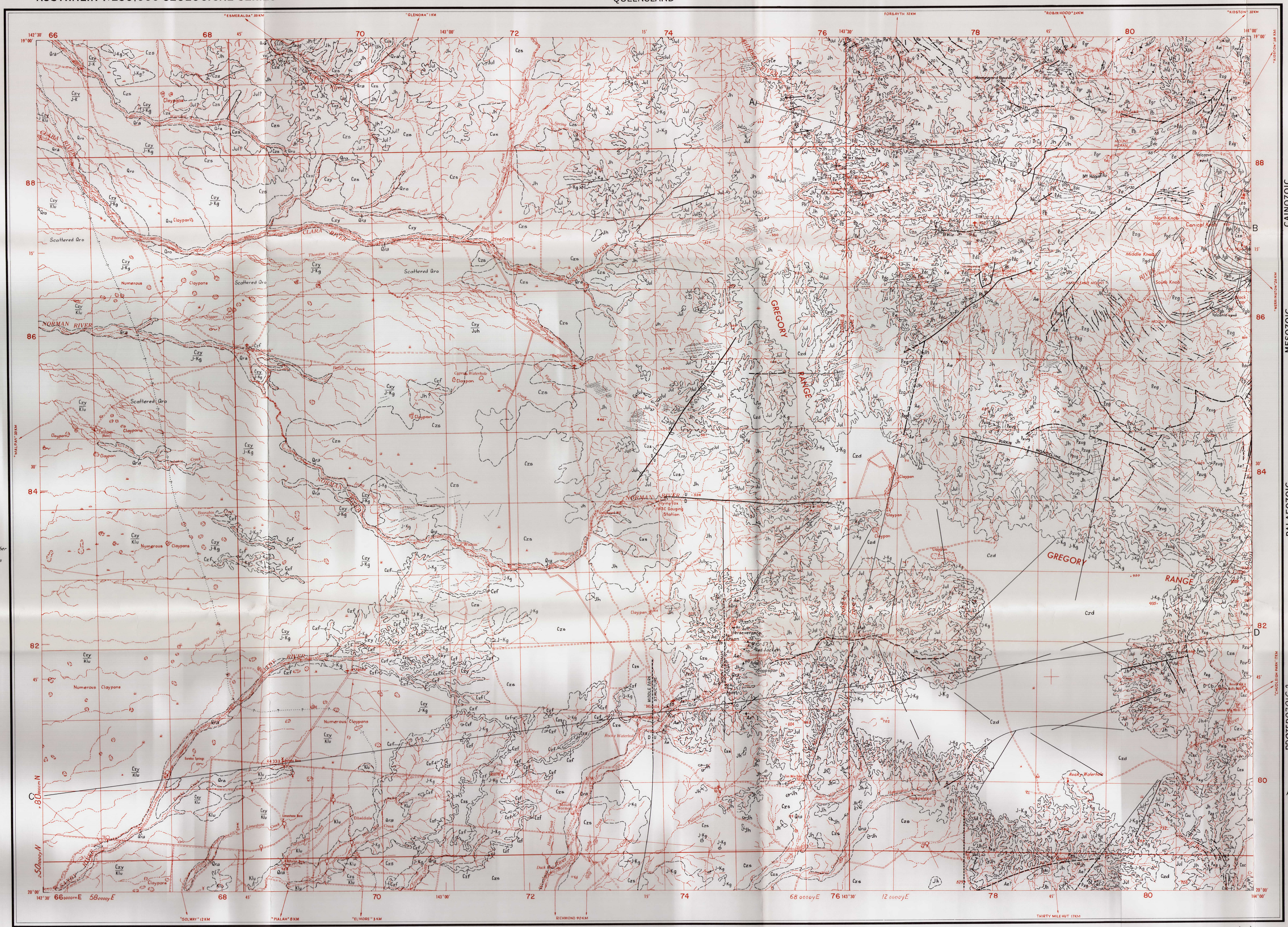
DOBBYN NO. 2: Core 4 (200'00" - 210'00") (Allaru Mudstone)
At least one species of *Inoceramus* is present here, indicating Lower Cretaceous age.

Cores 6 (375'00" - 385'00") and 7 (385'00" - 395'00") (Toolebuc (Kamileroi) Limestone)
No definite organic remains observed. Inorganic structures present simulating concentric organic structures.

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

GILBERTON
QUEENSLAND

SHEET SE 54-16



Reference

- Geological boundary
- Anticline, showing plunge
- Syncline, showing plunge
- Overturned syncline
- Monocline
- 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

- Plunge of drag fold
- Strike and dip of strata
- Strike and dip of foliation
- Vertical foliation
- Dip < 15° } air-photo interpretation
- Trend line } air-photo interpretation
- Joint pattern } air-photo interpretation
- Lineament } air-photo interpretation
- Plant fossil locality
- Measured section
- Dyke, r-rhyolite, s-syenite, p-pegmatite

- Mine
- Ae Agate
- Au Gold
- Bi Bismuth
- Cu Copper
- Pb Lead
- W Tungsten

- Artesian bore
- Sub-artesian bore

R4333 refers to bore registered number of the Queensland Irrigation and water Supply Commission records

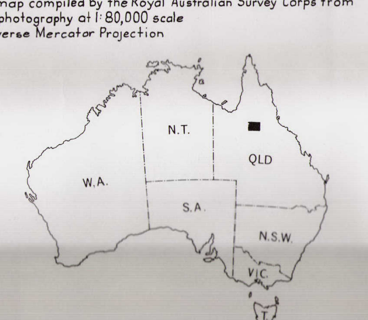
- Windpump
- Earth tank
- Dam
- Waterhole
- Spring
- Swamp

- Road
- Vehicle track
- Landing ground
- "Gilberton" Homestead
- Building
- Yd Yard
- Fence
- Astronomical station
- ·702 Elevation in metres–approximate

Reference

CAINOZOIC	QUATERNARY		Qra	Modern alluvium: quartzose sand; silt and clay
			Qro	Floodout alluvium: yellow quartzose sand
	PLIOCENE	Lynd Formation	Czy	Clayey quartzose sand and sandstone
		Chudleigh Basalt	Czc	Olivine basalt
			Czs	Colluvial and outwash sand and silt
	LATE CRETACEOUS TO EARLY TERTIARY		Czf	Ferruginous lithified gravel (ferricrete)
			Czd	Lithified soil and colluvial detritus
MESOZOIC	LOWER CRETACEOUS	Wallumbilla Formation	Klu	Mudstone, minor glauconitic sandstone, limestone
		Gilbert River Formation	J-Kg	Quartzose sandstone and conglomerate, minor siltstone
	JURASSIC	Eulo Queen Group: Loth Formation	Jul	Quartzose sandstone, siltstone, clayey sandstone
		Eulo Queen Group: Hampstead Sandstone	Jh	Quartzose sandstone and conglomerate
			J	Sandstone, siltstone and shale. Section only
PALAEOZOIC	UPPER PALAEOZOIC		Pzu	Rhyolite, quartz porphyry, syenite
			Pzug	Granite
	LOWER TO MIDDLE PERMIAN	Agate Creek Volcanics	Pa	Ignimbrite, rhyolite, agglomerate, basalt, sediments
	MIDDLE CARBONIFEROUS TO LOWER PERMIAN	Elizabeth Creek Granite	Pgz	Pink microadamellite
		Bagstowe Ring Dyke Complex	Pga	Pink microadamellite (Boundaries of individual dykes shown where mappable)
			Pgb	Pink and grey rhyolite
			Pgc	Andesite
			Pgd	Microgranodiorite
		Butlers Ignimbrite	Pb	Ignimbrite
	UPPER DEVONIAN TO LOWER CARBONIFEROUS	Gilberton Formation	D-Cg	Arkose, conglomerate and shale
		Bundock Creek Formation	D-Cb	Arkose, lithic sandstone and conglomerate, siltstone
	UPPER SILURIAN TO LOWER DEVONIAN	Dumbano Granite	Pzg	Grey biotite granite, adamellite, granodiorite, granite gneiss
	PROTEROZOIC OR CARBONIFEROUS	Croydon Ignimbrite	Pvc	Ignimbrite, rhyolite, rhyolite-porphyry
PROTEROZOIC ?		Forsayth Granite	Pgf	Grey porphyry biotite, adamellite, granodiorite
		Robin Hood Granite	Pgr	Pink, grey hornblende-biotite granite, adamellite, granodiorite
		Cobbold Dolerite	Pdc	Dolerite and amphibolite
		Bernecker Creek Formation	Pb	Calacreous sandstone and siltstone, calc-silicate hornfels, marble
		Paddys Creek Formation	Pp	Quartzite, quartz phyllite
		Etheridge Formation	Pe	Shale, siltstone, sandstone, chert
ARCHAEAN		Einasleigh Metamorphics	Ae	Granulite, gneiss, migmatite, amphibolite, schist, quartzite

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, Issued under the authority of the Hon. R.W. Swatz, M.B.E, E.D., Minister for National Development.
Base map compiled by the Royal Australian Survey Corps from aerial photography at 1:80,000 scale
Transverse Mercator Projection



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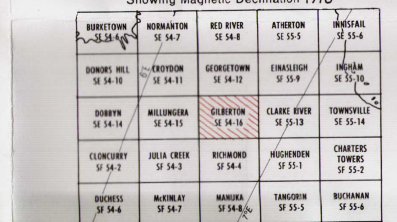
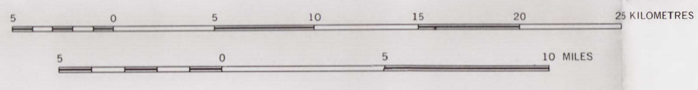
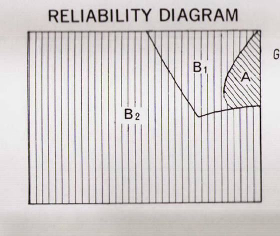


Scale 1:250,000

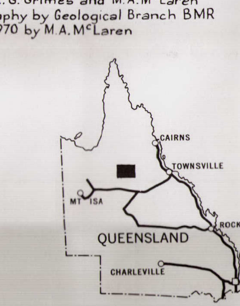


RELIABILITY DIAGRAM

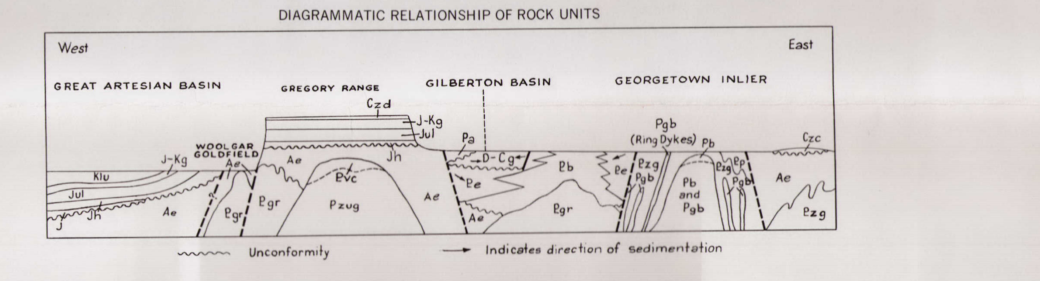


Geology
A Detailed mapping
B_1 Detailed reconnaissance: numerous traverses
B_2 General reconnaissance: many traverses and air-photo interpretation.

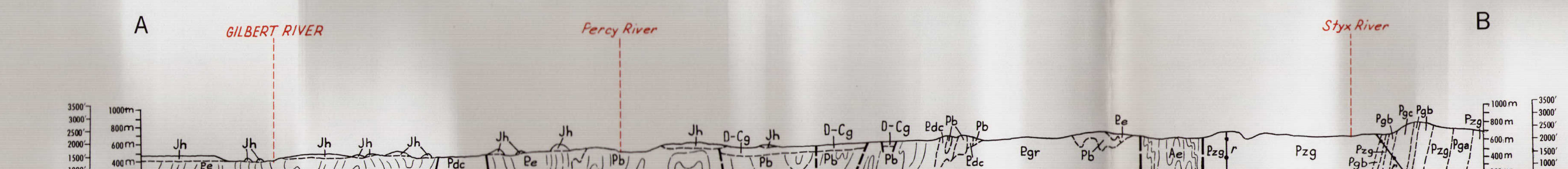
Geology 1956-1958 by D.A. White, C.D. Branch, K. Hughes (B.M.R.); D.H. Wyatt, Geological Survey of Queensland
Geology 1969 by H.F. Doutch, J.A. Ingram, J. Smart (B.M.R.); K.G. Grimes, Geological Survey of Queensland
Compiled 1969 by H.F. Doutch, J.A. Ingram, J. Smart, K.G. Grimes and M.A. McLaren
Cartography by Geological Branch BMR
Drawn 1970 by M.A. McLaren

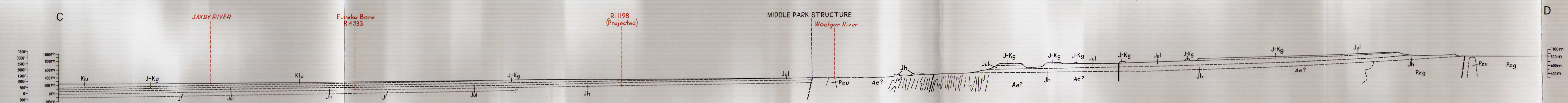


DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Sections
Cainozoic sediments omitted
Scale $\frac{V}{H} = 4$





PRELIMINARY TO SECOND EDITION, 1970
SUBJECT TO AMENDMENT

GILBERTON
SHEET SE 54-16

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

DOBBYN
QUEENSLAND

SHEET SE 54-14

Reference

CAINOZOIC

QUATERNARY
- Qra — Modern alluvium: sand and silt
- Qf — Older alluvium: quartzose sand and silt, minor clay
- Qt — Travertinous limestone

- Czr — Red and brown sand, silt and clay
- Czs — Colluvial and outwash sand
- Czg — High level gravel and sand

LATE CRETACEOUS TO EARLY TERTIARY
- Czd — Lithified deeply weathered detritus, brecciated, ferruginous
- (stippled) — Chemically altered (kaolinized, ferruginized) sediments
- Floraville Formation — Tfl — Quartzose sandstone and conglomerate

MESOZOIC

LOWER CRETACEOUS
- Normanton Formation — Kln — Labile sandstone, siltstone, minor mudstone, limestone
- Allaru Mudstone — Kla — Mudstone and siltstone, minor labile sandstone
- Kamileroi Limestone — Klk — Limestone, calcareous shale
- Blackdown Formation — Klb — Mudstone and siltstone, minor limestone; some labile sandstone near base

UPPER JURASSIC TO LOWER CRETACEOUS
- Gilbert River Formation — J-Kg — Quartzose sandstone and conglomerate, minor shale
- M — Sandstone, siltstone, shale

(J-Kg and M: Section only)

PRECAMBRIAN
- p€ — Metamorphosed sedimentary and igneous rocks, granite

Geological boundary

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

Where location of boundaries and faults is approximate, line is broken; where concealed, faults are shown by short dashes

•Mn Minor mineral occurence-manganese

⊗St Stratigraphic hole

Sub-artesian bore of Blackdown or younger aquifer system

Artesian bore / Sub-artesian bore — of pre-Blackdown aquifer system

R15675 refers to bore registered number of the Queensland Irrigation and Water Supply Commission records

Abandoned bore

Windpump

Earth tank

Dam

Waterhole

Swamp

Road

Vehicle track

Landing ground

■ "Canobie" Homestead

Building

Yd Yard

Fence

Telephone line

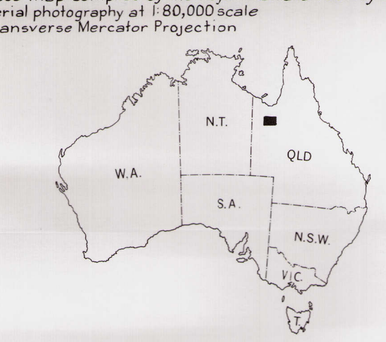
Astronomical station

•271 Elevation in metres-approximate

pa Position approximate

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon R.W. Swartz, M.B.E, E.D., Minister for National Development.
Base map compiled by the Royal Australian Survey Corps from aerial photography at 1:80,000 scale
Transverse Mercator Projection

NOTE ON GRID COORDINATES
Brown lines with black italic numbers (numbers shown only at SW corner of map and change of zone), indicate the 10,000 yard grid, Zone 6 (Australia Series), CLARKE 1858 SPHEROID. Transverse Mercator Projection
Brown numbered ticks (with larger upright numbers), inside the neatline are 20,000 metre intervals of the superimposed Australian Map Grid, Zone 54 AUSTRALIAN NATIONAL SPHEROID. Transverse Mercator Projection



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MOUNT DRUMMOND SE 53-12	LAWN HILL SE 54-9	DONORS HILL SE 54-10	CROYDON SE 54-11	GEORGETOWN SE 54-12
RANKEN SE 53-16	CAMOOWEAL SE 54-13	DOBBYN SE 54-14	MILLUNGERA SE 54-15	GILBERTON SE 54-16
AVON DOWNS SF 53-4	MOUNT ISA SF 54-1	CLONCURRY SF 54-2	JULIA CREEK SF 54-3	RICHMOND SF 54-4
SANDOVER RIVER SF 53-8	URANDANGI SF 54-5	DUCHESS SF 54-6	McKINLAY SF 54-7	MANUKA SF 54-8

ANNUAL CHANGE 0°30"E

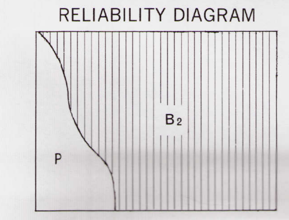
Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

Geology 1969 by J. Smart
Compiled 1969 by J. Smart and M.A. McLaren
Cartography by Geological Branch BMR
Drawn 1970 by M.A. McLaren

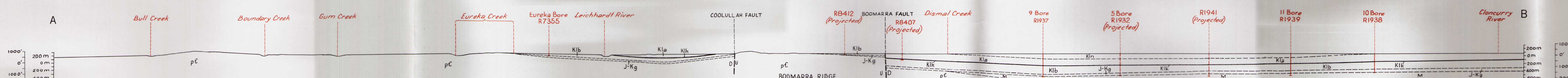
RELIABILITY DIAGRAM



Geology B2 General reconnaissance: many traverses, and air-photo interpretation.

P Published 1958 at 4 miles to 1 inch scale as Dobbyn sheet E54-14

Sections
Cainozoic sediments omitted
Scale $\frac{V}{H} = 4$



PRELIMINARY TO SECOND EDITION, 1970
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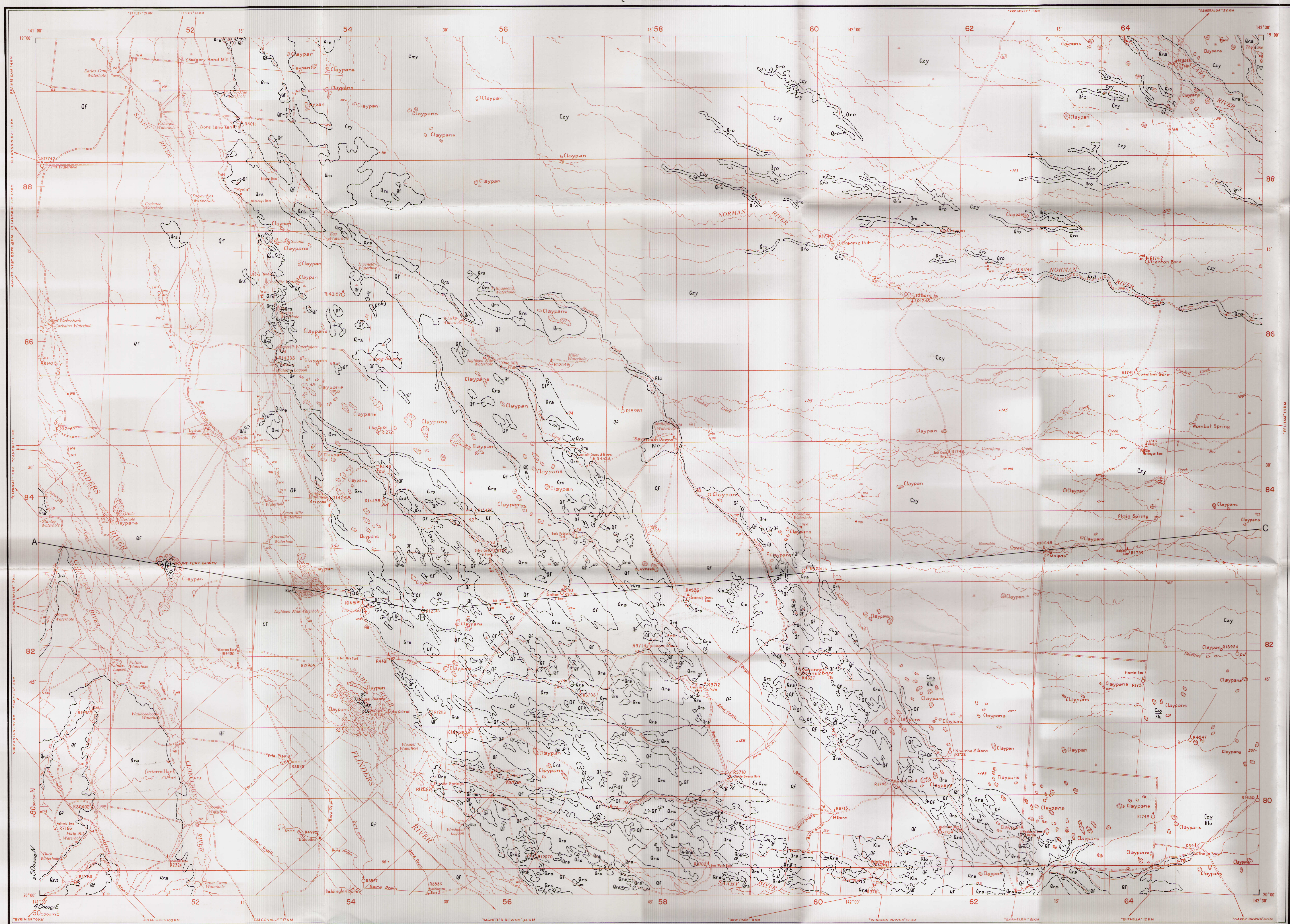
DOBBYN
SHEET SE 54-14

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

MILLUNGERA

QUEENSLAND

SHEET SE 54-15



Reference

CAINOZOIC — QUATERNARY

Qra	Modern alluvium: red sand; silt and pebbles
Qro	Floodout alluvium: quartzose sand
Qrs	Red and yellow quartzose sand
Qf	Older alluvium: sand, clayey sand and sandy clay; grey clay soil at surface
Czy	Clayey quartzose sand and sandstone

MESOZOIC — LOWER CRETACEOUS — Rolling Downs Group

Allaru Mudstone	Kla	Mudstone: minor limestone, labile sandstone
Toolebuc Limestone	Klo	Limestone, coquinite, calcareous shale
Wallumbilla Formation	Klu	Mudstone, minor glauconitic sandstone
	J-Kg	Quartzose sandstone and conglomerate, shale (Section only)
	M	Quartzose sandstone and siltstone (Section only)

PRECAMBRIAN

p€	Metasediments and schist

Geological boundary

Fault

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

25 Dip and strike of strata

Trend line - air-photo interpretation

Artesian bore
Sub-artesian bore — Producing mainly from Gilbert River Formation or older aquifer systems
Abandoned bore

R1739 refers to bore registration number of the Queensland Irrigation and Water Supply Commission records

Windpump

E Earth tank

WH Waterhole

Spring

Swamp

Road

Vehicle track

Landing ground

"Malpas" Homestead

Building

Yd Yard

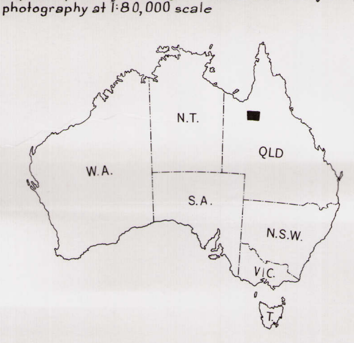
Fence

Astronomical station

187 Elevation in metres - approximate

pd Position doubtful

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. R.W. Swartz, M.B.E., E.D., Minister for National Development. Base map compiled by the Royal Australian Survey Corps from aerial photography at 1:80,000 scale



NOTE ON GRID COORDINATES

Brown lines with black italic numbers (numbers shown only at SW corner of map and change of zone), indicate the 10,000 yard grid, Zone 6 (Australia Series), CLARKE 1858 SPHEROID. Transverse Mercator Projection

Brown numbered ticks (with larger upright numbers), inside the neatline are 20,000 metre intervals of the superimposed Australian Map Grid, Zone 54 AUSTRALIAN NATIONAL SPHEROID. Transverse Mercator Projection

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WEST-MORELAND SE 54-5	BURKETOWN SE 54-6	NORMANTON SE 54-7	RED RIVER SE 54-8	ATHERTON SE 55-5
LAWN HILL SE 54-9	DONORS HILL SE 54-10	CROYDON SE 54-11	GEORGETOWN SE 54-12	EINASLEIGH SE 55-9
CAMOOWEAL SE 54-13	DOBBYN SE 54-14	MILLUNGERA SE 54-15	GILBERTON SE 54-16	CLARKE RIVER SE 55-13
MOUNT ISA SF 54-1	CLONCURRY SF 54-2	JULIA CREEK SF 54-3	RICHMOND SF 54-4	HUGHENDEN SF 55-1
URANDANGI SF 54-5	DUCHESS SF 54-6	McKINLAY SF 54-7	MANUKA SF 54-8	TANGORIN SF 55-5

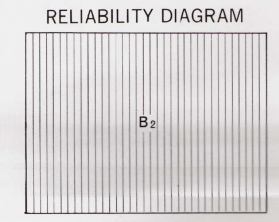
ANNUAL CHANGE 0°42'E

Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

RELIABILITY DIAGRAM



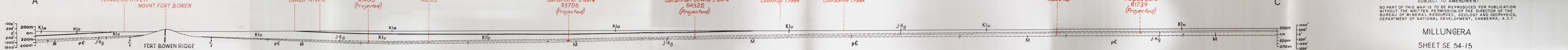
Geology B_2 General reconnaissance: many traverses, and air-photo interepretation

Geology 1969 by K.G. Grimes, Geological Survey of Queensland
Compiled 1969 by K.G. Grimes and M.A. McLaren
Cartography by Geological Branch BMR
Drawn 1970 by M.A. McLaren

Section

Cainozoic sediments omitted

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



PRELIMINARY EDITION, 1970

SUBJECT TO AMENDMENT

MILLUNGERA

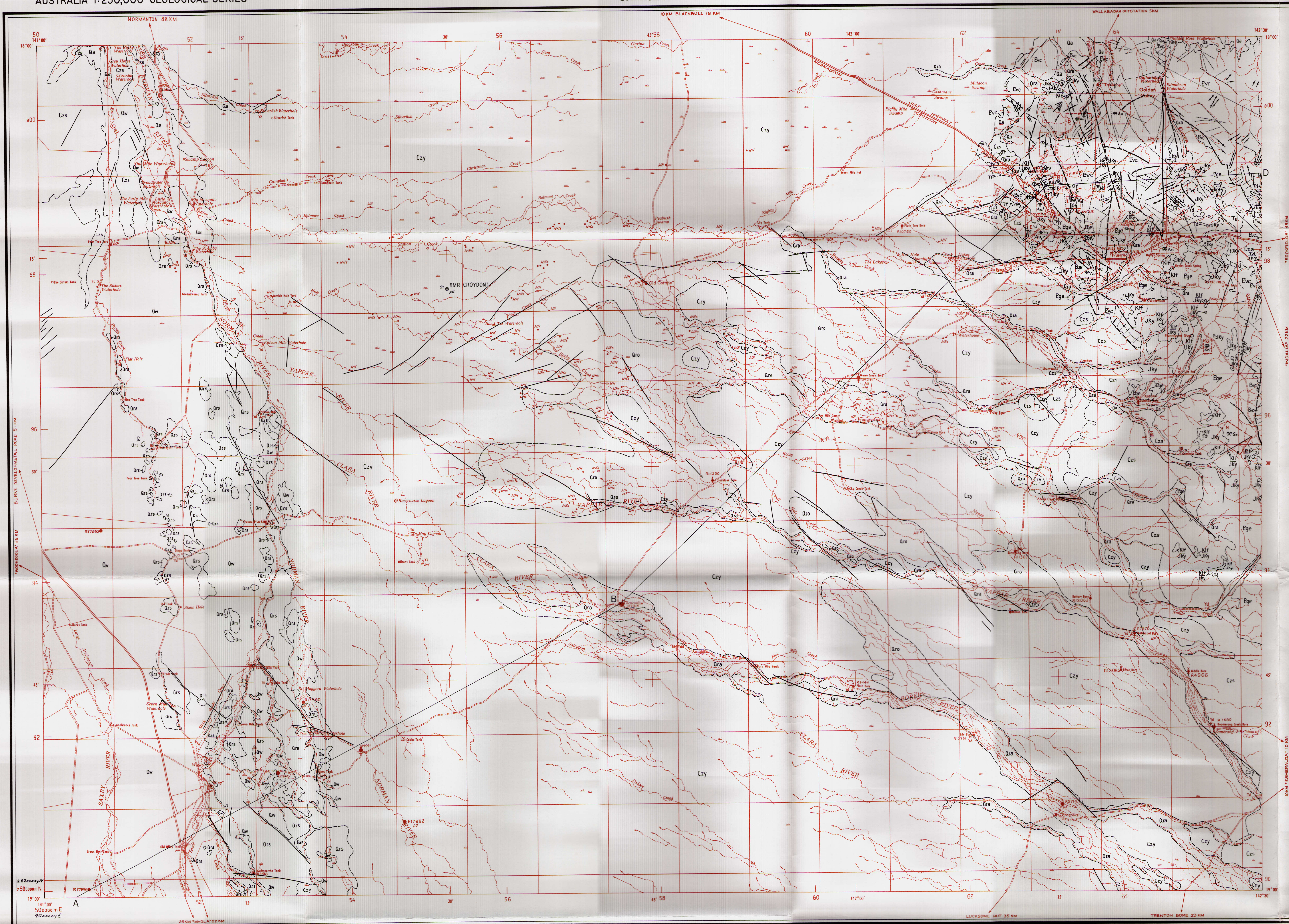
SHEET SE 54-15

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

CROYDON

QUEENSLAND

SHEET SE 54-11



Reference

(symbol)	Groups of abandoned mines
Au	Gold
Sn	Tin
-------	Mining area boundary

Gold Mines

A	Golden Valley Group
B	Tabletop Group
C	Twelve Mile Group
D	Golden Gate Group
E	Croydon Group
F	Croydon King Group
G	Mountain Maid Group
H	Homeward Bound Group
I	Mark Twain Group
J	Mulligan Group
K	Boomerang Group
L	Empress Group

Tin Mines

M	Mt. Cassiterite Group
N	Stanhills Tin Field

Reference

CAINOZOIC	QUATERNARY		Qa	Undivided flood plain alluvium: sand and clay	
			Qra	Stream bed sediments: quartzose sand, silt, clay	
			Qro	Floodout sediments: quartzose sand, silt, clay	
			Qrs	Red and yellow quartzose sand	
		Wondoola Beds	Qw	Fluvial deposits: clay and clayey sand	
		Wyaaba Beds	Czy	Clayey quartzose sand and sandstone	
			Czs	Colluvial and outwash deposits: quartzose sand and gravel	
	TERTIARY ?		Tf	Pisolitic laterite; ferricrete	
			Td	Lithified soil and colluvium, brecciated ('duricrust')	
MESOZOIC	LOWER CRETACEOUS	ROLLING DOWNS GROUP: Allaru Mudstone	Kla	Mudstone, minor limestone and labile sandstone	section only
		Toolebuc Limestone	Klo	Limestone, calcareous shale	section only
		Wallumbilla Formation	Klu	Mudstone, minor limestone; quartz-poor clayey sandstone in outcrop	
		Coffin Hill Member	JKg / Klf	Clayey sandstone, siltstone, conglomerate; shelly fossils	
	UPPER JURASSIC TO LOWER CRETACEOUS	Gilbert River Formation	JKg	Quartzose sandstone, minor conglomerate, siltstone shale; plant fossils	
		Yappa Member	JKg / JKy	Quartzose sandstone, minor conglomerate, siltstone shale; plant fossils	
PALAEOZOIC		Esmeralda Granite	Pge	Grey biotite granite	
		Croydon Ignimbrite	Pvc	Rhyolite and ignimbrite	
PRECAMBRIAN ?			p€	Basement rocks to Carpentaria Basin (may include Pge and Pvc)	section only

-------	Geological boundary
———	Fault

where location is approximate, line is broken; where inferred, queried; where concealed, shown by short dashes

———	Lineament	air-photo interpretation
	Joint pattern	air-photo interpretation
— — —	Trend line	air-photo interpretation
⊗St	Stratigraphic hole	
	Marine macrofossil locality	
	Plant fossil locality	
	Vein, dyke (commonly quartz)	
●	Bore	
	Artesian bore	of pre-Wallumbilla artesian aquifer system
	Sub-artesian bore	of pre-Wallumbilla artesian aquifer system

R17692 referes to bore registration number of Queensland Irrigation and Water Supply Commission's records

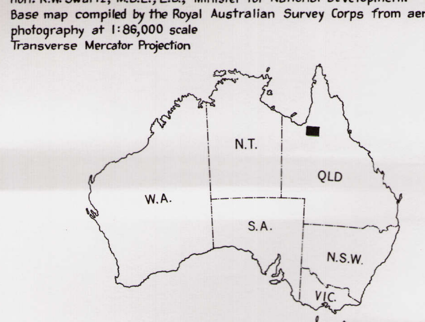
	Windpump
□S	Water storage
	Dam
WH	Waterhole
	Spring, intermittent
	Swamp
	Highway
	Road
	Vehicle track
	Railway - with station and siding
■"Prospect"	Homestead
■	Building
□Yd	Yard
	Fence
⊕	Astronomical station
pd	Position doubtful

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. R.W. Swartz, M.B.E., E.D., Minister for National Development.
Base map compiled by the Royal Australian Survey Corps from aerial photography at 1:86,000 scale
Transverse Mercator Projection

NOTE ON GRID COORDINATES

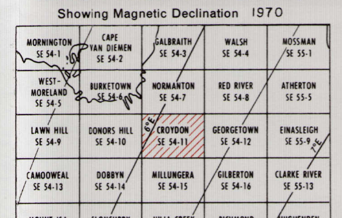
Brown lines with black italic numbers (numbers shown only at SW corner of map and change of zone), indicate the 10,000 yard grid, Zone 6 (Australia Series), CLARKE 1858 SPHEROID. Transverse Mercator Projection

Brown numbered ticks (with larger upright numbers), inside the neatline are 20,000 metre intervals of the superimposed Australian Map Grid, Zone 54 AUSTRALIAN NATIONAL SPHEROID. Transverse Mercator Projection



INDEX TO ADJOINING SHEETS

Showing Magnetic Declination 1970



ANNUAL CHANGE 0'37"E

Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

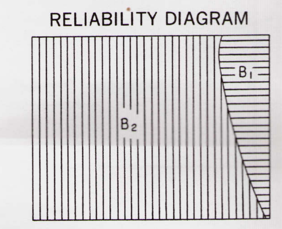
5 0 5 10 MILES

Section

Quaternary sediments omitted

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

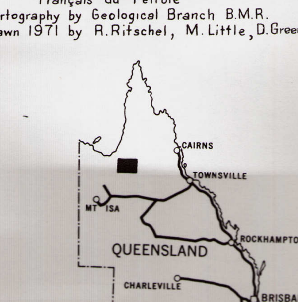
RELIABILITY DIAGRAM



B1 Detailed reconnaissance and air-photo interpretation

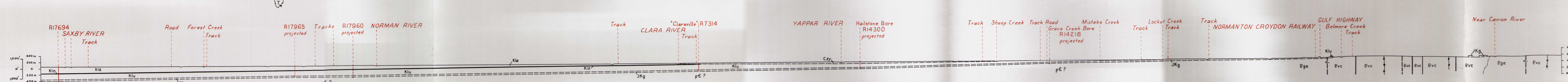
B2 General reconnaissance: some traverses, mainly air-photo interpretation

Geology 1966 by C.D. Branch
1969 by H.F. Doutch
Compiled 1971 by H.F. Doutch
Photo-interpretation 1966 by J.C. Rivereau, Institut Français du Pétrole
Cartography by Geological Branch B.M.R.
Drawn 1971 by R. Ritschel, M. Little, D. Green.



PRELIMINARY EDITION, 1971
SUBJECT TO AMENDMENT

CROYDON
SHEET SE 54-11



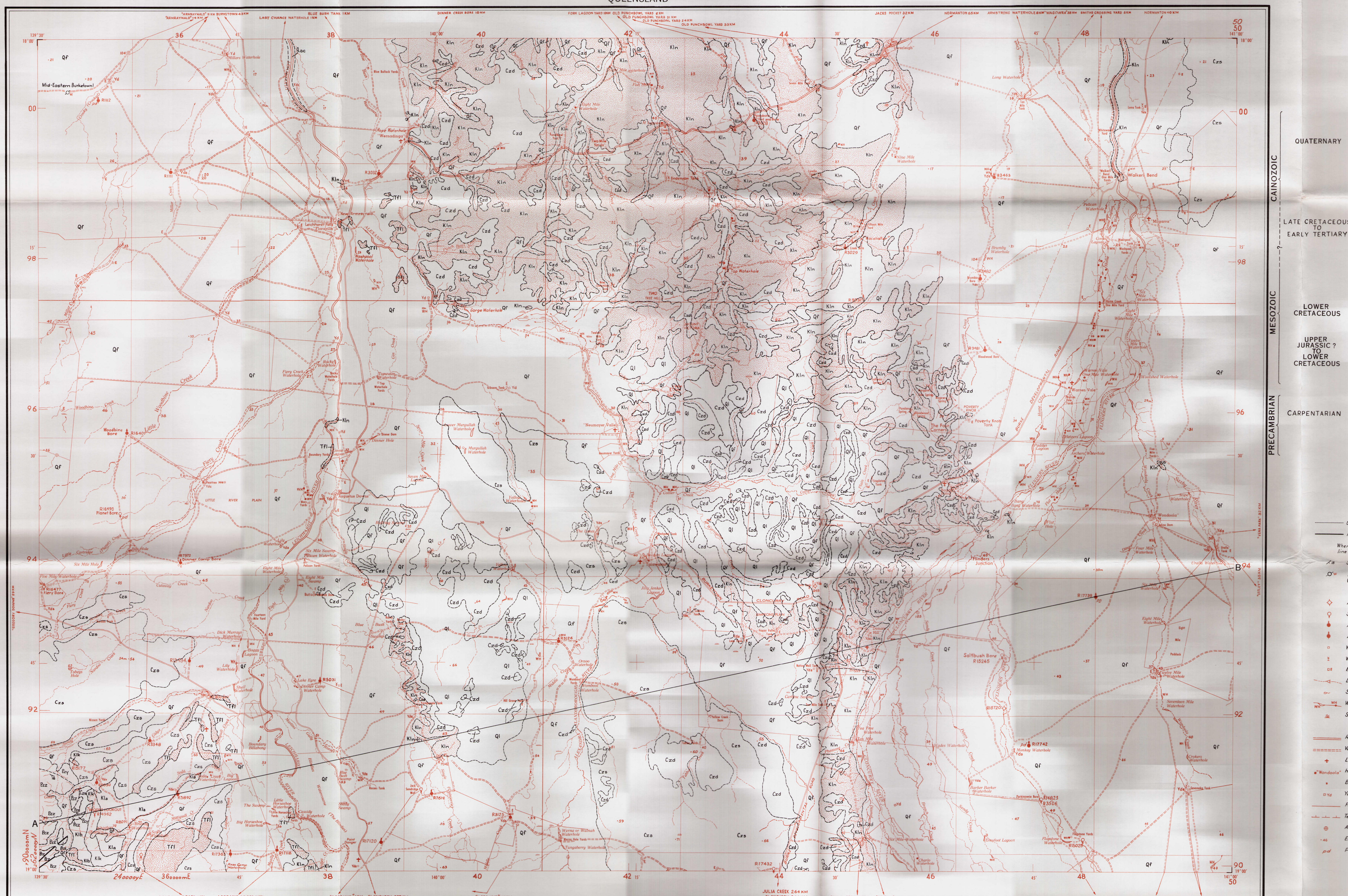
Printed by Mercury—Walch Pty Ltd., Hobart, Australia

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

DONORS HILL

QUEENSLAND

SHEET SE 54-10



Reference

CAINOZOIC	QUATERNARY		Qac	Younger alluvium: quartzose sand and silt, minor clay
			Qf	Older alluvium: quartzose sand and silt, minor clay
			Ql	Soil, minor colluvial quartzose sand
			Czs	Colluvial and outwash quartzose sand and gravel
	LATE CRETACEOUS TO EARLY TERTIARY		Czd	Hard fossil soil and colluvium, brecciated, ferruginous
				Deeply weathered (kaolinized, silicified and ferruginized) sediments
?		Floraville Formation	Tfl	Quartzose sandstone and conglomerate, minor mudstone, siltstone
MESOZOIC	LOWER CRETACEOUS	Normanton Formation	Kln	Labile sandstone, siltstone, mudstone and limestone
		Allaru Mudstone	Kla	Mudstone and siltstone, minor limestone and labile sandstone
		Kamileroi Limestone	Klk	Limestone, calcareous shale
		Blackdown Formation	Klb	Mudstone and siltstone; minor limestone and labile sandstone
	UPPER JURASSIC ? TO LOWER CRETACEOUS	Gilbert River Formation	J-Kg	Quartzose sandstone and conglomerate, shale (Section only)
			M	Siltstone, sandstone, red and brown shale (Section only)
PRECAMBRIAN	CARPENTARIAN	Ploughed Mountian Beds	Ꝑcz	Quartzite, quartzose sandstone and conglomerate
		Myally Beds	Ꝑcy	Feldspathic sandstone and conglomerate, rhyolite, agglomerate
			p€	Folded indurated sediments, granite. Section only

Geological boundary

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

Where location of boundaries and faults is approximate, line is broken; where inferred, queried

Strike and dip of strata

Petroleum exploration well-dry, abandoned (W indicates completed as water well)

Abandoned bore

Sub-artesian bore or well of Blackdown or younger aquifer system

Artesian bore } of pre-Blackdown aquifer system

Artesian bore, ceased to flow } of pre-Blackdown aquifer system

R 3482 refers to bore registered number of the Queensland Irrigation and Water Supply Commision records

Well

Windpump

Earth tank

Dam on stream

Spring

Waterhole

Swamp

Road

Vehicle track

Landing ground

"Wondoola" Homestead

Building

Yard

Fence

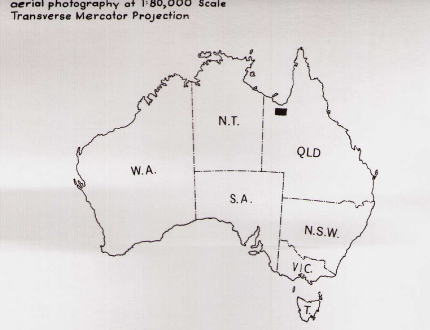
Telephone line

Astronomical station

Elevation in metres - approximate

Position doubtful

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. R. W. Swartz, M.B.E., E.D., Minister for National Development.
Base map compiled by the Royal Australian Survey Corps from aerial photography at 1:80,000 Scale
Transverse Mercator Projection



INDEX TO ADJOINING SHEETS

Showing Magnetic Declination 1970

ROBINSON RIVER SE 53-4	MORNINGTON SE 54-1	CAPE VAN DIEMEN SE 54-2	GALBRAITH SE 54-3	WALSH SE 54-4
CALVERT HILLS SE 53-8	WESTMORELAND SE 54-5	BURKETOWN SE 54-6	NORMANTON SE 54-7	RED RIVER SE 54-8
MOUNT DRUMMOND SE 53-12	LAWN HILL SE 54-9	DONORS HILL SE 54-10	CROYDON SE 54-11	GEORGETOWN SE 54-12
RANKEN SE 53-16	CAMOOWEAL SE 54-13	DOBBYN SE 54-14	MILLUNGERA SE 54-15	GILBERTON SE 54-16
AVON DOWNS SF 53-4	MOUNT ISA SF 54-1	CLONCURRY SF 54-2	JULIA CREEK SF 54-3	RICHMOND SF 54-4

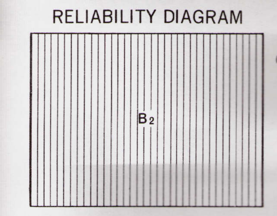
ANNUAL CHANGE 0°32'E

Scale 1:250,000

5 0 5 10 15 MILES

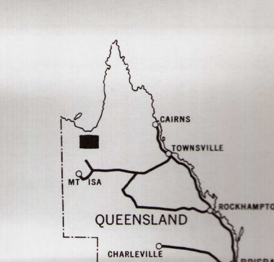
5 0 5 10 15 20 25 KILOMETRES

RELIABILITY DIAGRAM



Geology B2 General reconnaissance: many traverses, and air-photo interpretation

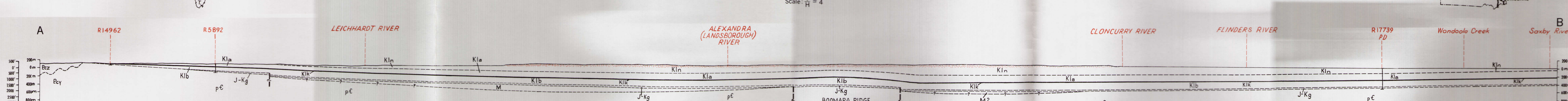
Geology 1969 by J. A. Ingram
Compiled 1969 by J. A. Ingram and M. A. McLaren
Cartography by Geological Branch B M R
Drawn by M. A. McLaren



Sections

Cainozoic sediments omitted

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



PRELIMINARY EDITION, 1970

SUBJECT TO AMENDMENT

DONORS HILL

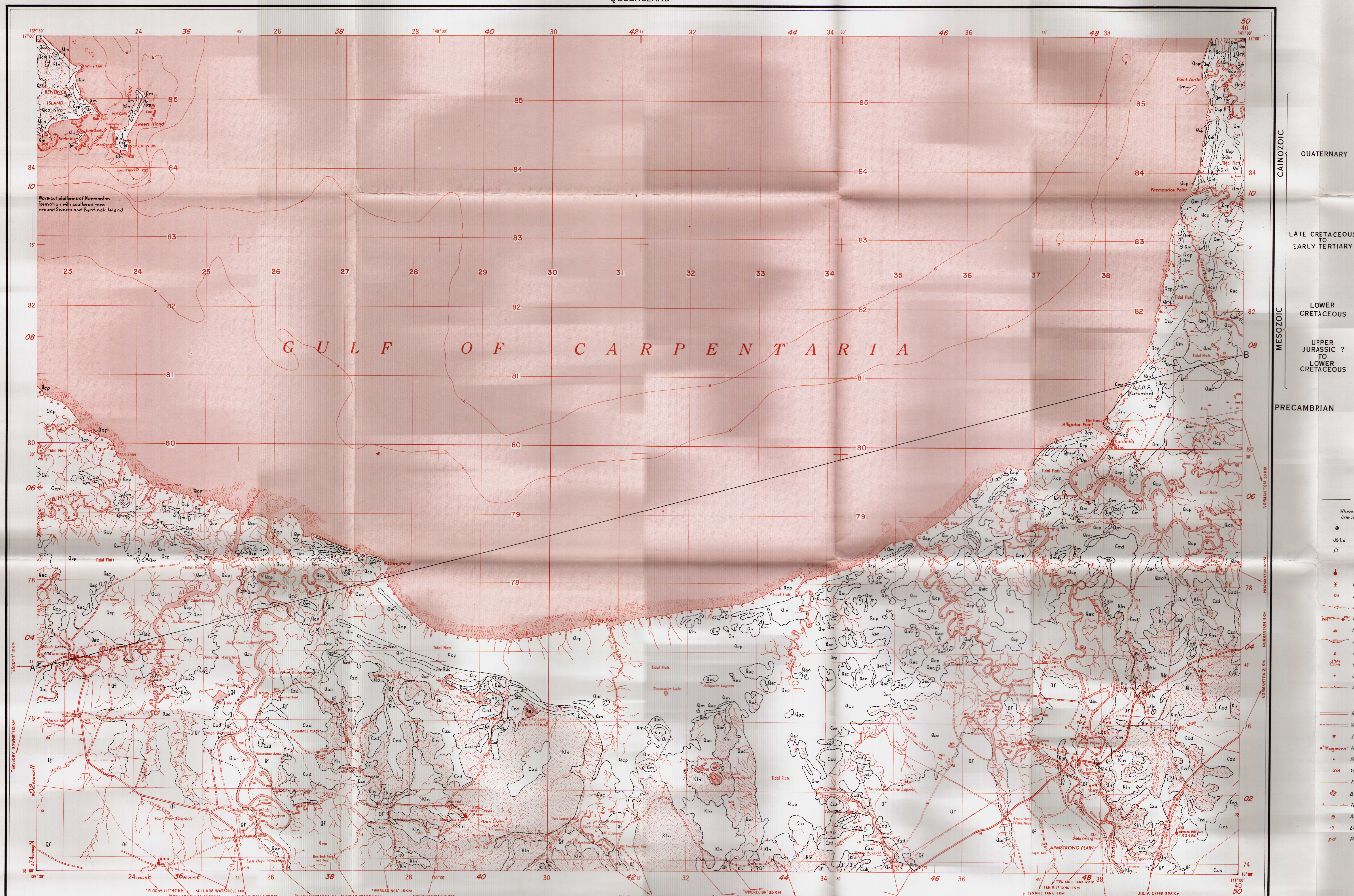
SHEET SE 54-10

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

BURKETOWN

QUEENSLAND

SHEET SE 54-6



Reference

CAINOZOIC		Cz	Undifferentiated. Section only
QUATERNARY		Qcp	Tidal flats: silty clay, salt
		Qac	Younger alluvium and coastal deposits: quartzose sand and silt, minor clay
		Qm	Beach ridges: coquina, calcarenite, shelly quartzose sand
		Qf	Older alluvium: quartzose sand and silt, minor clay
		Czs	Colluvial and outwash quartzose sand and gravel
LATE CRETACEOUS TO EARLY TERTIARY		Czd	Hard fossil soil and colluvium, brecciated, ferruginous
		(stippled)	Deeply weathered (kaolinized, silicified and ferruginized) sediments
MESOZOIC: LOWER CRETACEOUS	Normanton Formation	Kln	Labile sandstone, minor siltstone, mudstone and limestone
	Allaru Mudstone	Kla	Mudstone and siltstone, minor limestone and labile sandstone
	Kamileroi Limestone	Klk	Limestone, calcareous shale
	Blackdown Formation	Klb	Mudstone and siltstone, minor limestone and labile sandstone
UPPER JURASSIC ? TO LOWER CRETACEOUS	Gilbert River Formation	J-Kg	Quartzose sandstone and conglomerate, shale
		M	Siltstone, sandstone, red shale
PRECAMBRIAN		p€	Folded indurated sediments, metasediments, granite

Kla, Klk, Klb, J-Kg, M, p€: Section only

Geological boundary

Where location of boundaries is approximate, line is broken; where inferred, queried

Macrofossil locality

Ls Quarry-not worked. Ls-limestone

Petroleum exploration well-dry, abandoned.

Artesian bore of pre-Blackdown aquifer system — RI5569 refers to bore registration number of the Queensland Irrigation and Water Supply Commission records

Windpump

E Earth tank

Dam on stream

WH Waterhole

Swamp

Foreshore flats

Mangrove

Coral reef

Submerged rock

Bathymetric contours - converted from fathoms to nearest metre

Road

Vehicle track

Landing ground

"Magowra" Homestead

Building

Yd Yard

Fence

Built up area

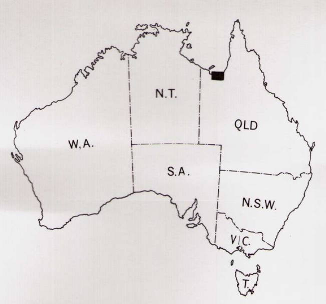
Telephone line

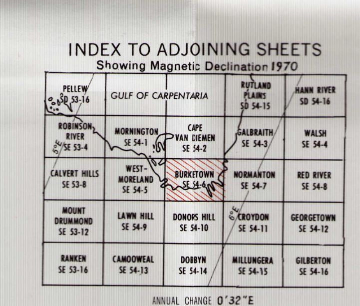
Astronomical station

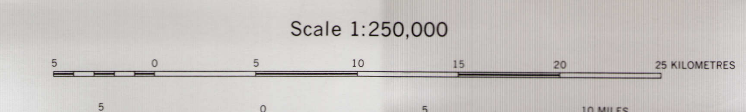
·9 Elevation in metres - approximate

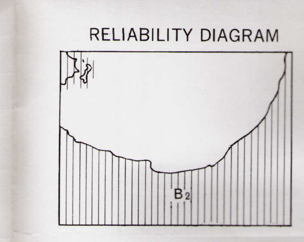
pd Position doubtful

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. R.W. Swartz, M.B.E., E.D., Minister for National Development.
Base map compiled by the Royal Australian Survey Corps from aerial photography at 1:80,000 scale
Transverse Mercator Projection









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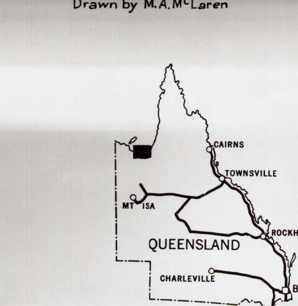
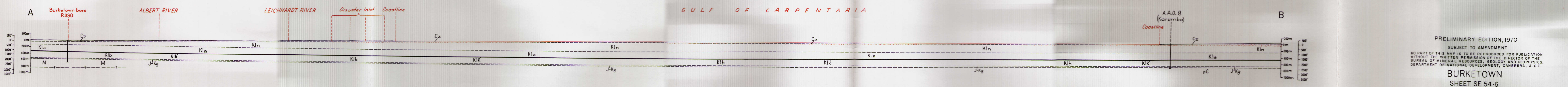


Sections

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



PRELIMINARY EDITION, 1970

SUBJECT TO AMENDMENT

BURKETOWN

SHEET SE 54-6

Plate 7


CORRELATION OF MEASURED SECTIONS
MESOZOIC
GREGORY RANGE
NORTH OF CROYDON
COFFIN HILL
SANDY CREEK
GLENORA
NORTH OF CLARA RIVER
WEST OF TIN HUT
EULO QUEEN CREEK
Blackdown Formation
=Wallumbilla Formation
LOWER CRETACEOUS
Gilbert River Formation
Coffin Hill Member
LOWER CRETACEOUS
Yappar Member
UPPER JURASSIC ? to LOWER CRETACEOUS
Gilbert River Formation
UPPER JURASSIC - LOWER CRETACEOUS
Loth Formation
MIDDLE TO UPPER JURASSIC
Hampstead Sandstone
JURASSIC
Eulo Queen Group
Type Section
VERTICAL SCALE
Metres
Feet
30
15
0
100
50
0
LOCALITY MAP
NORTH OF CROYDON
CROYDON
COFFIN HILL
GEORGETOWN
SANDY CREEK
GLENORA
NORTH OF CLARA RIVER
WEST OF TIN HUT
EULO QUEEN CREEK
basement
(Croydon Ignimbrite)
basement
(Esmeralda Granite)
basement
(Einasleigh Metamorphics)
(base unseen)
To accompany Record 1970/39
E54/A/13

Plate 8

GAMMA RAY LOG CORRELATION

across Carpentaria Basin

Datum: Top of Gilbert River Formation

To accompany Record 1970/39

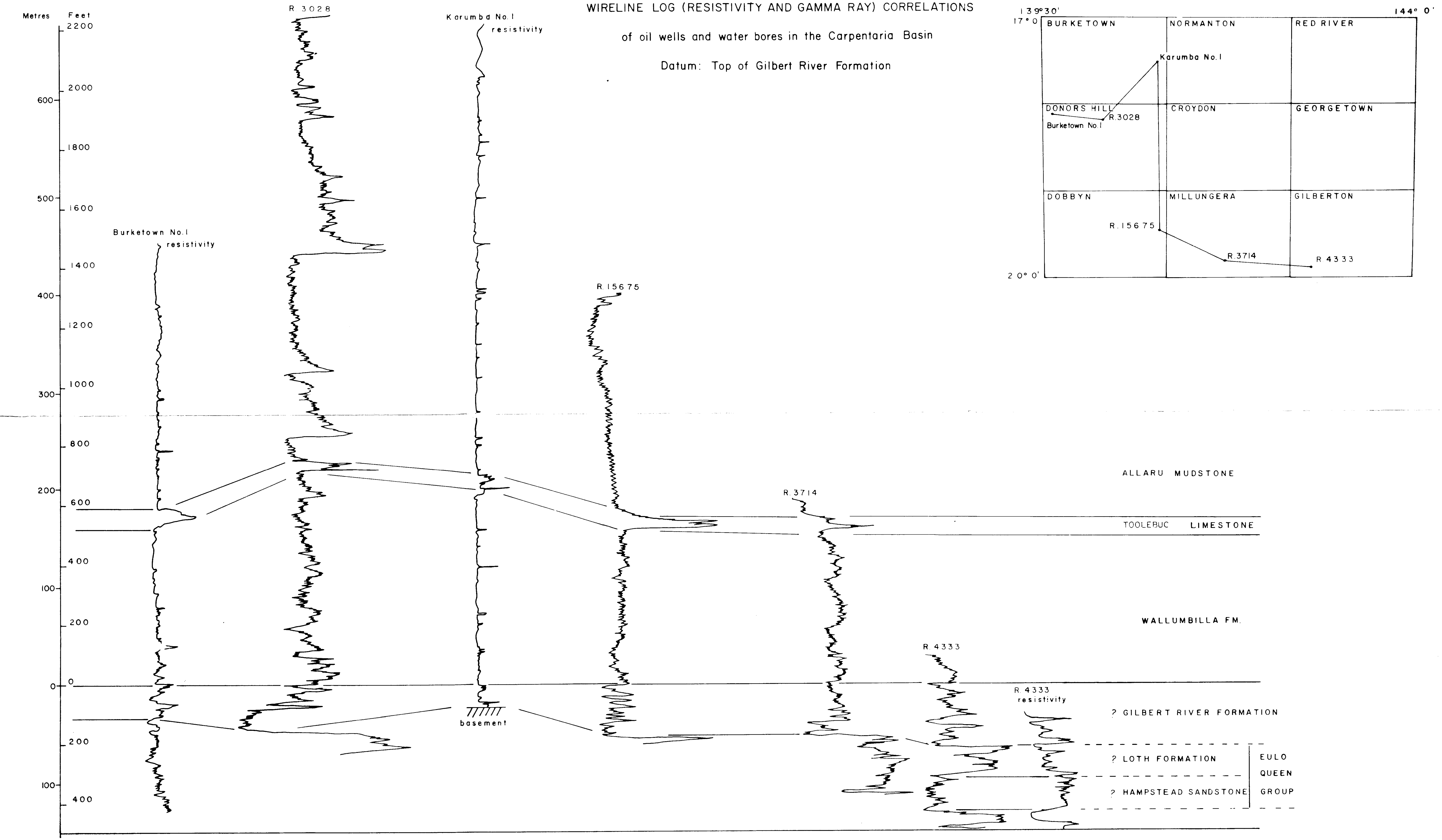
E54/A6

Plate 9

WIRELINE LOG (RESISTIVITY AND GAMMA RAY) CORRELATIONS

of oil wells and water bores in the Carpentaria Basin

Datum: Top of Gilbert River Formation



To accompany Record 1970/39

E54/A/7

Plate 10

GAMMA RAY LOG CORRELATION

in Carpentaria and North Eromanga Basins

Datum: Top of Gilbert River Formation

Q/A 311

To accompany Record 1970/39