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Record 1972/64

PROGRESS REPORT ON THE GEOLOGY OF THE CENTRAL CARPENTARIA BASIN

by

H.F. Doutch, J. Smart, K. Grimes*, S. Needham and C.J. Simpson

* Geological Survey of Queensland;
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SUMMARY

The central part of the Carpentaria Basin, between Normanton, Croydon, Wrotham Park, and Mitchell River Mission, consists of the Mesozoic Staaten River Embayment and a Cainozoic modification of it, the Gilbert-Mitchell Trough.

The Embayment contains the late Jurassic to early Cretaceous quartzose continental and shallow marine Gilbert River Formation, the Aptian to Albian argillaceous marine Rolling Downs Group, and unconformably overlying these the late Cretaceous? or early Tertiary quartzose continental Bulimba Formation.

The Gilbert-Mitchell Trough formed by downwarping of most of the Embayment after deposition of the Bulimba Formation. The late Cainozoic Wyaaba Beds were deposited in it. The Gilbert and Mitchell Fans have built upwards over the Wyaaba Beds and outwards into the Gulf of Carpentaria, interacting with coastal deposits resulting from Pleistocene changes in sea level.

INTRODUCTION

This Record contains results of reconnaissance geological mapping in the central Carpentaria Basin in 1970 by a joint field party of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics (BMR) and the Geological Survey of Queensland.

Details of Mesozoic and Cainozoic stratigraphy and structure worked out from the mapping in the Georgetown 1:250 000 Sheet area are described in Needham (1971). Results of drilling by BMR rigs in the area are given in Needham et al (1971), and Smart & Grimes (1971). Mapping carried out in the Lawn Hill, Westmoreland, Mornington, and Cape Van Diemen 1:250 000 Sheet areas is reported separately (Grimes, in prep., a).

Before field mapping started Simpson (1969) prepared a 1: 250 000 photogeological map and report on the Normanton sheet area, and mosaics and notes, for field use, of Galbraith and Rutland Plains sheet areas, and Maffi (1970) prepared a 1:250 000 photogeological map of the Red River Sheet area, and mosaics, for field use, of Walsh sheet area.

PHYSIOGRAPHY, GEOMORPHOLOGY, AND QUATERNARY GEOLOGY

Introduction

A comprehensive reconnaissance study of the physiographic evolution of the southern Carpentaria Basin was published by Twidale in Perry et al. (1964). Twidale published a more specialized account (1956b, 1966); many of his physiographic division boundaries have been retained here, although most have been renamed.

The area consists mainly of plains crossed by the lower reaches of the Norman, Gilbert, and Mitchell Rivers, which flow into the Gulf of Carpentaria (Fig. 1). Rivers commonly overflow their banks and cause extensive flooding during the monsoonal wet season, but in the drier months they normally degenerate into a series of waterholes. Although the main catchments of the drainage systems lie well beyond the limits of the area these rivers and their tributaries have been the dominant factors in the formation of most of the physiography and Cainozoic sedimentary bodies.

Over most of the area the surface slope is about 1 in 2 500 from the Gulf of Carpentaria up towards the Great Dividing Range to the east. Computer-plotted topographic form-lines (contour interval 5 m), based on BMR gravity station elevations and RASC spot heights, indicate a break in slope in the northeast and southeast (see Fig. 1). This is related to the boundary between the present-day erosional environment of the gently sloping Holroyd Plain, and the part erosional, part depositional, environments of the Gilbert and Mitchell Fans and the Staaten Interfan.

The physiography of the area is here interpreted geomorphologically, which involves all the geology of Pleistocene and Holocene times. Figure 2 illustrates the time relations between deposits of these ages in various environments.

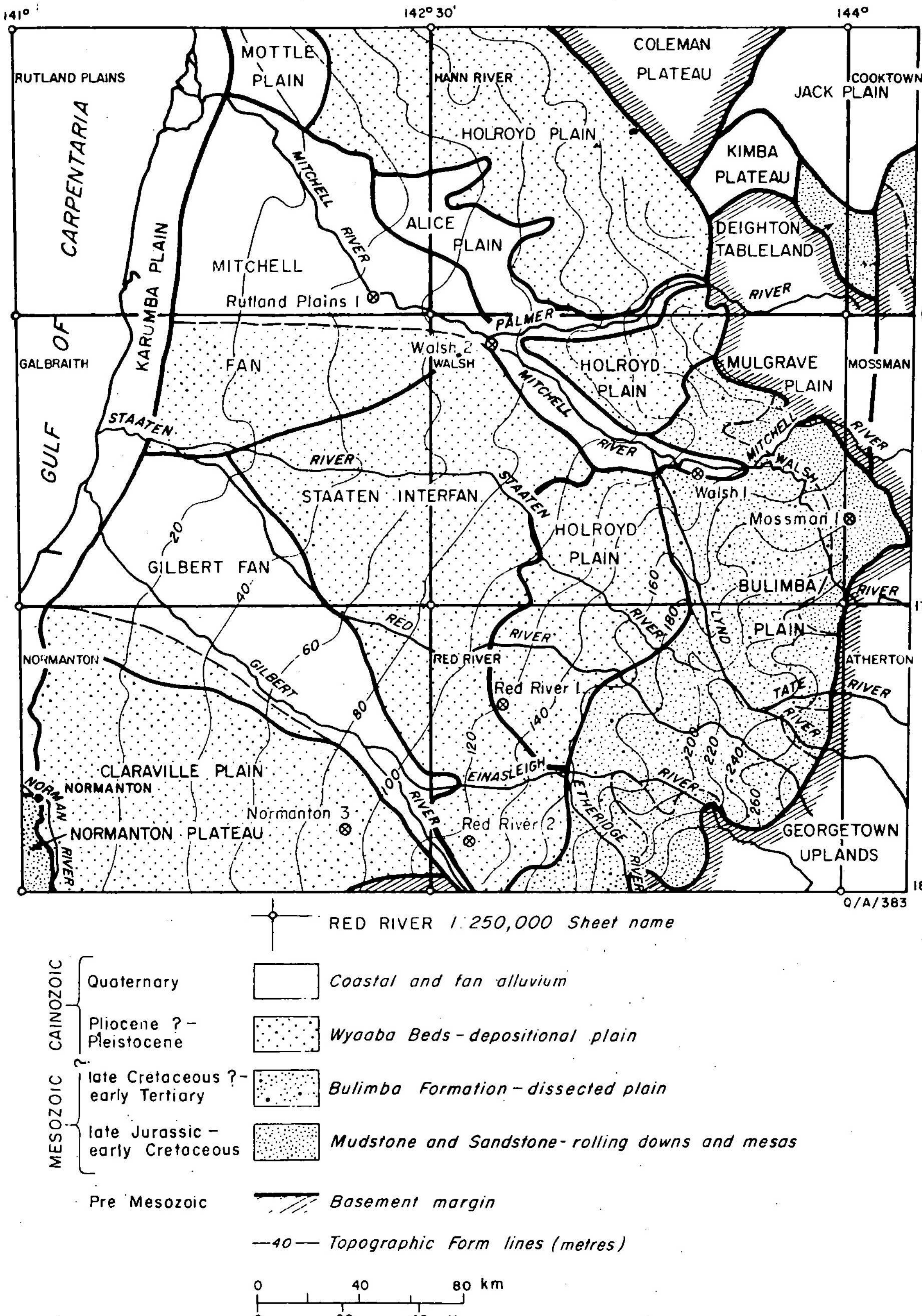
The Normanton Plateau

The Normanton Plateau area (Fig. 1) includes low piedmont deposits of colluvium and outwash deposits (Czs) resulting from erosion of the higher plateau regions. It includes the Normanton, Balbarini, and part of the Glenore land systems of Perry et al. (1964). The plateau's upper surface, up to 20 m above the surrounding plains, is developed on Lower Cretaceous Normanton Formation (Kln) sandstone. Erosion-resistant remnants of a ferruginous 'duricrust' (Td) are scattered over the plateau. The duricrust is probably a composite end product of silicification and ferruginization between Bulimba and Wyaaba times (see below) plus further ferruginization after Wyaaba time.

The duricrust has preserved sections of drainage systems of an older topography and where complete valleys remain they are lined with soil and colluvium (Cza). These ancient streams contrast in morphology with the young active streams currently incising the irregular margin of the plateau and to the Flinders River system as a whole, which shaped the plateau. Most of the level or low gradient areas of the plateau are coated with a veneer of sand or sandy soil.

FIGURE. 1

PHYSIOGRAPHY



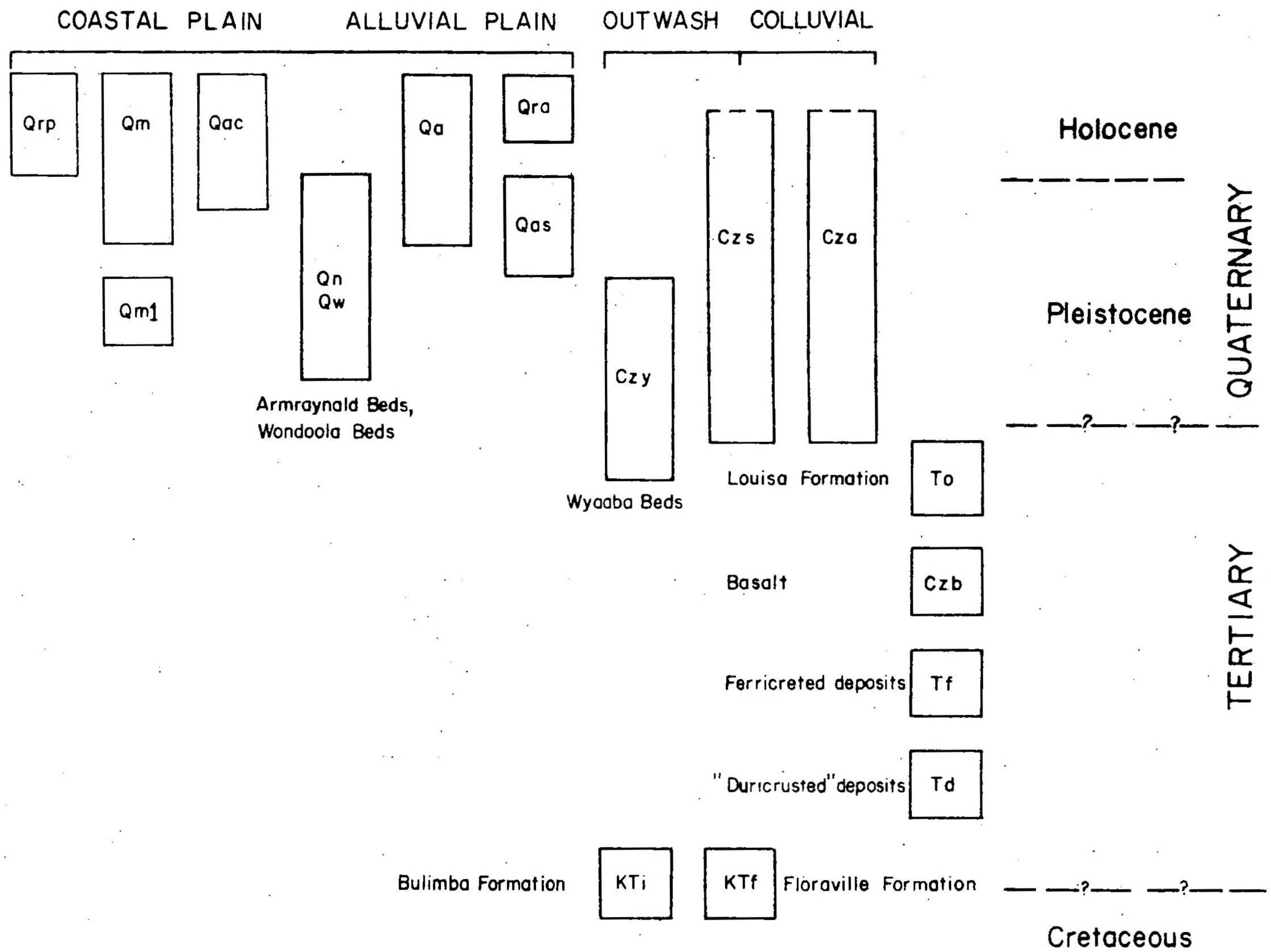


Fig. 2 TIME RELATIONS OF CAINOZOIC UNITS

To accompany Record 1972/64

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Bulimba and Holroyd Plains, and Staaten Interfan

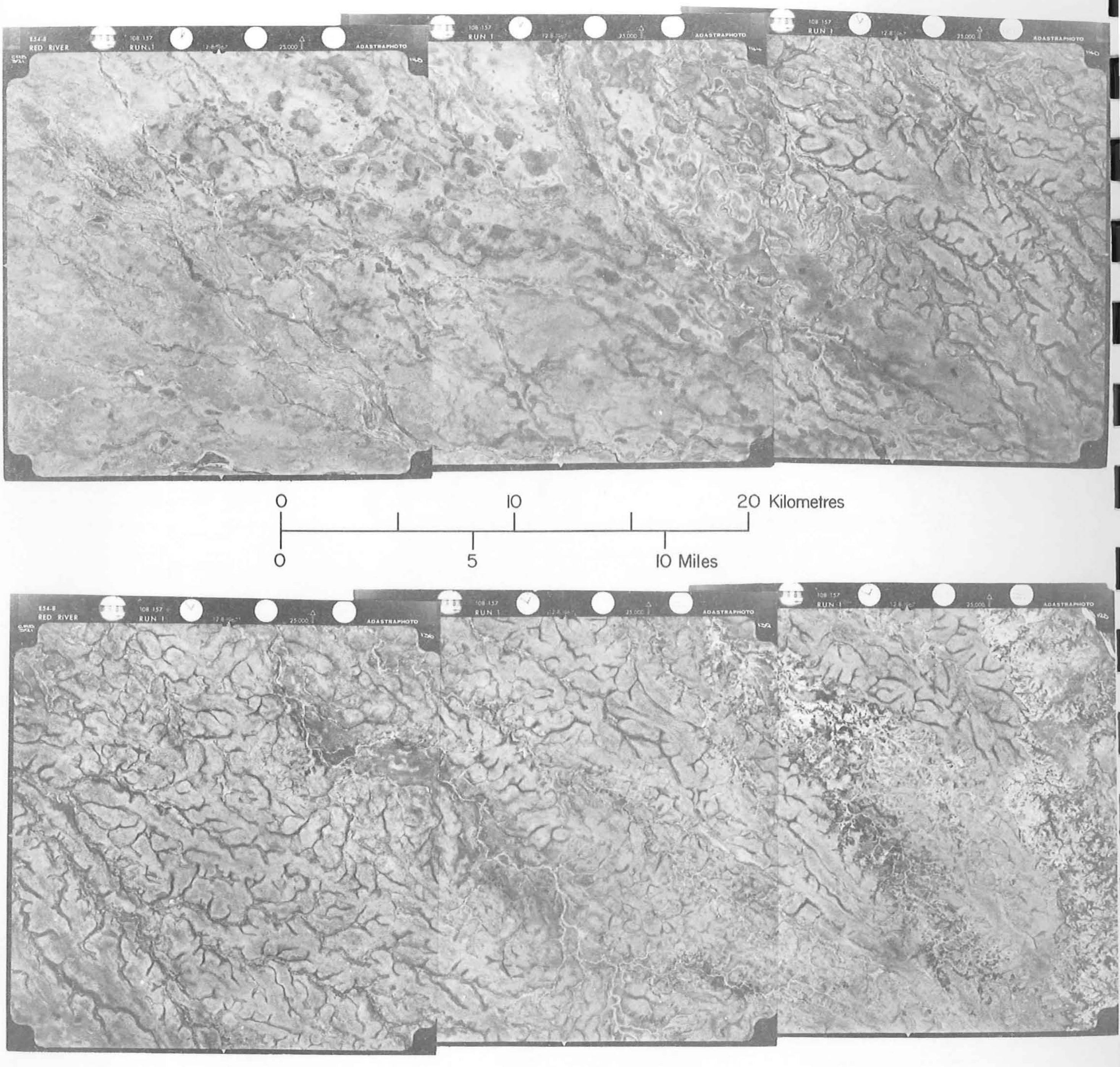

Fig. 3 Top photos: Staaten Interfan left and centre, grading into Holroyd Plain at right. All Wyaaba Beds.

Bottom photos: Holroyd Plain, left and centre (continuation of top photos) - Staaten River flows through dark area left of centre. Light areas at right are Bulimba Beds, western edge of Bulimba Plain. Lynd River extreme top right.

The Bulimba Plain (Figs. 1, 3) is a dissected plain consisting of low plateau remnants and rolling hills, and a few alluvial flats. Relief decreases from 50 m in the east to 10 m and less in the west. It is developed on the clayey sandstones of the Bulimba Formation and to a minor extent on the underlying Mesozoic rocks, and is probably the result of recent dissection of part of the Holroyd Plain, comtemporaneously with deposition of the Gilbert and Mitchell Fans. The drainage pattern is dendritic, controlled by jointing in the sandstones; streams have steep banks and sandy beds. The southern half of the plain (Red River and southern Walsh Sheets) and its eastern margin (western Mossman Sheet) correspond to the Red Plateau of Twidale (1966).

In outcrop, the Bulimba Formation and Mesozoic rocks on which the Bulimba Plain has developed are strongly ferruginized, and ferricretes are present in some areas. In the subsurface below the Wyaaba Beds, and in some places in outcrop below the ferruginous material, the Bulimba Formation has a zone of iron-staining and mottling. The event that produced this preceded Wyaaba Bed deposition and may have been the same one that resulted in mottling of the Normanton Formation on the Normanton Plateau. The weathering episode that produced the ferruginization and ferricrete was probably contemporaneous with the 'lateritization' of the Wyaaba Beds.

The Holroyd and Claraville Plains and Staaten Interfan

The Holroyd Plain (Figs. 1, 3) is coincident with the Balurga Land system and western plains of Galloway et al. (1970), which they defined as consisting of an extensive plain developed on weathered terrestrial sediments. The area has a very distinct photo pattern (Fig. 3).

The plain consists of low rounded sandy interfluves separating shallow swampy valleys. Relief is less than 5 m. The streams appear to be inactive and choked by detritus. The whole environment appears to be one of low energy. The drainage pattern (Fig. 3) is elongate dendritic with a dominant northwest trend over most of its area; it developed, and probably stagnated, before the recent erosional episode producing the Bulimba Plain.

To the east the tributaries of the Lynd River are actively eating into the margin of the plain; the margin is a pronounced scarp along much of the western side of the Lynd River (Fig. 3). To the east of the river (in Walsh Sheet) a few isolated plateaux in the Bulimba Plain are remnants of the Holroyd Plain.

The eastern margin of the Holroyd Plain is developed on the Bulimba Formation (KTi), but for the most part the plain contains Wyaaba Beds (Czy).

The Claraville Plain (Fig. 1) has an overall regional fall to the WNW. Topographic form-lines show that this slope has a gradient of 1 m per km over the eastern half of the plain (i.e. east of a line joining 'May Vale' to 'Miranda Downs'), and 0.5 m per km over the western half.

The plain is developed on Wyaaba Beds (Czy) and the surface consists predominantly of poorly consolidated clayey quartzose sand. Twidale (1966) considers that the plain was developed by the end of the Pliocene and has remained essentially the same since. Some sinuous remnants of sandy river channel deposits (Qas) are scattered over the plain and these form ridges less than 2 m high.

The westerly flowing Carron River and the southwesterly flowing Walker Creek - both tributaries of the Norman River - are the main systems draining the Claraville Plain within the area. These streams, although small and generally only shallowly incised, are in an erosive phase. Areas of recent floodplain alluvium (Qa) are associated with them. The flat inter-stream areas of the Claraville Plains are characterized by numerous claypans.

The Claraville Plain and Staaten Interfan equate with the Mayvale and parts of the Glenore land systems of Perry et al. (1964).

The Staaten Interfan (Figs 1, 3) appears to be an almost unchanged relic of the Claraville Plain (cf Twidale, 1956b, 1966), now isolated between the deposits of the Gilbert and Mitchell Fans. The Interfan is developed on the surface of the Wyaaba Beds (Czy). It is part of the Leinster land system of Galloway et al.,(1070); they interpret it, in part by its soil characteristics, as an extensive, uniform old alluvial plain. Local relief amplitude rarely execceds 2m. The plain has mainly a static environment, although seasonal flooding of creeks results in the deposition of minor flood-out deposits over it. The existence of the Staaten River is a result of the watershed effects of the topographically higher Gilbert and Mitchell Fans which enclose the Interfan area.

The Staaten River appears to have a higher energy level than the Gilbert and Mitchell Rivers as it is incised along most of its course, has no distributary network near the coast, and a less complex meander pattern in the coastal plains. It also appears to be capturing northwesterly flowing creeks in its headward erosion, e.g. in the Pandanus Creek area. North of the Staaten River in this area drainage is poorly developed.

In the southeast the Staaten Interfan rises to 100m above sea level. Above 55 m it is characterized here by stabilized sand dunes. It is possible that the dunes reflect an arid phase when loose alluvial sand was blown from the Holroyd Plain immediately to the southeast.

Galloway et al. (1970) named part of the Interfan and the Gilbert and Mitchell Fans the 'Lower Mitchell plains'; the rest of the interfan is part of their 'Western plains'.

The Mitchell and Gilbert Fans and the Alice and Mottle Plains

The Mitchell Fan (Fig. 1) is part of the Lower Mitchell plains of Galloway et al. (1970), whose maps shows it to comprise older alluvial plains (the Dunbar land system), younger alluvial plains (the Radnor land system), and active younger alluvial plains (the Cumbulla land system). The older plains, in the Dunbar land system, coincide with the older southern half of the Mitchell Fan in which the underlying Wyaaba Beds (Czy) predominate.

The fan lies below 55 m elevation and consists of Pleistocene to Holocene fluvial sand, silt, and clay (Qas, Qa, Qra). Channelling, levee, back plain, and back swamp features are common nearer the coast. A depositional environment may predominate, but there are many active channels characterized by slight incision and by the possession of laciniate meander plains (Twidale, 1966). 'Covered' plains (Twidale, op. cit.) associated with distributary drainage systems occur over the greater part of the fan.

The fan appears to have built up in two main stages: after the older part of the fan and the older beach ridges formed, the main channel system migrated northwards, and the younger part of the fan and its associated beach ridges developed, destroying old beach ridges in the process.

The coastal bulge that is parallel to the front of the fan suggests that it has been building up and out into the sea. The regional form-line pattern suggests that erosion now dominates over deposition even in the newer part of the fan; many stream channels are incised upstream from the meandering parts of their courses in the Karumba Plain.

The older sands of abandoned river channels (Qas) may in some places be older than flood-plain alluvium (Qa), in others contemporaneous or possibly younger. The younger sands (Qra) are mostly in short-lived deposits in active drainage channels.

The Alice Plain (Fig. 1) (dominantly Qa) is primarily the flood plain of the Alice River. It probably includes floodout deposits from other streams eroding the Holroyd Plain, and marginal deposits of the Mitchell River. The alluvia of the Alice Plain are on the whole probably older than those of the active newer half of the Mitchell Fan. The Alice River is incised into its plain; relief rarely exceeds 2 m. The regional form-line pattern suggests that the Alice Plain is topographically lower than the Mitchell Fan, and that, as in the Fan, erosion now dominates over deposition. The Alice Plain is part of the Leinster land system of Galloway et al. (1970).

The Mottle Plain (Fig. 1) is similar to the Alice Plain, although more alluvium is probably being deposited than eroded, perhaps because the source area for it, the Holroyd Plain, is close to the coast here. The Mottle Plain is the physiographic expression of the Mottle land system of Galloway et al., (op. cit.)

The Gilbert Fan (Fig. 1) is the broad depositional plain of the lower Gilbert and Einasleigh Rivers. This approximates to the Stirling Plain of Twidale (1956b, 1966) and to the Miranda, Gilbert, and Armraynald land systems of Perry et al. (1964). It was called a 'delta' by Warner (1968). Itsdeposits appear to be very thin.

The Fan is topographically higher than the surrounding plains. It consists of active and abandoned river channel deposits (Qra and Qas respectively), and levees and flood plain deposits (Qa). The rivers consist of numerous slightly increased anastomosing channels. The locations and directions of flow of prior channels of the Gilbert and Einasleigh Rivers are shown by remnant deposits of quartzose sand (Qas) which are on, or entrenched in, the Wyaaba Beds in many places. Their presence on the Claraville Plain suggests that it has been developed in part, if not wholly, by riverine depositional processes. The combined Gilbert and Einasleigh Rivers are depositing sediments (Qra) in the Gilbert Fan. Twidale (1956b, 1666) considers the age of the older alluvium to be Pleistocene.

Like the Mitchell Fan, the Gilbert Fan appears to be building upwards and seawards. In the past the distributary system has migrated from south to north, and then south to its present position. The rivers provided extensive floodout deposits, probably in wet seasons similar to those of the present. Drainage and depositional patterns reflect a response not only to variations in rainfall but also the changing sea level and to the formation and destruction of beach ridges.

<u>The coastal Karumba Plain and its sediments</u>

The <u>Karumba Plain</u> (Figs. 1, 4, 5) (Twidale, 1956 a & b; 1966) is equivalent to the Carpentaria land system of Perry et al. (1964). It forms a continuous fringe between 10 to 20 km wide along the coast. Clay flats and salt pans (Qrp), and thickly grassed plains of black soil (Qac) form swales between subparallel series of beach and sand ridges (Qm, Qm1), which are thickly wooded inland and become scrubby towards the coast (Figs. 4, 5). The beach ridges rise to 2 m above the pans and plains. The salt pans and associated mud flats are seasonally inundated by salty or brackish waters, and halophytic plants commonly grow along their margins. The coastline consists of shelly beach sand overlying marine muds which are exposed at low tide. Mangrove development, mostly associated with the lower parts of major river cources, is relatively sparse along the coast. Tidal mega-ripples parallel the shore in some places.

The most conspicuous feature of the coastal deposits of the Karumba Plain are the beach ridges (Qm1, Qm). They represent episodes of coastal prograding related to sea level fluctuations in the Quaternary. Coastal accretion was and is mostly by the deposition of silty clay in the form of mud flats which are usually exposed at low tide. This sediments is supplied by large rivers such as the Norman, Gilbert and Mitchell, and redistributed along the coast by coastal currents. Winnowing in the intertidal zone, and the accumulation of shell material, has resulted in the building of beach ridges.

The older beach ridges (Qm1) occur between 20-35 km from, and are subparallel to, the present coastline. They have little relief. They consist of belts of sandy soil favoured by trees. No abandoned river deposits (Qas) have been identified west of them. They appear to have been strands during the furthest transgression of Quaternary seas, when sea level was about 6m higher than at present (calculations are based on spot heights on BMR 1:250 000 Bouguer Anomaly map Normanton, 1969).

Karumba Plain

Fig. 4 Prograding coastline and old beach ridges, Spring Creek and Kelso area, GALBRAITH
Neg. 5867

Fig. 5 Meandering river crossing tidal salt flats, Station Creek, RUTLAND PLAINS
Neg. 5868

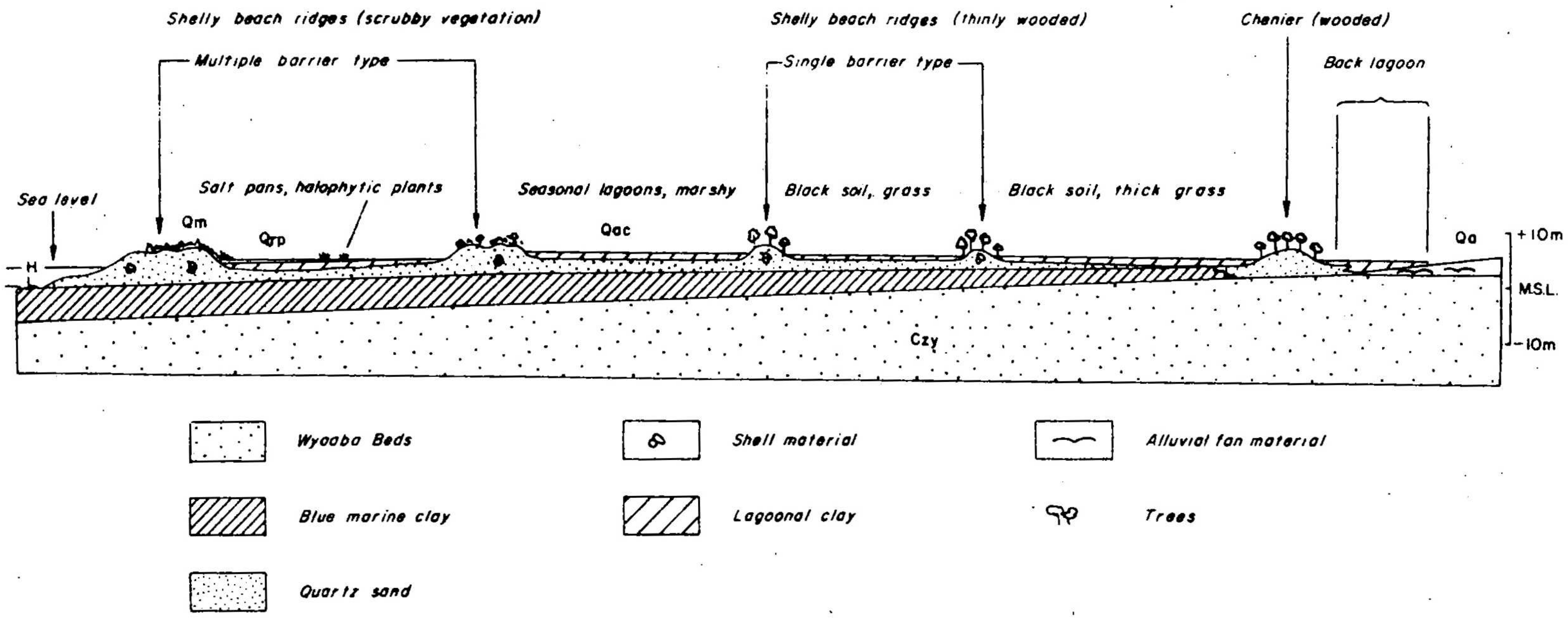

Fig.6 COASTAL DEPOSITS AND LANDFORMS

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Recent beach and sand ridges (Qm) occur as far as 10 km from the coast. These are predominantly shelly, sandy, deposits and have crests 4 to 6 m above present sea level. AAO 8 Karumba penetrated shell deposits to a depth of 15 m below sea level (Laing, 1960; Ingram, in press). The ridges elsewhere along the coast have been studied by Jackson, (1902), Valentin (1959, 1961), Whitehouse (1963), and by Twidale (1956a, 1966) who reports a radiocarbon date of 3320 ± 125 years for a ridge near Karumba.

The most inland Qm ridge line occurs commonly as isolated sand bodies devoid of shell fragments (Fig. 6). It was most probably a chenier, on elongate body of coarse sediment, generally sand or shell, lying in a coastal marsh (Curray, 1969); formation of cheniers depends on alternate periods of local transgression and regression, with a fluctuation in the rate of influx of sediment and winnowing by wave action.

Ridges nearer the coast are generally multiple sand bodies containing marine shells scattered in loose sand in the upper parts of the ridge but in places cemented into beach rock at the base of the ridge. They are true 'beach ridges' formed by successive accretion of new beach foreshores during lowering of sea level. The beach ridge pattern is similar to that on the west coast of Mexico described by Curray (op. cit.), who suggested that the ridges formed by the build-up of longshore bars by waves to sea level, followed by filling in of the lagoon behind the bars, thus resulting in progradation of the coast.

The beach ridges range from series of individual ridges, each formed from an old longshore barrier, to wide uniform ridges at or very near the present coast. The latter are formed by continuous accretion of shore face and foreshore without the formation of individual beach ridges. Interference in beach ridge development by creeks and rivers is displayed by the feathering and curving of ridges adjacent to the old river courses, and evidence of coastal realignment is provided by the truncation of older ridge by younger ones.

The swales between beach ridges are generally occupied by coastal alluvium (Fig. 6). Auger holes drilled in swales between beach ridges near the Edward River Mission by Whitehouse (1963) show that beach sand has been deposited as a continuous sheet over marine muds, and that periods of high-energy wave action have built up beach material to form ridges during arrested stages of shore progradation. Silty clays were deposited in the lagoons that formed in the swales as the sea level dropped and the coastline prograded.

Black soil has commonly developed over the swales, but in lower areas periodically inundated by salt water, salt pans are commonly developed (Qrp). Salt pans commonly border rivers and creeks in the Karumba Plain, and consist of up to 2mm of fibrous salt crystals over dark grey silty clay, peaty in appearance, with scattered salt crystals becoming less common with depth, and devoid of salt crystals at a depth of 4 mm. The salt crystals are loosened and blown away by the wind, sometimes forming tiny 'dunes' at the margins of the pans and around obstacles such as branches lying on the surface of the pan. Jackson (1902) reported on the distribution and occurrence of salt deposits).

The relations between cheniers, beach ridges, salt pans, lagoons, and swale soils are shown on Figure 6.

Twidale (1966) considered that nick-points of the Leichhardt and Gilbert Rivers indicated new erosion episodes due to uplift of the land. The abandonment of the strands and the creation of a new base level of erosion related to the nick points were probably due to the same event, which appears to have been more likely due to Holocene sea regression than to land uplift. However, Ingram (in press) reports beach deposits on Sweers Island 10 m above present sea level.

Most rivers crossing the Karumba Plain and originating elsewhere have a meandering habit (Fig. 5). Drainage originating in the plain is controlled by the characteristics of beach ridges and swales.

A decrease in velocity when they reach the plain probably causes larger rivers to meander through it. The decrease is due in part to tidal influences, in part to flatter slopes at the toes of the fans. Further, during the wet season each year the plain is inundated and river velocity decreases relative to load, and alluvium is widely deposited in areas adjacent to river channels and along the coast (the latter sediments being removed by coastal currents). The increase in river velocity and load in the wet season causes downstream migration of river channels by point-bar deposition of sediment along the lee of meanders, and erosion of the opposite bank.

The courses of creeks are commonly deflected by beach ridges, whereas the larger rivers have disrupted and breached the ridges during downstream meander migration. In some cases beach ridges and river courses have developed together. The mouths of many rivers and creeks are deflected by local coastal sea currents. Where large rivers have been strongly deflected so as to run parallel to the coast for a distance before entering the sea, the area surrounding the mouth of the river has been locally termed 'pocket' (e.g. Gilbert Pocket).

Salt and clay pans display characteristic secondary drainage patterns adjacent to the rivers; they are drained by radial gutters on the insides of meanders and by dendritic streams elsewhere (Twidale, 1966).

MESOZOIC STRATIGRAPHY

Introduction

Although the central part of the Carpentaria Basin is covered by Cainozoic sediments and the products of deep weathering, its Mesozoic geology appears to be similar to the southern part (Doutch et al., 1970), except that there is no evidence for the presence of the sandstones of the Jurassic Eulo Queen Group or equivalents. The basal basin deposits in this area are the late Jurassic - early Cretaceous continental and shallow marine quartzose sandstones of the Gilbert River Formation. They crop out sporadically along the eastern margin of the basin.

TABLE 1 - STRATIGRAPHY

ERA	PERIOD	ROCK UNIT	MAP SYMBOL	THICKNESS (metres)	LITHOLOGY	DEPOSITIONAL ENVIRONMENT & PROCESS	STRATIGRAPHIC RELATIONS: CORRELATIONS	ECONOMIC GEOLOGY	PRINCIPLE REFERENCES
CAINOZOIC	QUATERNARY (Qrp & 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; rests on Czy or KTi		Twidale, 1956a, & b, 1966) Valentin (1959, 1961) Whitehouse (1963) Doutch et al (1970) Ingram (in press)
		salt pan deposits	Qrp	2	Silty clay, salt			Minor salt	
		beach and sand ridges	Qm, Qml	<5	Coquina, calcarenite, shelly quartzose sand			lime from shells; building sand; minor perched aquifers	
		flood plain alluvium and floodout deposits	Qa	<10	Sand, silt clay	Alluvial Plains - Gilbert and Mitchell Fans and river flood plains & beds.	Qa contemporaneous with most Qas; Qra contemporaneous with youngest Qa. In some places Qas may overlie Qa, Qa may overlie KTi. All units rest on Czy from place to place	minor perched aquifers, minor springs?	Perry etal. (1964) Twidale (1956 a & b, 1966) Galloway et al. (1970).
		stream bed sediments	Qra	<5	Quartzose, sand, silt, clay				
		abandoned river channel deposits	Qas	<5	Quartzose sand				
		Wyaaba Beds	Czy	Up to 120	Poorly sorted grey clayey quartzose sand, sandstone and granule conglomerate, commonly pebbly; claystone	Outwash alluvium - Holroyd Plain, Claraville Plain and Staaten Interfan	Overlies KTi (disconformably) Lynd Formation of Laing & Power (1959)	aquifers commonly saline	Varner (1968); Appendix 1, this report
	TERTIARY (?)	Soil, colluvium	Cza	<5	Clay, quartzose sand	Fill in ancient valleys - colluvial	Overlies Td; probably contemporaneous with Css		
		Colluvium and outwash deposits	Css	<5	Quartzose sand and gravel	Colluvium: outwash alluvium - fluvial	Overlies Czy and KTi in places; probably contemporaneous in part with Qas and Czy		
		Louisa Fomration	To	Up to 15	Silcrete, silcrete gravel, quartz cobbles, pebbles and sand	lag deposits derived from duricrust?	Unconformably overlies Klu; may be equivalent to KTi		Woods (1961)
		Ferricrete	Tf	<2	Iron cemented gravel and colluvium; 'laterite'		Developed on JKg and KTi. Some may be younger than Wyaaba Beds		
		'Duricrust'	Td	<30	Hard fossil soil and colluvium; brecciated, ferruginous, siliceous. Rocks beneath are mottled, kaolinized silicified.	continental-deep weathering	Developed on Kln		Ingram (in press)
-?-	EARLY CRETACEOUS OR EARLY TERTIARY	Bulimba Formation	KTi	Up to 150	Poorly sorted clayey quartzose sandstone and granitic conglomerate, pebbly in places; interbedded sandy claystone	Continental-fluvial	Overlies Kln (disconformity?) - surface ferruginized (laterite?)	possible aquifers	Appendix 1, this report

TABLE 1 STRATIGRAPHY (Cont'd)

ERA	PERIOD			ROCK UNIT	MAP SYMBOL	THICKNESS (metres)	LITHOLOGY	DEPOSITIONAL ENVIRONMENT AND PROCESS	STRATIGRAPHIC RELATIONS: CORRELATIONS	ECONOMIC GEOLOGY	PRINCIPLE REFERENCES
MESOZOIC	EARLY CRETACEOUS	Albian	Rolling Downs Group	Normanton Formation	Kln	90*	Sandy clayey siltstone, silty mudstone, minor limestone and sandstone	Shallow marine and paralic	Conformably overlies Kla; offlaps to northwest and southeast? Correlated to Mackunda Formation, Eromanga Basin		Smart et al. (1971)
				Allaru Mudstone	Kla	310*	Shale, mudstone, some siltstone, limestone		Conformably overlies Klo; offlaps to northwest and southeast? Part of Normanton Formation of Meyers (1969). Cenomanian polynormps at 261 m in Wyaaba No. 1 (Burger, pers. comm.)		Vine et al. (1967) Smart et al. (1971)
				Toolebuc Limestone	Klo	<107*	Calcareous shale, limestone	marine	Conformably overlies Klu. Kamileroi Formation of Meyers (1969)	possible uranium, vanadium, shale oil	Vine & Day (1965) Vine et al. (167) Smart (1972)
		Aptian		Trimble Member ∅	Klt	68*	Labile sandstone, mudstone, minor limestone		Conformably overlain by Kla; part equivalent to Klt?	possible aquifers	Woods (1961) Appendix 1, this report
				Wallumbilla Formation ∅	Klu	240*	Mudstone, some siltstone, minor limestone, some glauconite		Conformably overlies JKg. Blackdown Formation of Meyers (1969)		Laing & Power (1959) Vine et al. (1967)
	LATE JURASSIC AND EARLY CRETACEOUS			Gilbert River Formation ∅	JKg	40*	Clayey quartzose sandstone, glauconitic in upper part	shallow, marine following fluvial.	Unconformable on basement rocks. Wrotham Park Sandstone of Laing & Power (1959).	excellent aquifer in Wyaaba No. 1	Meyers (1969) Smart et al. (1971)
				Coffin Hill Member	Klf	20-30	Clayey quartzose sandstone, minor siltstone, shale. Glauconitic in upper part.	near shore marine	Together make up Gilbert River Formation		
				Yappar Member	JKy	-0-45	Quartzose sandstone and conglomerate, minor shale	estuarine tidal channels and fluvial			

* based on Wyaaba No. 1, and other information in Warner (1968) and Meyers (1969). See Fig. 7
∅ See Appendix 1 as well as text
+ in BMR Walsh 1.

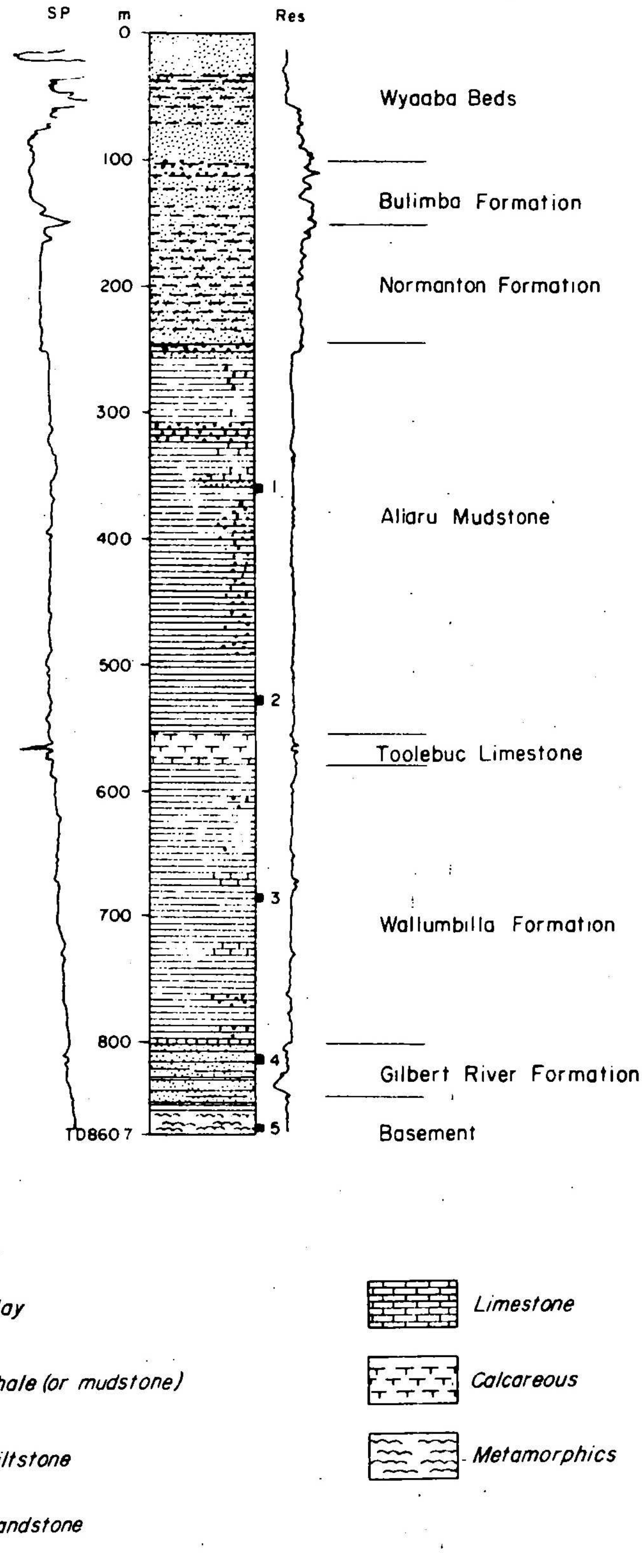

Fig 7 LITHOLOGICAL LOG AND ELECTRIC LOGS, FBH WYAABA No I (After Myers, 1969)

The quartzose Gilbert River Formation is succeeded, apparently conformably, by the mudstone, labile sandstone, and limestone formations of the Rolling Downs Group. The oldest formation of the group, the Wallumbilla Formation, crops out in a few places near the eastern margin of the basin; the overlying Toolebuc Limestone and Allaru Mudstone have been proved present only in bores. The youngest formation of the group, the Normanton Formation, crops out at Normanton and is present in the bores AA08 Karumba and FBH Wyaaba No. 1.

Figure 7, the log of FBH Wyaaba No. 1, illustrates the succession. Table 1 details stratigraphy and Appendix 1 contains discussions on stratigraphic nomenclature.

Gilbert River Formation

The Mesozoic sandstones of the Wrotham Park area were originally named the Wrotham Park Formation by Laing & Power (1959); however, recent mapping has shown that this unit can be correlated with the Gilbert River Formation of the Croydon area (as redefined by Smart et al., 1971), and the term Wrotham Park Formation has been dropped (Smart et al., in press).

It has been possible to distinguish in parts of the Walsh, Mossman, and Red River Sheets the two members recognized to the south by Smart et al. (1971). Elsewhere the formation has been mapped as a single unit.

The Yappar Member is the lower of the two members. It is of extremely variable thickness as the basal unconformity is very irregular, for example where the Nychum Volcanics are present as buried hills or plateaux, although where the formation lies over other basement rocks the member attains its more usual thickness of 35 to 45 m.

The Yappar Member is composed of light grey, brown, and red medium to coarse-grained quartzose sandstone, granule and pebble conglomerates, and minor beds of fine sandstone and mudstone. In some places basal conglomerate up to 2 m thick is composed of fragments of underlying Precambrian or Palaeozoic rocks. Glauconite[1] was not observed in the outcrops of this member but was found in some beds in the upper part of the unit in BMR Mossman 1 (Smart & Grimes, 1971).

In BMR Mossman 1 about 20 m of green polymictic conglomerate was penetrated at the bottom of the member without reaching basement. This anomalous thickness of conglomerate is thought to be a stream-bed deposit in a deep valley in the basal unconfirmity, as extrapolation from outcrop had suggested that basement would be much shallower in this area.

In outcrop the member frequently forms high red cliffs along plateaux edges. Crossbedding and ripple laminae are common. Mega-ripples and reversals of crossbed directions in vertical sequence were seen in outcrops at the headwaters of Blackfellows Creek, northeast of Wrotham Park (Fig. 8).

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1 Houston (in Woods, 1961) points out that true glauconite can only be differentiated from the chlorites by X-ray photography. The term 'gauconite' is used here in the broad sense for small, sandsized, greenish, rounded pellets of heterogeneous mineral content.

These structures have been interpreted as resulting from a tidal channel environment with alternating current directions (K.A.W. Crook, pers. comm.). Mega-ripples are also present near The Falls on the Mitchell River.

A few worm borings and trials have been observed towards the top of the member, generally in the finer-grained beds (Appendix 2). Plant roots (see Fig. 10) and ?Equisetalian stem bases (Fig. 11) were found towards the base of the member at one locality (Mossman, grid reference 186883 yd), and wood casts are common in some beds throughout the unit.

The earlier deposits of the member appear to have been deposited by streams in a dissected terrain. The later beds were laid down in estuaries and tidal inlets, and finally in larger bays, as the sea transgressed and the Mesozoic topography became further buried.

The Coffin Hill Member conformably overlies the Yappar Member. It is distinguished from the lower member by a fining of the sediments, the presence of beds with an abundant trace fauna, and widespread glauconite.

The rocks consists of light to dark brown medium to fine-grained quartzose sandstones, generally clayey, with interbeds of siltstone and claystone and a few beds of coarse sandstone. The unit forms low scarps and benches above the cliffs of the Yappar Member.

The glauconitic claystone and sandstone of the upper part of the Coffin Hill Member and of the overlying Wallumbilla Formation often display a patchy distribution of the sand and clay-size material. In the glauconitic claystones the glauconite grains are generally segregated into blebs and streaks with a clay matrix, distinct from the surrounding rock, which is nearly pure claystone with only sparse glauconite grains. The glauconitic clayey sandstones have a similar structure except that the sand grains (glauconite, and labile or quartzose grains) are dominant and the clay is restricted to streaks and blebs.

The reasons for these distributions are uncertain. In some places it appears to be due to the action of burrowing organisms, but elsewhere there is no evidence of organic activity. The glauconite zones in the glauconitic claystones could have been formed by the agglutination of the grains into lumps, or by the accumulation of grains in shallow depressions in the depositional surface followed by burial beneath further clayey material. In the clayey mudstones the situation could be reversed, though many of the clay blebs in them appear to be clasts derived from the erosion of nearby clay deposits. Whatever the explanations, it is generally accepted that glauconite is formed in areas of slow deposition.

The marine nature of the Coffin Hill Member is shown not only by the presence of glauconite throughout the unit but also by the presence of both shelly fossils and trace fossils.

Fig. 8 Megaripples in Yappar Member of Gilbert River Formation, headwaters of Blackfellows Creek, MOSSMAN

Neg. 4730

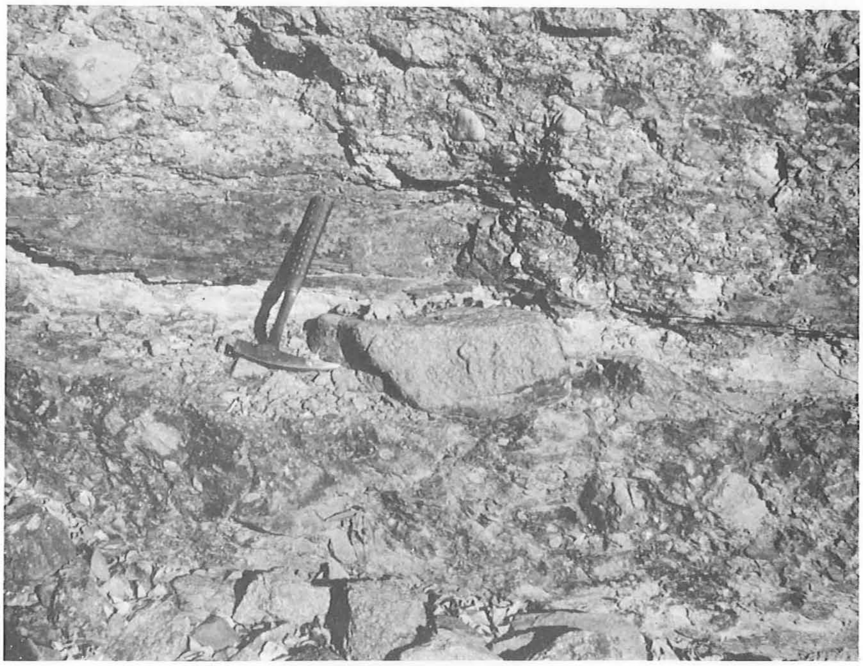


Fig. 9 Diamictite at the base of (below?) the Gilbert River Formation, The Falls, Mitchell River, WALSH

Neg. 4729

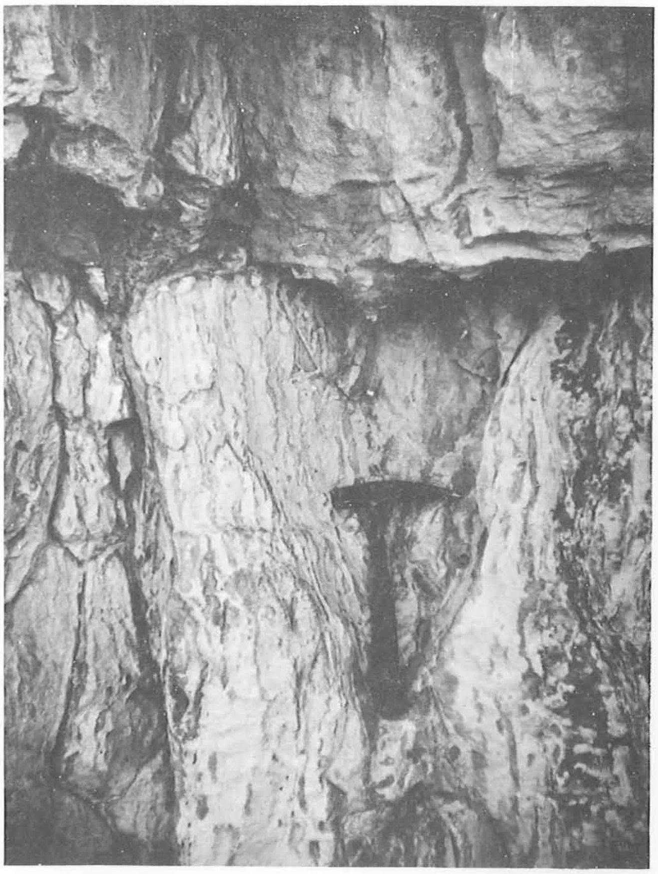


Fig. 10. Vertical structuring (root traces?), Yappar Member (?), Gilbert River Formation, Chillagoe-Wrotham Park road, MOSSMAN

Neg. 4753

Fig. 11. Root clumps and stem bases of an equisitalian (?) plant, Yappar Member (?), Gilbert River Formation, Chillagoe - Wrotham Park road, MOSSMAN

Neg. 4756

Body fossils are scarce. Terebratuloid brachiopods have been found at the top of a small mesa 5 km southwest of where the Wrotham Park road crosses Nolan Creek in west Mossman. Maccoyella barklyi was identified from this outcrop by Woods (1961). Several new shell fossil localities were found during the course of the 1970 season mapping, but the specimens collected have not yet been described or identified.

Woods (1961) suggested a Neocomian age for the 'Wrotham Park' Formation in this area, though farther to the south lower Aptian fossils are reported from the Coffin Hill member by Laing & Power (1959, 1960). Skwarko (in Doutch et al., 1970) in a preliminary report suggests an Aptian age for fossils from the Coffin Hill Member in the vicinity of Croydon.

The trace fossils of the Formation are described in the Appendix.

In the Normanton area the formation is absent in Mid-wood Normanton 2. This is part of the evidence for the existence of the Croydon-Smithburne High (see Structure).

Wallumbilla Formation

The Wallumbilla Formation (the Blackdown Formation of Laing & Power, 1959 - see Smart et al. in press) is the oldest unit of the Rolling Downs Group. Outcrops are restricted to the eastern margin of the area. There are isolated outcrop areas in Georgetown, Croydon, and Red River Sheet areas, but the main area is near Wrotham Park, in the Walsh and west Mossman Sheets.

The Georgetown Sheet outcrops are on the uppermost part of the plateau north of Glenora homestead (Doutch et al., 1970), and consist of 13.5 m of sandy mudstone and clayey labile sandstone altered by deep weathering. The outcrops at the Briden Hills, on Croydon Sheet consist of 7 m of mudstone, siltstone, and fine to medium-grained clayey labile sandstone, with fossil wood, and are overlain by a ferruginous deep weathering horizon. In Red River Sheet there are small areas of poor outcrop in the vicinity of Abingdon Downs, Torwood, and Blackdown homestead. Blackdown homestead is the type area of the Blackdown Formation of Laing & Power. These areas generally consist of 'black-soil' plains with little outcrop apart from scattered boulders of limestone in the soil.

In Walsh and west Mossman Sheets the formation crops out in a belt of 70 km long from north to south and 50 km wide. The best and most accessible outcrops are in creeks in the vicinity of Wrotham Park and Blackdown homesteads (Fig. 12). The lithology and palaeontology of these deposits have been described in detail by Woods (1961) who stated that the fossils were of Aptian age. The dominant lithology is dark grey ('blue-grey') laminated mudstone. However, this weathers to form a heavy black soil, and mudstone crops out only in stream banks. Elsewhere the only outcrops are of the more resistant beds of limestone and sandstone which occur throughout the unit. The formation was deposited in a shallow marine environment.

The limestones generally occur as zones of concretions. They are usually dull grey or light brown calcilutites, and commonly have a sand fraction, either disseminated throughout the rock, or concentrated in discrete blebs or streaks. The amount of sand present is variable but generally less than 40% of the rock. Some concretions are 3 m across. They are irregular or form flattened ellipsoids parallel to the bedding. Septarian structures are present in places. The fossils of the formation are nearly always preserved within these concretions. Woods (1961) describes irregular concretions from sandy beds towards the base of the formation which are texturally similar to the glauconitic 'claystone' from the top of the Gilbert River Formation (his Wrotham Park Sandstone). In some instances he found fossils which were not preserved beyond the boundaries of the concretions, suggesting weathering or incomplete preservation of a syngenetic structure before being covered with sediments.

The sandstone beds and lenses within the mudstones are most common towards the base. Most of these beds are composed of green-grey medium to fine-grained glauconitic labile or quartzose muddy standstone, which weathers brown. The proportion of glauconite varies and it is absent in some beds. Blebs and slivers of mudstone are commonly present. These beds are similar in lithology to the glauconitic sandstones to the east in the upper part of the underlying Coffin Hill member (q.v.)

A sandstone bed which crops out at the road crossing of Elizabeth Creek, east of Wrotham Park, and which extends south for about 5 km, is grey, poorly sorted, medium to very coarse, granular, lithic and sub-labile, with a lustre mottled calcite cement. The granules are composed dominantly of green and grey lithic fragments, and the sand grains are mostly quartz with some labile grains. The rock is massive and the bed is about 3 m thick. There are a few belemnite guards. This rock type has been found only in the one bed. It probably represents an isolated high-energy event in which coarse material was carried into the basin from the coastal zone to the east and dumped in this area.

The sandstone beds are similar in lithology to the topmost beds of the Coffin Hill member. The boundary between the two units is takens as the base of the lowest dark grey mudstone, but as the mudstone generally does not crop out some difficulty can be met in trying to distinguish the boundary. For example, the outcrop in the creek beside the yards at 168887 yd., Mossman Sheet is mapped as Coffin Hill member, but could be a bed within the Wallumbilla Formation, as the surrounding area is masked by Cainozoic sand and there is no other outcrop of Mesozoic rocks.

The Wallumbilla ('Blackdown') Formation has been recognized in AAO 8 Karumba and FBH Wyaaba 1 (see Meyers, 1969, and Smart et al.,in press) in Mid-Wood Normanton 2, and in BMR bores Normanton 1 & 3 and Red River 1 (Needham et al., 1971; Smart & Grimes, 1971).

The <u>Trimble Member</u> of the Wallumbilla Formation (Smart et al., in press) crops out at Woods (1961) type area on the Walsh River, and more extensively along strike northwest of the Mitchell River. It has also been identified in BMR Walsh 1 (Smart & Grimes, 1971). It consists of labile limestone and subordinate mudstone, with fossiliferous sandy glauconitic calcilutite concretions at the

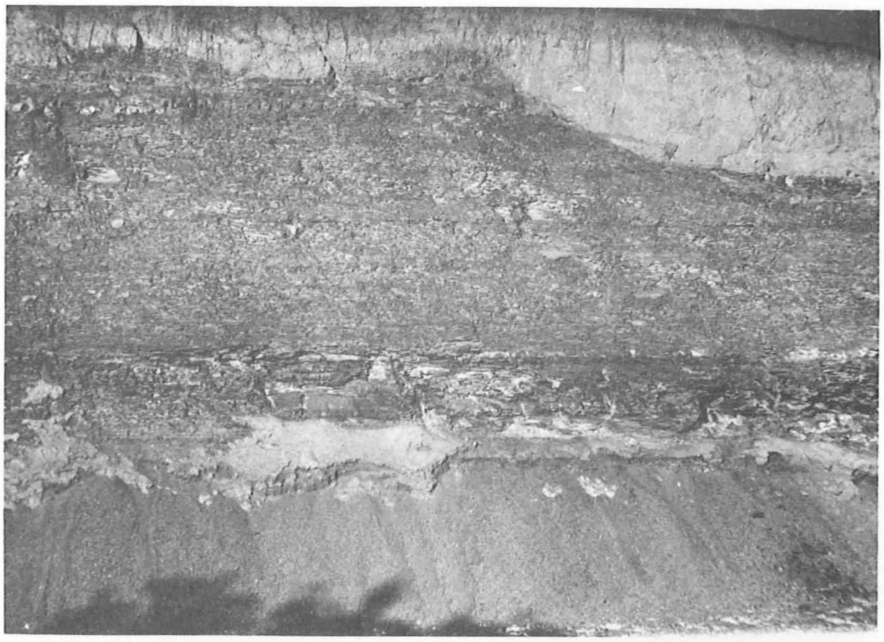


Fig. 12 Wallumbilla Formation mudstone, north of Boomer Waterhole, Walsh River, WALSH

Neg. 5865

Fig. 13 Granule conglomerate, Bulimba Formation. Probably cross bedded. North of Bulimba Homestead, WALSH

Neg. 4762

type area. The fossils are of Albian age.

Toolebuc Limestone

The Toolebuc Limestone does not crop out anywhere in the central part of the Carpentaria Basin, and does not seem to have been deposited in the east (cf. Trimble Member, and Smart et al., in press). It has been identified (as the Kamileroi Limestone by Meyers, 1969) in FBH Wyaaba No. 1 (Derrington, 1957; Dyson, 1958; and Fig. 7) in which it consists of fossilerous calcareous shale and limestone, and perhaps also of some of the underlying mudstone formerly included in the Wallumbilla Formation (cf. Smart, 1972 and in press). Fossils in outcrops to the south are of Albian age.

Allaru Mudstone

The Allaru Mudstone (the lower Normanton Formation of Myers, 1969, renamed by Smart et al., 1971) also does not crop out in the area. In the east, in BMR Walsh 1, it was deposited apparently conformably on the Trimble Member of the Wallumbilla Formation (Smart and Grimes, 1971; and Smart et al., in press). It is also present in AAO 8 Karumba and FBH Wyaaba 1 (Meyers, 1969, and Fig. 7). It consists of mudstone and minor limestone and labile sandstone.

It is of Albian age in the Eromanga Basin to the south. Burger (pers. comm.) recognizes Cenomanian polynomorphs in the formation in FBH Wyaaba No. 1. The northerly offlap suggested is more simply explained by eustacy than tectonism.

Normanton Formation

The Normanton Formation (upper Normanton Formation of Meyers 1969 - and see Smart et al., 1971) is the youngest preserved formation of the Rolling Downs Group known in the central Carpentaria Basin. It crops out at Normanton and occurs in AAO 8 Karumba and FBH Wyaaba No. 1 (Meyers, 1969).

At Normanton it forms the Normanton Plateau and consists of fine-grained labile sandstone, labile siltstone, and mudstone, everywhere altered by deep-weathering processes (brecciation, silicification, ferruginization, kaolinization, leaching). In the two bores it is more clayey, less sandy (Fig. 7).

Marine macrofossils in the type area on the western edge of the Normanton Plateau, at the Little Bynoe Crossing, are of Upper Albian age (Meyers, 1969).

CAINOZOIC STRATIGRAPHY

Introduction

Only the formally named units are discussed here (and see Smart et al., in press). Sediments younger than the Wyaaba Beds are described earlier, in Physiography, in the context of the geomorphological evolution of the area.

Table 1 contains a systematic summary of Cainozoic stratigraphy, and Figure 2 shows the time relations of Cainozoic units.

Bulimba Formation

The Bulimba Formation (KTi) (Fig. 13, and Smart et al., in press) consists of clayey quartzose sandstone and sandy claystone, the latter being dominant in bore holes in the west, where the formation is overlain by Wyaaba Beds. It is up to 150 m thick at the coast near the Mitchell River.

The formation was derived mainly from the Precambrian and Palaeozoic igneous and metamorphic rocks to the east and south and to a lesser extent from Mesozoic rocks. It was originally feldspathic or arkosic, but most feldspar has since changed to kaolin. The formation is poorly sorted throughout and cross-bedding is limited. Pebbles are rare, even near the present margins of the unit. Crossbeds in the area south of Bulimba Homestead, mainly small scale planar units and small troughs, indicate transport to the north and west.

It was apparently a continental deposit, and in places occurs in valleys eroded into Mesozoic sandstone units. Some of the ferruginization of of the formation in the Bulimba Plain, and that at its top in boreholes, occurred before deposition of the Wyaaba Beds and downwarping of the Gilbert-Mitchell Trough. Ferricrete on the Bulimba Formation in the Bulimba Plain is probably due to reworking of the older ferruginized beds at the time of 'lateritization' of the Wyaaba Beds.

Louisa Formation

The Louisa Formation (Woods, 1961), part of the Bulimba Plain, consists of small outliers of quartz cobbles, pebbles, and sand with broken silicified cappings, occurring in the Wrotham Park area.

Stratigraphically the Louisa Formation seems unlikely to be older than the Bulimba Formation. Woods (op. cit.) suggested that the Louisa Formation was of pre-'laterite' 'middle or lower Tertiary age'. His 'laterite' seems to be that found between the Bulimba Formation and the Wyaaba Beds, and it would follow that the Louisa Formation should be as old as, and possibly an outlying part of, the Bulimba Formation.

This may be so, but the siliceous nature of the deep weathering of the Louisa Formation is unlike the ferruginous alterations of the Bulimba Formation, and the two units may well have different ages. However, the topographic position of the Louisa Formation suggests that the unit may in part at least be older than the Wyaaba Beds.

Wyaaba Beds

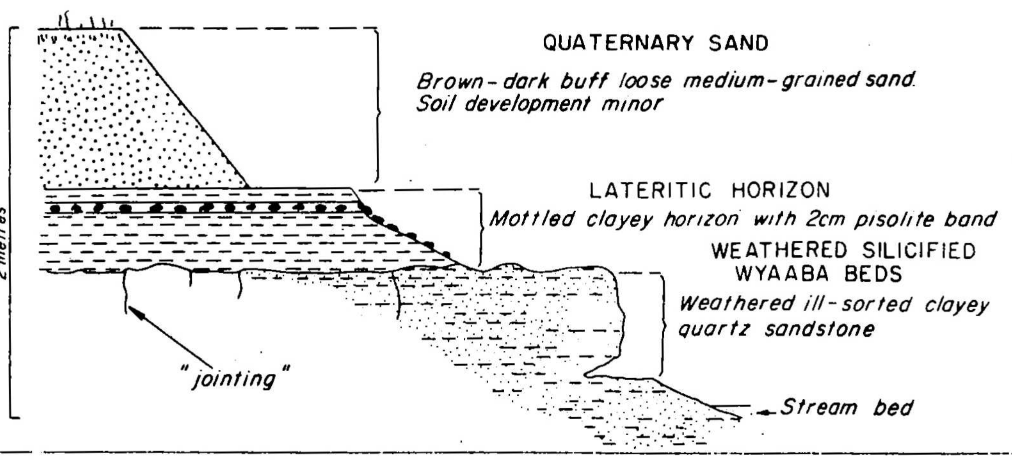
The Wyaaba Beds (Czy) (Smart et al., in press) consist of bores and tanks of clayey quartzose sand and sandstone. The lowest strata contain fragments of 'lateritic' material from the top of the Bulimba Formation and elsewhere. Less than 10 m of the unit is exposed anywhere by erosion. The Beds were probably continental deposits. They are up to 100 m thick at the coast north of the Staaten River.

The beds can be recognized on air-photographs by two major patterns, that of the Holroyd Plain, and that of the Claraville Plain and Staaten Interfan (Fig. 3). The latter two have a pattern made up of outwash and floodout deposits, parallel streams, and numerous claypans.

Fig. 14

IMMATURE LATERITIC PROFILE

Tea Tree Creek, Galbraith,
6 km west of Dunbar H.S.



To accompany Record 1972/64 *M(S) 201*

The Wyaaba Beds were deposited on an erosional surface. South of Normanton and Croydon the surface was developed mainly on Mesozoic rocks. To the north it continued across the Bulimba Formation in the Staaten River Embayment. During deposition of the Wyaaba Beds in the Embayment it was tectonically downwarped and downfaulted to become the Gilbert-Mitchell Trough. The Trough then filled with younger Wyaaba Beds to about its present level, that of the Claraville Plain and Staaten Interfan, the oldest beds being left unburied in the Holroyd Plain.

The Wyaaba Beds were derived by erosion from the Precambrian and Palaeozoic rocks of the Georgetown Inlier, Mesozoic rocks, and the Bulimba Formation. The oldest Wyaaba Beds were probably eroded for a while after the Gilbert-Mitchell Trough formed, and contributed detritus to younger strata in the unit.

Deposition of the Wyaaba Beds has probably been continuous since the Pliocene, making them approximate time equivalents of the Wondoola Beds and Armraynald Beds to the south and west (Fig. 2 and Smart et al., in press).

In many areas weathering of the Wyaaba Beds has resulted in the development of ferruginous pisolites and shallow mottling (Fig. 14). This has been described as 'lateritization' (Reynolds, 1960; Warner, 1968); however, the majority of workers (Perry et al., 1964; Isbell et al., 1963; Galloway et al., 1970) interpret it as a soil.

Whatever the processes, they were likely to have affected all outcrops of the time, and ferricretes and deep-weathering phenomena (ferruginization, silicification, brecciation)from Julia Creek to Cape York could be ascribed to them. This may be the age of bauxitization at Weipa.

Ferruginization in river beds may be of this age, but in many instances is younger still and in places affected deposits younger than the Wyaaba Beds.

The Wyaaba Beds and Bulimba Formation together probably constituted the Lynd Formation (see Smart et al.,in press).

STRUCTURE

The central part of the Carpentaria Basin is a structural sub-domain of the basin and consists of the Mesozoic Staaten River Embayment (Meyers, 1969) and a Cainozoic modification to it, the Gilbert-Mitchell Trough (Fig. 15).

The Embayment existed at the time of Mesozoic sedimentation, and was probably an erosional feature (cf. Twidale, 1956b, 1966) controlled by marginal faults or warps. Local uplifts, probably by block faulting, occurred along the southeast margin of the Embayment after Mesozoic deposition ceased and before the Bulimba Formation was deposited. After the Bulimba Formation was deposited the whole embayment was downwarped with a plunge to the northwest, forming the Gilbert-Mitchell Trough, which was later partly filled by the Wyaaba Beds.

In detail, little is known yet about the northeast margins of the Trough and Embayment. The name Alice-Palmer Structure is used to cover what is known. It appears to be a branch of the Palmerville Fault (Fig. 15). Sections suggest it is a steep flexure or fault where it parallels basement outcrops in the Walsh Sheet; further west, in Rutland Plains and Holroyd Sheets, air-photo interpretation suggests the structure is a shallow warp, the lateritized Bulimba (?) Formation having been flexed gently down to the southwest, where it eventually disappears below the Wyaaba Beds.

The southwest margins of the Trough and Embayment are the Robertson Structure, detailed by Needham (1971) and not discussed here, and the Croydon-Smithburne Basement High (Simpson, in press).

The Croydon-Smithburne Basement High is a basement structure over which the Mesozoic and Cainozoic formations are draped anticlinally. It is probably fault-bounded by the Robertson Structure along its northeast flank, but its southwest side is of uncertain character, and there is no marked discontinuity between it and the Claraville Shelf (an erosion surface?).

Detailed seismic work (Warner, 1963) shows that minor variations (in the order of 100 m) in the pre-Mesozoic basement surface in Normanton Sheet are coincident with positive and negative gravity anomalies (but cf. Robertson & Moss, 1959, on interpretation of seismic results). These variations seem to be developed on a broad basement high extending from Croydon to the southeast of the Sheet, towards the mouth of the Smithburne River to the northwest. This feature was interpreted from contemporary data and called the Croydon-Gregory Range Ridge by Reynolds (1960) and Meyers (1969). It corresponds with the Croydon-Smithburne Basement High.

Twidale (1966, p.22) suggests a small 'late Pliocene or early Pleistocene upwarp' along an axis between Croydon and Normanton, to account for drainage diversions thereabouts. This axis is southwest of, but parallel to, that shown for the Croydon-Smithburne Basement High, but the upwarp would most probably result from reactivation of the High. If the upwarp exists, as form lines on the base of the Wyaaba Beds suggest it might, then it would be the southwestern margin of the Gilbert-Mitchell Trough.

The original southeastern end of the Staaten River Embayment is difficult to reconstruct, as most of the Mesozoic rocks there were eroded away after the Pliocene (?) uplift (Doutch et al., 1970) which resulted in the baring of the Georgetown Inlier. Before this uplift occurred there were local basement movements in the area between Strathmore and Wrotham Park, between the times of deposition of Mesozoic strata and the Bulimba Formation.

In Red River Sheet the structures formed at this time are here named the Etheridge Structure, Abingdon Anticline, Dagworth Discontinuity, Middle Creek Structure, Lynd Lineament, Pinnacle Creek Structure, and Tate River Structure (Fig. 16).

The Abingdon Anticline is probably a similar structure to the Croydon-Smithburne Basement High; its origins may antedate Mesozoic deposition.

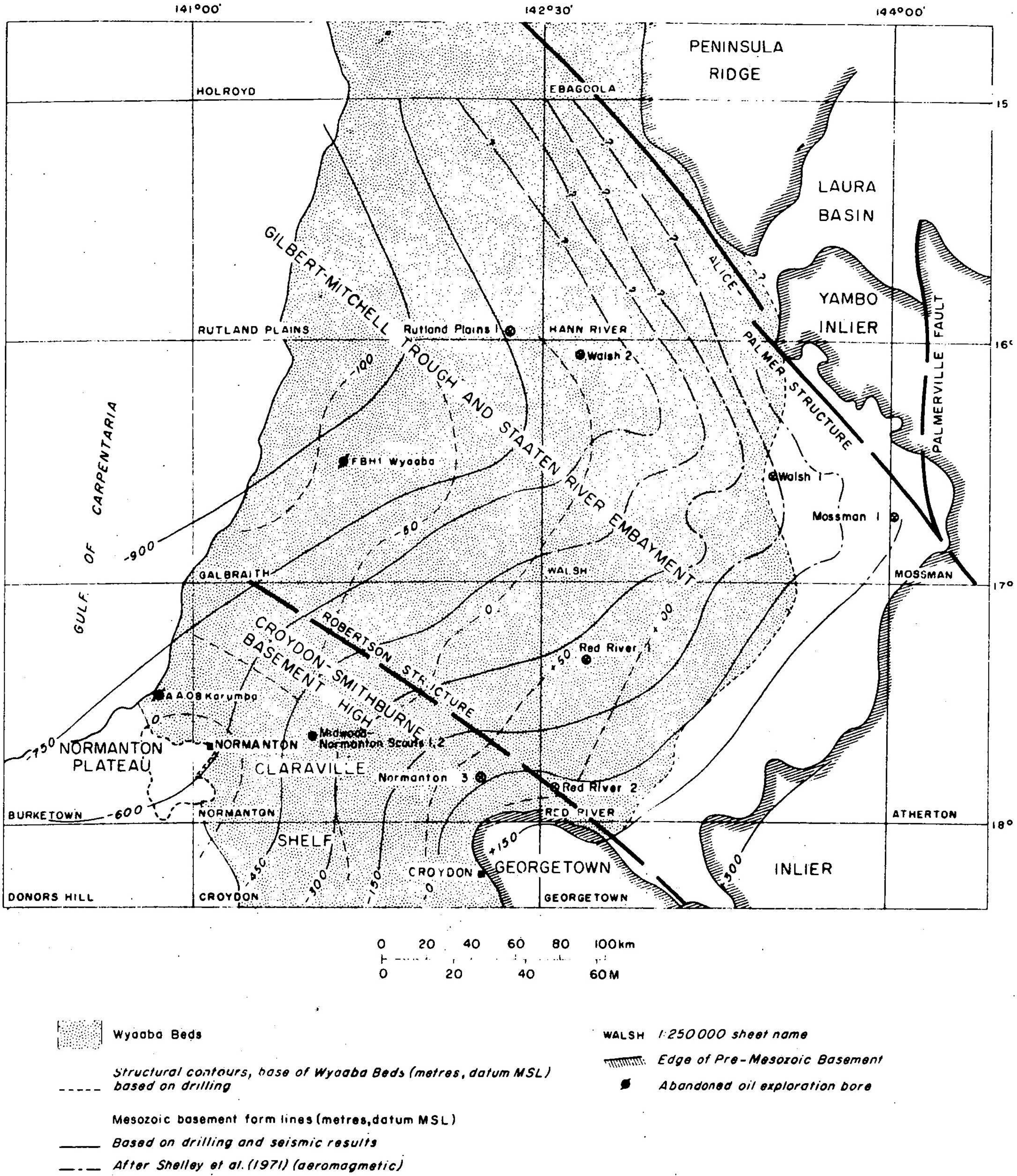
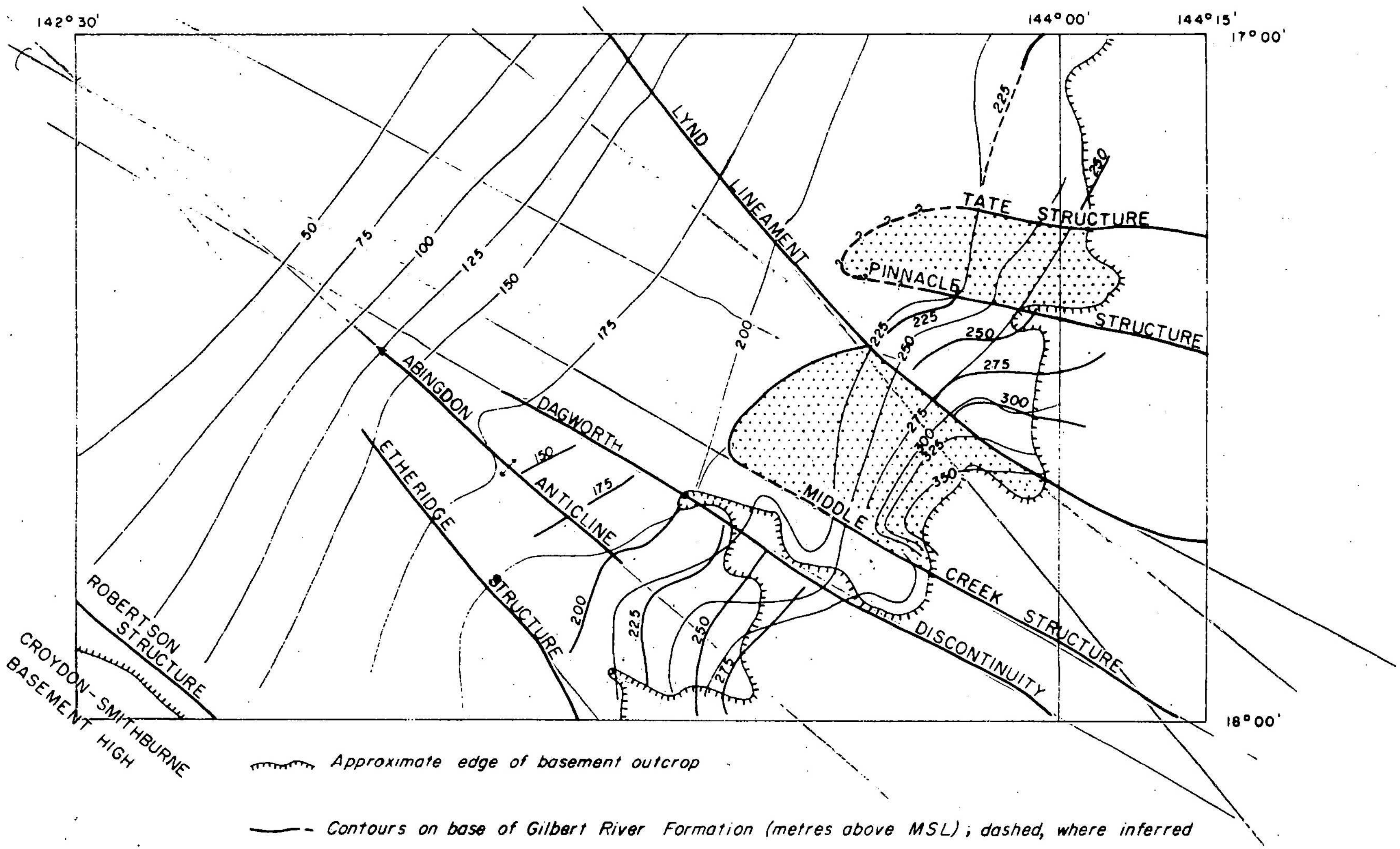


Fig 15 Structural elements in the eastern Carpentaria Basin



Approximate edge of basement outcrop

Contours on base of Gilbert River Formation (metres above MSL); dashed, where inferred

Contours on base of Bulimba Formation (metres above MSL)

Areas where Bulimba Formation overlies basement (Gilbert River Formation absent)

Fig. 16 BASEMENT STRUCTURE ON THE S.E. MARGIN OF THE GILBERT — MITCHELL TROUGH

Basement and Mesozoic rocks and the Bulimba Formation are exposed on it. It is bounded along its northern flank by the Dagworth Discontinuity, which is probably a fault; the nature of its southwestern margin, the Etheridge Structure, is unknown.

Pre-Bulimba movements of the Abingdon Anticline were probably contemporaneous with a period of uplift of the Boomarra Horst (Doutch et al., 1970; Smart, in press). There followed a period of erosion, and then of deposition of the Bulimba Formation unconformably on basement rock inliers in dissected Gilbert River Formation outcrop. After 'lateritization' of the Bulimba Formation the structure was further arched (part of the episode of Pliocene (?) uplift ?). Erosion since then has produced the outcrop pattern from which this history is deduced.

Northeast of the Abingdon Anticline there are two areas where the Bulimba Formation rests on basement rocks, or is interpreted as doing so from the abundant lineaments and joints in it in these areas, features rare elsewhere. The boundaries of these areas, the Tate, Pinnacle, and Middle Creek Structures and the Lynd Lineament, coincide with mapped lineaments, minor faults, margins of granite intrusions, and contour anomalies.

Although the Gilbert River Formation may be absent from these areas because it was never deposited there, structural contours on its base suggest former continuity of the unit across them. The history of the Abingdon Anticline supports the view that there was contemporaneous pre-Bulimba uplift in these two areas also, with consequent removal of the Gilbert River Formation from them by erosion before deposition of the Bulimba Formation.

The northwesterly plunge of all these uplifted areas is relatively steep. They are not reflected in structural contours on the top or base of the Bulimba Formation in the area overlain by the Wyaaba Beds.

On the whole the Gilbert-Mitchell Trough seems to be a downfaulted block, perhaps a graben, hinged and partly faulted along its northeast and southwest margins. It may still be deepening sporadically. Younger Cainozoic deposition in this structure may have started just before downwarping; the older early Tertiary or late Cretaceous Bulimba Formation probably antedated the Trough and could be said to be part of Embayment sedimentation.

The northwest limits of both the Embayment and the Trough are unknown. Both may once have been connected with deeper basins in the Arafura Sea region before formation of the Gulf of Carpentaria in the Pleistocene (Phipps, 1966). Meyers (1969) presents debatable basement contours and Tertiary isopachs which suggest that both features deepen below the Gulf as far west as longitude 139°E. Phipps (op. cit.) interprets Delhi Australian's aeromagnetic results (1962) as showing a northsouth basement high at that longitude. Bathymetry suggests that the northwest half of the Gulf may be an upfaulted block. Thus the existence of both Embayment and Trough west of longitude 139°E is doubtful. The formation of the Gulf of Carpentaria does not seem to have deepened the Trough offshore (cf. Phipps, 1970).

The Gilbert-Mitchell Trough is a more stable contemporary of the West Irian peri-orogenic basins (Visser & Hermes, 1962) and of the west Papuan Strickland Basin (APC, 1961). All three can be classified as foreland (foredeep) downwarps syngenetic with adjacent uplifts. In New Guinea this was late Cainozoic uplift of the highlands, and in Australia, uplift of the ancestral Great Dividing Range in Cape York Peninsula. Both uplifts occured along the edge of the Australian craton of that time.

GEOLOGICAL HISTORY

The geological history of the area is summarized in Table 2.

TABLE 2. GEOLOGICAL HISTORY

AGE	EVENT	REMARKS
Early Jurassic? to late Jurassic	Formation of Croydon - Smithburne High and associated structures.	Formation of Millungera Depression to south and Burketown Depression to west. Deposition in them of Eulo Queen Group and equivalents. Also deposition of Dalrymple Sandstone in Laura Basin.
Late Jurassic to Early Cretaceous	Deposition of quartzose Gilbert River Formation and onset of marine conditions Probably onlap from north and west.	Battle Camp Formation on Laura Basin.
Early Cretaceous (Aptian)	Deposition of Wallumbilla Formation - change to deeper water marine conditions. Sediments mainly mud.	
Aptian-Albian	Change to labile arenaceous sediments in east near basin margins (Trimble Member); deposition of Toolebuc Limestone in western area.	Rolling Downs Group. Similar history of sedimentation in Eromanga Basin. Lowest mudstone unit called Wolena Claystone in Laura Basin.
Albian-Cenomanian?	Return to dominantly muddy sediment - Allaru Mudstone. Onset of shallow marine-paralic conditions, probably due to regression, with deposition of labile Normanton Formation.	
Late Cretaceous?	Reactiviation of basement highs (Croydon-Smithburne High, and Abingdon Anticline), probably also Palmerville Fault. Partial erosion of Mesozoic on basement highs.	Block faulting in areas to the SW (Boomarra Horst etc.).
Late Cretaceous? to Tertiary	Deposition of continental clayey quartzose Bulimba Formation north of Croydon-Smithburne Basement High. Northern limit uncertain.	In east, overlaps some Mesozoic units to rest on basement.
	Deep weathering of Mesozoic rocks and Bulimba Formation.	Probably in more than one episode.
Mid-Tertiary?	Partial erosion of deep weathering profile.	Cza landscape one result.
Pliocene?	Beginning of Wyaaba Beds deposition soon followed by initiation of Gilbert-Mitchell Trough, by downwarping NE of hinge line coincident with Robertson Structure. Subsidence continued during deposition. Consequent earlier erosion period for Holroyd Plain begins and ends.	Also fault movements N of Gamboola and uplift resulting in Georgetown Inlier.

Table 2 (Cont'd)

AGE	EVENT	REMARKS
Pleistocene?	Deposition of Wondoola Beds of Wondoola Plain to the SW, interfingering with youngest Wyaaba Beds; Claraville Plain and Staaten Interfan products of Wyaaba Beds deposition.	Also Armraynald Beds of Armraynald Plain further west.
Pleistocene	'Lateritization' of Wyaaba Beds - probably pedological.	May be contemporaneous with bauxitization at Weipa.
	Partial erosion of Wyaaba 'Laterite', ? contemporaneous with abandoned stream channels (Qas). Later erosion period of Holroyd Plain, begins to produce Bulimba Plain, and Gilbert-Mitchell Fans and Karumba Plain begin and continue to present.	Erosion of Wondoola and Armraynald Beds and Plains in progress to S
?30 000 B.P.	Older beach ridges formed.	
3 300 B.P. to present	Younger beach ridges and 'stream laterites' formed.	Migrations of Gilbert and Mitchell Fans.

ECONOMIC GEOLOGY

Groundwater

Groundwater occurs in aquifers in the Gilbert River Formation and in Cainozoic deposits.

Warner (1968) records chemical analyses of artesian water, from what is thought to be the Gilbert River Formation, flowing from Normanton Town Bore (Registered Number 333) and AAO 8 Karumba. Shallow station broes in the Wrotham Park and Strathmore areas probably draw water from the same formation.

BMR Rutland Plains 1 and Walsh 2 obtained artesian water from the late Cretaceous? - early Tertiary Bulimba Formation (Smart & Grimes, 1971), and two station bores were sunk as a result.

Warner (op. cit.) carried out extensive investigations into the groundwater in the Wyaaba Beds (his Lynd Formation) in the Gilbert Fan and adjacent parts of the Staaten Interfan. The water obtained was inadequate for irrigation, of limited value for domestic use, but suitable for stock. Salinities commonly were high. A number of station bores tap this water.

Perched aquifers in the beach ridges of the coastal plain provide stock water which is less brackish than that in the Cainozoic deposits underlying them.

In all, this represents very little use of the groundwater available.

Construction Materials

Rivers, major creeks, and beach ridges contain huge quantities of quartz sand which is easily accessible. The Wyaaba Beds and Bulimba Formation contain a huge reserve of clayey sand and gravel.

The 'ferricrete' and 'duricrust' of the Normantaon Plateau and elsewhere are used as gravel for road making (Grant & Atchison, 1970); the Normanton aerodrome has a ferricrete surface. Shelly sand from beach ridges has been used for road surfacing; a coquinite from a nearby beach ridge has been used to surface the Inkerman airstrip.

Petroleum

The Mesozoic and Cainozoic sequence are nowehere more than 750 m thick in this area. Permeable beds of the Gilbert River Formation occurring at or near the base of the Carpentaria Basin are saturated with fresh or brackish water of meteoric origin and the possibility that petroleum has accumulated anywhere in the formation is slight. The rocks of the Rolling Downs Group are mostly impermeable. Exploratory work by private companies has been unsuccessful to date.

Bituminous shale is associated with the Toolebuc Limestone. It has been identified in the central Carpentaria Basin only in BMR Normanton 2, at

154 m, but may occur south of FBH Wyaaba 1. The oil shale is known to contain vandaium and uranium in the southern part of the basin.

Limestone

The Toolebuc Limestone does not crop out anywhere in the central Carpentaria Basin and would not be economically workable solely for limestone.

Beach ridges commonly have a high proportion of shells and could be a source for fluxing material, or lime or cement products.

Salt

Salt deposits, in places several centimetres thick, occur on tidal flats. The coastal plain is climatically suitable for the commercial evaporation of sea water during the annual dry season, but extensive wet season flooding would create problems of construction and access.

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APPENDIX

TRACE FOSSILS OF THE GILBERT RIVER FORMATION

by

K. Grimes

Trace fossils have been recorded throughout most of the late Jurassic and early Cretaceous Gilbert River Formation in the Wrothem Park area and are abundant in some beds of the Coffin Hill Member. Several trace fossil 'genera' have been identified from descriptions in recent publications (e.g. Hantzschel, 1962; Lessertisseur, 1955; Seilacher, 1964) to which the reader is referred for a more detailed description of the forms and nomenclature. The study of the forms is continuing, so the names assigned here are provisional. The different 'genera' are described below, followed by a discussion of their relationships to the sediments.

Description

Gyrochorte (Fig. 1 A & B). Bilobate ridges on the upper surfaces of sandstone beds ('positive epireliefs' - Seilacher, 1964). The surface of the trace is generally smooth apart from the central furrow, but in a few the lobes are made up of a series of knobs or pads. The genus is represented **by two recognizable species** in the Wrotham Park area.

Gyrochorte 'large species' (Fig. 1B). This has a width of 6 to 10 mm; some are as much as 0.5 m long. It is generally fairly straight or gently winding. This is the more common of the two species.

Gyrochorte 'small species' (Fig. 1A). A smaller form (3 to 5 mm wide) which follows a more contorted path, in some cases forming semi-regular close meanders suggestive of a feeding pattern. The subsidiary sculpture of knobs and pads is more common than in the larger species though the central furrow is not as well marked.

Both species occur on the upper surfaces of sandstone beds, which may be thickly bedded or thin and interbedded with mud layers. The surfaces of the beds are commonly ripple-marked; the traces follow the rippled surfaces without burrowing through the crests. A few grooves on the underside of some sandstone beds ('negative hyporeliefs' - Seilacher, op. cit.) are also present and are thought to represent the same genus. Fig. 3 may also be of a representative of this genus.

Skolithos spp. (Fig. 1C). Vertical, round, straight, or slightly curved, smooth-walled tubes. The size and spacing varies and it is thought that several species are present. The tubes are hollow or filled with sediment to give a positive relief. The tubes are in places paired, and in these cases could be a form of Diplocraterion, though no signs of a definite U-tube or spreite have been seen. The form is generally found in thick-bedded sandstone and is abundant in some beds.

Rhizocorallium spp. (Figs. 1F2). U-tubes with spreite (curved striations in the sediment between the two tubes). Both horizontal and inclined forms are present. This is a widespread genus which is present in the Wallumbilla and Normanton Formations and in the Mesozic sandstones overlying the Mt Isa Block. In the Wrotham Park area it occurs mostly in clayey sandstones, but has also been observed in clean sandstone and in mudstone.

Planolites spp. (Fig. 1G). Cylindircal, smooth-walled burrows of constant width but irregular direction. The burrows trend both vertically or horizontally but they commonly tend to remain close to a bedding plane. The diameter of the burrows tends to be constant in any given hand specimen but varies from 1.5 to 5 mm in different locations, suggesting that several species are present. The burrows are most common in the finer sandstone beds.

Chrondrites sp. (not illustrated). Fine (up to 3mm diameter), many branched mud-filled burrows in clayey sandstone.

Forms less readily identifiable are described below:

cf. Halymenidium (Fig. 1D). Irregular sand and silt-filled burrows in a clay matrix. The diameter of the burrows varies from 5 to 50 mm and the cross-sectional shape varies from circular to elliptical with the long axis horizontal. Vague lobes develop on the sides in places. The form was originally thought to be an irregular type of Planolites but has now been compared with the two species of Halymenidium described by Ksiazkiewicz (1970) on the basis of its fine sculpture, which consists of transverse narrow ridges. The fill material is commonly purple and coarser-grained than the surrounding clay. It probably represents faecal material.

cf. Stipsellus (Fig. 1E). Only a single specimen of this form has been collected but it has a distinctive morphology: it is a vertical sediment-filled tube, about 30 mm in diameter, with the filling in layered form giving a rugose surface. The name was derived by comparison with a description of Stipsellus by Hantzschel (1962). The form was found in a massive clayey fine sandstone, with vertical ?root casts and overlying a bed containing ?Equisitalian rootstocks.

cf. Chondrites (not illustrated). Only a single specimen, consisting of radiating and in places branching grooves on a bedding plane (negative epirelief).

Worm borings. Some beds have been completely disrupted by organic borings and it is generally not possible to recognize any individual forms. Though sections through some of the filled burrows may appear similar to sections through cf. Halymenidium, they cannot be definitely assigned to that form unless sculpture is present.

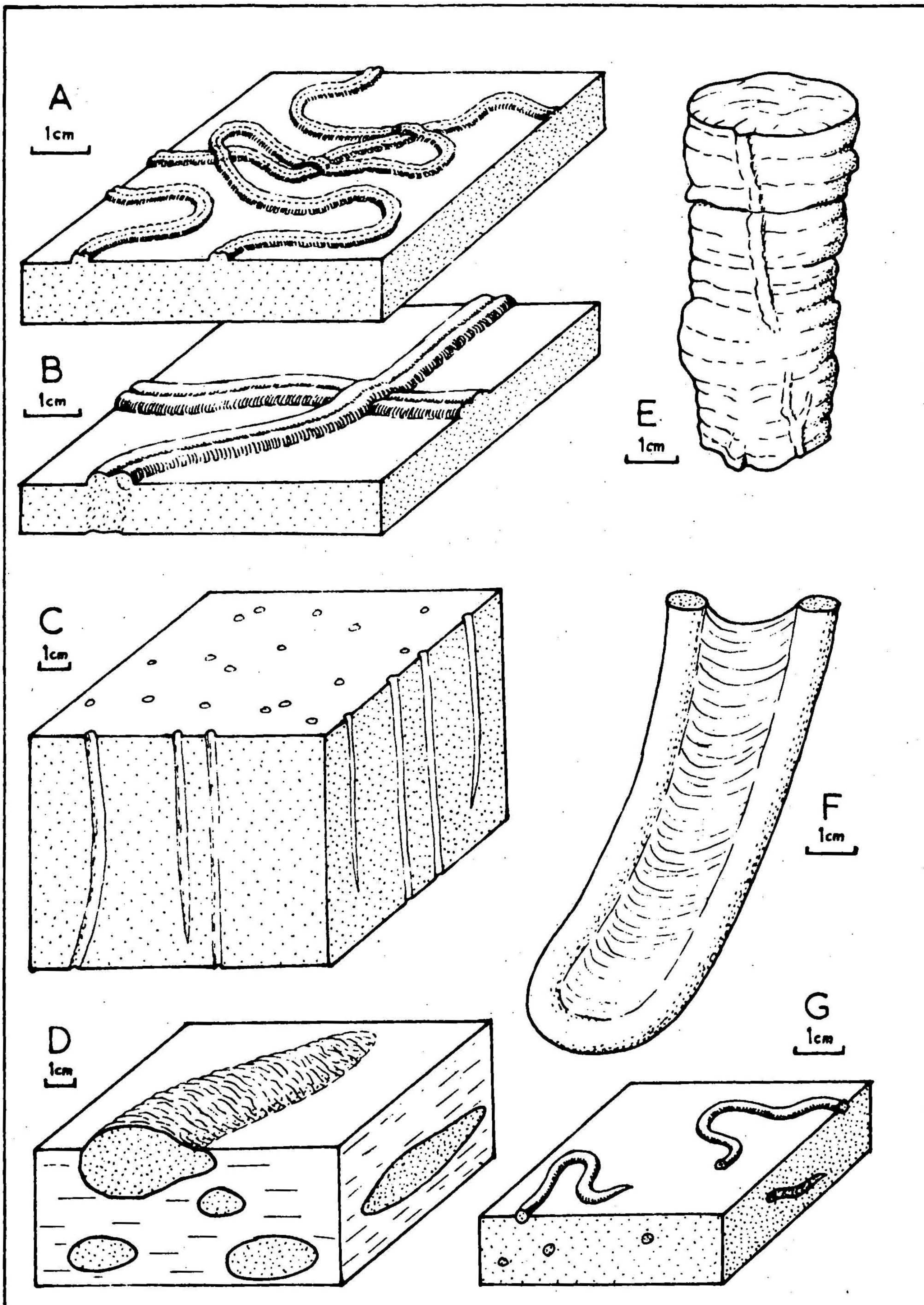
Discussion

The environment appears to have been shallow marine for all forms except cf. Stipsellus, which was possibly formed in a continental environment. Skolithos is almost entirely restricted to the massive sandstone. The large

APPENDIX

FIGURE 1. TRACE FOSSILS FROM THE GILBERT RIVER FORMATION IN THE WROTHAM PARK AREA

A	Gyrochorte, small species, note meandering form.
B	Gyrochorte, Large species.
C	Skolithos; the paired tubes could be Diplocraterion.
D	cf Halymenidium with surface sculpture, plus indeterminate worm boring.
E	cf Stipsellus.
F	Rhizocorallium, inclined form.
G	Planolites.



To accompany Record 1972/64 *M(P) 361*

Appendix Fig I Trace fossils in the Gilbert River formation

Appendix

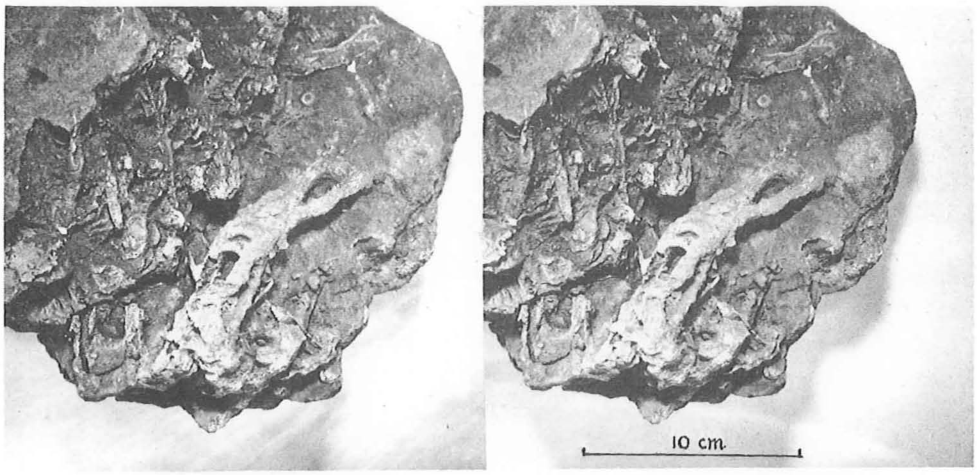


Fig. 2 Stereopair, Rhizocorallium sp. and worm borings, Bedding plane top left. Coffin Hill Member (?), Gilbert River Member, head of Blackfellows Creek, MOSSMAN

Negs 4065-6

Fig. 3 Gyrochorte sp.? Gilbert River Formation. Mesa on OK track, MOSSMAN

Neg. 4742

Gyrochorte, Rhizocorallium, Planolites, and Chrondrites also occur in massive sandstone, but not exclusively so. The interbedded sandstones and mudstones of the Coffin Hill Member provide the most abundant fauna, consisting of both Gyrochorte species, Rhizocorallium, Planolites, Chrondrites, cf. Chondrites, and a number of less definite forms. All of these are generally restricted to the sandy beds or the bed junctions. The sandstones commonly have ripple marks, ripple laminae, and load casts. The environment appears to have been a shallow (?intertidal) marine zone of fairly low energy. The mudstone interbedded with the sandstone, and also the thicker mudstones higher in the sequence, are commonly strongly churned by the worm borings. In some places the original sedimentary structures and the individual burrow-forms have been destroyed. In these mudstones the only definite trace is cf. Halymenidium, although some of the burrows could possibly be assigned to Planolites or Rhizocorallium.

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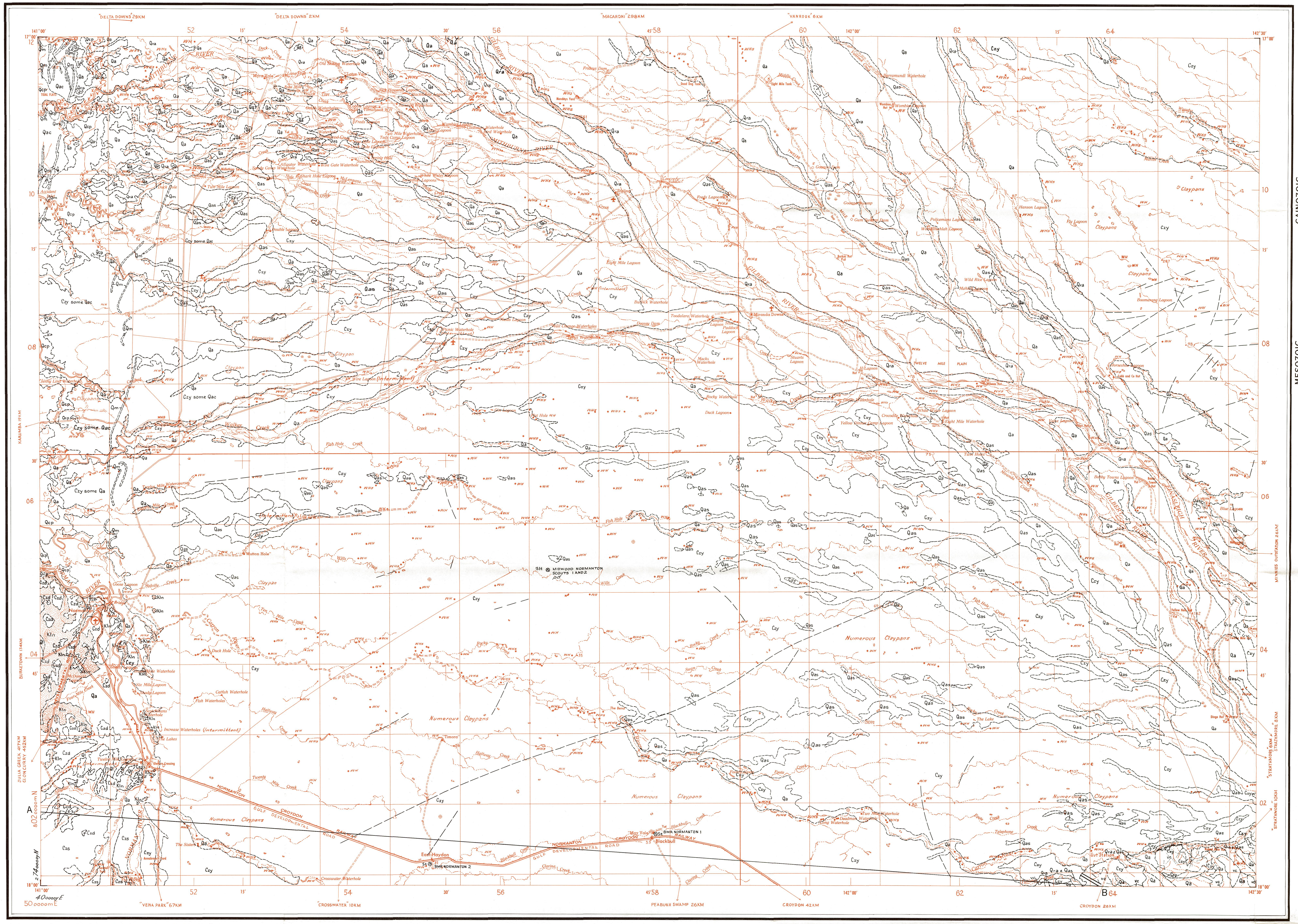
NORMANTON

QUEENSLAND

SHEET SE54-7



Reference

CAINOZOIC	QUATERNARY		Qra	Stream bed sediments: quartzose sand, silt, clay
			Qa	Flood plain alluvium: sand, silt, clay; including minor outwash deposits and local black soil
			Qas	Abandoned river channels: quatzose sand
			Qcp	Salt and tidal flats: silty clay and salt
			Qac	Coastal alluvium: quartzose sand and silt, minor clay
			Qm	Beach and sand ridges: coquina, calcarenite, shelly quartzose sand, quartzose sand
			Ql	Soil, minor colluvial quartzose sand
			Czs	Colluvial and outwash deposits: quartzose sand and gravel
			Czy	Poorly sorted clayey quartzose sandstone and grit, pebbly in places; interbedded sandy claystone
	LATE CRETACEOUS TO MID 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, siltstone, mudstone; limestone
		Allaru Mudstone	Kla	Mudstone and siltstone; minor limestone and labile sandstone (section only)
		Toolebuc Limestone	Klo	Limestone, calcareous shale (section only)
		Wallumbilla Formation	Klu	Mudstone, siltstone, minor limestone, commonly nodular (section only)
		Gilbert River Formation	J-Kg	Quartzose sandstone, with minor conglomerate, siltstone, shale (section only)
	PROTEROZOIC OR CARBONIFEROUS	Croydon Ignimbrite	vc	Ignimbrite, rhyolite, rhyolite-porphyry
	PRECAMBRIAN?		p€?	Basement rocks — section only

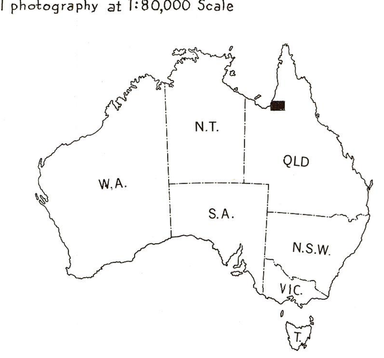
- Geological boundary
- Fault
- Where location of boundaries and faults is approximate, line is broken
- Trend line } air-photo interpretation
- Joint pattern } air-photo interpretation
- Lineament } air-photo interpretation
- St Statigraphic hole, SH Scout hole
- Windpump
- Water storage
- Waterhole
- Swamp
- Mangroves
- Highway
- Road
- Vehicle track
- Railway - with station and siding
- Airport
- Landing ground
- "Glenore" Homestead
- Building
- Yd Yard
- Fence
- Built up area
- Telephone line
- Astronomical station
- .60 Elevation in metres - approximate
- pd Position doubtful

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

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



INDEX TO ADJOINING SHEETS

Showing Magnetic Declination 1970

GULF OF CARPENTARIA		RUTLAND PLAINS SD 54-15	HANN RIVER SD 54-16	COOKTOWN SD 55-13
MORNINGTON SE 54-1	CAPE VAN DIEMEN SE 54-2	GALBRAITH SE 54-3	WALSH SE 54-4	MOSSMAN SE 55-1
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

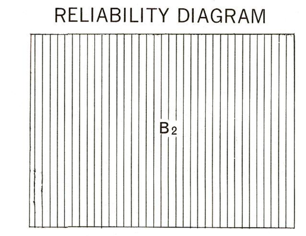
ANNUAL CHANGE 0°35'E

Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

RELIABILITY DIAGRAM



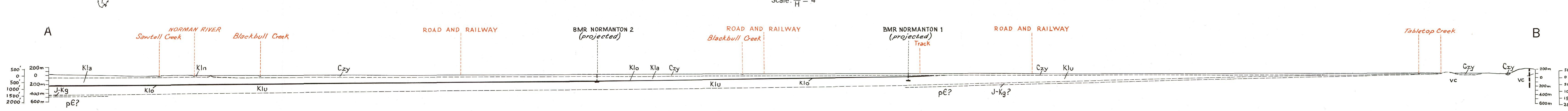
Geology B_2 General reconnaissance: few traverses, mainly air-photo interpretation

Geology 1969-1970 by C.J. Simpson and H.F. Doutch
Compiled 1969-1970 by C.J. Simpson and H.F. Doutch
Cartography by Geological Branch, BMR
Drawn 1970 by D. Green

Section

Cainozoic units (except Czy), omitted

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



PRELIMINARY EDITION, 1971

SUBJECT TO AMENDMENT

NORMANTON

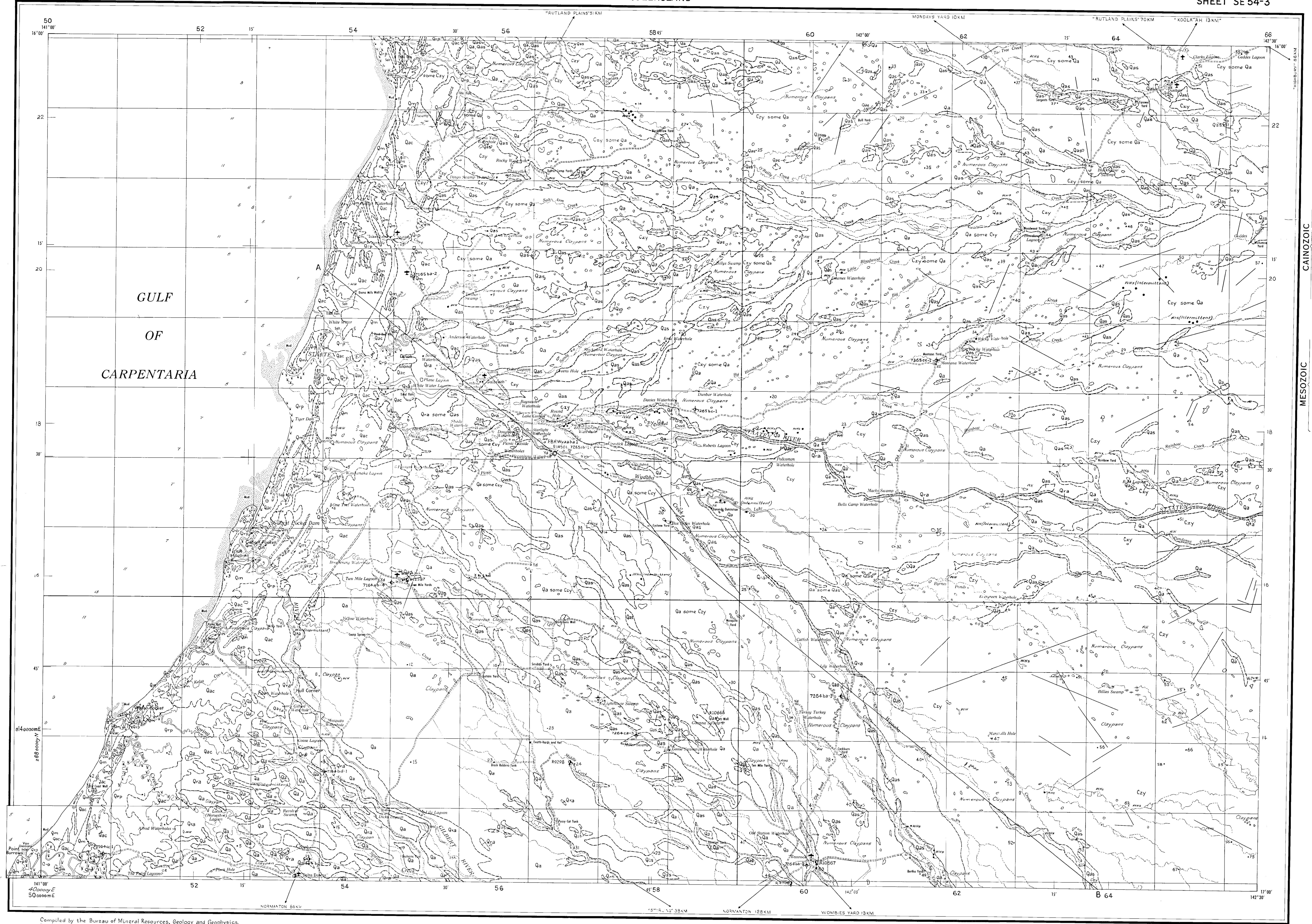
SHEET SE 54-7

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

GALBRAITH

QUEENSLAND

SHEET SE 54-3



Reference

CAINOZOIC	QUATERNARY		Qra	*Stream bed sediments: quartzose sand, silt, clay*
			Qa	*Flood plain alluvium: sand, silt, clay; including minor outwash deposits and local black soil*
			Qas	*Abandoned river channels: quartzose sand*
			Qrp	*Salt and tidal flats: silty clay and salt*
			Qm	*Beach and sand ridges: coquina, calcarenite, shelly quartzose sand, quartzose sand*
			Qac	*Coastal alluvium: quartzose sand and silt, minor clay*
	PLIOCENE? TO RECENT		Czy	*Poorly sorted clayey quartzose sand, sandstone and granule conglomerate, pebbly in places; interbedded sandy claystone*
	UPPER CRETACEOUS TO TERTIARY		KTi	*Poorly sorted clayey quartzose sandstone and granule conglomerate, pebbly in places; interbedded sandy claystone*
MESOZOIC	LOWER CRETACEOUS	Rolling Downs Group: Normanton Formation	Kln	*Labile sandstone, siltstone, mudstone; limestone*
		Rolling Downs Group: Allaru Mudstone	Kla	*Mudstone and siltstone; minor limestone and labile sandstone*
		Rolling Downs Group: Toolebuc Limestone	Klo	*Limestone, calcareous shale*
		Rolling Downs Group: Wallumbilla Formation	Klu	*Mudstone, siltstone, minor limestone, commonly nodular; labile glauconitic sandstone beds and lenses*
		Gilbert River Formation	JKg	*Quartzose sandstone, minor conglomerate, siltstone, shale*
PRECAMBRIAN?			p€	*Basement rocks to Mesozoic and Cainozoic sediments*

KTi to p€: *Section only*

Geological boundary - approximate

Lineament - air-photo interpretation

Petroleum exploration well - dry abandoned

Abandoned bore

Sub-artesian bore - salinity 2500-10000ppm

Sub-artesian bore - salinity > 10000ppm

R10667 *refers to bore registration number of the Queensland Irrigation and Water Supply Commission records*

Water bore - salinity < 2500ppm - abandoned

Water bore - salinity 2500-10000ppm - "

Water bore - salinity > 10000ppm - abandoned

7365cc-1 *refers to bore records Geological Survey of Queensland Report No. 24 (Hydrogeological Investigation)*

Windpump

Well

Earth tank

Dam

Waterhole

Swamp

Mangroves

Depth in metres

Vehicle track

Landing ground

"Vanrook" *Homestead*

Building

Yd *Yard*

Fence

Astronomical station

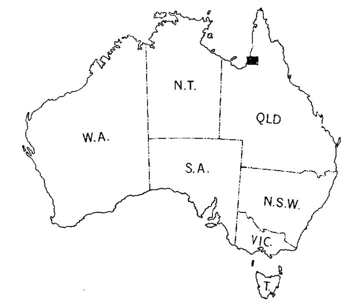
•58 *Elevation in metres - approximate*

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 1:50,000 Scale
Transverse Mercator Projection

NOTE ON GRID COORDINATES

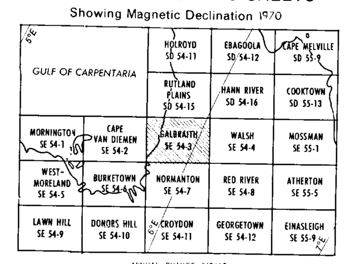
Brown lines with black italic numbers (numbers shown only at SW corner of map and change of zone), indicate the 10,000 yard grid, Zone 6 (Australia Series), CLARKE 1858 SPHEROID. Transverse Mercator Projection

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



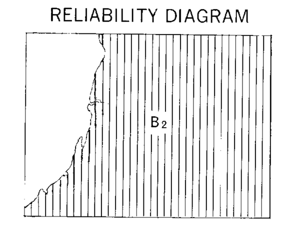
ANNUAL CHANGE 0°35'E

Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

RELIABILITY DIAGRAM



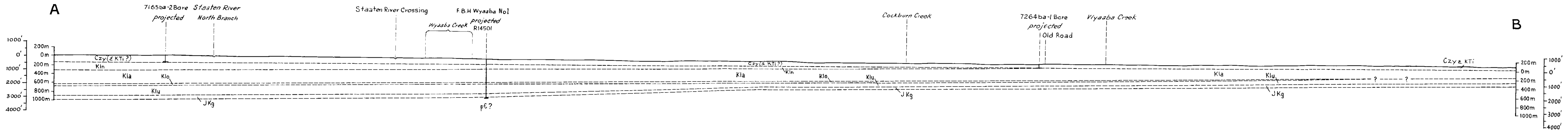
Geology B2 General reconnaissance: few traverses, mainly air-photo interpretation

Geology 1970 by R.S. Needham
Compiled 1970 by R.S. Needham
Cartography by Geological Branch, BMR
Drawn 1970 by D. Green

Section

Quaternary sediments omitted

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



PRELIMINARY EDITION, 1971

SUBJECT TO AMENDMENT

GALBRAITH

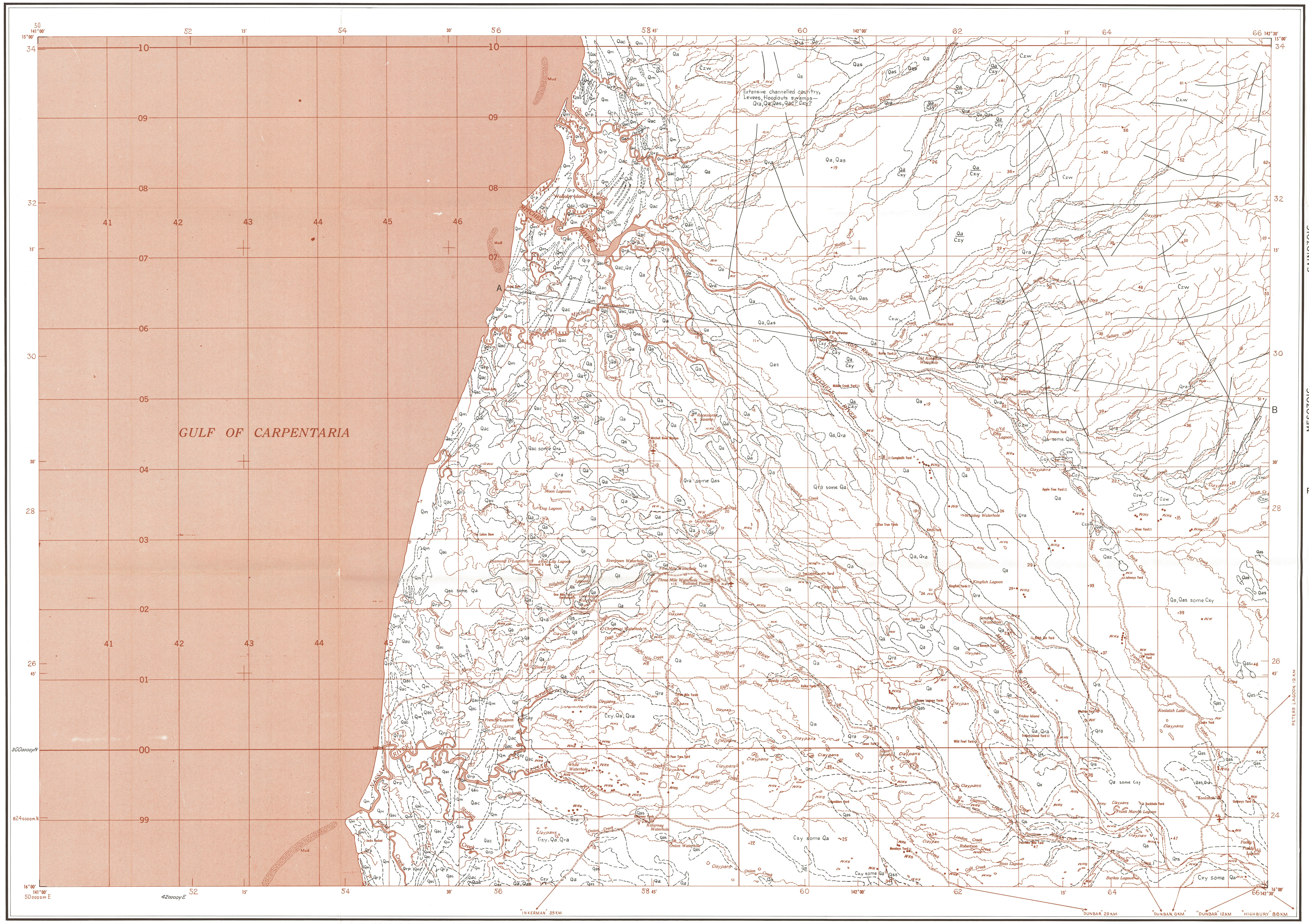
SHEET SE 54-3

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

RUTLAND PLAINS

QUEENSLAND

SHEET SD 54-15



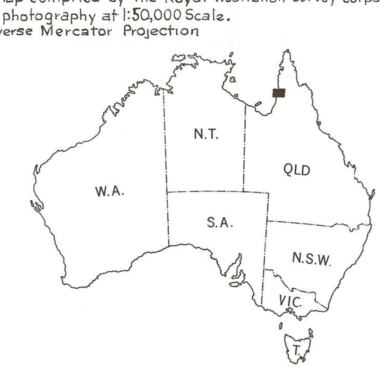
Reference

CAINOZOIC	QUATERNARY		Qra	Stream bed sediment: quartzose sand, silt, clay
			Qa	Flood plain alluvium: sand, silt, clay; including outwash deposits and local black soil
			Qas	Abandonded river channels: quartzose sand
			Qrp	Salt and tidal flats: silty clay and salt
			Qm	Beach and sand ridges: coquina, calcarenite, shelly quartzose sand, quartzose sand
			Qac	Coastal alluvium: quartzose sand and silt, minor clay
	PLIOCENE? TO RECENT		Czy	Poorly sorted clayey quartzose sand, sandstone and granule conglomerate, pebbly in places; interbedded sandy claystone
			Czw	Clayey quartzose sand and soil
	UPPER CRETACEOUS TO TERTIARY		KTi	Poorly sorted clayey quartzose sandstone and granule conglomerate, pebbly in places; interbedded sandy claystone
MESOZOIC	LOWER CRETACEOUS	Rolling Downs Group: Normanton Formation	Kln	Labile sandstone, siltstone, mudstone; limestone
		Rolling Downs Group: Allaru Mudstone	Kla	Mudstone and siltstone; minor limestone and labile sandstone
		Rolling Downs Group: Toolebuc Limestone	Klo	Limestone, calcareous shale
		Rolling Downs Group: Wallumbilla Formation	Klu	Mudstone, siltstone, minor limestone, commonly nodular; labile, glauconitic sandstone beds and lenses
		Gilbert River Formation	JKg	Quartzose sandstone, minor conglomerate, siltstone, shale
	JURASSIC		J	Sand and shale
PRECAMBRIAN?			p€	Basement rocks to Mesozoic and Cainozoic sediments

Section only (KTi to p€)

- Geological boundary, approximate
- Geological boundary, inferred
- Lineament, air-photo interpretation
- □S Water storage
- WH Waterhole
- Mangroves
- Vehicle track
- ■"Koolatah" Homestead
- Building
- Landing ground
- □Yd Yard
- Astronomical station
- • 43 Elevation in metres, 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 1:50,000 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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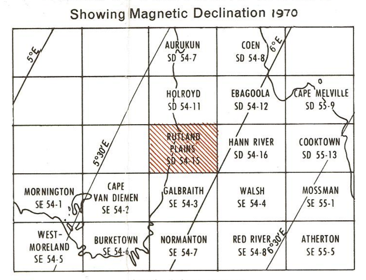
Showing Magnetic Declination 1970



ANNUAL CHANGE 0 0'30"E

Scale 1:250,000

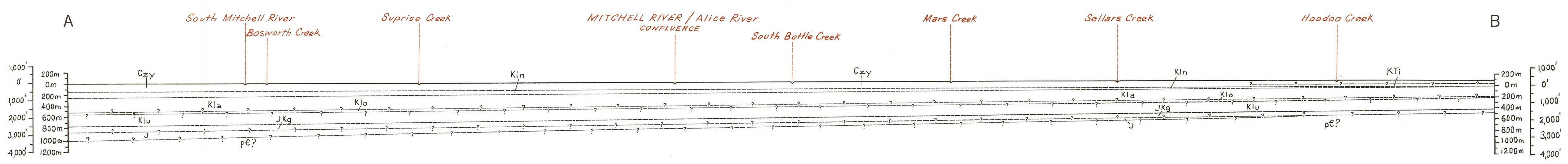
5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

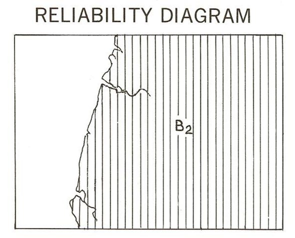
Section

Quaternary sediments omitted

Scale: V/H = 4

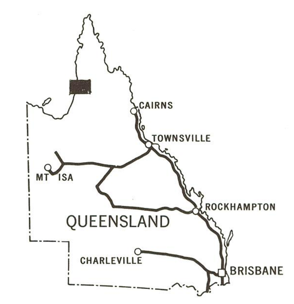


RELIABILITY DIAGRAM



Geology B_2 General reconnaissance: few traverses, mainly air-photo interpretation

Geology 1971 by R.S. Needham
Compiled 1971 by R.S. Needham
Cartography by Geological Branch BMR
Drawn 1971 by A. Urquhart and D. Green



PRELIMINARY EDITION, 1971
SUBJECT TO AMENDMENT

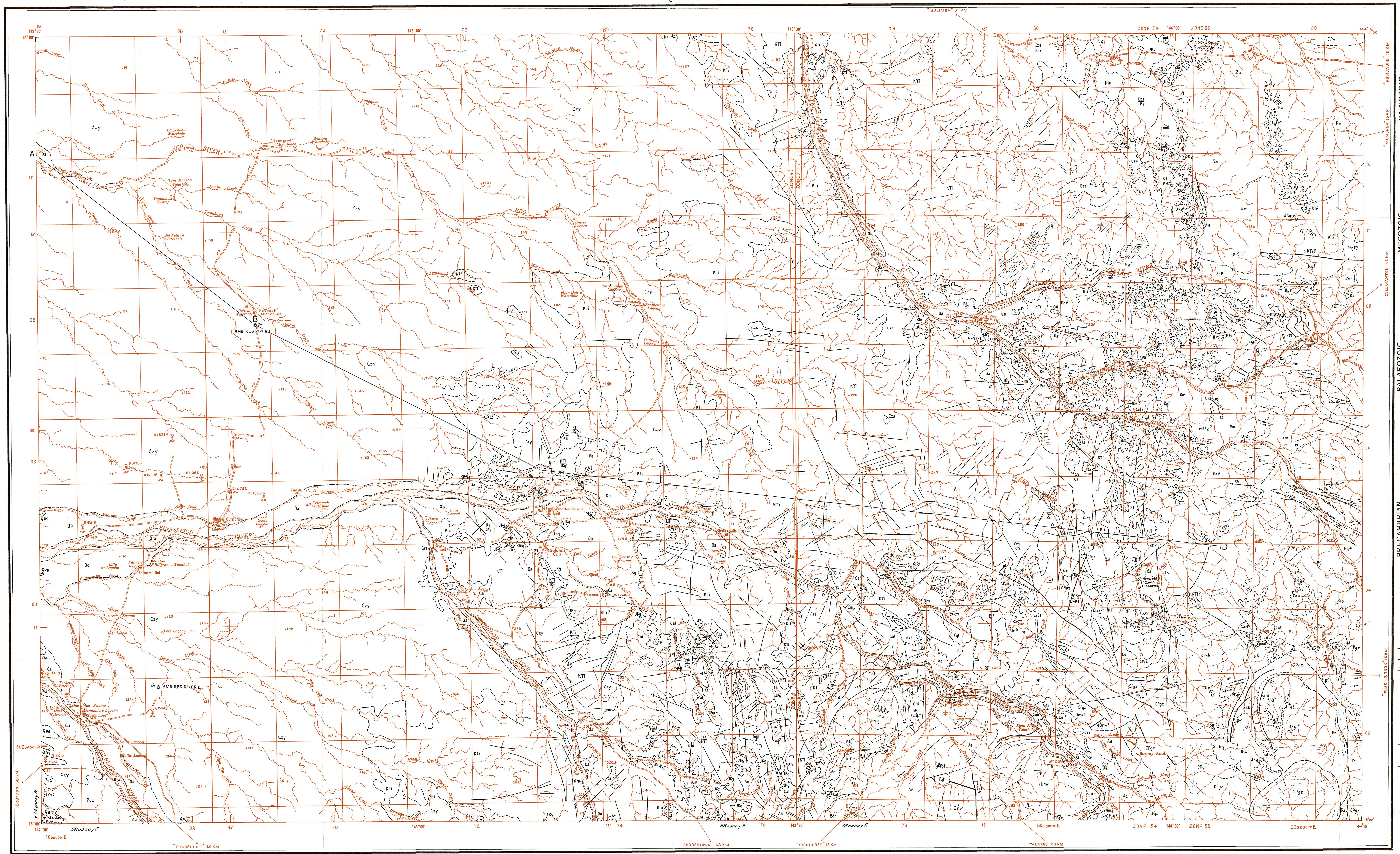
RUTLAND PLAINS
SHEET SD 54-15

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

RED RIVER PART ATHERTON

QUEENSLAND

SHEET SE 54-8 PART SHEET SE 55-5



Reference

CAINOZOIC	QUATERNARY	HOLOCENE		Qra	Quartzose sand, silt, clay: stream bed sediments
				Qa	Sand, silt, clay; including minor outwash deposits and localised black soil development: flood plain alluvium
				Qas	Quartzose sand: abandoned river channels
		PLIOCENE ? TO HOLOCENE		Czs	Quartzose sand and gravel: colluvial and outwash deposits
			Wyaaba Beds	Czy	Poorly sorted clayey quartzose sandstone and grit, pebbly in places; interbedded sandy claystone
				Czb	Basalt
			McBride Basalt	Czm	Olivine basalt
		TERTIARY ?		Td	Ferruginized lithified soil and colluvium (duricrust)
MESOZOIC		UPPER CRETACEOUS OR TERTIARY ?	Bulimba Formation	KTi	Poorly sorted clayey quartzose sandstone and granule conglomerate, pebbly in places, interbedded sandy claystone
		LOWER CRETACEOUS	Wallumbilla Formation	Klu	Mudstone, siltstone; minor limestone, commonly nodular; labile, glauconitic sandstone beds and lenses in lower part
		UPPER JURASSIC TO LOWER CRETACEOUS	Gilbert River Formation (JKg): Coffin Hill Member	Klf	Clayey sandstone, siltstone, some shale; locally glauconitic in upper portion; worm borings, trace fossils, some shelly fossils
			Gilbert River Formation	JKg	Quartzose sandstone, minor conglomerate, siltstone, shale
			Gilbert River Formation (JKg): Yappar Member	JKy	Quartzose sandstone, commonly pebbly, some conglomerate, wood fragments
PALAEOZOIC		UPPER PALAEOZOIC		Pzu	Dolerite, rhyolite, diorite
				Pzug	Granite
		PERMIAN	Warby Volcanics	Pw	Rhyodacite, rhyolite and volcanic breccia
		UPPER CARBONIFEROUS TO LOWER PERMIAN	Elizabeth Creek Granite	CPgz	Pink microadamellite
			Herbert River Granite	CPgh	Grey porphyritic adamellite, granodiorite
			Nychum Volcanics	CPn	Rhyolite, welded tuff, andesite, basalt, arkose shale, coaly shale; limestone
		UPPER CARBONIFEROUS	Galloway Volcanics	Cal	Rhyolite, tuff, ignimbrite, sediments
			Scardons Volcanics	Cs	Rhyodacite laras and welded tuffs
		DEVONIAN	Newcastle Range Volcanics	Dnw	Rhyolite, ignimbrite, pyroclastics, sediments
PRECAMBRIAN				p€	Schist, gneiss, granite, quartzite, amphibolite
		PROTEROZOIC	Croydon Ignimbrite	Bvc	Ignimbrite, rhyolite, rhyolite-porphyry
			Forsayth Granite	Bgf	Grey porphyritic biotite adamellite, granodiorite
			Cobbold Dolerite	Bdc	Dolerite and amphibolite
			Etheridge Formation	Be	Shale, siltstone, sandstone and chert
			McDevitt Metamorphics	Bm	Quartz-muscovite-garnet-cordierite schist, andalusite schist, quartzite
				Bd	Biotite-quartz-feldspar gneiss, quartzite amphibolite, feldspar-mica-quartz schist
		ARCHAEAN ?	Einasleigh Metamorphics	Ae	Granulite, gneiss, migmatite, amphibolite, schist, quartzite

- Geological boundary
- Syncline showing direction of plunge
- Fault (DU indicate relative movement down, up)
- Where location of boundaries and faults is approximate, line is broken; where boundaries are inferred, queried
- 10 Strike and dip of strata
- Unmeasured strike and dip of strata
- Dip 15°-45° (air-photo interpretation)
- Dip > 45° (air-photo interpretation)
- Trend line (air-photo interpretation)
- Joint pattern (air-photo interpretation)
- Lineament (air-photo interpretation)
- 60 Strike and dip of foliation
- 80 Platy flow-inclined
- Dyke, do-dolerite, Rh-rhyolite
- St Stratigraphic hole
- Sn Mine, Sn-tin

- Sub-artesian bore of Bulimba or younger aquifer system — R31367 refers to bore registration number of Queensland Irrigation and Water Supply Commission records
- Well
- E Earth tank
- Dam on stream
- WH Water hole
- Swamp
- Road
- Vehicle track
- Landing ground
- "Strathmore" Homestead
- Building, outstation
- Yd Yard
- Fence
- Telephone line
- 162 Astronomical station, 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

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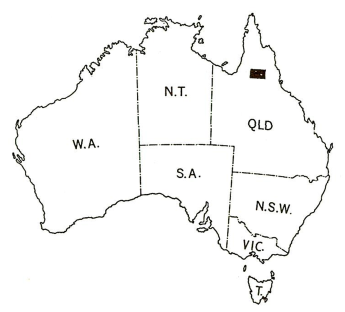
Brown numbered ticks (with larger upright numbers), inside the neatline are 20,000 metre intervals of the superimposed Australian Map Grid, Zones 54 and 55 AUSTRALIAN NATIONAL SPHEROID. Transverse Mercator Projection



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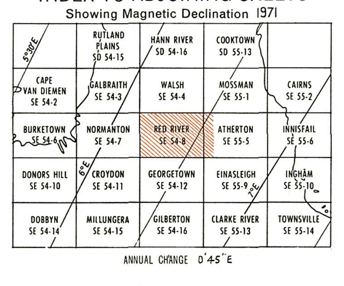
Showing Magnetic Declination 1971

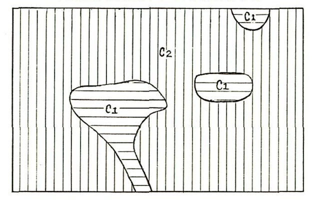


Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

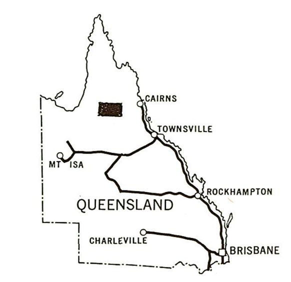
RELIABILITY DIAGRAM



Geology C1 General reconnaissance: many traverses, and air-photo interpretation

C2 General reconnaissance: some traverses, and air-photo interpretation

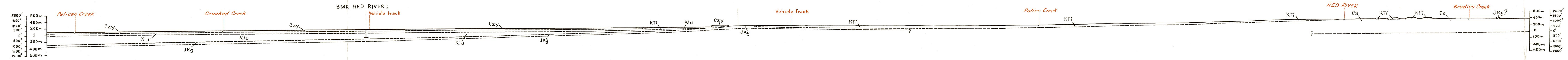
Geology 1956-1959 by J.G.Best, C.D.Branch, K.G.Lucas, R.M.Tucker, F.de Keyser, M.B.Bayly, K.W.Wolff, D.A.White, K.K.Hughes, D.H.Wyatt
1961 by C.D.Branch; 1970 by J.Smart; 1971 by K.Grimes, G.S.Q.
Compiled 1960 by J.G.Best; 1961 by C.D.Branch; 1970 by J.Smart and M.A.McLaren; 1972 by J.Smart and D.Green.
Cartography by Geological Branch BMR
Drawn 1971 by M.A.McLaren, R.Ritschel; 1972 D.Green.



Section

Quaternary sediments omitted

Scale: V/H = 4



PRELIMINARY EDITION, 1972

SUBJECT TO AMENDMENT

RED RIVER PART ATHERTON

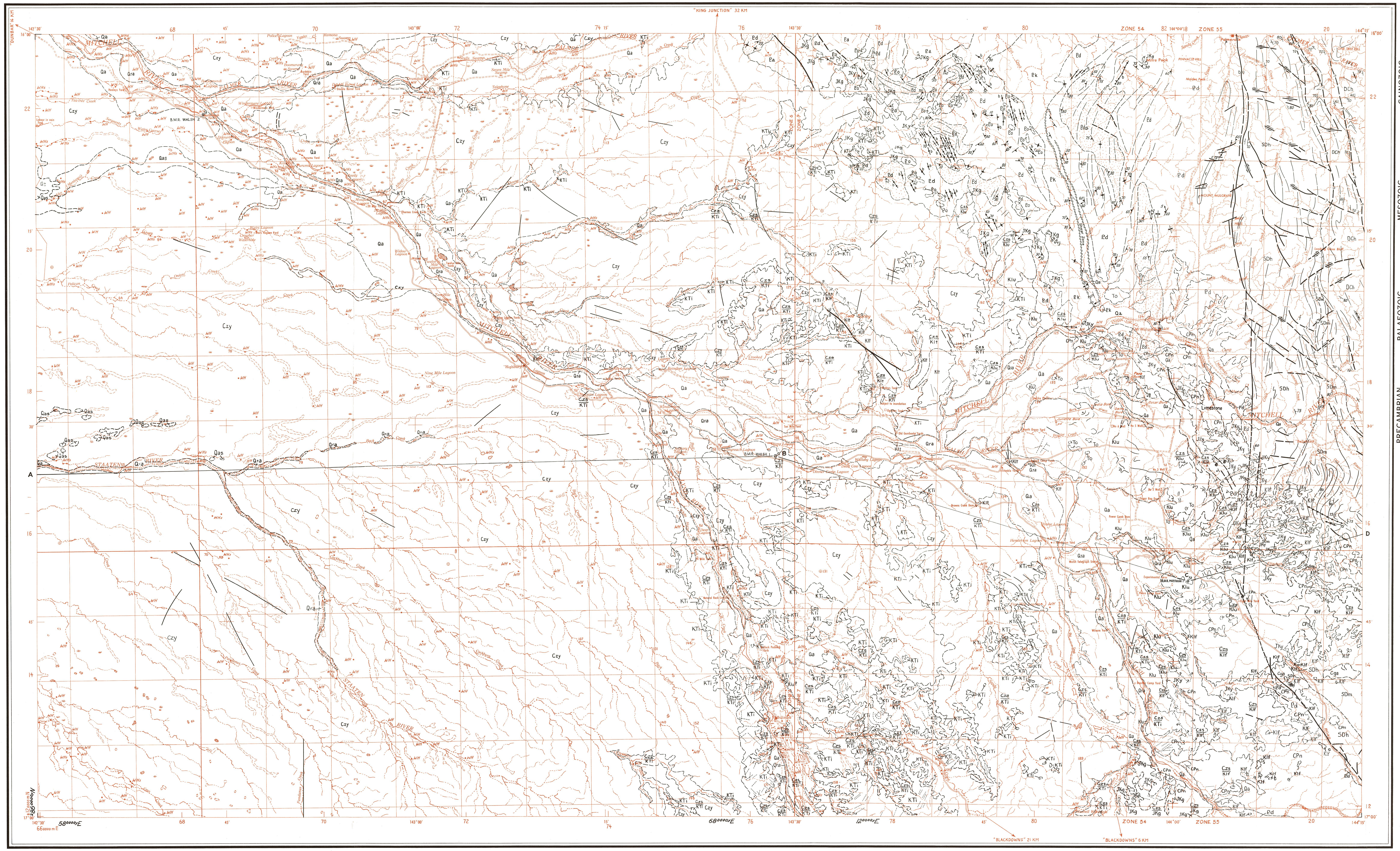
SHEET SE-54-8 PART SHEET SE-55-5

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

WALSH—PART MOSSMAN

QUEENSLAND

SHEET SE 54-4— PART SHEET SE 55-1



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Reference

CAINOZOIC (QUATERNARY)	HOLOCENE		Qra	Quartzose sand, silt, clay: stream bed deposits
			Qa	Clay, silt, sand: flood plain alluvium and outwash deposits includes some Qra and Qas
			Qas	Quartzose sand: abandoned stream channels
	PLIOCENE ? TO HOLOCENE		Czs	Quartzose sand, some clay: colluvial deposits
		Wyaaba Beds	Czy	Clayey quartzose sand, clay, gravel
	LOWER TO MID TERTIARY	Louisa Beds	To	Silcrete, gravel, quartzose sand
	UPPER CRETACEOUS OR TERTIARY	Bulimba Formation	KTi	Granular conglomerate, quartzose clayey sandstone, sandy claystone
MESOZOIC	LOWER CRETACEOUS	Rolling Downs Group: Allaru Mudstone	Kla	Mudstone; minor limestone, labile sandstone } Section only
		Toolebuc Limestone	Klo	Calcareous shale, limestone, coquinite
		Trimble Member	Klt	Mudstone, labile sandstone; minor limestone
		Wallumbilla Formation	Klu	Mudstone; minor labile and glauconitic sandstone, limestone
	UPPER JURASSIC TO LOWER CRETACEOUS	Coffin Hill Member	Klf	Glauconitic quartzose sandstone, shale
		Gilbert River Formation	JKg	Quartzose sandstone, shale, siltstone, minor conglomerate
		Yappar Member	JKy	Quartzose sandstone; minor conglomerate, shale, siltstone
PALAEOZOIC	UPPER CARBONIFEROUS TO LOWER PERMIAN	Nychum Volcanics	CPn	Rhyolite, welded tuff, andesite, basalt, arkose, shale, coaly shale, limestone
	MIDDLE TO UPPER CARBONIFEROUS	Almaden Granite	Cga	Grey medium-grained, porphyritic granodiorite
	MIDDLE DEVONIAN TO LOWER CARBONIFEROUS	Hodgkinson Formation	DCh	Greywacke, sandstone, silty mudstone, limestone, chert lenses
	UPPER SILURIAN TO LOWER DEVONIAN	Mt. Garnet Formation	SDm	Greywacke, conglomerate, chert, limestone lenses
		Chillagoe Formation	SDh	Limestone, chert, sandstone, siltstone
PRECAMBRIAN	PROTEROZOIC OR DEVONIAN	Cape York Peninsula Batholith: Kintore Adamellite	Ꝑk	Even grained biotite-muscovite adamellite, (garnet)-muscovite granite, garnet-muscovite granite-pegmatite
		Aralba Adamellite	Ꝑa	Porphyritic biotite-muscovite adamellite
	PROTEROZOIC		Ꝑo	Dolerite
		Dargalong Metamorphics	Ꝑd	Biotite-quartz-feldspar gneiss, quartzite, amphibolite, feldspar-mica-quartz schist
				Mainly (sillimanite)-muscovite-quartz schist, quartzite

- Geological boundary
- Fault (D, U indicate relative movement down, up)
- Fault, indicating relative horizontal movement

Where location of boundaries and faults is approximate, line is broken; where inferred, queried, concealed boundaries are dotted.

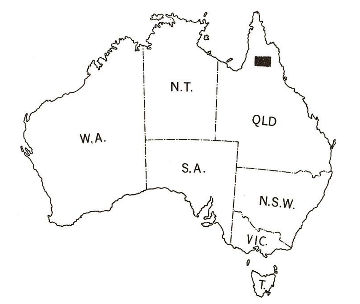
- Shear zone
- Strike and dip of strata
- Unmeasured strike and dip of strata
- Facing of strata not known
- Vertical strata
- Horizontal strata
- Overturned strata
- Plunge of minor syncline
- Dip < 15°
- Trend line
- Plunge added to trend line
- Joint pattern
- Lineament

} air-photo interpretation

- Strike and dip of foliation
- Unmeasured strike and dip of foliation
- Vertical foliation
- Strike of foliation, dip indeterminable
- Horizontal lineation
- Plunge of lineation
- Foliation with plunge of lineation
- Macrofossil locality
- Dyke; b-basic, r-rhyolite
- BMR Stratigraphic drill hole

- Bore
- Artesian bore flowing
- Artesian bore, ceased to flow
- Sub-artesian bore
- R3403 Bore registration number of the Queensland Irrigation and Water Supply Commission
- Well
- Earth tank or dam
- Dam on stream
- Windpump
- Waterhole
- Spring
- Swamp
- Road
- Vehicle track
- Fence
- Telephone line
- "Wrotham Park" Homestead
- Building
- Yard
- Astronomical station
- 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 1:50,000 Scale



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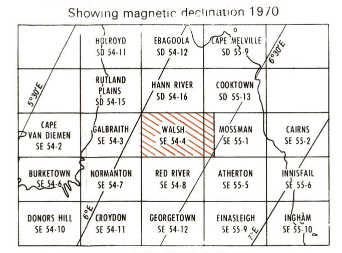
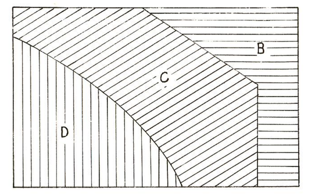


Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

RELIABILITY DIAGRAM

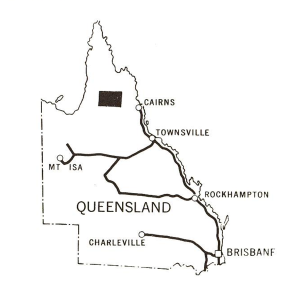


B Detailed reconnaissance: numerous traverses, and airphoto interpretation

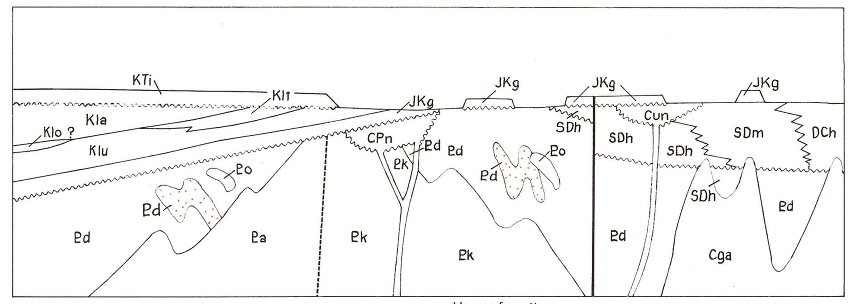
C General reconnaissance: many traverses, mainly air-photo interpretation

D Air photo interpretation

Geology 1963 by K.G. Lucas
1966 by D.S. Trail, I.R. Pontifex, W.D. Palfreyman
W.F. Willmott, (B.M.R.)
W.G. Whitaker, Geological Survey of Queensland
1970 by K.G. Grimes, G.S.Q.
Compiled 1966 by D.S. Trail, W.W. Webb.
1970 by K.G. Grimes, G.S.Q.
Cartography by Geological Branch, B.M.R.
Drawn by R. Ritschel, O. Rowsell



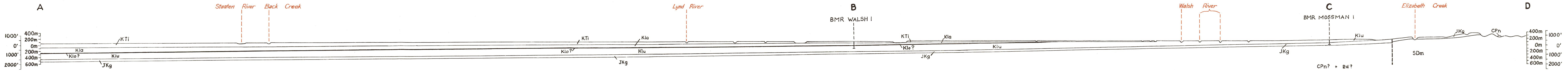
DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Section

Quaternary Sediments omitted

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



PRELIMINARY EDITION, 1972

SUBJECT TO AMENDMENT

WALSH-PART MOSSMAN

SHEET SE 54-4 — PART SHEET SE 55-1