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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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Geology of the Tambo/Augathella Area, Queensland

BY

N. F. EXON†, M. C. GALLOWAY†, D. J. CASEY*
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SUMMARY

The Devonian to Cainozoic rocks of the Tambo and Augathella 1:250,000 Sheet areas were mapped in 1964-65. The area covers parts of five sedimentary basins: the Adavale Basin sequence in the west, only in the subsurface; the Drummond, Bowen, and Galilee Basin sequences in the northeastern part of the Tambo Sheet area in outcrop, and throughout the area in the subsurface; and the Eromanga Basin sequence over the rest of the area.

In the Drummond Basin, about 1800 m of Upper Devonian to Lower Carboniferous sediments and volcanics are exposed in the northerly trending Mount Beaufort Anticline. About 1350 m of Devonian evaporites and other sediments in the Adavale Basin sequence occur in the Boree No. 1 well*. In Upper Carboniferous time there was a period of tectonism, followed by erosion. On the Springsure Shelf and in the Galilee Basin, the late Carboniferous to Upper Triassic sequences rest on this unconformity. The Springsure Shelf in the northeast terminates at the Birkhead Anticline, where the late Carboniferous to Permian Bowen Basin shelf sequence interfingers with the Galilee Basin sequence to the west; many units are common to both. The earliest deposits, in both basins, were 450 m of glacigene late Carboniferous to Lower Permian sediments, which are overlain by 750 m of Permian to Upper Triassic freshwater clastic sediments.

In the Eromanga Basin, sedimentation began in the Lower Jurassic, and continued well into the Cretaceous. The sequence consists of 750 m of Jurassic to early Cretaceous freshwater clastics, overlain by 1050 m of Aptian to Albian alternating marine and freshwater sediments.

Much of the Cretaceous sequence is covered by cappings of duricrust and Tertiary sandstone, and by sand and soil. The only igneous rock present is a small area of Tertiary basalt.

The main aquifers are the Jurassic and early Cretaceous sandstones. Petroleum exploration has been unsuccessful to date, but many structural traps have been defined and prospects are still considered to be fair.

* The full names of the oil exploration wells are listed in Table 1.

INTRODUCTION

This Report describes the results of a joint survey of the Augathella and Tambo 1:250,000 Sheet areas by the Bureau of Mineral Resources and Geological Survey of Queensland. The survey was part of a project to map the Great Artesian and Bowen Basins in Queensland. Before the field work began, Exon, Casey, and W.J. Perry (BMR) prepared a photogeological map of the Tambo Sheet.

The area mapped lies between longitude 145°30'E and 147°E and latitude 24°S and 26°S. The Tambo and Augathella Sheets are named after the two major towns in the area. Most of the rocks cropping out are Jurassic or younger in age, but rocks as old as Devonian crop out in the northeast. The pre-Jurassic sequence was mapped in 1964 by Exon & Kirkegaard (1965), and the younger sediments were mapped in 1965 by Exon, Galloway, and Casey; the results were combined in an unpublished report by Exon, Galloway, Casey, & Kirkegaard (1966). R.W. Day of the Australian National University examined collections of marine macrofossils and made further collections himself (Day, Appendix 1 in Exon et al., 1966). The geological maps of the Tambo and Augathella Sheet areas and the adjacent Blackall, Adavale, and Eddystone Sheet areas, with their explanatory notes have been completed (Exon, 1969; Galloway, 1970b; Casey & Galloway, in press; Galloway, 1970a; Exon, 1968b), and those on other adjacent Sheet areas are in preparation.

The widespread black-soil downs support a large pastoral industry. Access roads (Fig. 1) are good, and formed roads link the area with nearby towns. Late in 1965 the only sealed roads were the Landsborough Highway between Augathella, Tambo, and Blackall, and the Mitchell Highway between Augathella and Charleville. The unsealed roads are impassable after heavy rain. The Warrego Highway through Charleville and Morven links the area with Brisbane. Regular air services operate from Blackall and Charleville to Brisbane. The Western Railway links Charleville to Brisbane, and a branch line from Blackall joins the Longreach/Rockhampton railway.

Rainfall is unreliable, but the annual average is between 500 and 640 mm; much of it falls in the period from December to March. The vegetation is closely related to the underlying rocks and the various types of soil overlying them. Sandy soils are largely confined to the northeast, where they generally support open eucalypt forest and poor grass, or scrub consisting mainly of wattle, lancewood, and boodgeroo. The clayey soils of the northeast support scrub consisting of brigalow, belah, wilga, bottle trees, and sandalwood. The widespread black-soil downs are well grassed and virtually treeless.

Royal Australian Air Force air-photographs at a scale of 1:46,000, flown in 1951-54, provide a complete coverage of the area. The base map of the Tambo Sheet, at 1:250,000 scale, was supplied by the Department of National Development, and that of the Augathella Sheet by the Royal Australian Survey Corps; the 1:500,000 map was made by reduction of these two maps. Maps covering the area at a scale of 4 inches to 1 mile are available from the Department of Public Lands, Brisbane.

Water is obtained by bores from aquifers in the Great Artesian Basin; most of them have to be pumped, and only a few still maintain artesian flows. Small supplies are obtained from spear pumps in the sandy beds of the larger watercourses. The water bores are shown on the 1:250,000 geological maps.

Five shallow stratigraphic boreholes were drilled in the Tambo Sheet area in 1954 (Mollan, Exon, & Forbes, 1965), four in 1965 (Exon et al., 1966), and five in 1966 (Galloway & Ingram, 1967). Four holes were drilled in the Augathella Sheet area in 1966 (Galloway & Ingram, 1967). The boreholes are listed in Appendix 3, and graphic logs of most of them appear in this Report.

The fossil collections are stored at the Bureau of Mineral Resources in Canberra, and their locations are shown on the 1:250,000 Sheets. The marine macrofossils collected by

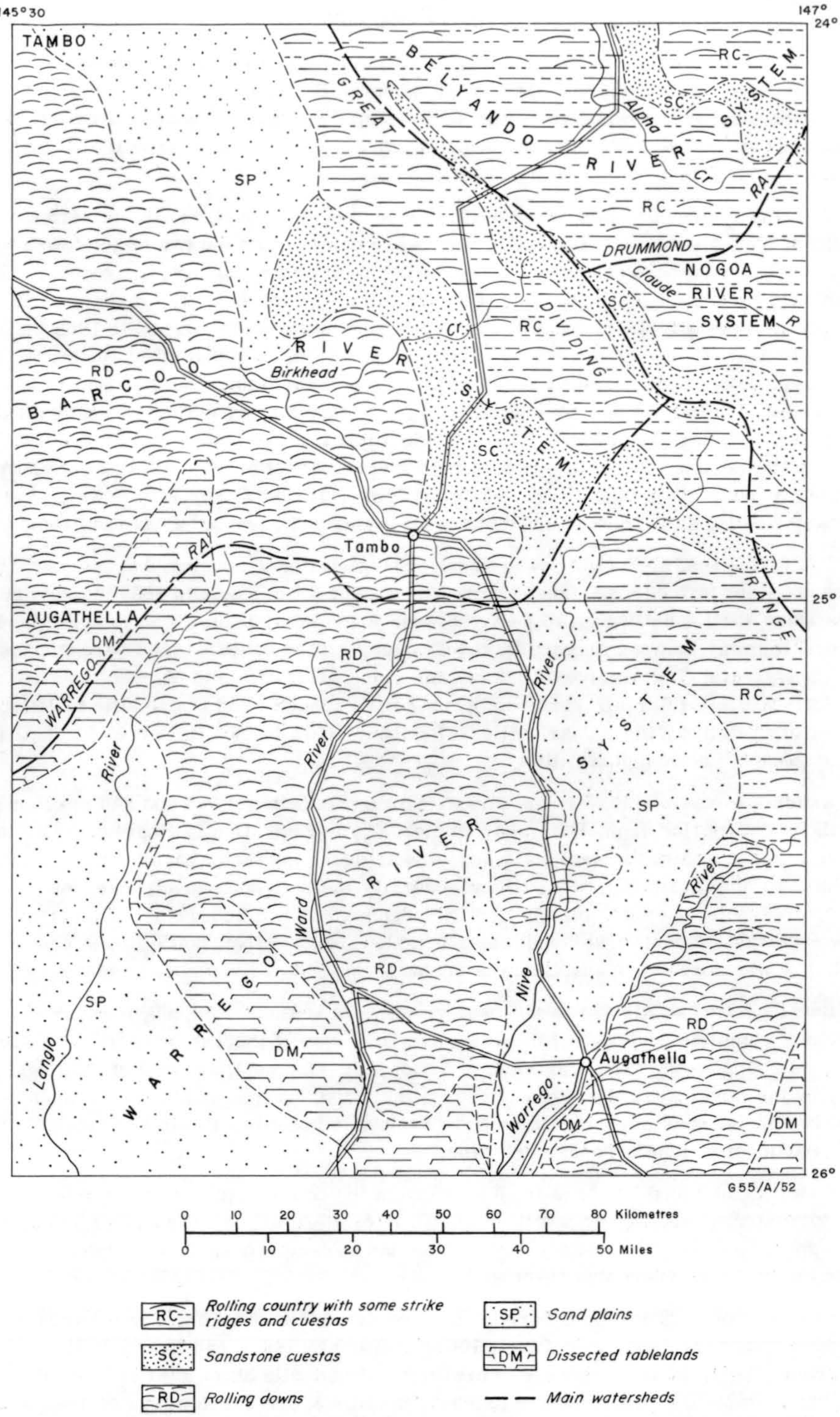

Fig. 1. Topography and drainage.

Reynolds (1960) have been described by Dickins (1960) and the microfossils by Crespin (1960). The marine macrofossils collected in 1965 are described by Day (1966, 1967, 1968, 1969), and the plant fossils by White (1966).

The petrography of surface samples has been described by Galloway (1967) and Exon (1968b). Grid references refer to the military grid on the geological map.

Nomenclature

Crook's (1960) classification of arenites is followed. 'Arenite' is used as the generalized non-genetic term for sand-sized clastic material. The arbitrary figure of 75 percent matrix is taken as the division between arenite and mudstone. All the arenites described fall into his genetic subdivision of 'sandstone' - traction current deposits. The term 'quartzose' is applied to those sandstones in which quartz forms more than 90 percent of the clasts; if quartz forms 75 to 90 percent of the clasts, the term 'sublabile' is applied; if less than 75 percent the term 'labile' is applied. If the ratio of feldspar to lithic fragments is greater than 3:1, or less than 1:3 respectively, the qualifying terms 'feldspathic' or 'lithic' can be used with 'sublabile sandstone'; and 'labile sandstone' can be 'feldspathic sandstone' or 'lithic sandstone'.

'Siltstone' is used for sediments whose grainsize ranges from 1/16 to 1/56 mm. The term 'mudstone' is used as a general name for non-fissile sediments of the lutite class, and 'shale' is defined as a fissile mudstone. 'Claystone' is used for sediment consisting dominantly of clay minerals. The Wentworth scale has been followed for grainsize terminology (Pettijohn, 1957; see also Fig. 3).

Palynology

Evans' palynological units of the Permian (Evans, 1964b) and Mesozoic (Evans, 1966a) have been adopted.

Acknowledgments

R.W. Day, late of the Australian National University, has made helpful comments on the Report. Thanks are due to the geologists of various oil companies, particularly those of American Overseas Petroleum Ltd and the Phillips Petroleum Co. The photogeological maps of the area by Geophoto Resources Consultants, provided by various companies, were much appreciated.

TOPOGRAPHY AND DRAINAGE

The Barcoo, Bulloo, Warrego, Nogoa, and Belyando River systems drain the area. The Barcoo joins Coopers Creek, which flows into Lake Eyre; the Bulloo flows into the Lake Bulloo internal drainage basin; the Warrego flows into the Darling River and thence to the Southern Ocean; the Nogoa flows into the Fitzroy River and thence to the Pacific Ocean; and the Belyando joins the Burdekin River, which flows to the east coast. Part of the watershed known as the Great Dividing Range separates the catchments of the Warrego and Barcoo river systems from those of the Belyando and Nogoa systems. The river systems, watersheds, and physiographic regions are shown in Figure 1.

The area has been divided into five physiographic units.

The rolling country with some strike ridges and cuestas is confined to the northeastern and eastern part of the Tambo/Augathella area. It consists of two topographic forms which alternate across the strike: they correspond with the less resistant finer-grained pre-Cretaceous rocks, and the more resistant sandstones which are described as a separate unit (see below). The rolling country includes the Devonian/Carboniferous sediments and volcanics, Upper Permian and Triassic sediments, the upper part of the Lower Jurassic sandstone sequence, the Middle Jurassic silty sequence, and part of the Upper Jurassic/Cretaceous sandstone sequence. The cuestas generally dip to the southwest.

The sandstone cuestas alternate with the rolling country. They are formed by resistant sandstones in the Permian Colinlea Sandstone, the Lower Jurassic Precipice and Boxvale Sandstones, the Jurassic Adori Sandstone, and the Hooray Sandstone. The cuestas form ranges with cliffs facing northeast, and a gradual dip slope to the southwest.

The dissected tablelands are flanked by irregular mesas and buttes, remnants of a formerly more extensive tableland. The mesas are capped by a resistant duricrust overlain by thin Cainozoic sediments. In the western part of the Augathella Sheet area, the dissected tablelands blend imperceptibly to the southwest into a sand plain.

The widespread rolling downs consist of gently undulating country with khaki clay soils. They are very fertile and are mainly used for grazing sheep. The grassy downs support a few stunted trees only along watercourses and on low stony rises. The downs grade into sand plains and the vegetation changes gradually from open grassland to lightly timbered areas.

The extensive sand plains are outwash plains formed by redistribution of sand derived from the Jurassic units. The plains commonly slope gently up to the areas from which the sand was derived. They support very poor grass and are lightly timbered.

PREVIOUS INVESTIGATIONS

Geological. Isolated observations on the geology of the area were made by Jack (1895), Ball (1926), and others. Jensen's (1922) report on the geology of the Tambo district included a geological map of part of the Tambo/Augathella area. Later, he investigated a reported oil seep in the Enniskillen Range and interpreted the regional structure from water-bore data; the results were incorporated in his report on the regional geology of the Roma, Springsure, Tambo, and Taroom areas (Jensen, 1926). Notes on the geology of the Blackall district, based on water-bore data, were also included. Woolley mapped the Permian to Triassic units (1941b) and Jurassic to Lower Cretaceous units (1941a) in part of the Tambo Sheet area (for comparison of his 1941a terminology with present terminology see Table 5). Malone (1964) described the depositional evolution of the Bowen Basin. Whitehouse (1954) made the first map showing the regional geology of the Great Artesian Basin, and co-ordinated recorded observations and stratigraphic nomenclature. General accounts of the geology of the basin, with comprehensive bibliographies, were compiled by Whitehouse (1954) and Hill & Denmead (1960). Vine (1966) has discussed recent mapping in the northern part of the Eromanga Basin.

The first Lower Cretaceous macrofossils were found in the 19th Century. Etheridge figured some of them in Jack & Etheridge (1892), and described others later (1907, 1909, 1920). Whitehouse also collected and reported on the fossils (Whitehouse, 1926a,b, 1930, 1940, 1945, 1954). Crespin (1945, 1960) has reported on the microfossils, and Dickins (1960) on the macrofossils collected during a reconnaissance of the Great Artesian Basin by Reynolds (1960). Day (1969) discusses the Great Artesian Basin.

Exploratory Drilling for Oil and Gas. Up to the end of 1967 six wells had been drilled in the search for petroleum in the Tambo/Augathella area. A summary of each well is given in Table 1, correlations in Figures 2, 4, and 10, and formation picks in Appendix 2. Only the earliest wells drilled, Malta Oil Co. No. 1 and Birkhead No. 1 were not subsidized. Completion reports on the subsidized wells are available at the Bureau of Mineral Resources and Geological Survey of Queensland. No petroleum discoveries of economic value have been made.

Geophysical. The extensive geophysical surveys carried out in the Tambo/Augathella area by private companies (generally subsidized by the Commonwealth Government) and the Bureau of Mineral Resources are summarized in Table 2. Geophysical information has been incorporated in a structural form-line map based on water-bore data and oil exploration wells (Fig. 18).

TABLE 1 : SUMMARY OF OIL EXPLORATION WELLS

Name of Well	Year Drilled	Total Depth (ft)	Hydrocarbon Shows	Sheet Area	Grid Reference	Reference
Malta Oil Co. No. 1 (Nive River)	1924-26	1,106?	None	Tambo	Not known; reported lat. $24^{\circ}55'$S, long. $146^{\circ}50'$E	GSQ (1960)
SPL Birkhead No. 1	1957	5,185	Gas show at 3600 ft. DST negative	Tambo	443,937	Grissett (1957)
Amoseas Westbourne No. 1	1964	4,867	None	Augathella	414,868	Gerrard (1964a)
Amoseas Boree No. 1	1964	8,781	None	Tambo	353,921	Gerrard (1964b)
Alliance Jericho No. 1	1965	9,142	None	S part of Jericho	-	AOD (1965)
Phillips-Sunray Carlow No. 1	1966	12,028	None	E part of Blackall	-	Kyranis (1966)
Phillips-Sunray Bury No. 1	1966	9,004	None	Augathella	376,886	Patterson (1966)
Amoseas Cunno No. 1	1966	2,781	None	W part of Eddystone	-	Amoseas (1966a)
Amoseas Balfour No. 1	1966	5,560	None	Augathella	478,826	Amoseas (1966b)

TABLE 2 : GEOPHYSICAL SURVEYS

Gravity	Type	Organisation	Reference
Scattered traverses	Regional	Shell (Qld) Development Pty Ltd	SQD (1952)
Road traverses	Regional	University of Sydney	Marshall & Narain (1954)
Throughout area	Reconnaissance	Bureau of Mineral Resources	Lonsdale (1965)
Most of E part of Tambo Sheet and Augathella Sheet	Reconnaissance	Magellan Petroleum Co.	Magellan (1963)
NE part of Tambo Sheet	Reconnaissance	Alliance Petroleum Co.	United (1964)
Central and S part of Tambo Sheet and central and E part of Augathella Sheet	Detailed	American Overseas Petroleum Co.	Petty (1964)
W part of Tambo Sheet	Detailed	American Overseas Petroleum Co.	Petty (1965)
Augathella Sheet	*Detailed and semi-detailed	Bureau of Mineral Resources	BMR (1967)
Tambo Sheet	*Detailed and semi-detailed	Bureau of Mineral Resources	BMR (1968)
Aeromagnetic	**Type**	**Organisation**	**Reference**
Most of Tambo Sheet and E part of Augathella Sheet	Detailed	Magellan Petroleum Co.	Magellan (1963)
E part of Tambo Sheet and NE part of Augathella Sheet	Detailed	Bureau of Mineral Resources	Wells & Milsom (1966)
E part of Tambo Sheet	Detailed and semi-detailed	Bureau of Mineral Resources	BMR (1964)
Seismic	**Type**	**Organisation**	**Reference**
N-central part of Augathella Sheet	Reconnaissance	Bureau of Mineral Resources	Bigg-Wither & Davies (1964) (Carried out in Nov. 1961)
NE part of Tambo Sheet	Reconnaissance	Oil Development NL	GGC (1963)

Seismic	Type	Organisation	Reference
W part of Augathella Sheet	Semi-detailed	Phillips Petroleum Co. and Sunray D.X. Oil Co.	Fjelstul & Tallis (1963)
Central part of Tambo and Augathella Sheet	Reconnaissance	American Overseas Petroleum Co.	Petty (1963a)
S-central part of Tambo and N-central part of Augathella Sheet	Detailed	American Overseas Petroleum Co.	Petty (1963b)
Central and E part of Augathella Sheet and S part of Tambo Sheet	Detailed and reconnaissance	American Overseas Petroleum Co.	GAI (1965)
SW part of Augathella Sheet	Reconnaissance	Phillips Petroleum Co. and Sunray D.X. Oil Co.	Tallis & Fjelstul (1965)
W edge of Augathella Sheet	Reconnaissance	Phillips Petroleum Co. and Sunray D.X. Oil Co.	Fjelstul & Rhodes (1966b)
W edge of Augathella Sheet	Semi-detailed	Phillips Petroleum Co. and Sunray D.X. Oil Co.	Fjelstul, Rhodes, & Collins (1966)
NW edge of Augathella Sheet	Detailed	Phillips Australian Oil Co. and Sunray D.X. Oil Co.	Phillips (1966)
W edge of Augathella Sheet	Detailed	Phillips Australian Oil Co. and Sunray D.X. Oil Co.	Fjelstul & Rhodes (1966a)
SW part of Tambo Sheet	Detailed	American Overseas Petroleum Co.	Ray (1967)

* Information compiled from earlier listed company surveys with supplementary work by the Bureau of Mineral Resources

DESCRIPTION OF ROCK UNITS

The rocks were deposited in five basins of different ages (see Fig. 17). The 1200 m of Devonian sedimentary rocks in the Adavale Basin consist of clastic and chemical sediments, including evaporites, which do not crop out, and the 2750 m of Devonian and Carboniferous rocks in the Drummond Basin consist of extrusive volcanics and freshwater sediments. Vulcanism diminished with time. The 900 m of Permian and Triassic freshwater sediments in the Bowen Basin and Galilee Basin rest unconformably on the older rocks.

The sequence in the Eromanga Basin consists of about 750 m of Lower Jurassic to early Cretaceous freshwater sediments, overlain by about 1050 m of fine-grained shallow marine and lacustrine Aptian to Albian sediments; the upper half of the Cretaceous sequence is entirely freshwater. There is a major regional unconformity at the base of the sequence.

Post-Cretaceous silicification is widespread, and there are Tertiary valley-fill deposits in some areas.

The sequence in the Drummond Basin is similar to the succession exposed in the Telemon Anticline (Mollan, Dickins, Exon, & Kirkegaard, 1969) except for the absence of the Mount Hall Conglomerate; the volcanic Star of Hope Formation (Olgers, 1969) can also be recognized.

The description of the sequence in the Adavale Basin on the flank of the Pleasant Creek Arch is based on well completion reports and papers by geologists of the Phillips Petroleum Co. and American Overseas Petroleum Ltd.

The Permian and Triassic sequences are almost identical with those in the western part of the Springsure Sheet area (Mollan et al., 1969), but west of the Birkhead Anticline, the Peawaddy Formation is indistinguishable from the Colinlea Sandstone, and the upper part of the Rewan Formation becomes the Dunda Beds of Vine, Jauncey, Casey, & Galloway (1965).

The Jurassic Sequence is essentially that of Woolley (1941a), though his nomenclature has been somewhat amended (see Table 5).

A correlation with the Surat Basin (Exon, 1966) equates the Birkhead Formation/ Adori Sandstone/Westbourne Formation interval with the Injune Creek Group (Exon, 1966), and the Hooray Sandstone with the Gubberamunda Sandstone/Orallo Formation/Blythesdale Formation interval (names after Day, 1964).

The Cretaceous Rolling Downs Group, comprising the Roma, Tambo, and Winton Formations of Whitehouse (1954), has been subdivided and modified as in Vine, Day, Milligan, Casey, Galloway, & Exon (1967) (see Table 6).

MIDDLE DEVONIAN TO LOWER CARBONIFEROUS (?)
(Adavale Basin Sequence)

The Palaeozoic sequence in the Adavale Basin does not crop out, and our knowledge of it is based on the drilling and geophysical surveys for Phillips Petroleum Co. and American Overseas Petroleum Ltd. Part of the sequence occurs in the Boree No. 1 and Bury No. 1 wells near the monoclinal north-northeasterly trending Pleasant Creek Arch (represented at the surface by the Enniskillen Anticline), which forms the eastern boundary of the present-day Adavale Basin. Seismic information indicates that the margin of the basin swings west near the northern boundary of the Tambo Sheet Area. The boundaries of the basin (after Tanner, in press) are shown in Figure 17, and the sequences in the various wells are given in Figure 2 and Table 3.

The nomenclature used in this Report follows the revised nomenclature incorporated in the explanatory notes on the Adavale 1:250,000 Sheet (Galloway, 1970a, appendix).

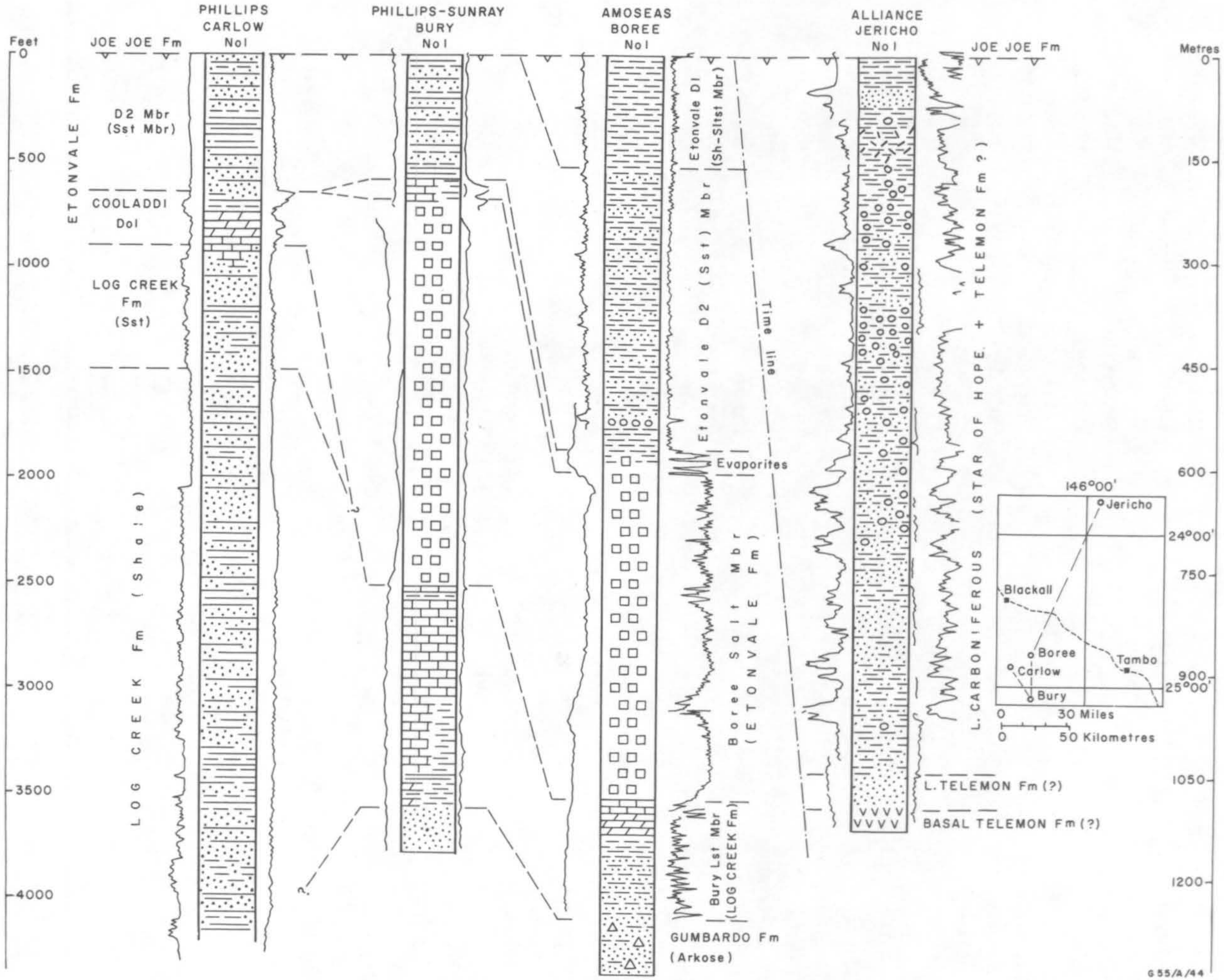

Fig. 2. Subsurface correlations of the pre-Upper Carboniferous.

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ABBREVIATIONS

Abundant	abd
Alluvium	Allv
Angular	ang
Band	Bnd
Basalt	Bs
Bed (ed)	Bd, bdd
Biotite	Biot
Black (ish)	blk, (blk)
Blue	bl
Brown	brn
Calcareous	calc
Carbonaceous	carb
Chert (y)	Cht, cht
Clay (ey)	Cl, cl
Claystone	Clst
Coal	C
Coarse	c
Conglomerate	Cgl
Creamy	crm
Cross-bedding	Xbdg
Dark	dk
Feldspar (thic)	Fld, fld
Ferruginous	fe
Fine	f
Flaggy	flg
Fossil	Foss
Fragment	Frag
Glass	Gls
Granule	Grnl
Gravel	Gvl
Green (ish)	gn, (gn)
Grey (ish)	gy, (gy)
Grit	Grt
Hard	hd
Indurated	indd
Labile, sublabile	lab, sublab
Laminae	Lam
Large (y)	lrg
Light	lt

Limestone	Lst
Lithic	li
Matrix	Mtx
Medium	m
Mica (ceous)	Mic, mic
Minor	mnr
Mudstone	Mdst
Muscovite	Musc
Pebble (y)	Pbl, pbl
Plant	Plt
Platy	plty
Poor (ly)	p
Porous	por
Porphyry	Po
Purple (ish)	purp, (purp)
Quartz (ose)	Qz, qzs
Reddish	(red)
Remains	Rem
Rhyolite	Rh
Rock	Rk
Sand(y)	Sd, sd
Sandstone	Sst
Shale	Sh
Silicified	si
Siltstone	Sltst
Silty	slt
Sorted	srtd
Very	v
Weathered	wthrd
White	wh
With	$\bar{c}$
Slightly or . . . ish	In ( )

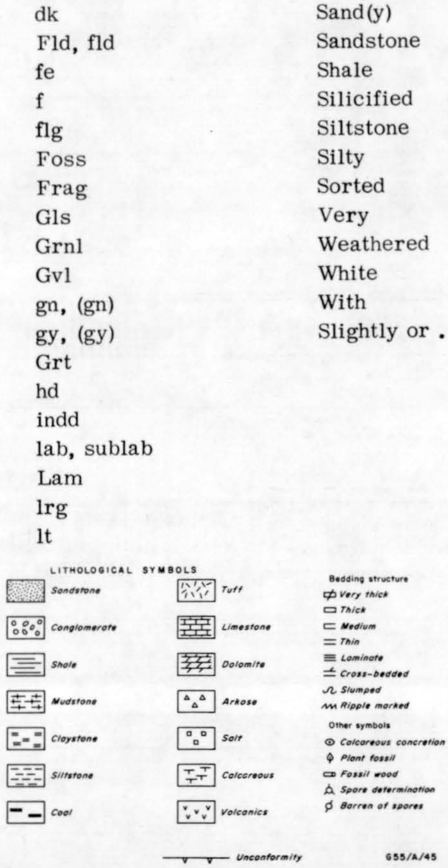

Fig. 3 Abbreviations and symbols used in columnar sections.

TABLE 3 : ADAVALE BASIN SEQUENCE

Phillips-Sunray Bury No. 1			Amoseas Boree No. 1	
Thickness (ft)	Formation Tops (ft)	Unit	Formation Tops (ft)	Thickness (ft)
2474	5264	Etonvale Fm	4457	3504
	absent	shale-siltstone mbr (D_1)	4457	525
560	5264	sandstone mbr (D_2)	4982	1316
1914	5824	Boree Salt Mbr	6298	1663
98	5824	evaporites	6298	115
1816	5922	sodium chloride	6413	1548
1076	7738	Log Creek Fm/Bury Limestone Mbr	7961	584
190+	8814	Gumbardo Fm arkose	8545	236+
TD	9004		8781	TD

The Adavale Group (see Heikkila, 1965) attains a maximum thickness of about 6000 m south of the Gilmore No. 1 well, and is subdivided into the Middle Devonian Gumbardo and Log Creek Formations, the Devonian Etonvale Formation, and the Upper Devonian to Lower Carboniferous (?) Buckabie Formation (Phillips Petroleum Co., 1964; Tanner, in press; Slanis & Netzel, 1967; Galloway, 1970a). In the Tambo/Augathella area it is truncated by a fault against the crystalline basement to the east and north. This sequence may have originally been continuous with the Upper Devonian sediments surrounding the Anakie Inlier, but the intervening sediments were largely stripped off before Lower Permian sedimentation commenced. In places pockets of Devonian sediments were preserved between the Adavale and Drummond Basins (e.g. Birkhead No. 1).

In the Tambo/Augathella area, which was probably isolated from the open sea to the west, arkosic sandstones equivalent to the Gumbardo Formation are overlain by up to 300 m of carbonate rocks of the Bury Limestone Member (Log Creek Formation). The thick salt sequence of the Boree Salt Member (Etonvale Formation) may be unconformable on the Bury Limestone Member. This sequence is overlain by the thick fine-grained clastic sediments of the Etonvale sandstone (D_2) and shale-siltstone (D_1) members (the D_1 member has been eroded from the sequence in the Bury No. 1 well).

Figure 2 shows the general relationship of the units in the Boree No. 1, Bury No. 1, and the more westerly Carlow No. 1 wells according to Slanis & Netzel (1967). Away from the shoreline, in Carlow No. 1 the salt grades into a 75 m carbonate sequence named the Cooladdi Dolomite Member. The Bury Limestone is represented by the shaly lower part of the Log Creek Formation, and a sandy upper part of the formation is also present. The arkose of the east gives way to the volcanics of the Gumbardo Formation proper.

The following descriptions are based on the completion reports on Boree No. 1 (Gerrard, 1964b) and Bury No. 1 (Patterson, 1966), using the nomenclature of Slanis & Netzel (1967).

Arkose and Arkosic Sandstone (Gumbardo Formation)

In Bury No. 1 the arkose and arkosic sandstone is 190 feet (57.9 m) thick (8814-9004 ft; 2686.5-2744.4 m). The lower 109 feet (33.2 m) is predominantly arkose or feldspathic sandstone, with some soft clay; the upper 81 feet (24.7 m) is hard tight quartz-rich sandstone, with minor dolomitic siltstone. In Boree No. 1 it is 236+ feet (71.9+ m) thick and consists of arkose and green silty claystone. The lowermost few feet are strongly silicified.

Bury Limestone Member (Log Creek Formation)

In Bury No. 1 the Bury Limestone Member is 1076 feet (327.9 m) thick (7738-8814 ft; 2358.5-2686.5 m). It consists predominantly of limestone, which is partly fossiliferous and/or dolomitic. The sequence contains interbeds of calcareous siltstone, especially towards the base. The marine macrofossils (McKellar, in Patterson, 1966) suggest a Middle Devonian age. In Boree No. 1 the corresponding carbonate sequence, which is 201 feet (61.3 m) thick (7961-8162 ft; 2426.5-2487.8 m), grades downwards into dolomite. Below the dolomite, to 8545 feet (2604.5 m), the sequence contains interbeds of siltstone, sandstone, and rare dolomite.

Boree Salt Member (Etonvale Formation)

The Boree Salt Member consists mainly of halite, with a little anhydrite and a trace of other salts. The thickness is uncertain as the salt has been contorted by flowage. The member is 1914 feet (583.4 m) thick (5824-7738 ft; 1775.1-2358.5 m) in Bury No. 1. The lower part of the sequence (1816 ft; 553.5 m) consists almost entirely of halite, with traces of anhydrite and other evaporites, and rare laminae and interbeds of shale. The upper part (98 ft; 29.9 m) consists of 22 feet (6.7 m) of dolomitic limestone (5900-5922 ft; 1798.3-1085 m) and 76 feet (23.2 m) of anhydrite (5824-5900 ft; 1775.1-1798.3 m).

In Boree No. 1, where the member is 1663 feet (506.9 m) thick (6298-7961 ft; 1919.6-2426.5 m), the lower halite sequence (6413-7961 ft; 1954.6-2426.5 m) contains less than 5 percent of shale and siltstone. The upper sequence is 115 feet (35.1 m) thick (6298-6413 ft; 1919.6-1954.7 m) and consists of interbedded gypsum and dolomitic siltstone and shale, with traces of anhydrite.

Sandstone member D_2 (Etonvale Formation)

In Bury No. 1 the sandstone unit D_2 is 560 feet (170.6 m) thick (5264-5824 ft; 1604.5-1775.1 m). The lowermost 82 feet (25 m) consists of grey breccia containing large angular fragments of limestone, shale, and sandstone, and smaller fragments of calcareous arkosic sandstone. Overlying this is 310 feet (94.5 m) (5430-5740 ft; 1655.1-1749.6 m) of siltstone and minor shale. The uppermost 166 feet (50.6 m) is composed of breccia with angular fragments of siltstone, shale, and sandstone. Deposition appears to have been contemporaneous with Middle Devonian orogenic movement.

In Boree No. 1 the sandstone unit D_2 is 1316 feet (401.1 m) thick (4982-6298 ft; 1518.5-1919.6 m). The lowermost part of the sequence consists of calcareous and dolomitic siltstone and shale. The lowermost beds are overlain by 9 feet (2.7 m) of intraformational conglomerate below 6158 feet (1876.9 m) containing pebbles of indurated sandstone and siltstone. The sequence above the conglomerate is similar to the lower one, but more sandy.

Shale-siltstone member D_1 (Etonvale Formation)

Unit D_1 is 525 feet (160 m) thick in Boree No. 1 (4457-4982 ft; 1358.5-1518.5 m), but it is not present in Bury No. 1. It is a monotonous succession of interbedded claystone, siltstone, and shale, with rare oolitic calcareous sandstone and limestone. The spores from core 10 (4776 ft; 1455.7 m) are Givetian or Frasnian in age (De Jersey, 1966).

UPPER DEVONIAN TO LOWER CARBONIFEROUS
(Drummond Basin Sequence)

The Upper Devonian to Lower Carboniferous sequence (Silver Hills Volcanics and Drummond Group; see Table 4) consists of volcanic rocks and sediments derived from them. Vulcanism decreased in intensity upwards. While these rocks were being deposited in the Drummond Basin, redbeds (largely sandstone of the Buckabie Formation) were laid down in the Adavale Basin to the west.

In the Jericho No. 1 well the sequence appears to be transitional between the sequences in the Drummond and Adavale Basins. The sequence below the Joe Joe Formation (5508-8807 ft; 1678.8-2684.3 m) consists of varicoloured sedimentary rocks which are mainly reddish. They are generally tuffaceous and include shale, argillite, lithic sandstone, pebbly argillite, and polymictic conglomerate. The cores show that the sequence is generally poorly bedded, and the presence of euhedral biotite and feldspar suggests that some of the beds are tuffaceous. The age of the sequence is unknown, but it must be equivalent to part of the Drummond Group, and was probably derived mainly from the volcanics in the Drummond Basin to the east. The sequence between 8870 feet (2763.6 m) and 9044 feet (2756.6 m) is more quartzose and consists largely of sandstone with lesser argillite. The sequence from 9044 to 9142 feet (2756.6-2786.5 m) is mainly hard agglomerate and tuff, similar to the pyroclastic rocks at the base of the Telemon Formation in the Mount Beaufort Anticline.

Silver Hills Volcanics

The name Silver Hills Volcanics was proposed by Veevers, Mollan, Olgers, & Kirkegaard (1964a, p.7) for the 'dominantly acid volcanic complex which lies west of the Anakie Inlier' in the Emerald Sheet area.

Throughout the Drummond Basin the Formation generally crops out in anticlines, and in the Tambo Sheet area it is found only in the southern end of the Mount Beaufort Anticline. It forms rounded hills covered with scrub and sparse trees. About 450 m of the upper part of the sequence is exposed, but the total thickness in the anticline is about 1050 m.

The formation consists mainly of basalt, andesite, and subordinate rhyolite, in contrast to the type area, where acid volcanics predominate. In places the lavas are porphyritic, and are commonly flow-banded; some contain zeolitic amygdales. Rhyolites are present high in the sequence and some contain pink spherulitic zeolites. Farther north the Silver Hills Volcanics include lenses of tuff, sandstone, conglomerate, and limestone, which Veevers et al. (1964a) include in the lower part of the Telemon Formation, but we and Olgers (1969) consider to be part of the Silver Hills Volcanics. The fossil plants in the sediments are of Upper Devonian age (White, 1962).

The vulcanism became more acidic with time. The associated sediments were probably laid down in a terrestrial environment; this conclusion is supported by the absence of marine fossils and the spherulitic texture of the lavas which indicates subaerial deposition.

TABLE 4 : PALAEOZOIC AND TRIASSIC STRATIGRAPHY

Period	Rock Unit (map symbol)	Lithology	Thickness (m)	Relationships	Environment of Deposition and Palaeontology
M. - U. Triassic	Moolayember Formation (Trm)	Siltstone, mudstone; buff, green, or grey quartzose to labile sandstone, calcareous in part	300± (0-195 subsurface)	Conformable on Clematis Sst. Not present in Boree No. 1 or Bury No. 1; probably eroded before deposition of Precipice Sst	Lacustrine, fluviatile. U. Triassic/ L. Jurassic plants (White, 1966), spores
	Clematis Sandstone (Tre)	Cross-bedded white quartzose to sublabile sandstone; minor conglomerate, siltstone, and mudstone	15-105	Apparently conformable on Dunda Beds and Rewan Fm. Regionally unconformable (e.g. overlies U. Permian in Carlow No. 1 and Boree No. 1)	Fluviatile. Plant fragments
L. Triassic	Dunda Beds (Trld)	Cross-bedded buff to yellowish brown quartzose to labile sandstone; minor siltstone and mudstone	45-60 (absent in S)	Facies equivalent N of Birkhead Anticline of upper part of Rewan Fm. Not present subsurface in S	Fluviatile. Plant fragments
	Rewan Formation (Trlr)	Buff, brown or green sublabile to labile sandstone; grey, green, and red siltstone and mudstone; minor calcareous siltstone and limestone	60 in NW, 120 S of Birkhead Anticline, but pinches out to SE and W subsurface	Conformable on Blackwater Gp. Overlapped to W and SE subsurface	Lacustrine, fluviatile. Fossil wood, TR2a acritarchs and spores
U. Permian	Blackwater Group (Puw)	Labile sandstone, some calcareous; carbonaceous siltstone, mudstone; minor coal	60-75 (not distinguishable in W, N, and SE subsurface)	Unrecognizable to W, N, and SE subsurface. Conformable on Black Alley Sh	Terrestrial, lacustrine; minor paludal. *Glossopteris* flora, fossil wood, P3d acritarchs and spores, P4 spores

Period	Rock Unit (map symbol)	Lithology	Thickness (m)	Relationships	Environment of Deposition and Palaeontology
U. Permian	Black Alley Shale (Puc)	Grey carbonaceous mudstone, white claystone, bentonitic clays, bentonite	45 (not distinguishable to W and SE subsurface)	Unrecognizable to W and SE subsurface. Conformable on Peawaddy Fm	Lacustrine; contemporaneous vulcanism. U. Permian acritarchs and spores (Evans, 1962)
	Peawaddy Formation (Pup)	Quartzose to sublabile sandstone, carbonaceous siltstone, mudstone	30-60 (absent in W subsurface)	Only recognizable in E. Apparently conformable on Colinlea Sst. Grades into Colinlea Sst NW of Birkhead Anticline	Lacustrine, fluviatile. Fish scales, U. Permian acritarchs and spores
L. Permian	Colinlea Sandstone (Plo)	Cross-bedded quartzose to sublabile sandstone, conglomerate; minor siltstone	135± (combined with Puw, Puc, Pup equivalent to W subsurface, about 60)	Disconformable on Reids Dome Beds. Unrecognizable to W subsurface	Fluviatile. *Glossopteris* flora, L. Permian spores
	Reids Dome Beds (Plj)	Siltstone, sandstone	15-	Disconformable on Joe Joe Fm. Pinches out to W	Lacustrine. *Glossopteris* flora
U.Carboniferous-L. Permian	Joe Joe Formation (C-Pj)	Siltstone, sandstone (in part calcareous), shale, conglomerate; minor tuff and limestone	450-	Unconformable on Ducabrook Fm. Thickness very variable; probably filled topographic depressions. Very thick to N in Jericho No. 1	Glacigene, fluviatile, lacustrine. Plant remains, animal tracks. Elsewhere Carboniferous plants (Mollan et al., 1969)

Period		Rock Unit (map symbol)	Lithology	Thickness (m)	Relationships	Environment of Deposition and Palaeontology
L. Carboniferous	DRUMMOND GROUP	Ducabrook Formation (Clu)	Dominantly green lithic sandstone, siltstone, shale, in part tuffaceous; minor tuff	750±	Only in NE (Drummond Basin). Conformable on Star of Hope Fm	Fluviatile, lacustrine; some contemporaneous vulcanism. Elsewhere Carboniferous fish (SQD, 1952) and plants (White, 1962)
		Star of Hope Formation (Cls)	Red and green lithic sandstone, siltstone, shale, in part tuffaceous; tuff	300±	Only in NE (Drummond Basin). Probably disconformable on Raymond Fm	Lacustrine, fluviatile, contemporaneous vulcanism. Plant fragments elsewhere
		Raymond Formation (Clr)	Flaggy quartzose to sublabile sandstone, pebbly sandstone; minor conglomerate	300±	Only in NE (Drummond Basin). Conformable on Telemon Fm	Flood-plain deposits. L. Carboniferous plants elsewhere (White, 1967)
U. Devonian-L.Carboniferous		Telemon Formation (D/Ct)	Dominantly lithic sandstone, siltstone, shale; minor limestone; basal lithic conglomerate, agglomerate, and tuff	150±	Only in NE (Drummond Basin). Disconformable on Silver Hills Volc	Flood-plain deposits; contemporaneous vulcanism early. Algae. Probable Carboniferous plants elsewhere (White, 1962)
		Silver Hills Volcanics (D/Cs)	Basalt, trachyte, rhyolite	1050+	Only in NE (Drummond Basin)	Terrestrial vulcanism. Contains U. Devonian *Leptophloeum australe* McCoy and equisetalean stems farther N

The Silver Hills Volcanics are overlain by conglomerates of the Telemon Formation which is, in part at least, Lower Carboniferous. In the Clermont Sheet area they rest on the Middle Devonian Retreat Granite (Veevers, Randal, Mollan, & Paten, 1964b). At one locality in the Mount Beaufort Anticline they contain Upper Devonian plants including Leptophloeum australe M'Coy (White, 1962). The formation is therefore considered to be Upper Devonian, but could range into the lowermost Carboniferous.

Telemon Formation

The Telemon Series of Shell (SQD, 1952) was renamed the Telemon Formation by Hill (1957). It crops out in the Clermont, Emerald, Springsure, and Tambo Sheet areas. In the Tambo Sheet area it forms strike ridges covered with scrub and scattered trees, on the eastern flank and southern nose of the Mount Beaufort Anticline. On the western flank it has been concealed by downfaulting.

Shell (SQD, 1952) subdivided the formation in the Springsure Sheet area into a 'lower conglomerate group' and an 'upper multicoloured group'. Mollan et al. (1969) estimated the thickness of the lower and upper 'groups' to be 600 and 1500 m in the Nogoa Anticline (80 km east) and 15 and 900 m in the Telemon Anticline (55 km east). In the Mount Beaufort Anticline, the lower conglomerate group contains pyroclastic rocks, and is 60 m thick where present. It pinches out to the south, where the upper multicoloured group reaches a maximum of 150 m.

The lower conglomerate group consists of lithic conglomerate at the base, succeeded by competent pyroclastic rocks. The pyroclastic rocks form a strike ridge dipping southeast, with a relief of about 100 m above the rolling country underlain by the Silver Hills Volcanics. They consist mainly of poorly bedded red and green lithic tuff, agglomerate, and variably welded pyroclastic flows. Some grey cherty ash beds and banded acid flows are also present.

The upper multicoloured group consists almost exclusively of fine-grained green, brown, buff, and grey lithic sandstone, siltstone, and shale, which are calcareous in places. The sandstone ranges from friable to tough. The sandstone and siltstone are thin to medium-bedded, and in places flaggy. Low-angle cross-bedding is present in places. Clay clasts and carbonaceous fragments are abundant in some beds. The shale is laminated to thin-bedded. The sequence also contains a little red tuffaceous sandstone, fine-grained thin-bedded limestone, algal limestone, and pale grey cherty beds which are probably altered tuff.

The Telemon Formation rests apparently conformably on the Silver Hills Volcanics, but the presence of basal conglomerate suggests a disconformity. The formation is about 150 m thick in the Mount Beaufort Anticline, compared with about 2150 m in the type area.

No marine fossils have been found in the formation, and the thin algal limestones were probably deposited in brackish lakes. The basal conglomerates were deposited in alluvial fans derived from high areas of Silver Hills Volcanics to the west. The deposition of the conglomerates was followed by a period of explosive vulcanism. Finally, the fine-grained sediments forming the upper part of the sequence were deposited on floodplains by sluggish streams. Their source was still the Silver Hills Volcanics.

The formation overlies the Silver Hills Volcanics, which contain some Upper Devonian plants, and underlies the Raymond Formation; in the Springsure Sheet area, the Raymond Formation overlies the Mount Hall Conglomerate, which contains plants of probable Lower Carboniferous age (Mollan et al., 1969). The St Anns Formation of the Buchanan Sheet area contains Upper Devonian or Lower Carboniferous plants (Olgers, Doutch, & Eftekharnezhad, 1967) and is older than the Telemon Formation. An outcrop about 6 km north of Telemon homestead in the Springsure Sheet area contains Lower Carboniferous plants, and because the Telemon Formation was believed to be Upper Devonian it was mapped as Ducabrook Formation (Mollan et al., 1969). On structural ground it is almost certain that this outcrop is part of the Telemon Formation.

Thus the age of the formation is Lower Carboniferous in part, but may range down into the Upper Devonian.

Raymond Formation

The Flaggy Sandstone Group of Shell (SQD, 1952) was renamed the Raymond Flaggy Sandstone by Hill (1957), Raymond Sandstone by Veevers et al. (1964a), and Raymond Formation by Olgers (in press).

The formation crops out widely in the Drummond Basin. In the Tambo Sheet area it forms strike ridges in the southern and eastern parts of the Mount Beaufort Anticline. A pebbly lens forms a prominent hill in the south, but to the west the formation is truncated by a fault.

The Raymond Formation consists of fine to medium-grained quartzose to sublabile sandstone and, in the south, pebbly sandstone and some conglomerate. The sandstone ranges from flaggy to thickly bedded and cross-bedded. It is white or buff in colour, and clayey. The conglomerate is thick-bedded and cross-bedded, and consists of pebbles of quartz with subordinate chert, acid volcanics, and silicified sandstone, set in a sandy matrix. The contact with the underlying Telemon Formation is apparently conformable.

The formation consists of fluviatile and lacustrine flood-plain deposits which have probably been partly reworked. The quartzose sediments, unlike those of the Telemon Formation, were not derived from the Silver Hills Volcanics, which were possibly covered at this time. The inferred directions of the currents in the Mount Hall Formation, which overlies the Telemon Formation in the adjacent Emerald Sheet area, suggest deposition from northerly flowing streams (F. Olgers, pers. comm.). The quartz-feldspar porphyry basement in the Cunno No. 1 and Balfour No. 1 wells to the south could be the source of the Raymond Formation.

In the type area (Springsure Sheet) and Tambo Sheet area the formation is about 300 m thick, compared with 500 m farther north in the Emerald Sheet area.

The formation lies between the Telemon and Star of Hope Formations, both of which are Lower Carboniferous in age. In the Buchanan Sheet area (White, 1967) it contains the Lower Carboniferous plants *Lepidodendron veltheimianum* and *Stigmaria ficoides*.

Star of Hope Formation

The Star of Hope Formation (De Bretizel, 1966) crops out widely in the Drummond Basin. In the Tambo Sheet area it occurs on both sides of the fault in the western limb of the Mount Beaufort Anticline. It is generally poorly exposed and is partly covered by scrub and small trees.

Thin to medium-bedded siltstone and sandstone predominate. The siltstone may be green or red, and in one place it contains large fibrous calcareous nodules. The sandstone is green, red, or buff, and ranges from lithic sublabile to lithic; it is commonly tuffaceous, and a fine-grained hematitic tuff was also seen.

The Star of Hope Formation rests conformably on the Raymond Formation. West of the fault in the Mount Beaufort Anticline it is unconformably overlain by the Joe Joe Formation, whereas to the east it is conformably overlain by the Ducabrook Formation. The contacts are not exposed, and it is difficult to distinguish between the Star of Hope and Ducabrook Formations. In the Emerald Sheet area they can be readily identified, because the Star of Hope Formation is essentially volcanic (Olgers, 1969), and they have been traced into the Tambo Sheet area on the air-photographs.

In the Tambo Sheet area deposition was some distance from the volcanic source and largely in shallow lakes. The formation is about 300 m thick.

No fossils were found in the Tambo Sheet area, but elsewhere (White, 1967) the formation contains Lower Carboniferous plants.

Ducabrook Formation

The Ducabrook Formation (Hill, 1957) crops out extensively in the Drummond Basin. In the Tambo Sheet area it is probably confined to the east of the fault in the Mount Beaufort Anticline. Similar sediments crop out west of the fault, but the structural relationships suggest that they belong to the Star of Hope Formation. The Ducabrook Formation crops out poorly in low cuestas.

The formation consists of multicoloured lithic sandstone, siltstone, and shale. The sequence is generally well bedded, with some low-angle cross-bedding, and is estimated to be about 750 m thick in the Tambo Sheet area.

The Ducabrook Formation overlies the Star of Hope Formation. It was deposited in a shallow basin with rapid changes from lacustrine to deltaic and fluviatile conditions. Most of the detritus consists of volcanic material which was probably derived from the older volcanic sequences, although there was some contemporaneous vulcanism in adjacent areas.

The following Lower Carboniferous fossils have been recorded in the Emerald Sheet area: Lepidodendron veltheimianum, Stigmaria ficoides (White, 1962), Gyracanthides murrayi and fragments of palaeoniscoid fish (Hills in SQD, 1952). In the Springsure Sheet area (Mollan et al., 1969) small pelecypods, probably freshwater forms, are abundant in some beds.

CARBONIFEROUS TO LOWER PERMIAN

Joe Joe Formation

The Joe Joe Formation (SQD, 1952; Mollan et al., 1969) crops out around the southern and western parts of the Drummond Basin, and is widespread subsurface in the Bowen and Galilee Basins. In the northeastern part of the Tambo Sheet area it crops out over about 260 sq km around Spider and Native Companion Creeks. The lower conglomeratic part, which is not well exposed, forms grassy rounded hills with a dendritic drainage pattern and widespread deposits of gravel; the upper fine-grained part forms low cuestas with a sparse cover of trees.

The lower part of the Joe Joe Formation is up to 150 m thick, and consists essentially of polymictic conglomerate, greenish lithic sublabile to lithic sandstone, and subordinate lenses of siltstone.

The sandstone is mainly fine to medium-grained. It is grey-green, green, or brown, and lithic to lithic sublabile, and contains clasts of fine-grained acid volcanics, devitrified glass, feldspar, and quartz. Bedding is thick but poorly developed, and in many places the rock contains calcareous concretions and has a calcareous matrix. Coarse-grained granular and pebbly sandstones are fairly common.

The conglomerate is composed mainly of angular to subrounded pebbles and cobbles set in a sandy or silty matrix. The clasts include volcanic rocks, sandstone, siltstone, shale, and quartzite, with subordinate chert, limestone, and quartz. Most of the volcanic rocks were derived from the nearby Silver Hills Volcanics and Ducabrook Formation.

The presence of faceted pebbles and occasional large erratics in the conglomerate and sandstone indicates that the rocks are partly glacial in origin. In various places the glacial erratics have been weathered out of the sandstone and conglomerate, and the residual erratics from the conglomerates near the base of the formation are up to about 10 m long. Most of the erratics consist of tuff or agglomerate derived from the Silver Hills Volcanics and basal part of the Telemon Formation. South of the Mount Beaufort Anticline (grid ref. 504005), where a line of erratics has been weathered out, they consist of pyroclastic flow rocks composed of fragments of red acid lava set in a dark red stony matrix. One and a half kilometres father west, the weathered-out erratics consist of fine-grained porphyritic volcanic rocks, and 16 km west of the anticline (grid. ref. 487012) the residual erratics consist of angular cobbles of porphyritic acid lava.

The upper part of the formation, which consists essentially of well bedded greenish siltstone and sublabile to lithic sandstone, can be subdivided into units roughly comparable to those in the western part of the Springsure Sheet area (Mollan et al., 1969). The thickness cited in Table 5 is based on dips measured to the west of Garden Gully homestead.

TABLE 5 : UPPER PART OF THE JOE JOE FORMATION

Thickness (m)	
60	Sandstone, sublabile to labile, greenish brown to buff, poorly bedded, fine to medium-grained, calcareous beds and calcareous accretions in places, some cross-bedding.
150	Siltstone, shale, lesser limestone, laminated to thin-bedded, in places varve-like or platy, green or grey, some ripple marks, fine cross-bedding, current striae, large nodules, some arthropod tracks; some sandstone, greenish, sublabile, and a little tuff, hard, pink. Plant fragments abundant at some levels.
60	Sandstone, quartzose to sublabile, fine-grained, greenish, thin to thick-bedded; siltstone; tuff, hard, very fine-grained, pink and white; sandstone, tuffaceous, feldspathic. Plant remains common.

In other areas the platy siltstone is calcareous and associated with platy limestone. Thick calcareous lenses and large knobbly accretions, possibly of algal origin, also occur. Mud cracks and current striations caused by dragging debris are present in some beds. The arthropod tracks are identical with those in the Springsure Sheet area (Mollan et al., 1969). Equisetalean stems and strap-like leaves are common in the tuff and siltstone, and are carbonized in some beds.

The Joe Joe Formation rests unconformably on the Devonian and Carboniferous sediments from which it was entirely derived. On the air-photographs the bedding trends in the underlying formations disappear under the amorphous pattern of the Joe Joe Formation conglomerates.

After uplift, erosion of the Ducabrook Formation exposed the Devonian sequence in the Mount Beaufort Anticline. During the extensive period of glaciation which followed, the Joe Joe Formation was deposited by glaciers and streams moving down the slopes of the anticlinal mountain range. The lower part of the formation is fluvioglacial; the occasional large erratics may have been dropped from floating ice, or deposited in moraines. The siltstone and shale, including some varved sediments, were deposited in shallow lakes fed by glacial meltwater. Ripple marks, cross-bedding, and drag striae are common, and some thin calcareous beds are also present. From time to time, the siltstone and shale on the margins of the lakes were dried out and cracked; later they were torn up or undercut and incorporated as fragments in sandstone. Plant life was widespread around the margins of the lakes, and animal tracks are common. The presence of beds of tuff, which commonly contain plant remains, indicates some contemporaneous volcanic activity.

The average thickness of the Joe Joe Formation in the Tambo Sheet area is 450 m: the lower part is 150 m thick and the upper part 300 m. The formation is absent in Westbourne No. 1 on the Birkhead Axis, but is 3617 feet (1102.4 m) thick in Jericho No. 1 in the Galilee Basin (Fig. 4; Appendix 2).

Plant remains are widespread, but are of little use for dating. The carboniferous form Cardiopteris polymorpha has been recorded in the Springsure Sheet area (Mollan et al., 1969). The spores from Jericho No. 1, 80 km west of the outcrop area, indicate that it is partly Permian (Evans, 1966b), but in Birkhead No. 1, 65 km southwest, no Permian spores were found. The younger part of the Joe Joe Formation is generally better preserved in the west, probably because there was less erosion in the west before the deposition of the Colinlea Sandstone. The formation is considered to be Carboniferous to Lower Permian in age.

PERMIAN

Reids Dome Beds

The Reids Dome Beds (Mollan et al., 1969) crop out in the Nogoa Anticline and on the Springsure Shelf as a thin sequence of Glossopteris-bearing siltstone and sandstone, which extends for 8 km into the Tambo Sheet area: it forms the uppermost part of the slope at the foot of the scarp of the Colinlea Sandstone.

The Reids Dome Beds (see Fig. 5) consist of thin to medium-bedded purplish grey siltstone and white quartzose sandstone. The siltstone is ripple-marked in places; the sandstone is fine-grained and medium to thick-bedded. Plant roots (Vertebraria) and poorly preserved leaf fragments are common.

The beds rest, probably disconformably, on the Joe Joe Formation and are disconformably overlain by the Colinlea Sandstone. The dip is very low and no discordance was detected. The uppermost sandstone of the Joe Joe Formation is ferruginized, and there was probably a period of erosion and weathering (Fig. 5) before the Reids Dome Beds were laid down. The sporadic distribution of the beds suggests that they were deposited in shallow depressions in the land surface, and some of the sequence may have been eroded before the Colinlea Sandstone was laid down.

The sequence is only 40 feet (12 m) thick in the measured section (Fig. 5) and 120 feet (37 m) thick on the Springsure Shelf. The relationship of this sequence to the thick sequence in the Denison Trough is uncertain. The presence of several Glossopteris species (Mollan et al., 1969) indicates a Permian age, and as they underlie the Colinlea Sandstone the Reids Dome Beds are considered to be Lower Permian.

Colinlea Sandstone

The Colinlea Sandstone (Mollan, Kirkegaard, Exon, & Dickins, 1964; Mollan et al., 1969) crops out on the Springsure Shelf and in the Tambo and Jericho Sheet areas. In the northeastern part of the Tambo Sheet area it forms a west-northwesterly belt. The quartzose sandstone in the east is deeply incised, but the labile to sublabile sandstone in the west has a more subdued topography. Dip slopes and bedding trends are usually discernible on the air-photographs, and the sandy soil supports a dense cover of small trees.

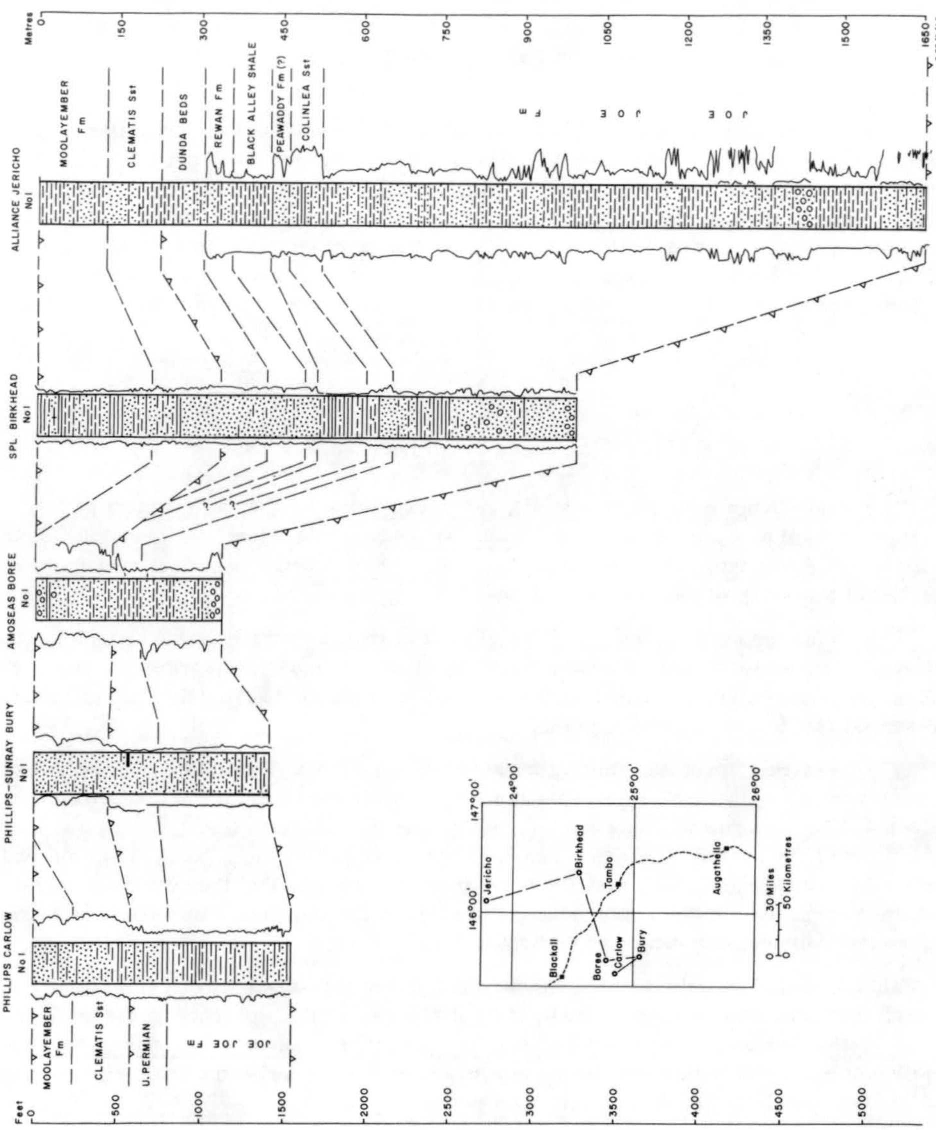

Fig. 4. Subsurface correlations of the Upper Carboniferous to Triassic.

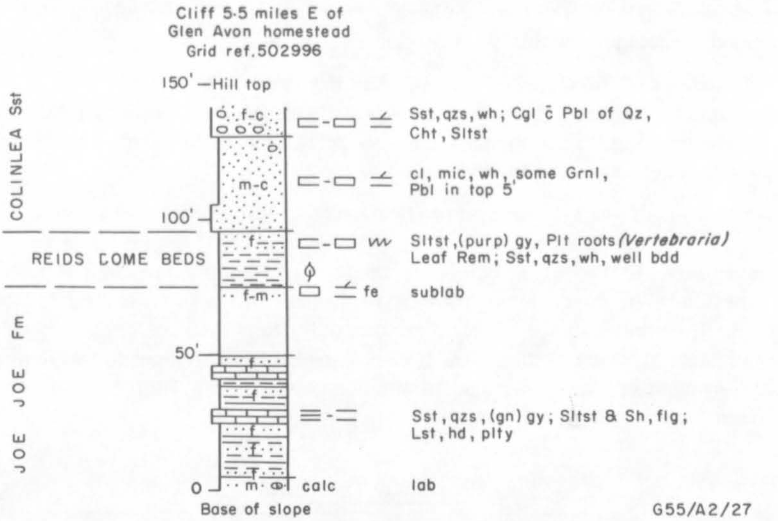

Fig. 5. Measured section (S11) of the Joe Joe Formation, Reids Dome Beds, and Colinlea Sandstone.

The Colinlea Sandstone consists mainly of quartzose to sublabile sandstone, with a little siltstone and conglomerate. Most of the sandstone is white, medium to coarse-grained, medium to thickly bedded, and typically cross-bedded; it contains some feldspar and muscovite, and a little clay matrix. The thinly bedded fine-grained sandstone grades into siltstone which contains plant fragments in places. Thickly bedded pebbly quartzose sandstone and conglomerate are common. The pebbles are mainly quartz, with subordinate chert, porphyritic acid volcanics, quartzite, and sedimentary rocks; the proportion of pebbles of acid volcanics increases upwards, as do those of muscovite and clay matrix (possibly representing an increase in feldspar).

Northeast of Glen Avon homestead the base of the Colinlea Sandstone consists of a 15-cm bed of conglomerate composed mainly of subangular pebbles of quartz and angular pebbles of sandstone derived from the underlying sandstone of the Joe Joe Formation. The base of the Colinlea Sandstone, near the Glen Avon/Alpha road, contains pebbly bands in which most of the pebbles are porphyritic volcanics and lithic clastic sediments; a few tabular pebbles of phyllite and schist were also noted.

Torbanite and coal crop out in a small creek 3 km north of Glen Avon homestead. The torbanite deposits were drilled by the Queensland Department of Mines (Connah, 1964), and are estimated to contain reserves of 680,000 to 820,000 cu m of distillate.

In the east the Colinlea Sandstone rests disconformably on the Reids Dome Beds, with a marked change in lithology from siltstone and fine-grained well bedded sandstone to pebbly cross-bedded sandstone. Elsewhere, the Colinlea Sandstone rests disconformably on the Joe Joe Formation and the basal beds commonly contain clasts derived from the Joe Joe Formation. The upper part of the Colinlea Sandstone, northwest of the Birkhead Anticline, is probably a time equivalent of the Peawaddy Formation to the southeast (see p.26).

The sands were deposited in rivers and deltas on a gently subsiding shelf. What little information is available on the orientation of the cross-bedding suggests deposition by southerly or southeasterly flowing streams. The presence of acritarchs in the sandstone at the top of the equivalent of the Peawaddy Formation in Birkhead No. 1 suggests marine conditions at this level. Most of the competent pebbles were reworked from the conglomerates in the Joe Joe Formation and Mount Hall Conglomerate; some of the less competent pebbles of sedimentary rocks were also derived from the Joe Joe Formation, but others were formed by scouring within the Colinlea Sandstone.

The thickness of the Colinlea Sandstone in the Tambo Sheet area is about 140 m as in the western part of the Springsure Sheet area, but it probably decreases slightly to the west. In the subsurface (Fig. 7) the formation is recognizable only in Jericho No. 1 (to the north of the Tambo Sheet area) and in Birkhead No. 1.

The plant fossils in the Springsure Sheet area (Mollan et al., 1969) are of Lower Permian age, and in the Jericho Sheet area (Vine et al., 1965) Upper Permian. The spores from Springsure BMR No. 6 belong to the Lower Permian unit P3b of Evans (1966b). The formation may range from Lower to Upper Permian from east to west, but the sequence in the west may be Upper Permian only. Northwest of the Birkhead Anticline, the upper part of the Colinlea Sandstone is probably equivalent to the Upper Permian Peawaddy Formation, and the age of the formation in the Tambo Sheet area probably ranges from Lower to Upper Permian.

Peawaddy Formation

The Peawaddy Formation (Mollan et al., 1964, 1969) crops out in the northeastern Tambo Sheet area as a narrow west-northwesterly belt, marked by a sparsely timbered sandy valley between the Colinlea Sandstone and the black-soil plain of the Black Alley Shale. Northwest of the Birkhead Anticline, the equivalent sequence has been assigned to the Colinlea Sandstone.

The formation is poorly exposed, and most of the outcrops consist of quartzose to feldspathic sublabile sandstone, with a little siltstone. The sandstone is white to buff, fine to medium-grained, and medium-bedded, with a soft clay matrix and some muscovite and minor lithic fragments. The few clayey sandstones present are probably altered feldspathic sandstone. The siltstone is laminated, finely cross-bedded, and grey, with carbonized plant fragments in places. Soft fine-grained carbonaceous sandstone is present in places.

In Tambo BMR No. 33, halfway across the belt of Permian outcrop in the Tambo Sheet area, the Peawaddy interval is 46 m thick (Fig. 6). The upper half consists of quartzose sandstone, clayey in places; the lower half is composed of interlaminated cross-bedded dark grey carbonaceous micaceous siltstone and mudstone, and grey quartzose sandstone and siltstone, similar to the type section in the Springsure Sheet area, but more quartzose and less silty. These changes continue westwards until, on or near the Birkhead Anticline, the formation is indistinguishable from the Colinlea Sandstone and becomes part of it. On the map the boundary has been arbitrarily placed under the alluvium of Alpha Creek.

In Tambo BMR No. 32, near Durrandella homestead beyond the most northwesterly outcrop of the Peawaddy Formation, the top of the Colinlea Sandstone comprises 30 m of quartzose sandstone and a little carbonaceous siltstone which are recognizable as related to the Peawaddy Formation. To the east, the Peawaddy Formation conformably overlies the Colinlea Sandstone, and the base is taken immediately above the uppermost bed of conglomerate.

The formation was deposited in fresh water. The lower silty part was laid down in standing water, and the abundant carbonaceous material indicates a reducing environment. Later, the water became shallower, and fine to medium-grained sandstone was deposited in marginal rivers and lakes. The predominant marine environment in the type area apparently extended as far west as Mantuan Downs homestead in the Springsure Sheet area (Mollan et al., 1969), but not as far as the Tambo Sheet. However, the presence of acritarchs in the uppermost sandstone in Birkhead No. 1 suggests some marine influence at the close of Peawaddy time.

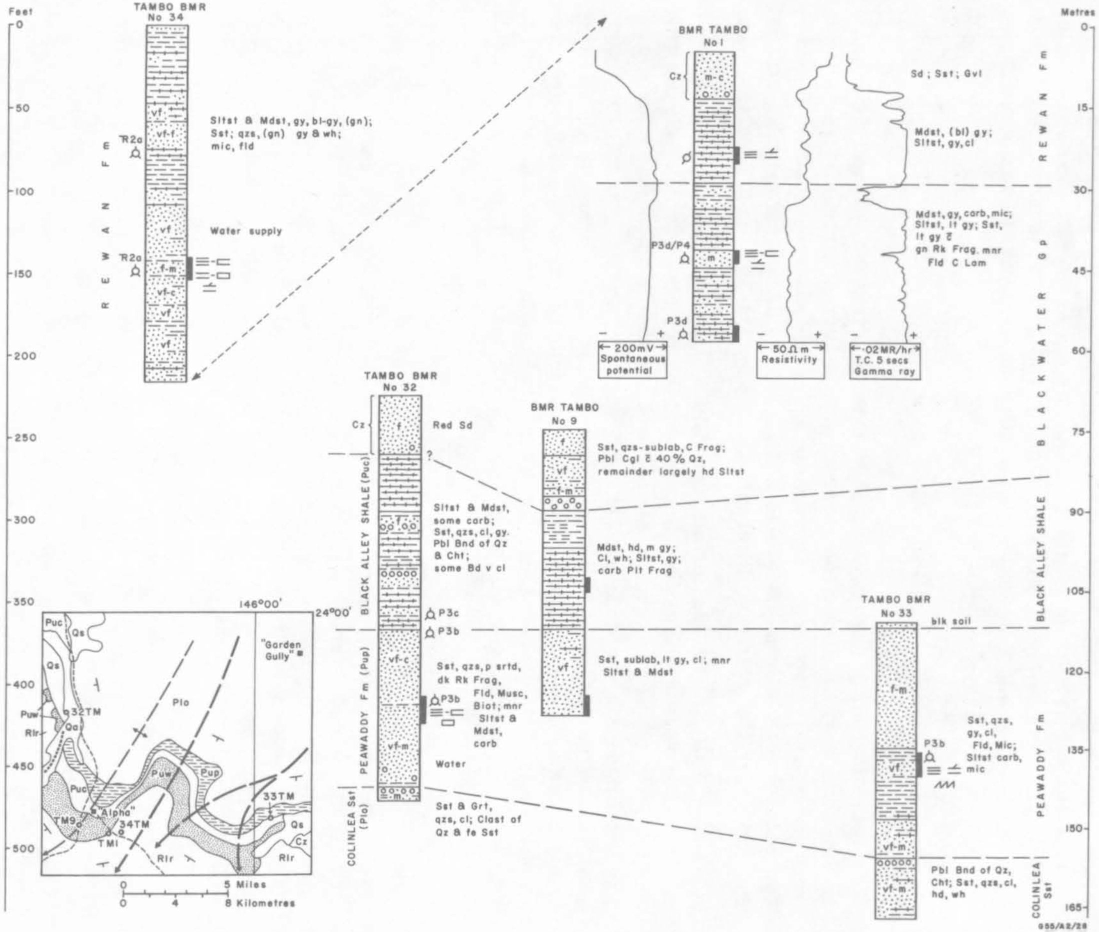

Fig. 6. Stratigraphic boreholes in the Permian and Lower Triassic.

The formation thins across the Tambo Sheet area from an estimated 200 feet (60 m) in the east to 150 feet (46 m) in Tambo BMR No. 33; the equivalent sequence in Tambo BMR No. 32 is 100 feet (30 m) thick. Farther east, near Tanderra homestead, 65 km east of the Tambo/Springsure Sheet boundary, the thickness was estimated as 130 m (Mollan et al., 1969).

A few fish scales were found in sandstone in a small creek 1.5 km east-northeast of Alpha homestead (grid ref. 47139860). The shell fragments reported by Woolley (1941b) near Alpha homestead were equated with the Mantuan Productus Bed Fauna. The acritarch swarm at 3240 feet (987.6 m) in Birkhead No. 1 contains the same species as in the swarm of acritarchs immediately above the Mantuan Productus Bed in the Denison Trough (P.R. Evans, pers. comm.). Spores of units P3b/P4 occur in BMR Tambo No. 9 (see Appendix 1). The age of the formation is Upper Permian.

Black Alley Shale

The Black Alley Shale (Mollan et al., 1969) extends across the Springsure Shelf into the northeastern part of Tambo Sheet area, where it crops out in a narrow sinuous northwesterly belt. The formation is covered by well grassed treeless black soil, and is only exposed in deeply entrenched creeks and gullies. On the air-photographs it can be distinguished from the overlying Blackwater Group by the absence of bedding trends.

In Tambo BMR No. 32 the formation consists of grey mudstone, which weathers brown, and light-coloured claystone. The only good outcrop seen was in a gully near the northern boundary of the Tambo Sheet, where buff thin to medium-bedded siltstone and weathered mudstone and claystone crop out. The siltstone is tightly folded, and faulted on a small scale. The outcrop is in line with several faults to the southwest, and this may explain the deformation of the beds. Alternatively, the folding may be due to the presence of bentonitic clay, as in the type area. The distinctive mosaic of cracks in the mudstone and black soil is identical with that illustrated by Thompson & Duff (1965) in the Reids Dome area.

In the Birkhead No. 1 well, we have identified the interval from 2930 to 3240 feet (893.1-987.6 m) as Black Alley Shale. The log of the hole (Grissett, 1957) shows grey ash, dense igneous sediments, greenish unctuous shale, grey and tan arenaceous limestone, carbonaceous shale, very fine-grained dark grey well cemented slightly calcareous very tight sand, grading into sandy shale, and dark grey shale and sandy shale. The cuttings in this section are very sparse, and most of the section probably consists of mudstone and claystone. Core 3 (2971-2972.5 ft; 905.6-906.1 m) consists of fine to coarse-grained partly lignitic tuffaceous lithic sandstone.

The greenish unctuous shale can probably be correlated with the typical greenish bentonitic clay in the type area in the Springsure Sheet. The remainder of the sequence is similar to the sequence cropping out in the Tambo Sheet area but, in addition, tuffs, limestone, and sandstone are present.

The Black Alley Shale rests conformably on the Peawaddy Formation in the southeast and on the Colinlea Sandstone in the northwest. The transition from sandstone to mudstone corresponds with the change from tree-covered sandy soil to well grassed black soil.

The formation was probably deposited slowly in a gently subsiding basin. Elsewhere, marine conditions prevailed at times in the lowermost part of the sequence. Contemporaneous vulcanism is indicated by the presence of tuff, and some of the soft beds of clay are probably weathered volcanic material.

In the Springsure Sheet area (Mollan et al., 1969) the thickness of the formation ranges from 120 m in the east to 60 m in the west; and it continues to thin gradually by glacial meltwater. Ripple marks, cross-bedding, and drag striae are common, and some thin calcareous beds are also present. From time to time, the siltstone and shale on the margins of the lakes were dried out and cracked; later they were torn up or undercut and incorporated as fragments in sandstone. Plant life was widespread around the margins of the lakes, and animal tracks are common. The presence of beds of tuff, which commonly contain plant remains, indicates some contemporaneous volcanic activity.

The average thickness of the Joe Joe Formation in the Tambo Sheet area is 450 m: the lower part is 150 m thick and the upper part 300 m. The formation is absent in Westbourne No. 1 on the Birkhead Axis, but is 3617 feet (1102.4 m) thick in Jericho No. 1 in the Galilee Basin (Fig. 4; Appendix 2).

Plant remains are widespread, but are of little use for dating. The carboniferous form Cardiopteris polymorpha has been recorded in the Springsure Sheet area (Mollan et al., 1969). The spores from Jericho No. 1, 80 km west of the outcrop area, indicate that it is partly Permian (Evans, 1966b), but in Birkhead No. 1, 65 km southwest, no Permian spores were found. The younger part of the Joe Joe Formation is generally better preserved in the west, probably because there was less erosion in the west before the deposition of the Colinlea Sandstone. The formation is considered to be Carboniferous to Lower Permian in age.

PERMIAN

Reids Dome Beds

The Reids Dome Beds (Mollan et al., 1969) crop out in the Nogoa Anticline and on the Springsure Shelf as a thin sequence of Glossopteris-bearing siltstone and sandstone, which extends for 8 km into the Tambo Sheet area: it forms the uppermost part of the slope at the foot of the scarp of the Colinlea Sandstone.

The Reids Dome Beds (see Fig. 5) consist of thin to medium-bedded purplish grey siltstone and white quartzose sandstone. The siltstone is ripple-marked in places; the sandstone is fine-grained and medium to thick-bedded. Plant roots (Vertebraria) and poorly preserved leaf fragments are common.

The beds rest, probably disconformably, on the Joe Joe Formation and are disconformably overlain by the Colinlea Sandstone. The dip is very low and no discordance was detected. The uppermost sandstone of the Joe Joe Formation is ferruginized, and there was probably a period of erosion and weathering (Fig. 5) before the Reids Dome Beds were laid down. The sporadic distribution of the beds suggests that they were deposited in shallow depressions in the land surface, and some of the sequence may have been eroded before the Colinlea Sandstone was laid down.

The sequence is only 40 feet (12 m) thick in the measured section (Fig. 5) and 120 feet (37 m) thick on the Springsure Shelf. The relationship of this sequence to the thick sequence in the Denison Trough is uncertain. The presence of several Glossopteris species (Mollan et al., 1969) indicates a Permian age, and as they underlie the Colinlea Sandstone the Reids Dome Beds are considered to be Lower Permian.

Colinlea Sandstone

The Colinlea Sandstone (Mollan, Kirkegaard, Exon, & Dickins, 1964; Mollan et al., 1969) crops out on the Springsure Shelf and in the Tambo and Jericho Sheet areas. In the northeastern part of the Tambo Sheet area it forms a west-northwesterly belt. The quartzose sandstone in the east is deeply incised, but the labile to sublabile sandstone in the west has a more subdued topography. Dip slopes and bedding trends are usually discernible on the air-photographs, and the sandy soil supports a dense cover of small trees.

The Blackwater Group contains Glossopteris and fossil wood. In the Springsure Sheet area (Mollan et al., 1969) it contains Upper Permian plants. Core 2 from BMR Tambo No.1 contains a P4 spore assemblage, and core 3 contains a P3d assemblage which includes a high percentage of acritarchs (Appendix 1); cuttings from 2900 feet (883.9 m) in the Birkhead No. 1 well contain Permian spores (Evans, 1962). The age of the group is Upper Permian.

TRIASSIC

Rewan Formation

The Rewan Formation (Isbell, 1955) is preserved over much of the southern half of the Bowen Basin, including the Springsure and Eddystone Sheet areas. It crops out in the northeastern part of the Tambo Sheet area as a sinuous northwesterly belt. The formation is lightly timbered and is generally poorly exposed. The resistant beds form small cuestas and mesas, and in places the basal part of the sequence forms scarps above the less resistant Blackwater Group.

The formation consists mainly of sandstone with subordinate siltstone and mudstone. In the type area (Springsure Sheet, Mollan et al., 1969) mudstone is predominant, but to the west on the Springsure Shelf, sandstone is widely exposed, and in the Tambo Sheet area (Figs 6, 7) it is predominant.

The sandstone is white or greenish grey when fresh, and weathers brown or greenish brown. It is dominantly lithic, but grades through lithic sublabile to quartzose, and is more quartzose towards the base. Feldspar is abundant in some beds. The lithic fragments consist mainly of acid volcanic rocks and fine sediments. Muscovite and biotite are abundant in some beds, and tourmaline is a widespread minor constituent. The bedding is generally medium to very thick, and planar and scour cross-bedding are common. Grainsize ranges from very fine to very coarse. In some beds green or white clay clasts are common; they are either scattered throughout or concentrated in layers.

The siltstone is well bedded, laminated to thin-bedded, and may contain low-angle cross-bedding and ripple marks; oscillation ripple marks (Fig. 8) are well preserved in the siltstone 9.5 km west of Durrandella homestead. In outcrop, the siltstone is grey, green, or rarely red, but in boreholes it is commonly blue-green or blue-grey. In places beds of calcareous siltstone and platy limestone are present, and thin bands of tough ferruginous siltstone occur throughout the sequence. Interbedded green and red mudstone is commonly associated with multicoloured siltstone. The mudstone, which is mottled in places, is fairly widespread in the upper part of the sequence, and outcrops up to about 5 m thick have been noted. Grey mudstone is also common. Siltstone and mudstone are apparently more abundant in the east. Carbonaceous material is not common.

Tambo BMR No. 34 and BMR Tambo No. 1 (Fig. 6), near Alpha homestead, penetrated 260 feet (80 m) of the lower part of the formation and BMR Tambo No. 8 penetrated the uppermost 170 feet (50 m). Tambo BMR No. 34 and BMR Tambo No. 8 probably overlap by about 30 m. The sequence consists of laminated grey, green, and blue siltstone and mudstone, and thin to medium-bedded, green and white, very fine-grained quartzose to labile sandstone.

At the base of the formation, 6 km east of Alpha homestead, fossil logs, up to 10 m long, are found near the siltstone and sandstone outcrops. The siltstone is calcareous, tough, and massive, and grades into fine labile sandstone; the sandstone is fine to medium-grained, calcareous, grey to brown, and labile, and contains exceedingly abundant green clay clasts and some carbonaceous plant remains. It contains vitreous quartz and is probably tuffaceous in origin. It is strikingly similar to sediments in the Brumby Sandstone, which is in the same stratigraphical position farther east (A.R. Jensen, pers. comm.).

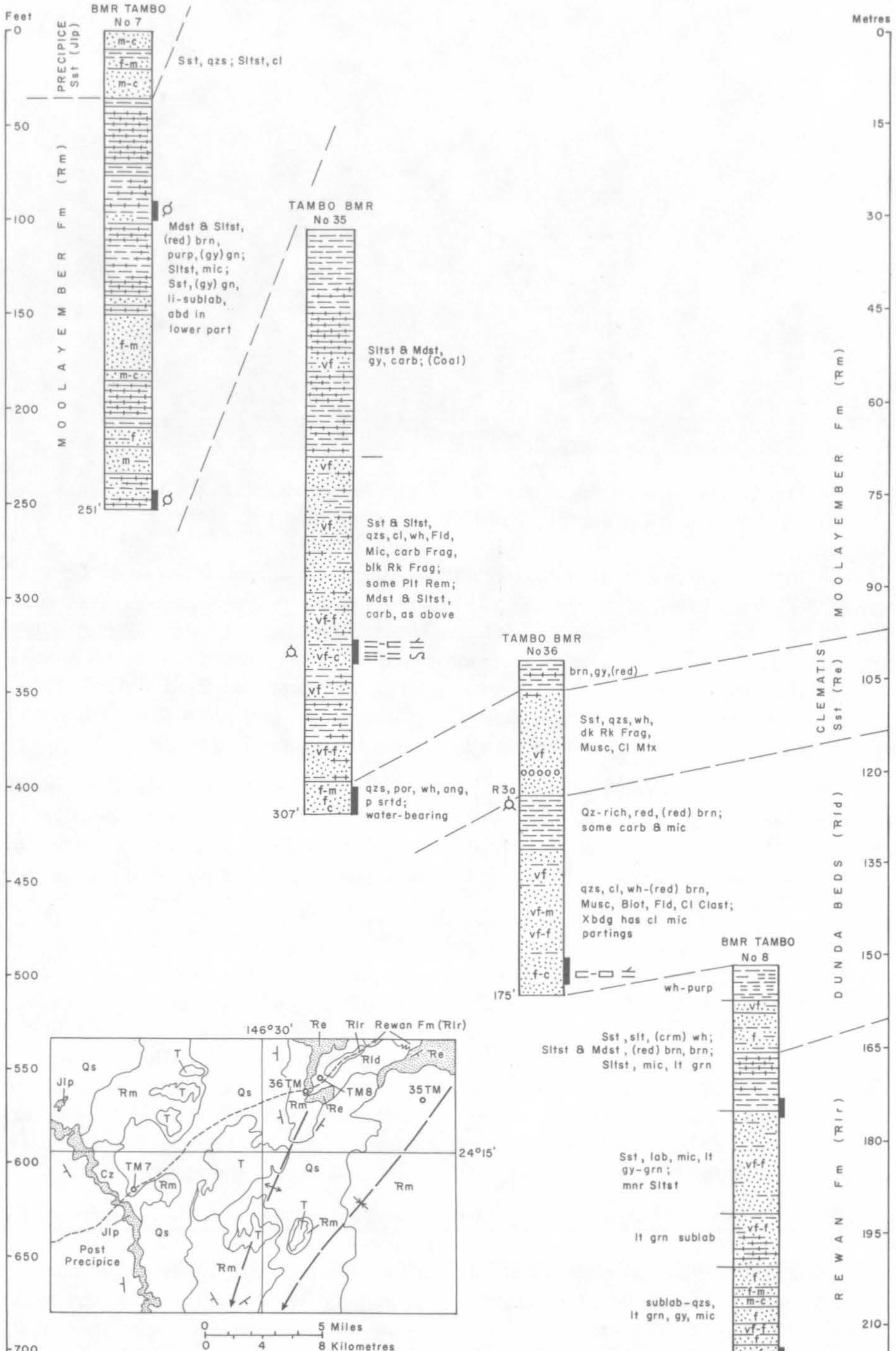

Fig. 7. Stratigraphic boreholes in the Triassic.

Fig. 8. Oscillation ripple marks in a thin siltstone bed in the lower part of Rewan Formation, Tambo Sheet area (grid ref. 46600035).

The Rewan Formation rests apparently conformably on the Blackwater Group. The base of the lowest green siltstone bed was generally taken as the boundary. At the contact in BMR Tambo No. 1, blue-grey mudstone overlies white siltstone and grey sublabile sandstone; carbonaceous material is much more abundant below the contact. Core 1, at 60 feet (18.3 m), yielded a Triassic spore assemblage, and core 2, at 120 feet (36.6 m), yielded a Permian assemblage (Appendix 1) of spore unit P3d or P4. This suggests that there may be a time-break between the Blackwater Group and Rewan Formation.

The Rewan Formation is overlain by the Clematis Sandstone south of the Birkhead Anticline. Near the anticlinal axis, the sandstone in the upper part of the Rewan Formation grades laterally into the less lithic sandstone of the Dunda Beds (see p.33). To the north, the lower part of the Rewan Formation is overlain, possibly disconformably, by the Dunda Beds.

The conditions of deposition were markedly different from the redbed conditions which prevailed in the type area. In the Tambo Sheet area, the formation was laid down in a non-marine environment. The finer sediments are probably lacustrine, whereas the sandstones are at least partly fluviatile. The sequence becomes coarser in grain and more fluviatile upwards. After the lower predominantly fine-grained part of the formation was deposited, there was a slight change in facies which suggests the existence of two depositional areas, intermittently separated by a northeasterly ridge corresponding to the axis of the Birkhead Anticline. The Dunda Beds to the north and west were laid down contemporaneously with the upper part of the Rewan Formation to the south and east of the ridge.

The abundance of mud clasts, which indicate desiccation, and the presence of fossil wood, suggest a terrestrial environment, and the paucity of carbonaceous material suggests that oxidizing conditions prevailed. The colour of the mudstones is probably due to hydrated iron oxides. A possible marine interval is suggested by the presence of acritarchs in Tambo BMR No. 34. The scattered measurements on the cross-bedding suggest that the sands were deposited by streams flowing northwest.

The estimated thickness of the Rewan Formation is 120 m southeast of the Birkhead Anticline, and 60 m to the northwest, where only the lower part of the formation is present;

it is 480 m thick in the type section, and about 120 m thick near Mantuan Downs homestead on the Springsure Shelf (Mollan et al., 1969). The formation is present subsurface in the central and northern parts of the area, but is overlapped by the Clematis Sandstone to the southwest and southeast (Fig. 4; Appendix 2).

Fossil wood is found low in the sequence. In Tambo BMR No. 34, spores of the Triassic unit Tr2a (see Appendix 1) were recorded in the interval from 70 to 80 feet (21.3-24.4 m); a few acritarchs are also present. This horizon is equivalent to the acritarch-rich Tr2a assemblage in core 1 (1212 ft; 369.4 m) in the Jericho No. 1 well (P.R. Evans, pers. comm.) 80 km to the west. The Rewan Formation is of Triassic age, but the lowermost Triassic may be absent in the Tambo Sheet area.

Dunda Beds

The name Dunda Beds was proposed by Vine et al. (1965) for 'a dominantly sandstone sequence, which rests conformably on the Rewan Formation on the north-eastern margin of the Eromanga Basin, and is probably a facies variant of the upper part of the Rewan Formation in the Denison Trough'. The Dunda Beds crop out in the Buchanan, Galilee, Jericho, and Tambo Sheet areas. In the Tambo Sheet area they occupy a meridional belt west of Durrandella homestead, north of the Birkhead Anticline. The sequence forms gently dipping cuestas, and is lightly timbered.

The Dunda Beds consist mainly of very fine to medium-grained brown and yellowish brown clayey lithic to quartzose sandstone, and some siltstone. The sandstone is largely medium to very thick-bedded, and strongly scour and planar cross-bedded. It is mature; the lithic fragments consist of fine-grained acid volcanics and subordinate fine-grained sediments. Near the top of the sequence, west of Durrandella homestead, there is about 15 m of fine to medium-grained buff micaceous sublabile sandstone. The sandstone is thin to medium-bedded, with low-angle cross-bedding.

The sandstone outcrops are generally weathered and in places ironstained. The rock contains abundant quartz, quartzite, fragments of acid volcanic and clayey rocks, feldspar, and some black rock fragments and muscovite. Biotite is a minor constituent in some beds, and white or yellow clay clasts are abundant. Siltstone is only rarely seen in outcrop, but in Tambo BMR No. 36 (Fig. 7) there is 25 feet (7.5 m) of grey and reddish brown siltstone at the top of the sequence below the white unweathered Clematis Sandstone. The siltstone is partly carbonaceous and micaceous, and may correspond to the thinly bedded sandstone farther north. Below the siltstone in Tambo BMR No. 36 is 70 feet (21 m) of yellowish ironstained weathered quartzose sandstone (Fig. 7). Similar sandstone is present in the uppermost 40 feet (12 m) of BMR Tambo No. 8, and the change to the multicoloured sediments of the Rewan Formation is quite sharp.

The Dunda Beds are mainly fluviatile, with some possible lacustrine intervals. The orientation of the cross-bedding varies widely. North of the Tambo Sheet area (Vine et al., 1965), the sediment was derived mainly from the east, possibly from the volcanics and sediments in the Drummond Basin. The Dunda Beds were probably uplifted, deeply weathered, and partly eroded before the Clematis Sandstone was laid down. Subsurface they are overlapped by the Clematis Sandstone to the west (Fig. 4).

In the Tambo Sheet area the maximum thickness is about 60 m in the north, but decreases to about 45 m in the axial region of the Birkhead Anticline. The thickness is 60 to 90 m in the northern part of the Jericho Sheet area (Vine et al., 1965).

No fossils were found in the Tambo Sheet area, but Vine et al. (1965) collected plants which have been dated as Triassic to Lower Jurassic (White, 1965). By correlation with the upper part of the Rewan Formation, and because they are overlain by the Middle Triassic Clematis Sandstone, the Dunda Beds are considered to be Lower Triassic.

Relationship to the Rewan Formation. The Dunda Beds are a facies equivalent of the upper part of the Rewan Formation. The sandstone of the Dunda Beds is more quartzose and feldspathic, and contains a smaller proportion of fragments of sedimentary and volcanic rocks, than that of the Rewan Formation. In the field it is characteristically yellowish, compared to the greenish or brown sandstone in the Rewan Formation, and is generally more thickly bedded and strongly cross-bedded. Multicoloured mudstone and siltstone are confined to the Rewan Formation. On the Alpha/Tambo road 11 km south of Alpha homestead the contact between the basal Dunda Beds and the Rewan Formation is visible. Here, 1.2 m of the red and green mudstone is overlain by 15 cm of ferruginized micaceous siltstone, followed by fine to coarse thickly bedded cross-bedded clayey sandstone of the Dunda Beds. The contact is strongly scoured and the basal sandstone contains large greenish clay clasts, probably derived from the underlying sequence. Thus the contact is, locally at least, disconformable.

Clematis Sandstone

The Clematis Sandstone (Jensen, 1926; Olgers, Webb, Smit, & Coxhead, 1966) crops out extensively in the southern part of the Bowen Basin. In the northeastern part of Tambo Sheet area, it occupies a sinuous northwesterly belt consisting of densely timbered low ridges and dip slopes separated by low sandy lightly timbered areas. In the east, where dips are extremely low, flat lightly timbered sandy benches are developed.

The Clematis Sandstone consists mainly of mature sandstone and fine conglomerate. The sandstone is white to buff, very fine to coarse-grained, thinly to very thickly bedded, and cross-bedded. It is a lithic sandstone containing a high proportion of acid volcanic detritus. It may be micaceous, feldspathic, or clayey, and is strongly cross-bedded. Some ripple marks and clay clasts were found. Beds of quartz pebbles and conglomerate are fairly common, and interbeds of quartz-rich siltstone and mudstone occur at some levels. Thin hard ferruginous bands are also present, one of which contains concretions up to 30 cm across. The formation is a moderately good aquifer.

Two sections are given in Figure 7. Tambo BMR No. 35, 3 km north of Skye homestead, intersected the sharp contact between the overlying thinly bedded grey siltstone and fine clayey sandstone of the Moolayember Formation and the coarse-grained thickly bedded white quartzose sandstone of the Clematis Sandstone. In Tambo BMR No. 36 the Clematis Sandstone consists of 55 feet (16.5 m) of uniform fine-grained quartzose sandstone, resting on the uppermost siltstone of the Dunda Beds, overlain by 15 feet (4.5 m) of siltstone of the Moolayember Formation.

The Clematis Sandstone rests apparently conformably on the Dunda Beds in the north, and the Rewan Formation in the south. Subsurface (see Fig. 4; Appendix 2), the Clematis Sandstone is unconformable with the underlying units, and overlaps progressively older units to the west and southeast. There is a sharp change from the yellow, brown, or greenish labile and sublabile sandstone of the underlying units to the clean white quartzose sandstone of the Clematis Sandstone. Near Merrijig Creek, the base of the Clematis Sandstone consists of a 10-cm bed of kaolinitic clay. The deep weathering of the Dunda Beds, in particular, suggests a hiatus before the Clematis Sandstone was laid down.

The Clematis Sandstone was laid down in a fluviatile environment, and was probably derived from a pre-existing sandstone. North of the Birkhead Anticline, the irregular cross-bedding indicates currents flowing west, north, and east, but in the south, the cross-bedding generally dips consistently to the northwest.

The estimated thickness in outcrop is generally about 100 m, and is consistently between 100 and 120 m in the subsurface. However, where the outcrop crosses the Birkhead Anticline the Clematis Sandstone is only 55 feet (16.5 m) thick, as shown by Tambo BMR 36 (Fig. 7). Elsewhere, the estimated thickness is 150 m in Reids Dome, 60 m on the

Springsure Shelf (Mollan et al., 1969), and 100 m in the southern part of the Jericho Sheet area (Vine et al., 1965).

No fossils were found in the Tambo Sheet area. The plants collected elsewhere (Mollan et al., 1969; Vine et al., 1965) are Triassic to Lower Jurassic in age, and the spores indicate a probable Middle Triassic age (P.R. Evans, pers. comm.).

Moolayember Formation

The Moolayember Formation (Reeves, 1947; Mollan et al., 1972) crops out extensively in the southern part of the Bowen Basin. In the Tambo Sheet area, it crops out in a northwesterly belt some 15 km wide, north of the scarp of the Precipice Sandstone. The belt has a low relief and supports sparse brigalow and wilga scrub. In the north, the formation is generally covered by thick soil. A few of the quartzose sandstones form low cuestas, but bedding trends are usually not discernible on the air-photographs.

Siltstone and sandstone predominate in outcrop. The siltstone is commonly khaki-brown or buff, but the fresh rock exposed below the Tertiary sediments or Precipice Sandstone is generally green or grey. Purple siltstone, weathering to ash-grey, is common in the upper part of the section. The siltstone is laminated to medium-bedded, and may be cross-bedded or ripple-marked. It ranges from quartz-rich to labile, and commonly contains mica, carbonaceous material, and plant fragments.

The sandstone is commonly brown to greenish, fine to medium-grained, generally lithic sublabile to lithic, and may contain abundant feldspar. In many places it is calcareous or argillaceous, and may contain muscovite, biotite, and clay clasts. It is medium to thick-bedded and commonly cross-bedded. Concretions, lenses, and beds of tough brown, grey, or green calcareous sandstone, grading into sandy limestone, are present, and some thin beds of fine-grained tough grey limestone also occur. Resistant beds of buff very fine-grained quartzose to sublabile sandstone occur throughout the formation, particularly in the northwest. They are thin to medium-bedded, and rarely ripple-marked. Poorly preserved plant remains are widespread. Green, grey, or purple mudstone crops out in a few places, and red claystone was seen at one locality.

Three kilometres east of Marston homestead, there is a particularly good exposure of about 50 m of predominantly fine-grained sediments beneath Tertiary sandstone. The sequence consists mainly of green, grey, and purple mudstone, buff ripple-marked thin to medium-bedded cross-bedded siltstone and very fine-grained sandstone, and grey to green medium-grained medium-bedded lithic sandstone, containing black and green rock fragments and some feldspar and large calcareous lenses.

In Tambo BMR No. 35 (Fig. 7) the lower part of the formation consists of a monotonous sequence of grey and white siltstone, mudstone, and fine quartzose sandstone, with traces of coal. The contact with the underlying fine to coarse-grained white water-bearing quartzose Clematis Sandstone is very sharp. The upper part of the formation in BMR Tambo No. 7 (Fig. 7) consists of multicoloured mudstone, siltstone, and lithic to lithic sublabile sandstone.

The Moolayember Formation rests conformably on the Clematis Sandstone. On the crest of the Birkhead Anticline the contact is transitional, and the clean white fine-grained thin to medium-bedded quartzose Clematis Sandstone is overlain by a sequence of similar sandstone interbedded with clayey siltstone and labile carbonaceous micaceous siltstone containing varicoloured particles and strap-like leaves of Calamites. The sequence becomes more lithic upwards and it seems that a quartzose source gave way to a lithic source as time went on. The presence of high-angle cross-beds in places indicates periods of fluviatile deposition. At one locality, the current direction suggested by the symmetrical ripple marks in a fine-grained sandstone is at right angles to the direction indicated by the high-angle cross-beds. This may have been due to reworking of the sand by wave action in very shallow water. South of the Birkhead Anticline, the orientation of the cross-bedding suggests deposition by southerly and southwesterly currents. The sediments were derived largely from pre-existing sediments. The sequence was uplifted, warped, weathered, and partly eroded, before the Precipice Sandstone was laid down. Pre-Jurassic weathering may account for the leached labile sandstone and pink and ash-grey siltstone at the top of the sequence.

In the east, the formation is over 300 m thick; in the northeast it is covered by soil. The thickness is variable, owing to erosion before deposition of the Precipice Sandstone : the formation is not present to the west in the Boree No. 1 and Bury No. 1 wells, but reappears beyond the Pleasant Creek Arch in Carlow No. 1 (Fig. 4). The thickness is 300 m in the type section (Mollan et al., 1972) and less than 300 m in the Jericho Sheet area (Vine et al., 1965).

Poorly preserved plant remains were noted in the Tambo Sheet area, and Upper Triassic to Lower Jurassic plants have been found just east of the Sheet boundary (White, 1966). They include Dicroidium odontopteroides (Morr.) Gothan, D. feistmanteli (Johnst.) Gothan, Pterophyllum nathorsti (Seward), Otozamites obtusus L. & H., ?O. queenslandi Walkom, and Baiera bidens (Ten. Woods). The spores belong to Evans' unit Tr3 of Middle to Upper Triassic age (P.R. Evans, pers. comm.)

LOWER JURASSIC (Table 6)

In the Tambo Sheet area the Lower Jurassic sequence crops out in a northwesterly belt composed of three conformable sandstone units : the Precipice Sandstone, the Boxvale Sandstone Member of the Evergreen Formation, and the Hutton Sandstone.

The Precipice Sandstone and Boxvale Sandstone are almost identical. Both consist of a lower sequence of thickly bedded cross-bedded fine to coarse sandstone and an upper sequence of thinly bedded fine-grained sandstone and siltstone. The two units form the prominent northwesterly trending Great Dividing Range, which has a relief of about 150 m. Both units thin to the northwest, and pinch out in the north.

Two major benches, one in each unit, can be traced on the air-photographs across from the Springsure and Eddystone Sheet areas, where the units are more clearly defined. This photogeological correlation has been confirmed by the measured sections (Fig. 9), and by the spores from BMR Tambo No. 2.

The Hutton Sandstone is largely composed of poorly bedded sublabile sandstone, with abundant siltstone towards the top. The formation is easily weathered and poorly exposed.

Subsurface, in the Eromanga Basin, the three units can seldom be distinguished from each other, and are generally referred to as the Hutton-Precipice equivalent (see Fig. 10).

Precipice Sandstone

The Precipice Sandstone (Whitehouse, 1954; Mollan et al., 1972) crops out extensively in the Surat Basin. In the eastern half of the Tambo Sheet area, it generally forms the lower of the two prominent cuestas facing northeast in the Great Dividing Range. It is covered with sandy soil, and supports open eucalypt forest and poor grass.

The formation consists of quartzose sandstone and siltstone, and can generally be divided into a lower sandy scarp-forming unit, and an upper silty sequence which forms the slope below the scarp of the Boxvale Sandstone. In the extreme north the upper unit forms a more conspicuous scarp than the lower part.

The lower unit consists almost entirely of sandstone, with a little siltstone. The sandstone is white, quartzose, and commonly clayey; minor constituents are feldspar,

TABLE 6 : POST-TRIASSIC STRATIGRAPHY

Period	Rock Unit (map symbol)			Lithology	Thickness (m)	Relationships	Environment of Deposition and Palaeontology
Quaternary			(Qa)	Alluvial sand, gravel, clay	9		Fluviatile
			(Qs)	Sand, soil	15		
Undifferentiated			(Cz)	Poorly bedded clayey sandstone, siltstone, claystone	15	Weathering products of underlying formations, consolidated in situ. Generally apparently conformable on underlying units	
			(Czd)	Duricrust (silcrete, laterite)	9	Alteration products of underlying formations	
Tertiary			(T)	Well bedded clayey sandstone, conglomerate, siltstone	30	Unconformable on underlying units	Fluviatile. Wood fragments
			(Tb)	Olivine basalt flows	4.5		Terrestrial
L.-U.(?) Cretaceous	Rolling Downs Group	Manuka Subgroup	Winton Formation (Kw)	Labile sandstone, siltstone, mudstone, in part calcareous; minor coal, peat, and intraformational conglomerate	465+	Conformable on Mackunda Fm	Lacustrine. Plant fragments, fossil wood, K2 spores

Period				Rock Unit (map symbol)	Lithology	Thickness (m)	Relationships	Environment of Deposition and Palaeontology
L. Cretaceous	ROLLING DOWNS GROUP	Manuka Subgroup		Mackunda Formation (Klm)	Labile to sublabile sandstone, siltstone, mudstone, in part calcareous; minor limestone and coquinite	105-150	Conformable on Allaru Mdst	Shallow marine, lacustrine. Marine macrofauna, K2 spores, Foraminifera, ostracods
		Wilgunya Subgroup (Klw)		Allaru Mudstone (Kla)	Grey to buff siltstone and mudstone, in part calcareous; minor limestone	150-270	Conformable on Toolebuc Lst	Shallow marine. Molluscan marine fauna, K2 spores, arenaceous Foraminifera
				Toolebuc Limestone (Klo)	Pale grey very fine-grained concretionary limestone, calcareous shale	3-7 (absent in E)	Conformable on Coreena Mbr. Pinches out to E	Shallow marine; clear water. Restricted, mainly pelecypod, marine fauna; fossil wood, K2 spores, planktonic Foraminifera, Radiolaria, dinoflagellates, hystrichospheres, acritarchs
			Wallumbilla Formation	Coreena member (Klc)	Grey to buff mudstone, siltstone, and very fine-grained labile sandstone; some calcareous beds, coquinite, and intraformational conglomerate	25-90	Generally conformable on Doncaster Mbr; boundary erosional in places	Shallow marine, lacustrine. Molluscan marine fauna, fossil wood, K1b-d spores, arenaceous Foraminifera, minor microplankton
				Doncaster Member (Kld)	Grey mudstone and siltstone; lenses of glauconitic sandstone near base	150-210 (lower sandstone part, 0-150)	Conformable on Hooray Sst	Shallow marine. Molluscan marine fauna, fossil wood, K1b-c spores, arenaceous Foraminifera, Radiolaria, dinoflagellates, hystrichospheres

Period		Rock Unit (map symbol)	Lithology	Thickness (m)	Relationships	Environment of Deposition and Palaeontology
U. Jurassic- L. Cretaceous		Hooray Sandstone (J-Kh)	Cross-bedded white clayey sublabile to labile sandstone, some pebbly; conglomerate, siltstone. Lower part, fine-grained; upper part, pebbly	45-120 (lower part, 0-70; upper part, 0-60)	Conformable on Westbourne Fm, but has unconformity within it. Thins slightly to W subsurface	Fluviatile. Plant fragments, K1a and J5-6 spores, some microplankton
U. Jurassic	INJUNE CREEK GROUP	Westbourne Formation (Juw)	Grey carbonaceous siltstone and mudstone; very fine-grained buff quartz sandstone	Generally 120 (thins to 12 in N)	Conformable on Adori Sst. Very thin (12 m) in central-N	Lacustrine, deltaic. Plant fragments, J5 acritarchs and spores
M.-U. Jurassic	INJUNE CREEK GROUP	Adori Sandstone (Ja)	Cross-bedded white clayey sublabile to labile sandstone, pebbly in part; siltstone	30-70	Conformable on Boxvale Sst Mbr; contact shows local scouring. Thins slightly to W subsurface	Fluviatile, minor lacustrine. Triassic/Jurassic plants (White, 1966), J5 spores
M. Jurassic	INJUNE CREEK GROUP	Birkhead Formation (Jmb)	Grey or green sublabile to labile sandstone, calcareous in part; carbonaceous siltstone and mudstone; minor coal	150+	Conformable on Hutton Sst.	Lacustrine. Plant fragments, J4-5 spores

Period	Rock Unit (map symbol)	Lithology	Thickness (m)	Relationships	Environment of Deposition and Palaeontology
L. Jurassic	Hutton Sandstone (Jlh)	Cross-bedded buff clayey quartzose to labile sandstone, siltstone, mudstone	120-150	Overlaps Boxvale Sst Mbr and Precipice Sst NW of Birkhead Anticline, where it overlies Moolayember Fm. Part of Hutton/Precipice Sst equivalent subsurface	Fluviatile, lacustrine. Plant fragments, fossil wood, J2-3 spores
	Boxvale Sandstone Member of Evergreen Formation (Jlb)	Cross-bedded white quartzose sandstone, pebbly in part; siltstone	0-75	Conformable on Precipice Sst. Pinches out W of Birkhead Anticline. Part of Hutton/Precipice Sst equivalent subsurface	Fluviatile, lacustrine. Plant fragments, J2 spores
	Precipice Sandstone (Jlp)	Cross-bedded white quartzose sandstone, pebbly in part; siltstone	0-120	Unconformable on Moolayember Fm; completely overlaps same formation subsurface. Pinches out NW of Birkhead Anticline. Part of Hutton/Precipice Sst equivalent subsurface	Fluviatile, lacustrine. Plant fragments, J1 spores

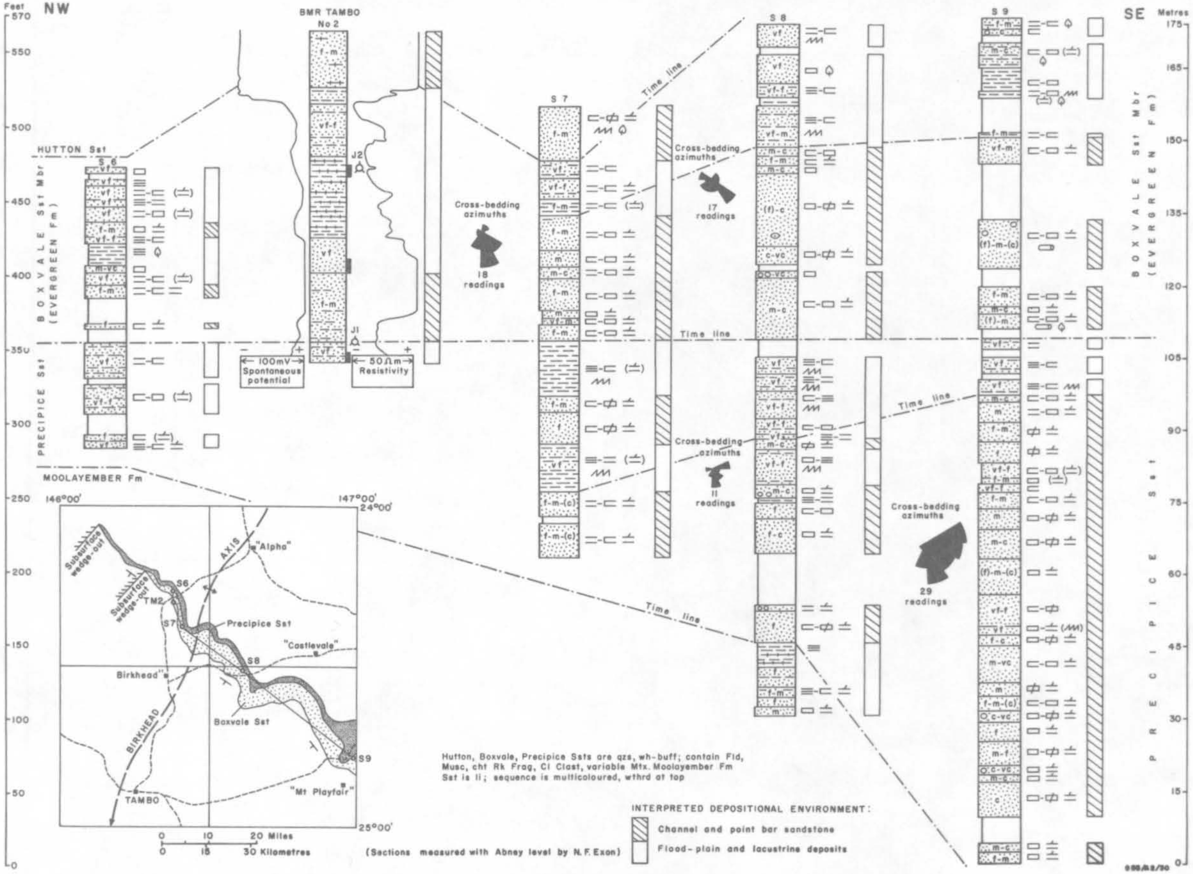

Fig. 9. Variations in the Precipice Sandstone/Boxvale Sandstone Member sequence.

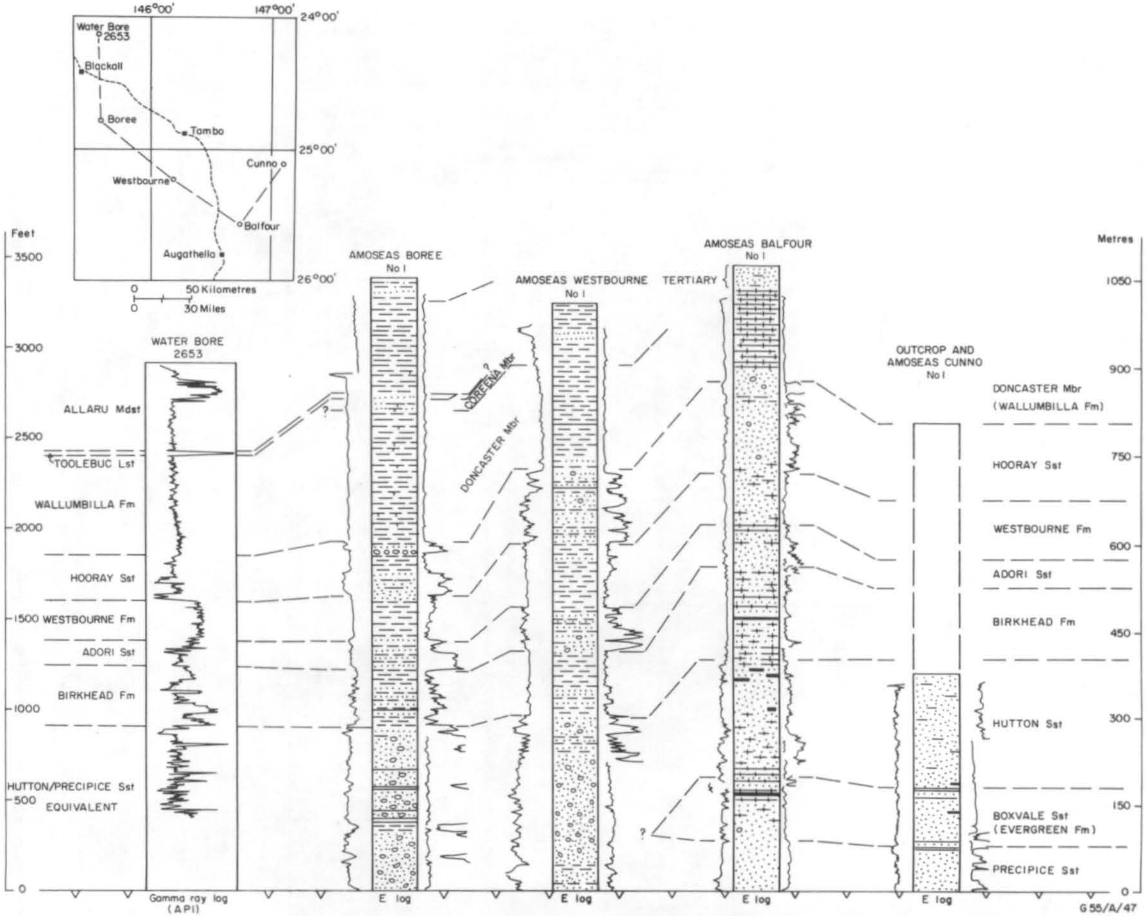

Fig. 10. Subsurface correlations of the Jurassic and Cretaceous.

muscovite, and dark rock fragments. It is generally medium to very thickly bedded, strongly scour and planar cross-bedded, and commonly contains clay clasts. It ranges from fine to very coarse-grained, and quartz granules are abundant in some beds. In places angular to rounded pebbles of quartz, quartzite, rhyolite, and indurated siltstone, and a few pebbles of less resistant siltstone and claystone are present. This part of the sequence was laid down as channel sands and point bar deposits.

The upper part of the sequence consists essentially of very fine to fine-grained quartzose sandstone and siltstone. The sandstone ranges from very clean to clayey. The sediments are laminated to medium-bedded, and commonly ripple-marked; occasional low-angle cross-beds are present. The siltstone generally weathers white. Some beds of fine to coarse cross-bedded quartzose sandstone, similar to those in the lower part of the formation, are also present in the upper unit. The sand and silt were mainly deposited in flood-plains and lakes.

The Precipice Sandstone rests unconformably on the Moolayember Formation. North of Brumby Creek, the Moolayember Formation has been folded, with dips up to 15°, but the folds do not continue into the Precipice Sandstone. The contact is generally obscured by scree from the overlying Cainozoic sediments. In section S8 (Fig. 9), the change from the weathered and leached siltstone and mudstone of the uppermost part of the Moolayember Formation to the clean white sandstone of the Precipice Sandstone is very sharp, and it is clear that the older sediments were uplifted, weathered, and eroded before the Precipice Sandstone was laid down. The Precipice Sandstone was derived from pre-existing sedimentary rocks, including the Moolayember Formation.

The formation thins to the northwest (see Figs 9, 12), and apparently pinches out near Burnt Yard Creek, in the extreme northern part of the area. In the Warrong No. 1 well, in the central-northern part of the Eddystone Sheet area, there is 150 m of Precipice Sandstone (Mollan et al., 1972); approximately 110 km to the west-northwest (Fig. 9, sect. S9), it is 120 m thick; near the Birkhead Anticline (Fig. 9, sect. S7) it is 45 m thick. The lower part of the sequence is much thicker than the upper part in the southeast, but in the northwest the thickness is about the same.

The plant remains are not sufficiently well preserved for identification. Core 3 (at 210 ft; 64 m) in BMR Tambo No. 2 yielded spores of Evans' unit J1 (see Appendix 1) of Lower Jurassic age (Evans, 1966 a). Evans (1964a, 1965) has discussed the age of the Precipice Sandstone.

Boxvale Sandstone Member of the Evergreen Formation

The Boxvale Sandstone Member (Mollan et al., 1972) crops out around the southern and southwestern margins of the Bowen Basin. In the eastern part of the Tambo Sheet area it forms the upper of two prominent cuestas in the Great Dividing Range. The member is covered by sandy soil and supports open eucalypt forest and poor grass.

It consists of quartzose sandstone and siltstone. Measured sections are illustrated in Figure 9. The member can be divided into a lower sandy and an upper silty sequence; the lower is usually slightly thicker.

The lower unit generally crops out as a steep scarp. It consists of white fine to coarse quartzose sandstone, which is usually very clean and friable. The sandstone contains some feldspar, muscovite, and dark rock fragments, and in places granules and pebbles of quartz, quartzite, and some chert and siltstone. It is generally medium to thickly bedded, strongly scour and planar cross-bedded, and in places contains clay clasts. Wood impressions and remains, and some plant roots, were seen in places. The beds were laid down as point bar deposits and channel sands.

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The upper unit consists of very fine to fine-grained buff and white quartzose sandstone grading into siltstone. It generally forms a slope, but in the north forms a scarp. It is thinly to thickly bedded and generally better bedded than the lower part of the sequence; low-angle cross-bedding is common. The sandstone is lithologically similar to that of the lower unit. The siltstone is purplish grey or grey when fresh, but weathers white. In BMR Tambo No. 2, there is some black carbonaceous mudstone. The sediments are commonly ripple-marked and, in places, contain abundant worm casts and plant remains. The sands and silts were laid down on flood-plains and in lakes.

In the type area, in the Taroom Sheet area, the Evergreen Formation consists of a lower shaly unit overlain by the Boxvale Sandstone Member, which underlies the Westgrove Ironstone Member. Immediately west of the Maranoa Anticline, in the Eddystone Sheet area, the shaly part of the Evergreen Formation pinches out. The Westgrove Ironstone Member persists westwards to within 30 km of the Tambo Sheet (Mollan et al., 1972), where it also pinches out. Thus, in the Tambo Sheet area, the Evergreen Formation is entirely represented by the Boxvale Sandstone.

The Boxvale Sandstone rests apparently conformably on the Precipice Sandstone. The basal part of the sequence is generally much coarser than the thinly bedded upper part of the Precipice Sandstone. On the Tambo/Springsure road (Fig. 9, sect. S9) the sandstone is ironstained, and the scarp of the Boxvale Sandstone is much darker than the Precipice Sandstone in the scarp below.

The Boxvale Sandstone was deposited in a similar environment to that of the Precipice Sandstone (see p. 46).

The member thins from about 75 m in the southeast (Fig. 9, sect. S9) to about 45 m near the Birkhead Anticline (BMR Tambo No. 2); it pinches out 13 km south of Frost Creek in the north. It is about 80 m thick in the central-northern part of Eddystone Sheet area (Mollan et al., 1972).

Plant remains are common, but none have been identified. Spores from core 1 (87 ft 2 in; 26.73 m) in BMR Tambo No. 2, near the top of the member, belong to Evans' spore unit J2 (see Appendix 1) of Lower Jurassic age (Evans, 1966a). The member is therefore considered to be Lower Jurassic in age.

Hutton Sandstone

The Hutton Sandstone (Reeves, 1947, p. 1346; Mollan et al., 1972) crops out in the Taroom, Eddystone, Springsure, and Tambo Sheet areas. In the eastern half of the Tambo Sheet area, the Hutton Sandstone crops out poorly in a northwesterly belt of low sandy country, about 8 km wide, on the western slopes of the Great Dividing Range. The sandy soil supports grass and some open forest.

The formation consists mainly of sandstone, with abundant siltstone and mudstone near the top. The sandstone ranges from quartzose to labile, but is dominantly sublabile, and becomes more labile upwards. It is white or buff, when not ironstained. It is commonly clayey, and contains feldspar, dark rock fragments, subordinate muscovite, and a little biotite. The grainsize is very variable, and gritty beds occur in places; small quartz pebbles are scattered through some beds. The bedding is generally thick and poorly developed, but in places highly variable scour and planar cross-beds are present; near the top of the formation the bedding is more distinct, and thin bedding is more common. A few beds of calcareous sandstone are present near the top of the formation.

The siltstone and associated mudstone are grey to purplish, and commonly contain abundant carbonaceous material. They are normally laminated to thinly bedded. Claystone stringers occur at some levels. Three kilometres east-northeast of Shady Downs homestead (see Fig. 11), fine to coarse quartzose sandstone overlies a bed of white silty claystone. One pebbly bed contains two large fragments of claystone derived from the underlying claystone.

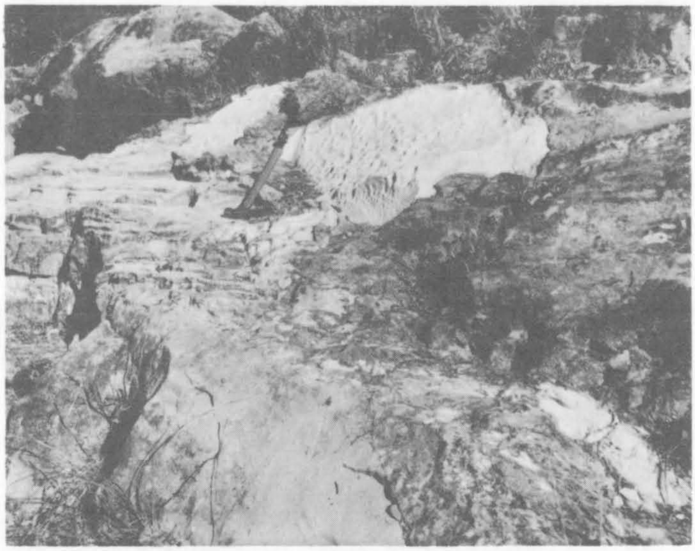

Fig. 11. Large white claystone clasts in pebbly quartzose sandstone of the Hutton Sandstone, Tambo Sheet area (grid ref. 443965).

Beds with abundant worm casts, clay clasts, wood impressions and fragments, and carbonaceous leaf and root remains are more common in the upper part of the formation. They occur mainly in the siltstone, but wood and clay clasts are common in the sandstone. Botryoidal bog iron oxides, and minor bog manganese oxides, are confined to the upper part of the sequence, as are minor coaly and calcareous beds. The formation is a good aquifer, and is extensively used in the Great Artesian Basin. Ferruginization of sandstone and siltstone is common, and ironstone concretions are found in places.

The Hutton Sandstone rests apparently conformably on the Boxvale Sandstone southeast of the Birkhead Anticline, but to the northwest it overlaps the Boxvale and Precipice Sandstones and rests on the Moolayember Formation in the extreme north.

The scouring of the contact between the silty upper part of the Boxvale Sandstone and the coarser Hutton Sandstone, southeast of the Birkhead Anticline, suggests a significant depositional break between the two units. The contact is well exposed near BMR Tambo No. 2, beside the Alpha/Tambo road. The upper part of the Boxvale Sandstone consists mainly of laminated to thinly bedded ripple-marked white siltstone with some low-angle cross-bedding; it also contains some thicker-bedded quartzose sandstone. Bedding in the overlying fine to medium-grained quartzose Hutton Sandstone is thick but poorly developed, and includes high-angle cross-bedding. The Hutton Sandstone is clayey and contains feldspar, rock fragments, muscovite, and siltstone clasts. The contact is irregular, and locally unconformable. Immediately above the contact the sandstone contains granules and small pebbles of quartz, quartzite, and chert, and some silicified wood; the basal beds contain numerous siltstone clasts.

The contact with the overlying Birkhead Formation is transitional, with labile sandstone, siltstone, and mudstone both above and below the contact. The lowermost thick calcareous sandstone bed is taken as the base of the Birkhead Formation; this normally corresponds to the edge of the black-soil country, which was used as a marker in some areas.

During deposition of the Hutton Sandstone, the environment changed gradually from fluviatile to lacustrine, and the sands became more labile with time. Towards the close of Hutton Sandstone time, bog iron oxides and a little manganese oxide accumulated in quiet lacustrine conditions. The large variation in the orientation of the cross-bedding suggests deposition from meandering streams.

In the Tambo Sheet area the Hutton Sandstone probably thins to the northwest from about 150 to 120 m. The thickness is probably comparable with the estimated thickness of 135 to 150 m in the central-northern part of the Eddystone Sheet area (Mollan et al., 1972).

None of the plant remains found in the Tambo Sheet area have been identified, but palynological evidence (De Jersey & Paten, 1964) indicates that the formation is Lower to Middle Jurassic in age. It is underlain by Middle Jurassic sediments.

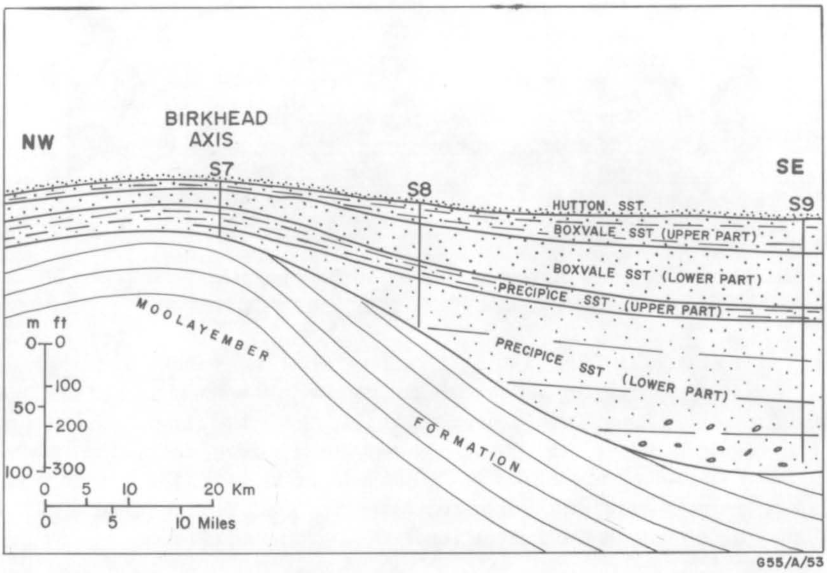

Fig. 12. Deposition of the Lower Jurassic sandstones.

Environment of Deposition in Lower Jurassic Time

(Figs 9, 12)

Early in Precipice Sandstone time the northeasterly trending Birkhead Axis was an elevated zone with a gentle slope to the west and a considerably steeper one to the east. In the west, most of the sediment was deposited by sluggish streams which did not extend far from the axis, but in the east, stream velocities were higher and the sediment was carried much farther away from the axis. The greatest thickness of sediment was deposited about 65 km southeast of the axis. It consisted of coarse well sorted sand and pebbly sand, winnowed by braided streams. The fine material was probably deposited farther downstream (e.g. the argillaceous Evergreen Formation in Balfour No. 1).

As the axis was worn down and the valley was filled, the streams became more sluggish and deposited most of their load in flood-plains and lakes near the axis. West of the axis, sedimentation continued slowly as before.

At the start of Boxvale Sandstone time the axis was rejuvenated and the same cycle was repeated, although the effects are less pronounced. The lower part of the Boxvale sandstone is coarser and thicker away from the axis, but is not particularly pebbly; the upper part thickens rather than thins into the valley.

Another slight rejuvenation resulted in the deposition of medium-grained quartzose sands (Hutton Sandstone) on the Boxvale Sandstone. This blanket sand was evenly deposited throughout the area. As time went by the size of the sediment diminished, and towards the end of Hutton Sandstone time some lacustrine siltstone and mudstone were laid down. Finally, there was a gradual change to the lacustrine conditions of the calcareous siltstone and lithic sandstone of the Birkhead Formation.

MIDDLE JURASSIC TO LOWER CRETACEOUS

The Middle Jurassic to Lower Cretaceous sequence includes the Injune Creek Group, which is divided into three formations, and the overlying Hooray Sandstone. The Middle Jurassic Birkhead Formation is a lacustrine sequence, consisting of about 150 m of labile sandstone, siltstone, and mudstone, which grades down into the Hutton Sandstone. It is overlain, with regional conformity, by about 60 m of fluviatile sublabile to labile sandstone of the Adori Sandstone, followed conformably by the Upper Jurassic Westbourne Formation. The Westbourne Formation is about 100 m thick and consists of very fine-grained fluviatile quartzose sandstone, siltstone, and shale.

The Hooray Sandstone consists of a lower sequence of thinly bedded fine-grained sandstone resting conformably on the Westbourne Formation, and a coarse to conglomeratic fluviatile upper sequence which lies on the scoured surface of the lower part. The thickness of the formation, and of each unit, varies greatly. The Hooray Sandstone ranges from Upper Jurassic to Lower Cretaceous in age.

Exon (1966) presented new data relating to the Jurassic/Cretaceous sequence in parts of the Eromanga and Surat Basins, revised existing stratigraphic nomenclature, and correlated the stratigraphy of the two basins. He also defined the Birkhead Formation, Adori Sandstone, Westbourne Formation, and Hooray Sandstone.

The subdivisions of the sequence in the Tambo Sheet area are essentially those of Woolley (1941a). In the unpublished completion reports on the Westbourne No. 1 and Boree No. 1 wells, American Overseas Petroleum Ltd (Gerrard, 1964a, b) used Woolley's nomenclature as modified by Hill & Denmead (1960); they also suggested the formal name of Westbourne Formation for Woolley's Upper Intermediate Series, in the belief that it was the lateral equivalent of the Orallo Formation (Day, 1964) in the Roma area. American Overseas Petroleum Ltd subsequently informed the Bureau of Mineral Resources that the gamma-ray logs indicate that the Westbourne Formation lies stratigraphically below the Gubberamunda Sandstone in the Roma area, and this has since been confirmed by subsequent palynological investigations, field mapping, and stratigraphic drilling.

The succession and correlation in the Surat and Eromanga Basins are given in Table 7, in which the old and new stratigraphic nomenclatures are also compared.

The Nebine Ridge, which separates the Eromanga and Surat Basins, has played an important role in the geological history of the region. To the west of the ridge, which is expressed at the surface by the Maranoa Anticline about 40 km east of the Augathella Sheet area, arenites greatly predominate, and the upper part of the sequence is much thinner than in the Surat Basin.

Injune Creek Group

The term Injune Creek Coal Beds was first used by Jensen (1921) for Jurassic sediments in the Roma/Injune area. In later publications, Jensen abandoned the name Injune Creek Coal Beds, and subdivided the Walloon Coal Measures into Upper, Middle, Lower, and Basal Walloon. Reeves (1947) used the name Lower Walloon Series for the

TABLE 7 : NOMENCLATURE AND CORRELATES IN THE JURASSIC SEQUENCE IN THE EROMANGA AND SURAT BASINS

Recent Usage Eromanga Basin (e.g. LOL Saltern Creek No. 1 well, Mott & Associates, 1964)	Woolley (1941a) Eromanga Basin	Present Nomenclature and Correlation: Eromanga Basin (Tambo area)	Present Nomenclature and Correlation: Surat Basin (Roma area)	Recent Usage Surat Basin (e.g. AAO Blyth Creek No. 1 well, Minad, 1964)
Transition Beds	Hooray Sst	Hooray Sst**	Bungil Fm+	Transition Mbr (Blythesdale Fm)
			Mooga Sst+	Mooga Mbr (Blythesdale Fm)
			Orallo Fm*	Fossil Wood Mbr (Blythesdale Fm)
Mooga Sst			Gubberamunda Sst*	Gubberamunda Mbr (Blythesdale Fm)
Fossil Wood Beds	Upper Intermediate series	Westbourne Fm***	Westbourne Fm*** (Injune Creek Gp)	Injune Creek Beds
Gubberamunda Sst	Adori Sst	Adori Sst**	Springbok Sst / (Injune Creek Gp)	
Walloon Coal Measures	Lower Intermediate Series	Birkhead Fm**	Birkhead Fm** (Injune Creek Gp)	
Hutton Sst		Hutton Sst	Hutton Sst	Hutton Sst

* After Day (1964)
*** After Gerrard (1964b)
** Exon (1966)
/ As amended by Power & Devine (1968)
\+ After Exon & Vine (1970)

formation. Laing (in Hill & Denmead, 1960) suggested that the term Injune Creek Beds should be reinstated for the Roma/Injune area, and Exon (1966) raised the unit to group status. The history of the Injune Creek Beds is discussed in more detail by Mollan et al. (1972).

Birkhead Formation

The Birkhead Formation is the sequence of brown and grey fine-grained calcareous labile sandstone and siltstone between the non-calcareous Adori and Hutton Sandstones (Exon, 1966). It has a maximum thickness of about 180 m in the Tambo/Augathella area. The name is derived from Birkhead Creek, near Birkhead homestead, in the Tambo Sheet area. The type area is Birkhead Creek where it runs parallel to the Alpha/ Tambo road.

A type section was not measured because of the paucity of outcrops, and the interval from 1880 to 2244 feet (573-684 m) in Westbourne No. 1 was selected as the type section (Exon, 1966). The well lies 65 km southwest of the type area. The type section consists of dark grey and brown mudstone, calcareous grey and brown quartzose siltstone, and minor coal and fine-grained sandstone. The fine-grained grey or green calcareous labile sandstone and siltstone commonly crop out as concretions, but carbonaceous mudstone and coal are rarely exposed. The logs of the exploration wells provide a more representative record of the lithology.

To the southeast, the Birkhead Formation crops out in the Surat Basin, and it is widely distributed subsurface in the Eromanga and Surat Basins. In the Tambo/Augathella area the formation crops out in a northwesterly belt, about 8 km wide, which extends from Mount Playfair homestead in the southeast to near Valparaiso homestead in the north, where it disappears beneath a cover of sand. It forms gently undulating plains with a sparse cover of trees. The best exposures are along the Alpha/Tambo road near Green Hills homestead where there are numerous large calcareous concretions on the surface and some good exposures in road cuttings.

The Birkhead Formation lies conformably between the Hutton and Adori Sandstones, but the upper contact shows local scouring. There is a marked contrast between the dark brown calcareous labile sandstone and siltstone of the Birkhead Formation and the white clayey sublabile Hutton Sandstone, but nevertheless the contact is transitional (see p.47).

The Birkhead Formation is present in all the exploration wells in the Tambo Sheet area (Fig. 10; Appendix 2).

In Westbourne No. 1 (Gerrard, 1964a) the formation consists mainly of dark grey and brown fissile shale with minor interbeds of locally calcareous siltstone; and in Boree No. 1 (Gerrard, 1964b) the sequence includes an interval of white quartzose, locally calcareous, granular to fine-grained sandstone, interbedded with grey and brown calcareous siltstone, and rare beds of coal and lignite. The spore assemblages in both intervals indicate a Middle Jurassic age. In the Westbourne, Boree, and Carlow wells, the Birkhead Formation is overlain by the Adori Sandstone and rests on a Lower Jurassic sandstone sequence, which is probably a correlate of the Hutton and Precipice Sandstones.

The lithological descriptions of the Birkhead No. 1 well (Grissett, 1957) were made with the aid of electric logs. The interval from surface to 516 feet (157.3 m), which consists mainly of grey silty shale and fine-grained white sandstone, is taken to be the Birkhead Formation. It overlies the medium to coarse-grained grey Hutton Sandstone. The spores from cuttings at depths of 197 feet (60 m), 227 feet (69.2 m), and 520 feet (158.5 m) are characteristic of the Hutton Sandstone and the base of the Walloon Coal Measures north of Roma (Evans, 1962). This determination does not conflict with the interpretation proposed above.

A well was drilled, by the Malta Oil Company, 55 km east of Tambo (lat. 24°55'S, long. 146°50'E) to a doubtfully authenticated depth of 1385 feet (422.1 m). A well sited at this point would have penetrated almost the whole of the Adori Sandstone before reaching the Birkhead Formation. However, the sketchy lithological log available (GSQ, 1960) shows that the well passed through only 22 feet (9.8 m) of sandstone and then coaly grey and brown shale to 485 feet (147.8 m), grey sandy shale to 810 feet (246.9 m), and sandstone to 1065 feet (324.6 m). The interval from 0 to 22 feet could be considered to be Adori Sandstone, and the sequence from 22 to 810 feet (9.8-246.9 m) could represent the Birkhead Formation. This would mean that the location of the well as given above is incorrect, and no trace of it was found during the present survey.

In the Tambo/Augathella area the Birkhead Formation is mainly lacustrine, with subordinate fluviatile deposits and coal measures. The high calcium carbonate content indicates that sedimentation probably took place in an area of restricted drainage, and the immaturity of the sediments indicates rapid erosion. The presence of fresh intermediate volcanic detritus suggests contemporaneous vulcanism.

The Birkhead Formation is poorly exposed in the Tambo/Augathella area, but is estimated to be about 150 m thick. It becomes much thinner in the north, where it is largely covered by sand.

Indeterminate plant debris is common in the Birkhead Formation, but palynological evidence points to a Middle Jurassic age (unit J4 of Evans, 1966a). The equivalent coal measures near Injune are of Middle Jurassic age (De Jersey & Paten, 1964).

Adori Sandstone

The Adori Sandstone (Hill & Denmead, 1960) was defined by Exon (1966) as a medium to fine-grained somewhat pebbly sandstone with its type section at Adori Hill (Fig. 13, sect. S2). The formation is widely distributed in the Eromanga Basin, and is correlated with the Springbok Sandstone east of the Nebine Ridge. In the Tambo/Augathella area the formation crops out in a narrow belt extending from Stockade Creek in the east to Sydenham homestead in the north. In the type area the formation has a rugged topography. The beds form scarps with two prominent benches in places. In the north, the formation is exposed in low benches, which in places are capped by Cainozoic sediments.

In sections S2 and S3 (Fig. 13) the Adori Sandstone is composed mainly of sandstone and some white siltstone. The sandstone is generally buff to white, medium to fine-grained, medium-bedded, clayey and sublabile to labile; clay clasts, quartz, and pebbles of volcanic rock are common. Pebbly sandstone and conglomerate are largely confined to the lower part of the formation (Figs 13, 14). The pebbles and occasional cobbles consist mainly of quartz, quartzite, and black chert, with locally abundant claystone and fine siltstone. Some pebbles of porphyritic acid volcanics, and a few fragments of fossil wood, phyllite, porphyritic basalt, and rhyolite are also present.

Planar and scour cross-bedding are well developed, and the main current directions range from south to southwest. In section S3, 35 km north of Tambo, the sandstone in the lower part of the section is planar cross-bedded to the southwest, while in the upper part the direction of the currents was to the southeast. In this section, which shows the full sequence, there is a lower sandstone unit, 30 m thick, a middle silty unit, 25 m thick, and an upper sandstone unit 15 m thick.

In the Tambo/Augathella area the Adori Sandstone lies conformably between the Westbourne and Birkhead Formations. The pebbly and gritty sublabile planar cross-bedded Adori Sandstone contrasts strongly with the siltstone, mudstone, and calcareous lithic sandstone of the Birkhead Formation. The contact is scoured, and the Birkhead Formation is generally leached (Fig. 14).

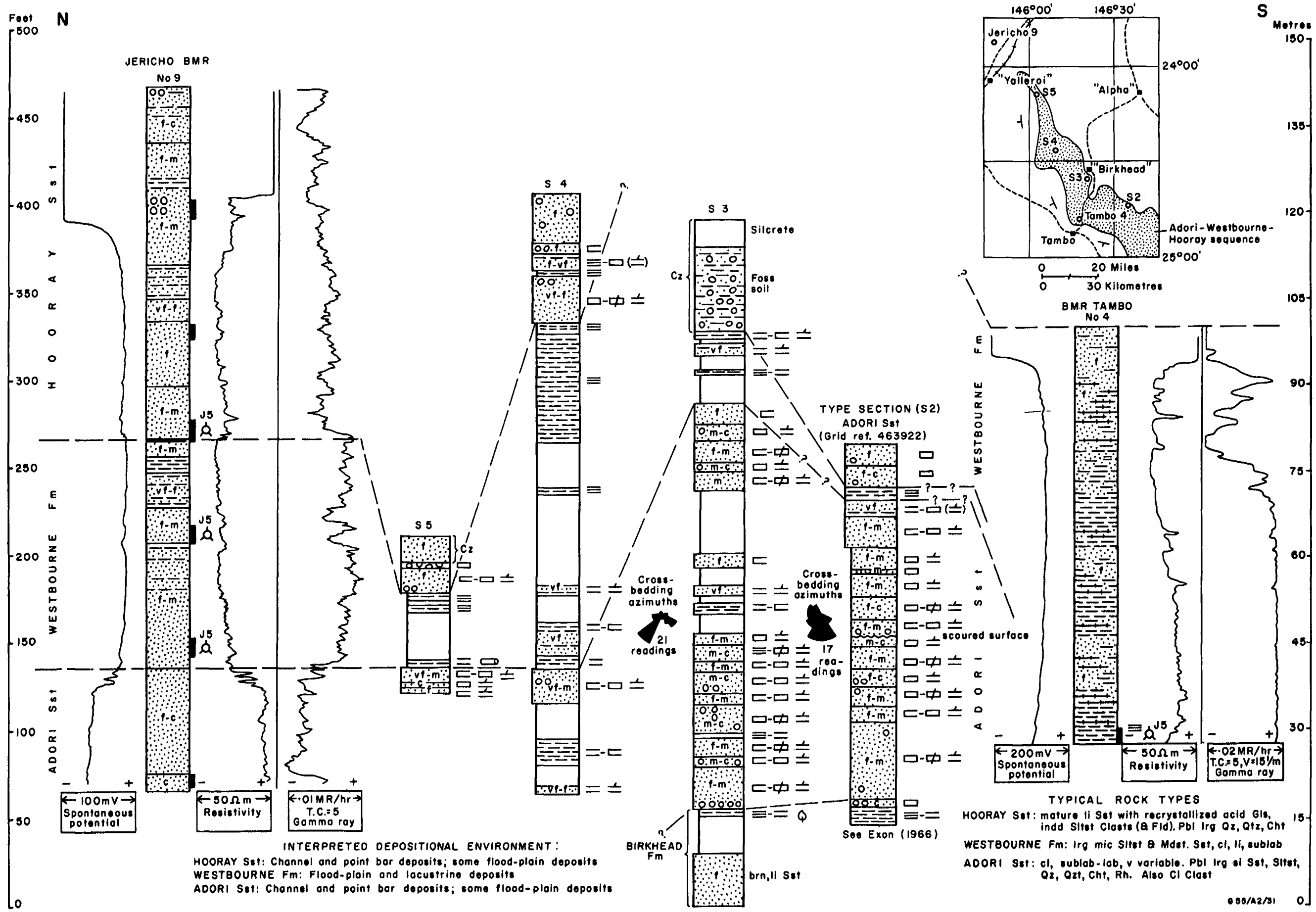

Fig. 13. Columnar sections and borehole logs in the Upper Jurassic sequence.

Fig. 14. **Basal conglomerate** of the Adori Sandstone with pebbles of scoured and leached sediments from the uppermost part of the Birkhead Formation, Tambo Sheet area (grid. ref. 446933).

The thin-bedded micaceous grey siltstone and very fine sandstone of the Westbourne Formation are quite distinct from the medium-grained white or light brown pebbly sublabile to labile Adori Sandstone.

The Adori Sandstone can be recognized in all the exploratory wells penetrating the Jurassic sequence (Appendix 2).

In Westbourne No. 1 (Gerrard, 1964a) the formation is composed of medium-grained quartz-rich planar-cross-bedded sandstone with interbedded siltstone and shale. In Boree No. 1 (Gerrard, 1964b) the sequence is finer in grain and better sorted than in Westbourne No. 1; the uppermost part of the sequence is silty and argillaceous.

The poor sorting, planar cross-bedding, and fairly coarse grainsize of the sediments indicate deposition from fast-flowing streams, and the relatively high proportion of fresh feldspar suggests that the sediments were not transported far. The main current directions suggest that the Lower Jurassic sandstones to the north provide a source for some of the material. Depositional breaks are indicated by the presence of erosional surfaces and clay fragments.

In the type section, which includes only the lower part of the formation, the Adori Sandstone is 182 feet (55.5 m) thick; in section S3, in which the formations above and below are present, it is 233 feet (71 m) thick. Northwest of the Birkhead Anticline it becomes much thinner and possibly lenses out beneath the extensive cover of sand. To the southeast, it pinches out near Mount Elliott in the central-southern part of the Eddystone Sheet area. Subsurface, it is generally 45 to 60 m thick.

On palynological evidence, Evans (1966a) suggests that the Adori Sandstone belongs to his J5 unit of Middle to Upper Jurassic age. The plant fossils from the silty middle part of the formation (G1822) are considered by White (1966) to be of Upper Triassic to Jurassic age: they include Lepidopteris stormbergensis (Seward) nov. comb., Taeniopteris spatulata McClelland, Cladophlebis australis (Morr.), Ptilophyllum pecten (Phillips), Sphenopteris sp., and Gingko antarctica Saporta.

Westbourne Formation

The Westbourne Formation was defined by American Overseas Petroleum Ltd (in Gerrard, 1964b); a modified description, incorporating the results of later field work, was published with their agreement in Exon (1966). The name is derived from the Westbourne No. 1 well in the Augathella Sheet area, and the type section is the interval from 1279 to 1651 feet (389.8-503.2 m) in the same well. The type section consists of shale and siltstone and subordinate very fine-grained sandstone.

The formation is widely distributed subsurface in the eastern part of the Eromanga Basin (see table in Exon, 1966), and crosses the Maranoa Anticline into the Surat Basin. In the Tambo/Augathella area it forms a southeasterly belt extending from Sydenham homestead in the north to Caldervale homestead in the east. North of Sydenham homestead it disappears under the cover of sand. The formation is poorly exposed and generally forms a valley between the surrounding sandstone units. It is readily gullied and eroded, and supports a fairly open cover of small trees on clayey brown soil.

The formation consists essentially of siltstone, mudstone, and very fine-grained quartz-rich sandstone. The siltstone is grey to khaki, carbonaceous and micaceous, calcareous in places, and grades into mudstone. It is laminated to thinly bedded, and in some outcrops contains discoidal ironstone concretions, which were probably originally calcareous. The flat surfaces developed on the formation are commonly littered with ferruginized thinly bedded siltstone rubble. The sandstone is buff, thinly to thickly bedded, and cross-bedded. Low-angle cross-bedding is common, but planar and scour cross-beds are also present. The orientation of the cross-bedding ranges through 360°, and is well illustrated in the interbedded siltstone and sandstone cropping out in cuttings on the Alpha/Tambo road. Here combinations of scour cross-beds have been ferruginized to form bodies up to 2 m long, not unlike ironstone concretions. Ripple marks are found on some bedding planes. The sandstone contains feldspar, a little muscovite and biotite, and some fragments of black chert. It is generally quartz-rich, but in places contains shaly fragments. The grainsize, although generally very fine, ranges up to medium in some beds, especially in the basal part of the formation, where several bands of small quartz pebbles may be present.

Siltstone predominates in the three measured sections - S3, S4, and S5 (Fig. 13). In BMR Tambo No. 4 (see Fig. 13), which began just below the Hooray Sandstone, the upper part of the sequence consists mainly of carbonaceous micaceous siltstone grading into mudstone, and subordinate fine-grained sublabile to labile sandstone. The sandstone contains quartz, rock fragments, and feldspar, and subordinate chlorite, muscovite, and biotite. The gamma-ray log of the hole shows that there is 30 m of moderately sandy section, overlying a silty section. The silty section has a high gamma-ray count which makes the formation a good marker.

The Westbourne Formation rests conformably on the Adori Sandstone, but the boundary is transitional, and the base is taken at the lowest thick bed of siltstone or mudstone.

The general fine grainsize, thin bedding, low-angle cross-bedding, and the presence of abundant carbonaceous and calcareous material, worm casts, and animal tracks suggests a lacustrine environment of deposition. Plant roots indicate periods of exposure. The sandstone commonly contains high-angle cross-beds with an irregular orientation, and was probably deposited in deltas around the margins of lakes. The presence of rare acritarchs in BMR Tambo No. 4 suggests marine influence at some levels.

Measured sections indicate that the Westbourne Formation is 120 m thick near Tambo (Woolley, 1941a), but it thins to 60 m 50 km to the north (Fig. 14, sect. S4), and still farther north in the Alice River No. 1 well, it is only 76 feet (23.2 m) thick. Subsurface, the thickness is fairly constant from east to west (see map).

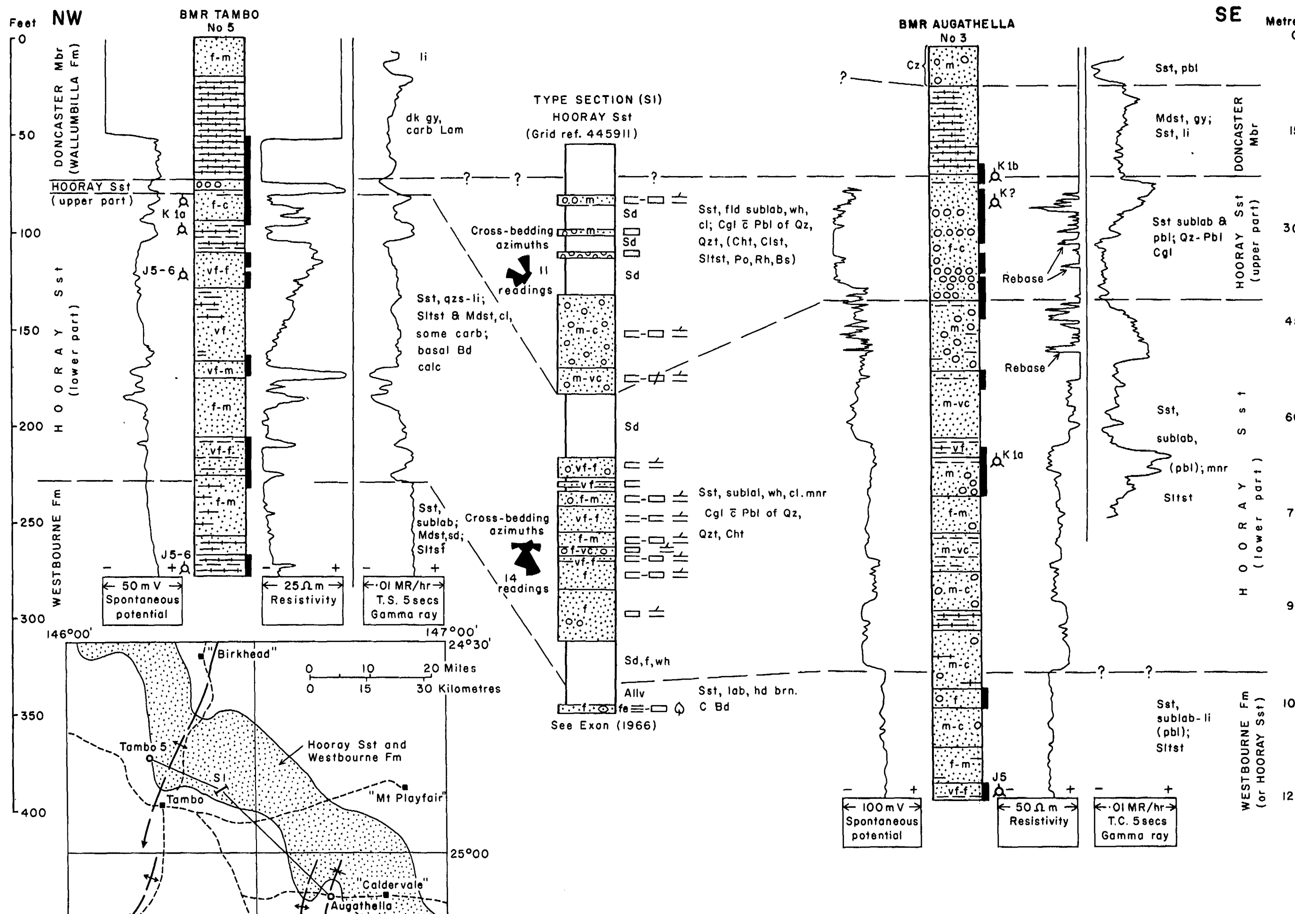

Fig. 15. Stratigraphic boreholes and columnar section in the Hooray Sandstone.

The Westbourne Formation contains fragmentary plant remains and Upper Jurassic spores (P.R. Evans, pers. comm.). The spores and acritarchs from BMR Tambo No. 4 belong to Evans' (1966a) unit J5 and those from BMR Tambo No. 5 to unit J5-6 (see Appendix 1). Elsewhere, spores of unit J6 have been found near the top of the formation.

Hooray Sandstone

The Hooray Sandstone was named by Hill & Denmead (1960), and a type section (Fig. 15, sect. S1), in Hooray Creek, 20 km east-northeast of Tambo, was described by Exon (1966). The section consists of 75 m of very fine to pebbly white sublabile sandstone and conglomerate. The fine-grained lower part of the unit and coarse-grained upper part are unconformable (Figs 15, 16) and could be mapped as separate formations. The Hooray Sandstone crops out in the Tambo, Augathella, Eddystone, and Mitchell Sheet areas. It is widely distributed subsurface in the eastern part of the Eromanga Basin; the well sections are shown in Figure 10 and tabulated in Appendix 2. In the Tambo/Augathella area the Hooray Sandstone is poorly exposed in a sinuous north-westerly belt extending southwards from Winooka homestead across the Tambo Sheet and the northeastern corner of the Augathella Sheet. North of Winooka homestead the formation is covered by sand. In places it forms scarps and cuestas, especially where it is capped by hard Cainozoic rocks. The poor sandy soil generally supports a light cover of small eucalypts.

Fig. 16. Scoured contact between the fine-grained lower part of the Hooray Sandstone and the conglomeratic upper part of the formation. About 30 km west of Caldervale homestead (grid ref. 466878).

The formation consists mainly of cross-bedded thin to thick-bedded white clayey sublabile sandstone, with some pebbly sandstone and polymictic conglomerate (see Fig. 15). It is a good aquifer. In Westbourne No. 1 and Boree No. 1 the formation consists of a fine-grained sandstone sequence overlain by a silty or shaly sequence, followed by conglomerate. In Boree No. 1, the sandstone sequence is 129 feet (39.3 m) thick, the shaly sequence is 99 feet (30.2 m) thick, and the conglomeratic beds are 59 feet (18 m) thick. Gerrard (1964b) has reported minor nests of glauconite in the shaly sequence, and a little glauconite was also identified in the Hooray Sandstone in BMR Mitchell No. 7 and No. 4 near the Maranoa Anticline (Exon, Milligan, Casey, & Galloway, 1967).

The lower part of the formation consists of thin to thick-bedded fine-grained sandstone and siltstone, with subordinate medium-grained sandstone. There are a few beds of small quartz pebbles in some areas. Small-scale scour and planar cross-beds, with highly variable azimuths, are a characteristic feature. The sandstone in the type section is coarser in grain and more thickly bedded than average. It is generally clayey and sublabile, and contains black rock fragments, feldspar and, in places, muscovite and fragments of red rock. Fossil wood, worm casts, and ripple marks occur in some beds.

The upper part of the formation consists of white medium to very coarse sublabile sandstone, pebbly sandstone, and conglomerate, The sandstone is indistinguishable from that of the lower part. Large-scale scour and planar cross-bedding, with an average azimuth consistently to the northwest or north, and thick beds, are characteristic. The sandstone is similar to that in the Eddystone Sheet area, where it consists predominantly of quartz and quartzite, with abundant fragments of recrystallized fine-grained acid volcanic rocks and considerable feldspar. The remainder of the rock is largely clay matrix and pore space, with accessory iron oxide, mica, zircon, and tourmaline. The sandstone in the Tambo/Augathella area is similar in composition (Galloway, 1967). The conglomerate contains subangular to subrounded pebbles and cobbles of quartz, quartzite, and fine-grained sediments, with subordinate black and red chert, porphyritic acid volcanics, and a little porphyritic basalt, rhyolite, and phyllite. Many of the fragments of sandstone, siltstone, and claystone were derived from the lower part of the formation, but the more competent pebbles were probably derived from the Palaeozoic rocks.

The Hooray Sandstone rests conformably on the Westbourne Formation, and the contact is marked in places by a few small pebbles. There is a sharp change in lithology from the grey carbonaceous siltstone and mudstone and clean quartz-rich sandstone of the Westbourne Formation to the clayey white siltstone and sandstone of the Hooray Sandstone. The Hooray Sandstone is correlated with the Gubberamunda Sandstone, Orallo Formation, Mooga Sandstone, and Bungil Formation in the Surat Basin.

The sediments of the lower part of the Hooray Sandstone were transported south and deposited in shallow lakes and deltas. Sedimentation did not extend over the low ridge formed by the Maranoa Anticline. Later, when the Maranoa Anticline was uplifted, streams flowing north away from the uplifted area deposited the upper part of the formation. The streams removed much of the lower part of the formation, and much clayey material was incorporated in the sandstones. The contact is strongly scoured with pebbly cross-beds overlying fine-grained sandstone.

The thickness of the formation ranges from 45 to about 120 m. The lower part is absent northeast of Enniskillen homestead, and also probably to the southeast in the Augathella Sheet area; it has a maximum thickness of 70 m in Boree No. 1. The maximum thickness of the upper part is 60 m, and at one locality in the Augathella Sheet area it is only 45 cm thick.

No macrofossils or identifiable plants have been found in the Hooray Sandstone. The dinoflagellates in the upper part of the lower unit in BMR Tambo No. 5 (Burger, 1967b) indicate marine conditions. The presence of spores of units K1a and J5-6 in BMR Tambo No. 5 and BMR Augathella No. 3 (Burger, 1967b; Appendix 1) indicate that the Hooray Sandstone extends from Middle Jurassic to Lower Cretaceous.

LOWER TO UPPER(?) CRETACEOUS

Rolling Downs Group

The Rolling Downs Group is a conformable Cretaceous sequence in the Great Artesian Basin which began with a marine transgression in Aptian time. It was named the 'Rolling

Downs formation' by Jack (1886). The recent changes in nomenclature are given in Table 8. In the Tambo/Augathella area it overlies the Hooray Sandstone and is overlain, in places, by Cainozoic sediments. Day (1967) and Vine (in prep.) have discussed the environment of deposition of the Rolling Downs Group in some detail.

TABLE 8 : ROLLING DOWNS GROUP NOMENCLATURE

<table>
<tr><th rowspan="2">Whitehouse (1954)</th><th colspan="2" rowspan="2">Vine & Day (1965) (Northern Eromanga Basin)</th><th colspan="4">This Report (after Vine et al., 1967)</th></tr>
<tr><th colspan="3">Rock Units (Tambo/Augathella area)</th><th>Faunal Divisions</th></tr>
<tr><td>Winton Fm</td><td colspan="2">Winton Fm</td><td rowspan="2">Manuka Subgp</td><td colspan="2">Winton Fm</td><td rowspan="5">Tambo</td></tr>
<tr><td>Winton Fm or Tambo Fm</td><td colspan="2">Mackunda Fm</td><td colspan="2">Mackunda Fm</td></tr>
<tr><td rowspan="3">Tambo Fm</td><td rowspan="5">Wilgunya Fm</td><td>Allaru Mbr</td><td rowspan="5">Wilgunya Subgp</td><td colspan="2">Allaru Mudst</td></tr>
<tr><td>Toolebuc Mbr</td><td colspan="2">Toolebuc Lst</td></tr>
<tr><td>Ranmoor Mbr</td><td rowspan="3">Wallumbilla Fm</td><td>Coreena Mbr</td></tr>
<tr><td rowspan="2">Roma Fm</td><td>Jones Valley Mbr</td><td rowspan="2">Doncaster Mbr</td><td rowspan="2">Roma</td></tr>
<tr><td>Doncaster Mbr</td></tr>
</table>

The important marine macrofossils, which occur in all the units below the Winton Formation, are listed in Table 9, and the fossils collected during this survey are discussed in Appendix 1.

TABLE 9 : IMPORTANT MARINE MACROFOSSILS IN THE ROLLING DOWNS GROUP

Doncaster Member (Aptian)

Pelecypods	Maccoyella barklyi*
	Fissilunula clarkei+
	Tatella maranoana+
Belemnite	Peratobelus
Ammonites	Tropaeum
	Aioloceras

Coreena Member (Aptian ? - Albian)

Belemnites	Dimitobelus
	Peratobelus
Pelecypods	Pseudavicula papyracea*
	Barcoona trigonalis+

Toolebuc Limestone (Albian)

Pelecypods	Aucellina hughendenensis*
	Inoceramus*

Allaru Mudstone (Albian)

Ammonites	Prohysteroceras
	Labeceras
	Myloceras
Pelecypods	Inoceramus*
	Aucellina hughendenensis*

Mackunda Formation (Upper Albian)

Belemnite	Dimitobelus
Pelecypods	Inoceramus*
	Maccoyella rockwoodensis*
	Nototrigonia+

* Sessile shallow water forms; filter feeders

\+ Shallow burrowers, mainly filter feeders

Wallumbilla Formation

The Wallumbilla Formation (Vine et al., 1967) contains a number of members of which only the Doncaster and Coreena Members are present in the Tambo/Augathella area.

Doncaster Member

The Doncaster Member (Vine & Day, 1965) crops out around the northern and eastern margins of the Eromanga Basin, continues over the Nebine Ridge into the Surat Basin, and is widely distributed subsurface. It forms poor rubbly outcrops in the plains around Tambo and extends north and southeast of the town. It also crops out east of Augathella.

The sequence consists of dark blue-grey mudstone and some fine-grained glauconitic labile siltstone, both of which weather buff-yellow. Gypsum is common throughout, and the member is locally fossiliferous. The mudstone is massive and laminated or thinly laminated. In the Augathella Sheet area, mudstone and a little fine-grained glauconitic sandstone occur in the lowermost 30 m. The mudstone contains scattered angular granules of quartz.

The Doncaster Member rests conformably on the Hooray Sandstone. In much of the Tambo Sheet area and in a small area north of Hoganthulla Creek, in the Augathella Sheet area (see p.59), there is a transitional sandstone sequence at the base of the Doncaster Member. Elsewhere, mudstone directly overlies the Hooray Sandstone. The basal sandstone in the Doncaster Member is green, glauconitic, and lithic sublabile to lithic, whereas the Hooray Sandstone is white, sublabile, and seldom glauconitic.

Marine macrofossils are common in the Doncaster Member at some levels; the shelly fossils are preserved whole, unlike those in the coquinites of the Coreena Member or Mackunda Formation. The rare ammonites are commonly filled with coarse crystalline calcite except for the outer body chambers which, where preserved, are filled with silt. As the siphuncle was not ruptured, it is inferred that the sediments were laid down in a placid environment. The muddy sediment, the presence of gypsum, and the mode of preservation of the fauna indicate deposition in a shallow epicontinental sea, surrounded by lowlands supplying only fine detritus.

The Doncaster Member is 210 m thick in the Carlow No. 1 and Boree No. 1 wells, but to the south it thins to 150 m, and the same thickness is maintained to the southern edge of the Augathella Sheet area.

The shelly Aptian fauna (Day, 1966, 1968, 1969) consists of pelecypods, some belemnites, gastropods, scaphopods, and rare ammonites. Lower Cretaceous microplankton of the Dingodinium cerviculum Zone and some spores are present in BMR Augathella No. 3 (Burger, 1967b; Appendix 1). Elsewhere, the Doncaster Member contains spores of the unit K1b-c (Burger, 1968a).

A few arenaceous Foraminifera of Lower Cretaceous age were recovered from a shot-hole sample (grid ref. 50578171) (Terpstra, in Exon et al., 1966) and from sandstone in the north bank of the Barcoo River (loc. T16) at Tambo (Crespin, 1960).

The sandy sequence at the base of the Doncaster Member is shown by stippling on the geological map. It is most extensively developed around the Birkhead Anticline in the Tambo Sheet area, and less widely north of Hoganthulla Creek in the Augathella Sheet area.

The sequence is transitional between the freshwater sandstone of the Hooray Sandstone and the predominantly argillaceous marine sequence of the Rolling Downs Group. In the Tambo Sheet area it crops out as fine to medium-grained glauconitic lithic sublabile to lithic sandstone, but in BMR Tambo No. 3 it also includes some 18 m of grey mudstone, grading into siltstone, and thin interbeds of lithic sandstone, containing glauconite, feldspar, rock fragments, and muscovite.

A measured section northwest of Tralee homestead consists mainly of lithic sublabile sandstone. The rock is medium to fine-grained, gritty, poorly sorted, extremely clayey, and glauconitic. The sandstone is usually pale grey to light green, but weathers brown, possibly due to the alteration of glauconite. A few marine fossils have been recorded. In this section, 30 m of sandstone is exposed, but the top of the sequence is concealed. The total thickness is estimated to be 45 m. Outcrops in the Augathella Sheet area consist of partly silicified and partly calcareous sublabile sandstone and gritty sandstone.

All the sandstones are glauconitic, and as the lithic fragments consist mainly of fine-grained acid volcanics, they were probably derived from the same source as the Hooray Sandstone (Galloway, 1967).

The main sandy sequence lies on the flank of the Birkhead Anticline, and is probably a littoral facies. Elsewhere mudstone was deposited at the same time. The basal sandstone is poorly exposed, but is apparently conformable with the Hooray Sandstone.

Aptian pelecypods and a few gastropods are present in the basal sandstone of the Doncaster Member (Day, 1966, 1968), and it is possible that it is equivalent to the sandy Minmi Member of the Blythesdale Formation in the Roma Sheet area, although the fauna in the Tambo Sheet area may be younger.

Shot-hole samples (G2121) from the basal sandstone in the Augathella Sheet area were found to contain a few arenaceous Foraminifera of Lower Cretaceous age (Terpstra, in Exon et al., 1966).

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Coreena Member

The Coreena Member (Vine et al., 1967) is a sequence of coarse siltstone, grading into very fine sandstone, interbedded with mudstone. It overlies the Doncaster Member and is conformably overlain by the Toolebuc Limestone, or, in its absence, by the Allaru Member. The member crops out around the eastern margin of the Eromanga Basin, from the Muttaburra Sheet area southwards. In the Tambo/Augathella area, the member is exposed as rubble and rubbly outcrops in a belt roughly parallel to and west of the Landsborough Highway. The topographic relief is slightly greater than that of the Doncaster Member or Allaru Mudstone, and is comparable with that on the Toolebuc Limestone. The subsurface extent to the west is unknown.

The most common rocks exposed are very fine to fine labile sandstone and coarse siltstone; medium-grained sublabile sandstone is very rare. Galloway (1967) has examined 13 thin sections of calcareous sandstone, all of which are glauconitic and labile, and contain abundant fragments of andesite and plagioclase. Thus there was a change in provenance at the end of Doncaster Member time, and contemporaneous andesitic vulcanism became the dominant source of detritus.

The sediments with a calcareous matrix are more resistant to weathering than the non-calcareous sediments, and are thus more commonly exposed. Thin sets of cross-beds were noted, but the foresets do not appear to have a consistent trend. The logs of water bores and oil exploration wells indicate that non-calcareous sediments are more common, and mudstone much more common, than is indicated by field observations.

Good supplies of water are obtained from the Coreena Member, and on Oakwood and Wansey Downs holdings there are a number of artesian bores which probably tap permeable sandstones that are not exposed at the surface.

The Coreena Member rests conformably on the Doncaster Member, and occupies the same stratigraphical position as the Ranmoor Member in the northern part of the Eromanga Basin.

In the Tambo/Augathella area the thickness of the Coreena Member varies considerably over small distances. In the type area north of Barcaldine, the thickness is estimated to be 100 m. In the Carlow No. 1 and Boree No. 1 wells the sequence is about 25 m thick, but in Bury No. 1 and Westbourne No. 1 it is over 120 m thick.

The member is roughly divisible into lower and upper units. The lower is characterized by the presence of coquinite containing abundant shell fragments and beds of the small pelecypod Barcoona, and the upper by the presence of abundant intraformational conglomerate and wood fragments, and the absence of marine macrofossils. The two units are best developed in the Augathella Sheet area south of Chatham homestead.

The rich shelly marine fauna of pelecypods, belemnites, scaphopods, and a few gastropods indicates an age ranging from lower Albian at the base to middle Albian at the top. The pelecypods are all shallow-water forms. Worm trails and a few ammonite fragments were seen. In the lower part of the member the presence of worm tubes, coquinites, and intraformational conglomerate, and the random orientation of the cross-bedding, suggest deposition in a coastal or nearshore environment, where erosion and reworking were active. The interbedded mudstone probably indicates shortlived changes in the depth of water, or temporary base levelling of streams draining the source areas. Some of the fossil collections (e.g. G1933) contain reworked fossils of the Roma fauna mixed with typical Tambo fossils, which Day (1967) suggests have been derived from the underlying Doncaster Member. The reworking seems to be largely confined to the area around the Birkhead/Ward River Anticline, which was probably rising at that time. The upper part of the member contains an abundance of wood fragments, intraformational conglomerate, and worm tubes, and was probably laid down under terrestrial conditions similar to those which prevailed when the Winton Formation was deposited. Marine fossils are absent.

The spores and microplankton from the Tambo/Augathella area have not been investigated, but elsewhere spores of unit K1d and microplankton of the Zone of Odontochitina operculata have been recorded in the lower part of the Doncaster Member (Burger, 1968a), and spores of unit K2a and microplankton of the Zone of Muderongia tetracantha/Odontochitina operculata in the upper part (Burger, 1968b). The cuttings from BMR Tambo No. 6 contain a few calcareous Foraminifera (Terpstra, 1968).

Toolebuc Limestone

The Toolebuc Limestone (Vine et al., 1967) is widely distributed in the Eromanga Basin. In the Tambo/Augathella area it crops out in an almost continuous belt west of the Enniskillen Anticline, and as discontinuous outcrops as far east as Chatham homestead. West of the Ward River Anticline the formation can be identified on the gamma-ray logs of water bores and oil exploration wells by a very sharp increase in radioactivity. Along the anticline there are no outcrops of Toolebuc Limestone, and the Allaru Mudstone presumably rests directly on the Coreena Member; yet to the east of the anticline the Toolebuc anomaly is apparent in some bores. Possibly the depositional floor over the anticline was more elevated than surrounding areas, either above wavebase or even above sea level, and there was no accumulation of radioactive minerals.

The Toolebuc Limestone consists of fine-grained pale grey limestone, which generally crops out as concretions averaging 15 cm across. A little white and pink finely crystalline to earthy concretionary limestone also crops out. In other areas (Vine & Day, 1965), the formation contains a considerable proportion of calcareous shale and platy limestone which crops out poorly.

These widespread calcareous sediments reflect a regional tectonic event or climatic change. The limestone has a much more restricted fauna than the enclosing sediments, but it contains pelagic Foraminifera which suggest connexion with the open sea. The calcium carbonate was probably precipitated by marine organisms, such as algae.

The outcrops of the Toolebuc Limestone are about 3 m thick, but the gamma-ray logs indicate a thickness of 4.5 to 7.5 m. In other areas (e.g. the Maneroo Sheet area, Jauncey, 1967) only the top of the Toolebuc Limestone can be defined by the gamma-ray log.

The shelly fauna consists almost entirely of great numbers of the two sessile pelecypods Inoceramus sp. and Aucellina hughendenensis, which indicate an Albian age (Day, 1966, 1968, 1969).

Samples from many areas in the basin contain swarms of Globigerina, which do not occur at other levels in the Rolling Downs Group (Crespin, 1963). The equivalent mudstones in BMR Tambo No. 6 (120-150 ft; 36.6-45.7 m) contain abundant Globigerina; no arenaceous Foraminifera are present, but Radiolaria and fish teeth occur (Terpstra, 1968). The age of the assemblage is Albian. These cores also contain an Albian (K2a) microflora, and dinoflagellates (Appendix 1).

Allaru Mudstone

In the Tambo/Augathella area the Allaru Mudstone (Vine et al., 1967) forms sparse rubbly outcrops in black-soil plains. The belt trends south-southeast from the northwestern part of the Tambo Sheet area to the central-southern part of the Augathella Sheet area. Relief is low, and outcrops are littered with small angular blocks of calcareous siltstone and mudstone. The rocks are dark blue-grey when fresh, but weather buff. Thin beds of cone-in-cone limestone are also present. Subsurface, the formation consists mainly of non-calcareous mudstone, but siltstone is more abundant than in the type area. The formation can be readily identified as an argillaceous interval on the wireline logs.

In the northern part of the Tambo Sheet area the formation is about 270 m thick; to the south, it is 498 feet (151.8 m) thick in Boree No. 1 and 680 feet (207.3 m) in Bury No. 1.

The formation contains an abundant and varied assemblage of pelecypods and ammonites, and some gastropods and belemnites. The shelly fossils are preserved whole, and as the siphuncles of the ammonites (as in the Doncaster Member) were not ruptured before preservation it is inferred that deposition took place in quiet marine conditions. The fineness of the sediment suggests slow deposition, and the abundance of gypsum indicates shallow water. Thus the formation was probably deposited in a shallow epicontinental sea surrounded by lowlands; a connexion with the open sea is suggested by the abundance of ammonites.

The marine macrofossils in the Allaru Mudstone are probably upper Albian in age (Day, 1966, 1968, 1969). Ammonites are particularly common along a topographic ridge which extends from locality G2096, 15 km southwest of Tambo, south to locality G2053, 6 km east of Highfields homestead (Augathella Sheet). In other areas (e.g. in BMR Longreach No. 1) it contains a K2 microflora and microplankton of the Odontochitina operculata Zone (Burger, 1968b). Crespin (1960) identified a few arenaceous Foraminifera from locality T12, 18 km west of Tambo, and Terpstra (1968) found Foraminifera (including Globigerina) and Radiolaria in BMR Tambo No. 6.

Mackunda Formation

The Mackunda Formation (Vine & Day, 1965) forms numerous rubbly outcrops along the western edge of the Tambo Sheet area, and in the Augathella Sheet area it crops out west of the Ward River, as an inlier in the Noella Syncline (east of the Ward River), and in the Biddenham Syncline in the central-southern part of the Sheet.

The formation consists of labile to sublabile siltstone and sandstone interbedded and interlaminated with mudstone. The sandstone is generally very fine to fine-grained, and rarely medium-grained. The grains are well sorted and the matrix is argillaceous or calcareous. The calcareous sandstone grades into sandy limestone. All seven of the calcareous sandstones examined by Galloway (1967) consist of glauconitic labile sandstone with abundant fragments of andesite and plagioclase. The sandstones which do not have a calcareous or argillaceous matrix are good aquifers and numerous bores yield subartesian water from them. The mudstones are similar to those in the Allaru Mudstone. The formation contains some coquinite beds, which are less common than in the Longreach and Maneroo Sheet areas (Vine et al., 1965), and conformably overlies the Allaru Mudstone.

The Mackunda Formation is similar to the lower part of the Coreena Member, and both were probably deposited near the shore, perhaps largely on beaches (see p. 60).

The formation is rich in pelecypods which Day (1966, 1968) regards as upper Albian. A K2 microflora has been identified in BMR Longreach No. 2 (Burger, 1968b). The arenaceous Foraminifera have been described by Crespin (1960). Calcareous Foraminifera are abundant in the subsurface elsewhere, and in the Tambo/Augathella area several Lower Cretaceous species have been recorded in outcrop samples (T3 and T5) from west-southwest of Tambo.

Winton Formation

The Winton Formation (Whitehouse, 1954) forms rubbly outcrops on the rolling downs in the western part of the Augathella Sheet area. It consists mainly of interbedded mudstone, labile sandstone, and intraformational conglomerate. The sandstone (Galloway, 1967) contains abundant feldspar and fragments of andesite. The sediments have a calcareous or argillaceous matrix; the calcareous beds are more resistant to weathering and crop out more commonly. The formation contains small scattered seams of coal and peat, particularly in the lowermost part; the peat outcrops are commonly silicified.

The Winton Formation rests with a transitional contact on the Mackunda Formation. Compared with the Mackunda Formation, the sandstone is commonly coarser and more thickly bedded (0.5-9 m). The formation contains subartesian aquifers.

The lack of marine fossils, and the presence of abundant plant remains, indicate that the Winton Formation was deposited entirely in fresh water. The fineness of the sediment suggests deposition from sluggish streams, or lakes and deltas. From time to time the sediments were desiccated; subsequently inundation produced intraformational conglomerate.

The original thickness of the Winton Formation is unknown, as the top is eroded. In the Springleigh Bore (R3489), in the Blackall Sheet area, the sequence is 1550 feet (472.4 m) thick. It probably thickens to the west and south.

The Winton Formation contains plant fragments and fossil wood, none of which are diagnostic. The few plants identified farther north (Vine & Day, 1965) suggest that the lower part of the formation ranges from Lower Cretaceous to Upper Cretaceous in age. The spores from BMR Augathella No. 4 are probably Upper Cretaceous (Burger, 1967b; Appendix 1). Palynological studies of material from the Mayneside No. 1 (AAP, 1965b) and Fermoy No. 1 (AAP, 1965a) wells indicate a Lower Cretaceous age for part of the formation. Elsewhere, freshwater pelecypods are common in places, and in Fermoy No. 1, marine Peridiniens (microplankton) were found 275 m above the base of the Cainozoic formation.

CAINOZOIC

Tertiary Basalt (Tb)

The only Tertiary basalts present are a single hill-capping and two dykes in the extreme southeast of the Tambo Sheet area.

The hill-capping, 13 km west of Mount Playfair homestead, consists of about 5 m of rubbly basalt overlying silicified Adori Sandstone. The hardening of the underlying sandstone, siltstone, and conglomerate was probably caused by the basalt. The two dykes, 9.5 and 13 km southeast of Mount Playfair homestead, trend northwest, parallel to the strike of the gently dipping sediments.

The basalt contains phenocrysts of olivine set in a fine-grained groundmass of augite, andesine, and glass.

These isolated occurrences are probably remnants of an extensive Tertiary basalt complex which included Mount Playfair and Mount Pluto to the east (Mollan, 1965).

Tertiary Sediments (T)

Tertiary sediments are widely distributed in a belt across the Tambo Sheet area from the northeast to southwest, and in the northwest and southeast of the Augathella Sheet area. They consist of fluviatile sandstone and conglomerate, and subordinate siltstone and claystone, which are commonly ferruginized, leached, or mottled; they crop out as hill-cappings up to 30 m thick.

In the far northeast there are mesas with quartz sandstone and conglomerate, probably derived from the Colinlea Sandstone, overlying the Joe Joe Formation. Some of the basal beds contain angular fragments of quartzose sandstone and, in places, siltstone comparable with that in the Joe Joe Formation.

In many of the mesas overlying the Triassic sequence, the basal beds consist of conglomerate composed of angular fragments of sandstone similar to that in the Rewan and Moolayember Formations. Most of the fragments are only a few centimetres across, but they range up to about 1 m. The upper part of the mesas generally consists of medium-grained quartzose sandstone, which is moderately well sorted but usually lacks bedding.

On the Moolayember Formation the sandstone is generally better sorted and quartz-pebble conglomerate is subordinate. The sandstone is mainly clayey, leached, and structureless. Some is cross-bedded, thick-bedded, and in places ripple-marked; some contains fragments of wood. It was probably derived largely from the Jurassic sandstones to the southwest.

The Tertiary sediments overlying the Jurassic/Cretaceous sequence consist principally of poorly bedded fine to medium-grained clayey sandstone and conglomerate. Where developed, bedding is thick. A basal conglomerate consisting of angular pebbles and cobbles, up to 15 cm across, in a sandstone matrix, is commonly found (e.g. about 1.5 km east of Highlands homestead). The pebbles are mainly quartz, quartzite, and silicified sandstone, with subordinate siltstone and chert, and occasional porphyritic acid volcanics. Higher up the sequence, the pebbles in the conglomerates consist almost entirely of quartz, quartzite, and chert. Thick white siltstone and claystone sequences are prominent in some areas. The Tertiary sediments can usually be distinguished from the Adori Sandstone or Hooray Sandstone by the less well developed bedding, blocky weathering, and the presence of quartz-pebble conglomerate.

The large plateaux in the Warrego and Enniskillen Ranges, and in the southeastern part of the Augathella Sheet, are blanketed with sand, and Tertiary outcrops are found only around the edges of the plateaux. The fine-grained clayey Tertiary sandstone is difficult to distinguish from the weathered sandstone of the Rolling Downs Group. The sequence is generally less than 15 m thick.

All these deposits, which postdate the Cretaceous, are assumed to be of Tertiary age. In Tertiary time there was an extensive river system which derived material from the underlying sediments. The fine material was mostly carried away, but the coarser material was deposited close to its source. The sediments were ferruginized in part; pisolitic surfaces are still present in the extreme north of the Tambo Sheet area northeast of Marston homestead, and in the southeastern part of the Augathella Sheet area. Later erosion left only the present-day high-level outliers.

Undifferentiated Cainozoic Sediments (Cz)

The sediments shown as 'Cz' on the map are poorly bedded or unbedded. They were formed by weathering of underlying sediments and were recemented after little or no movement. Clayey sandstone, derived from underlying sandstones, is widespread, but siltstone and claystone predominate in places.

In the far northeast, where they overlie the Colinlea Sandstone, the sediments form mesas of extremely poorly sorted conglomerate and quartzose sandstone. The large clasts of quartzose sandstone were derived from the Colinlea Sandstone.

Around Glen Avon homestead in the northeast, thin boulder deposits rest apparently conformably on the gently dipping cuestas of pre-Tertiary sediments. They contain boulders of silcrete, and cobbles and boulders of silicified wood. The conglomerates are overlain by poorly sorted lateritized sandstone.

The low mounds of clayey quartz sandstone at the base of the Jurassic sandstone escarpment slope gently away from the scarp. They represent consolidated scree.

The poorly bedded ferruginized or silicified deposits on the Adori Sandstone and Hooray Sandstone are generally less than 5 m thick, but are considerably thicker in places. They are difficult to distinguish from the Tertiary sandstone (T).

A duricrust (Czd) was also developed in Cainozoic time. It was formed by the alteration of the pre-Cainozoic sediments in situ. It forms plateaux and mesas, especially in the western half of the Augathella Sheet area, where the presence of sand pipes, up to 3 m deep and 1 m across, in the duricrust, indicates that soil profile and duricrust were formed at the same time. Silcrete boulder deposits are present around some Tertiary mesas in the northeastern part of the Tambo Sheet area.

QUATERNARY

Assigned to the Quaternary are: the unconsolidated sands, gravels, and clays in the beds, flood-plains, and outwash fans of present-day rivers (Qa); the sands and soils overlying the sandy formations, Moolayember Formation, and Rolling Downs Group (Qs); and the old river terraces above the present river banks and flood-plains (Qs).

STRUCTURE

The main structural elements are shown in Figure 17. In general, there is a regional dip to the southwest, on which are superimposed north-northeasterly fold axes; thus the structures generally plunge to the south. Progressively older units are exposed from southwest to northeast. The dip measurements in the post-Triassic sediments in the Tambo Sheet area (Woolley, 1941a) suggest a regional dip of about half a degree, but it probably flattens gradually to the southwest. Average dips in outcrop are about 30° in the Drummond Basin sequence, 10° in the Joe Joe Formation, 5° in the Permian, 3° in the Triassic, and 0.5° in the Jurassic and Cretaceous. Most of the structures continued to grow from Carboniferous to Cretaceous times - probably spasmodically. Most of them were formed by a combination of tectonic and drape folding.

Data from the drillers' logs of water bores, and from wireline and lithological logs of oil exploration wells, have been integrated with field observations, photogeological interpretation and, in places, seismic data, to compile a structural form-line map on the top of the Hooray Sandstone (Fig. 18). The map shows the north-northeasterly structural trend and regional southwesterly dip.

Three minor cross-folds have been mapped in the central part of the Augathella Sheet area, but no significant faulting has been detected in Jurassic/Cretaceous sediments.

Folding in the pre-Jurassic sequence (which is exposed in the Tambo Sheet area only) is generally reflected by more gentle folding in the overlying sequence (Figs 18, 19). However, two small but moderately strongly folded structures near Brumby Creek are not reflected in the Jurassic sediments. Fold axes are sinuous and bifurcate in places; they have a general north-northeasterly trend and plunge to the south. Dips to the southeast are generally steeper than those to the west. The folding has been complicated either by basement relief, or by a secondary stress direction, or perhaps both. Folds in this sequence are commonly box-like, probably caused by two directions of stress.

Major faulting at the surface is confined to the Mount Beaufort Anticline, where a large fault cuts out the whole of the Ducabrook Formation on the western flank of the anticline.

The Mount Beaufort Anticline, in the extreme northeast of the Tambo Sheet area, is the only one in which Devonian and Lower Carboniferous rocks are exposed. Only the southern part of the anticline lies within the area mapped. Earlier mapping by Veevers et al. (1964a) has shown it to be asymmetrical, with the eastern flank the steeper.

The folding is moderately strong, with dips up to 35°. Several later faults complicate the anticline. The largest of these trends north-northwest, and cuts off the fold axis where it intersects the Belyando River. It is a scissors fault, with a downthrow in the north of more than 1200 m to the west, and in the south of about 100 m to the east. The fault lies on the trend of a major structural discontinuity known as the Belyando Feature (Vine et al., 1965) to the north, to which it is probably related.

Main Structures (from west to east)

The broad symmetrical Enniskillen Anticline corresponds with the monoclinal Pleasant Creek Arch which, in pre-Permian time, formed the eastern margin of the Adavale Basin. A seismic survey across the arch (Fjelstul & Tallis, 1963) suggests erosion of Upper Permian sediments from the crest of the structure before deposition of the Mesozoic sequence. The Bury No. 1 well was drilled on a closure on the western limb of the anticline.

The Woolga Syncline is a broad synclinal warp. On top of the Hooray Sandstone, structural relief between the crest of the Enniskillen Anticline and the trough of the Woolga Syncline is about 150 m. Seismic surveys (Petty, 1963b; Fjelstul & Tallis, 1963) show that the anticline persists downwards into the Permian rocks.

The symmetrical Birkhead/Ward River Anticline extends right across the Tambo Sheet. At the Tambo/Augathella Sheet boundary the axis of the structure is displaced 8 km to the east, and then continues southwards as the Ward River Anticline. In the area of displacement of the two structures, only a single anticline is apparent at the unconformity below the Permian (Petty, 1963b; Fjelstul & Tallis, 1963). The anticline is exceptionally broad at the Tambo/Augathella Sheet boundary. The Westbourne No. 1 well was drilled on the Ward River Anticline.

The Birkhead Anticline has had a profound influence on the history of the Tambo/Augathella area, and is the dominant structure in the Tambo Sheet area. It has grown slowly through time, and most of the sedimentary sequences thin over the crest; the thinning is depositional in some cases, and probably erosional in others. The Permian Peawaddy Formation, which extends several hundred kilometres east of the anticline, changes facies, and is not identifiable, west of the anticline. The Dunda Beds of the northwest also become unrecognizable at the anticline, where they pass laterally into the upper part of the Rewan Formation. The Jurassic Precipice and Boxvale Sandstones were deposited by streams running down the eastern side of the uplifted Birkhead Anticline, and pinch out a short distance west of it. The sandy, probably littoral, facies of the lower part of the Doncaster Member is seen only near the Birkhead Anticline.

There is a culmination on the anticline, which is well defined by the cliffs of the Adori Sandstone, south of Killarney Park homestead. Birkhead No. 1, a dry hole, was drilled in the northern part of this culmination.

Normal faults are developed parallel to the axis, on the northern flank of the anticline, in the pre-Jurassic sediments.

In the Noella Syncline the Jurassic/Cretaceous sequence is folded into an asymmetrical structure, with a steeper western limb. The dip between the syncline and the Ward River Anticline in the northern part of the Augathella Sheet area is higher than other flank dips in the region (see Figs 18, 19). The structures are probably separated by a fault in the basement.

Avonmore/Truno Anticline, Glen Avon Syncline, Voltigeur Anticline, Castlevale Syncline

The Avonmore/Truno Anticline is a sinuous structure, which is joined in two places by southwesterly trending anticlines. The most northerly is west of the Avonmore Anticline,

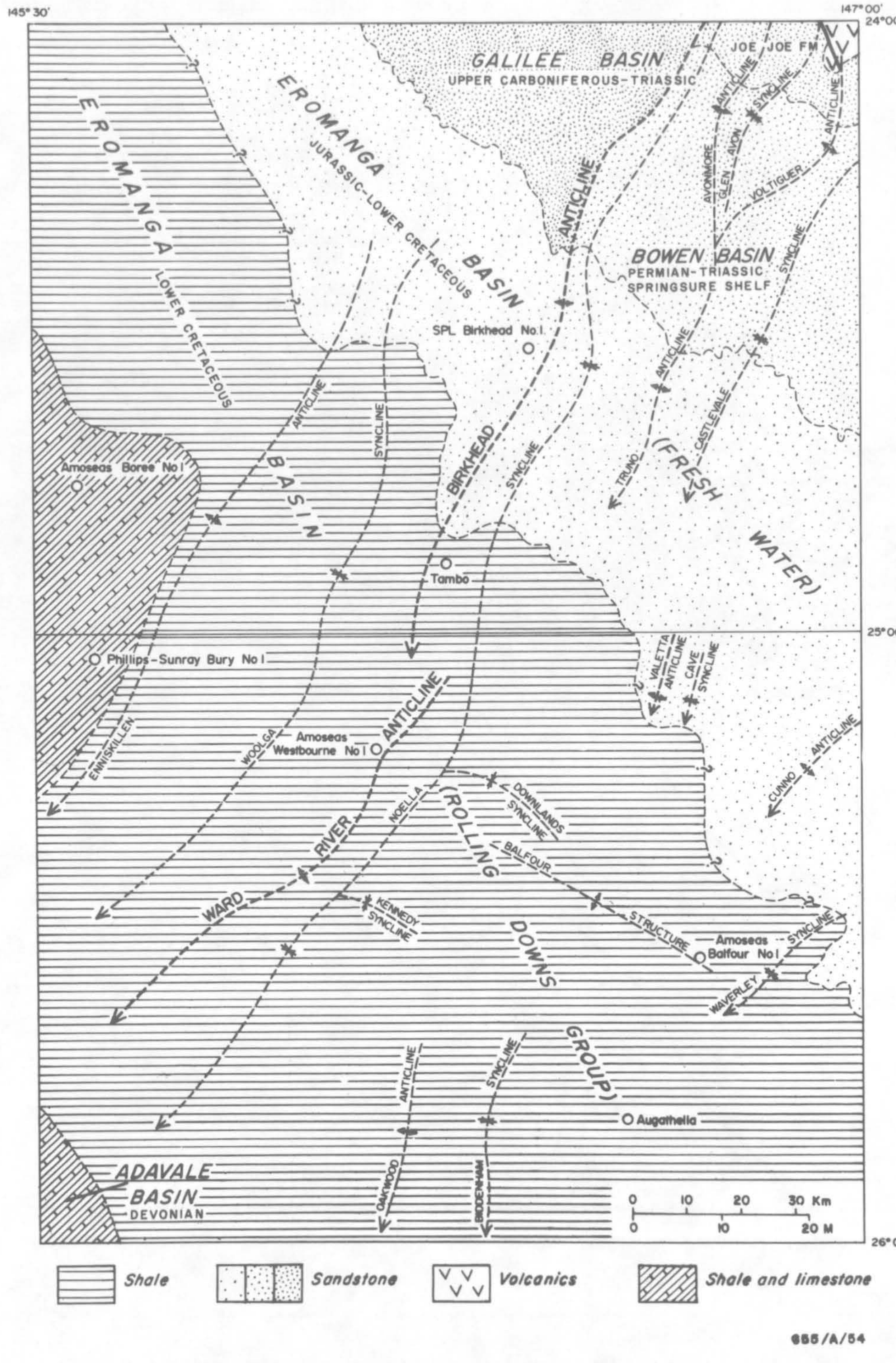


Fig. 17. Main geological divisions and structure.

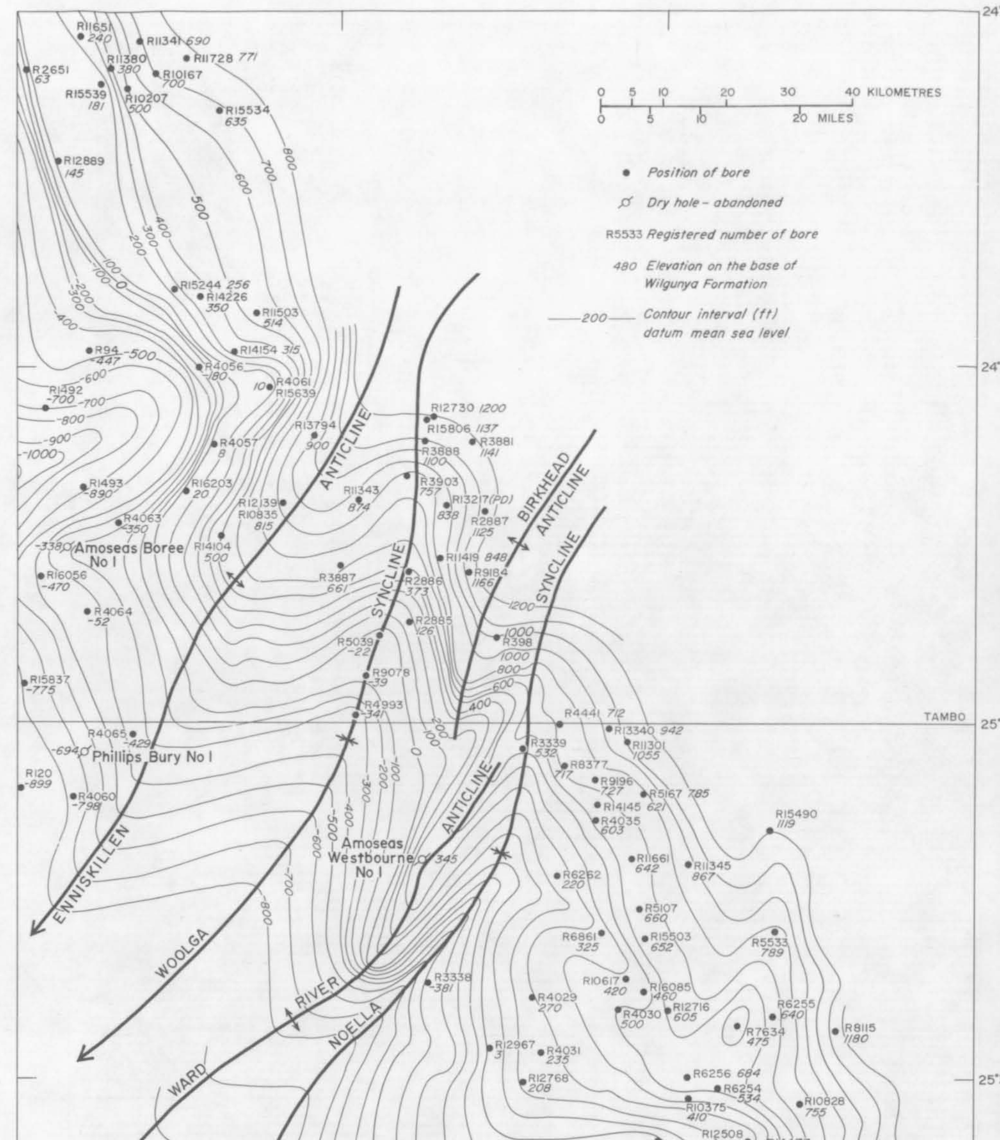
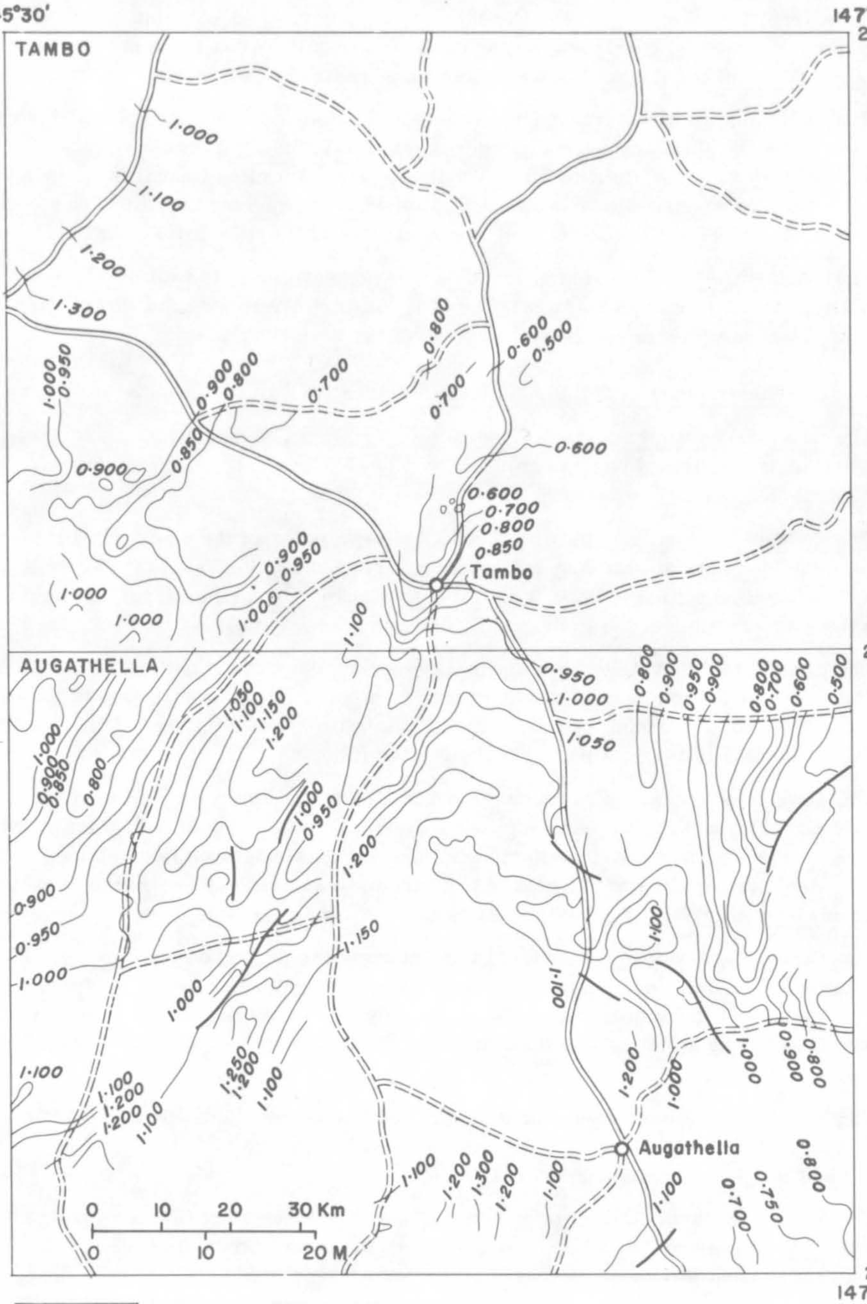


Fig. 18. Contours on the top of the Hooray Sandstone. Based on drillers' logs of water bores and logs of oil exploration wells.



A Blackall-Mitchell seismic survey. Petty (1963a)

B Tambo seismic survey. Petty (1963b)

C Augathella sesmic survey. GAI (1965)

D Seismograph survey of Highfields area. Fjelstul & Tallis (1963)

G 55/A/56

Fig. 19. Seismic contours on top of Permian reflector.

east of Alpha homestead. The Voltigeur Anticline, named from Voltigeur Creek, joins the structure from the east, near Duck Creek; a strongly developed anticline in the Moolayember Formation joins, from the west, at the same point. Between these anticlines is the Glen Avon Syncline and the unnamed syncline along Brumby Creek.

The three major structures have strongly folded the Joe Joe Formation and, somewhat less strongly, the Permo-Triassic sequence. The Voltigeur Anticline may be related to the Mount Beaufort Anticline. The Avonmore/Truno Anticline is expressed by gentle folds in the Lower and Middle Jurassic sediments, but dies out below the Westbourne Formation, near Truno homestead in the southeastern part of the Tambo Sheet area.

The Castlevale Syncline, which trends north-northeasterly, is well developed in the Upper Permian near Balmy Creek, but becomes gentler up the succession. In the Jurassic it is a broad warp which cannot be traced south of the Nive River.

Folds in the Eastern Part of the Augathella Sheet Area

The Oakwood Anticline, east of the Noella Syncline, is exposed at the surface; its eastern limb is illustrated by a seismic line run by Geophysical Associates International (GAI, 1965).

The Biddenham Syncline is well defined by a large inlier of the Mackunda Formation in the central-south of the Augathella Sheet area. It is illustrated by a seismic line across the structure (GAI, 1965). It probably extends north-northeastwards until it dies out in the southern limb of the Raincourt Structure.

The presence of the Valetta Anticline is suggested by the outcrop pattern of the Hooray Sandstone, and by the presence of the Doncaster Member in seismic shotholes to the east. The structure is confirmed by the seismic line along Stockade Creek. Minor faulting parallel to the axis of the anticline is evident in the field.

The Cave Syncline is indicated by the outcrop pattern of the Hooray Sandstone along Stockade Creek, and by the presence of the Doncaster Member in seismic holes between outcrops of the Hooray Sandstone to the east and west. Its existence is confirmed by the seismic line across Stockade Creek (GAI, 1965). Seismic evidence suggests faulting between this structure and the Valetta Anticline.

The Cunno No. 1 well in the Eddystone Sheet area was drilled on the Cunno Anticline on a culmination defined by pre-Jurassic seismic reflectors. Seismic evidence (GAI, 1965) indicates that the anticline extends southwestwards to the Balfour Structure. On the southern flank of the anticline, the linearity of the formation boundaries strongly suggests that they are faulted.

The Waverley Syncline and two unnamed structures occur south of the Cunno Anticline.

Cross-folds in the Augathella Sheet Area

Three structures lie normal to and east of the Noella Syncline; they are, from north to south, the Downlands Syncline, the anticlinal Raincourt Structure, and the Kennedy Syncline; all of them terminate westward at the Noella Syncline.

The Downlands Syncline plunges westwards, and is apparent at the surface and in the subsurface. The syncline probably dies out to the east where it intersects the southern continuation of the Valetta Anticline.

In the Augathella seismic survey (GAI, 1965), a closure on an Upper Permian reflector, on an extension of the eastern end of the structure, was named the Balfour Structure, and the Balfour No. 1 well was drilled on it. A closure on the Upper Permian, on the western end of the Raincourt Structure, was named the Narrga Anticline. The closures seem to coincide with intersections of north-northeasterly trending anticlines, and the saddles with complementary synclines. The Narrga Anticline is the intersection of the Raincourt Structure and the Oakwood Anticline; the Balfour Structure is the intersection of the Raincourt Structure and the Cunno Anticline. The Raincourt Structure may be a later fold superimposed on the older north-northeasterly structures.

The Kennedy Syncline is a small syncline evident from surface mapping. It is situated south of the Raincourt Structure and plunges westwards. It possibly dies out eastwards where it meets the Oakwood Anticline.

GEOLOGICAL HISTORY

During Devonian and Carboniferous times, deposition in the west was dominantly clastic and marine, with some chemical sediments, but in the east it was largely volcanic with very little marine influence. In the Devonian, a western miogeosyncline was separated from an eastern eugeosyncline by a low ridge between the present-day Enniskillen and the Birkhead/Ward River Anticlines. The ridge consisted of sediments which had been metamorphosed in the Silurian. Deposition may or may not have lapped over the ridge, but evaporites were formed on the western flank in the Devonian.

In the west, early Devonian clastic sediments lapped against the ridge, and these in turn were overlapped by up to about 300 m of carbonate rocks, 300 m of salt, and 30 m or more of anhydrite and other evaporites. This sequence (the Etonvale D3 member) was deposited while the area was isolated from the open sea to the west. Normal clastic conditions returned and a considerable thickness of sediment (the Etonvale D2 member) was deposited. Most of the sediments were laid down in fresh water, except perhaps for a few oolitic beds. Deposition probably continued into the Carboniferous.

In the east a downwarp, probably of the pre-Devonian metamorphosed sediments and plutonic rocks, initiated the Drummond Basin, probably in early Devonian time. About 180 m of Upper Devonian to Lower Carboniferous sediments and volcanics are now exposed in this basin. The oldest unit exposed (the Silver Hills Volcanics) consists of flows and pyroclastics deposited, in part at least, under water. After a period of non-deposition, a Lower Carboniferous sequence of 1350 m of quartzose and multicoloured sandstone, siltstone, shale, and minor tuff (the Drummond Group) was laid down under varying, largely freshwater, conditions.

Lower Carboniferous deposition was followed by a period of orogeny characterized by large-scale normal faulting and considerable folding. The western sequence subsided to form the Adavale Basin, but the younger sediments were eroded for a time. A north-northeasterly monocline, with dips up to 45^{o}, developed along the western side of the basement ridge, the edge of which is the Pleasant Creek Arch. The salt beds were mobilized during tectonism, and caused structural disharmony between the upper and lower parts of the Etonvale Formation. In the Drummond Basin the most intense folding and faulting formed the northerly trending Mount Beaufort Anticline.

After a period of erosion, including glaciation, the area was blanketed with a considerable thickness of glacigene Upper Carboniferous to Lower Permian sediments (the Joe Joe Formation). Another period of erosion followed further slight folding. The folding from Carboniferous to Cretaceous time generally followed the old axes. In the east the sequence on the Springsure Shelf is similar to that in the Bowen Basin. The shelf terminates at the Birkhead Anticline; to the west of this anticline the bulk facies changes, and the sequence belongs to the eastern edge of the Galilee Basin. Differences in the Permian between the two depositional areas are slight; about 900 m of Permian to late Triassic sediments were deposited in both, and fairly gentle folding continued spasmodically.

In the Lower Permian a blanket of sand was deposited in the northeast, but probably not elsewhere. In the Upper Permian, after a short-lived marine transgression which reached the eastern flank of the Birkhead Anticline, the environment changed and lacustrine mudstone was deposited; some volcanic activity gave rise to bentonitic beds in the east. Coal-measure conditions prevailed for a short time, in some areas, at the close of the Permian.

The Triassic sequence consists of about 600 m of fluviatile and lacustrine sediments. At this time the south-southwesterly trending Birkhead/Ward River Anticline was growing slowly, and had a profound effect on sedimentation. The labile sandstone and multicoloured sandstone and mudstone of the upper part of the Rewan Formation intertongue with the sandstone of the Dunda Beds across the anticline. After an erosional break, the fluviatile quartzose sands of the Clematis Sandstone, which are considerably reduced in thickness over the anticline, blanketed the area; to the west they overlap on to the Upper Permian. Another period of lacustrine deposition was followed by uplift and erosion. At this time a regional dip to the southwest of about 2^{o} developed, and the various units were bevelled. On the Enniskillen Anticline the Moolayember Formation was completely removed by erosion.

Sedimentation in the Eromanga Basin began in the Lower Jurassic and continued well into the Cretaceous. The sequence is conformable throughout, and there is virtually no change in the type of sediment across the area. Folding was largely confined to warping over basement ridges. In the Jurassic 750 m of freshwater sediments were laid down. They consist of alternating fluviatile sands and lacustrine sediments deposited during cycles which were probably controlled by periodic uplift.

Early in the Lower Jurassic, the Birkhead Anticline was re-elevated and streams running down its southern flank deposited fluviatile sands. In the west, this sandstone overlaps on to the Upper Permian. Later sand deposition continued across the anticline, and overlapped on to the late Triassic beds, before giving way to lacustrine conditions in the Middle Jurassic. Fluviatile conditions recurred late in the Middle Jurassic and towards the end of the Jurassic and early Cretaceous.

About 1000 m of sediment was deposited in a great shallow basin in Lower Cretaceous time (the Rolling Downs Group). The source areas had low relief, and produced only fine sediments. Conditions varied from shallow marine to freshwater lacustrine, and occasionally fluviatile.

The last marine incursion was in late Albian time (the Mackunda Formation), but freshwater sedimentation continued into the Upper Cretaceous. Conditions in the great inland sea were generally unfavourable for most marine life, and the fauna is restricted.

During the Upper Cretaceous and possibly Lower Tertiary times the entire sequence was tilted about 1^{o} more to the southwest, and the succession was bevelled to a fairly flat surface. The soil profile, especially on the Rolling Downs Group, was silicified in Tertiary time. Later there was more erosion, and fluviatile sands were laid down in stream valleys on beds as old as Upper Carboniferous.

ECONOMIC GEOLOGY

Water

Most of the Tambo/Augathella area is part of the Great Artesian Basin, where both artesian and subartesian aquifers are present. The Hooray Sandstone and Adori Sandstone are the main aquifers and produce good supplies of potable water. In the eastern part of the basin, where there is only a thin cover of marine Cretaceous sediments, good supplies of groundwater can be obtained from the Lower Jurassic sandstones. The drillers' logs are not sufficiently detailed to distinguish between the Hutton, Boxvale, and Precipice

Sandstones. Most of the bores were originally artesian, but many of them, particularly in the deeper part of the basin, have ceased to flow and the water is pumped from shallow depths. The Westbourne and Birkhead Formations are generally aquicludes, although small supplies have been obtained from them in places.

In the western part of the Augathella Sheet area, some of the sandstones in the Winton and Mackunda Formations contain useful supplies of water. Most of the bores are less than 300 m deep, and none of them are artesian. The water is usually brackish, and may eventually become too saline even for stock. In the Augathella Sheet area, some of the artesian bores tap supplies in the Coreena Member of the Wallumbilla Formation.

East of the Precipice Sandstone, the Clematis and Colinlea Sandstones contain good supplies of water. The water from the Clematis Sandstone is usually potable, but that from the Colinlea Sandstone is generally brackish to saline. Small supplies can also be obtained from the Joe Joe and Ducabrook Formations.

There are numerous earth tanks and dams in and near creeks, gullies, and depressions, especially in areas of clayey soil. The tanks and dams are particularly common on the black and brown soils of the Rolling Downs Group and Birkhead Formation.

Oil and Gas

Six wells have been drilled in the search for oil and gas in the Tambo/Augathella area, and a general summary of each is given in Table 1. No discoveries of value have yet been made in the area, but the density of drilling is only about one hole to 10,000 sq km.

The best targets appear to be the Adavale Basin sequence, and any marine Permian rocks (Peawaddy Formation or its equivalent) which may be present. Traces of oil were found in the marine Minmi Member of the Blythesdale Group, in the Mitchell Sheet area (Galloway & Duff, 1966), and its equivalent in the Tambo/Augathella area, the sandstone at the base of the Doncaster Member, is a possible target. None of the marine Cretaceous sequence can be discounted, as clean sandstones, which produce water supplies in bores, are present in both the Coreena Member and Mackunda Formation. Depth of burial may have been greater in the past than at present.

Both the Triassic and Jurassic sequences contain acritarchs at some levels, which suggests periods of marine influence. The Devonian Dunstable Formation, if present, may be partly marine, but it is generally blanketed by a thick sequence of Silver Hills Volcanics.

There is an abundance of porous sandstones which would be excellent reservoirs: they include the Mount Hall Conglomerate, Colinlea Sandstone, Dunda Beds, and the Clematis, Precipice, Boxvale, Hutton, Adori, and Hooray Sandstones. The numerous anticlines and synclines are most strongly developed in the oldest rocks, and are little more than drape structures in the Jurassic and Cretaceous sediments. Several of the structures have been drilled where there is closure. The thinning of the formations across the larger structures is probably partly depositional and partly erosional, and stratigraphic traps are probably present on the flanks of many of the anticlines. Subsurface faults have been recognized, and fault traps could be present. More seismic work will reveal other possible traps, and the area still has possible potential for hydrocarbon production.

Constructional Materials

Good-quality road construction materials are scarce in the black-soil plains of the Tambo/Augathella area. Lenses of tough calcareous sandstone are common in the Cretaceous sediments, but they are usually too small to be used as a source of paving material. The thin surface layer of ironstained siliceous gravel ('gidgea gravel') is widely used in sealing main roads. In places the duricrust capping the Cretaceous sediments has been used for road material, but it is not very satisfactory.

In the sandy country in the northeastern part of the Tambo Sheet area, roads are generally not surfaced, except in low-lying areas, where local gravels are used. The roads in this area are impassable after heavy rain.

The basalt-capped hill some 65 km east of Tambo could be used for road metal. The basalt is fine-grained and durable, and is only 5 km south of the formed road from Tambo to Mount Playfair. The hill has gentle slopes and is easily accessible. The various extrusive igneous rocks of the Silver Hills Volcanics in the Mount Beaufort Anticline, in the extreme northeast, could also be used for road metal. They crop out about 20 km east of the formed road from Star Downs homestead to Alpha.

The hard massive welded ash flows and tuffs of the Silver Hills Volcanics, which crop out as high ridges in the Mount Beaufort Anticline, could be used as decorative and ornamental stone. The stone is predominantly red or green, with varicoloured fragments, and ranges from fine to coarse in grain.

Bentonite

The bentonite in the Black Alley Shale to the east probably persists across the northeastern part of the Tambo Sheet area (see p.28). Thompson & Duff (1965) have shown that some of the bentonite in the Springsure/Serocold Anticline is suitable as a base for drilling mud. The leases in the Springsure Sheet area extend as far west as Mantuan Downs homestead, only 25 km east of the Tambo Sheet boundary.

Torbanite

Torbanite and coal crop out in the Colinlea Sandstone in a small creek 3 km north of Glen Avon homestead, in the northeastern part of the Tambo Sheet area. The extent of the torbanite was investigated by the Queensland Department of Mines (Connah, 1964), and the reserves are estimated to be 680,000 to 820,000 cu m of distillate.

Coal

Coal of potential economic value occurs in the Blackwater Group, in the northeastern part of the Tambo Sheet area (see p.29). There have been a few reports of coal bands in drilling, and the electric log of Birkhead No. 1 suggests the presence of several coal seams, about 2 m thick, near the top of the group.

Coal has been recorded in seismic shot-holes in the Birkhead Formation in the Caldervale homestead/Cunno homestead area (at the junction of the Tambo, Augathella, Eddystone, and Springsure Sheet areas), and drillers' logs show coal seams in the Winton Formation. Thin seams of coal are probably present in the Colinlea Sandstone and some of the Jurassic sandstones.

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APPENDIX 1

PALYNOLOGY OF SHALLOW STRATIGRAPHIC BOREHOLES

AND OIL EXPLORATION WELLS

by

P.R. Evans* and D. Burger

INTRODUCTION

Over a period of years cores, sidewall cores, and cuttings from shallow stratigraphic boreholes and deep exploration wells, which penetrated sediments ranging in age from Devonian to Cretaceous, in the Tambo and Augathella 1:250,000 Sheet areas, were examined for plant microfossils. The assemblages are compared with the palynological units in the Cooper, Galilee, and Eromanga Basins.

This Appendix is compiled from previous reports of observations by Burger (in Galloway & Ingram, 1967), Evans (1966b,e; 1967) and from subsequently derived information.

Two deep wells have been drilled in the Tambo Sheet area. Palynological interpretation of the first, Birkhead No. 1, was attempted by Evans (1961, 1962a), but in view of more recent work a third revision is included here. Fossils extracted from particular samples from the Upper Carboniferous and Permian sections of the well are listed in Table A. New observations on the Triassic of the well are listed in the text as necessary. The other well, Boree No. 1, was examined by Evans and De Jersey (in Gerrard, 1964b), but additional information collected by E.A. Hodgson and P.R. Evans is incorporated below.

Five shallow holes were drilled in the pre-Jurassic sediments in 1964 (Exon & Kirkegaard, 1965); the results of the examination of samples from these holes are presented in Tables A, B, and D. Nine more shallow holes were drilled in the Permo-Triassic and younger sediments (Exon, Galloway, Casey, and Kirkegaard, 1966); the palynology of these holes is summarized in the text and in Tables B and C.

In the Augathella Sheet area four shallow holes were drilled in the Jurassic and Cretaceous sediments; the palynology of BMR Augathella No. 3 and No. 4 is presented in Table E. One deep well was drilled in the area, Westbourne No. 1, and some observations on this well are included in the text. Deep wells drilled after 1966 are not considered in this report, as they are still under study.

The location of the boreholes and wells is shown on Figure A. General pollen stratigraphy of a wider area, including data from other boreholes, is given in Figure B.

PALYNOLOGICALLY UNDETERMINED AGE

The Westbourne No. 1 well finished in hard steel-grey indurated shale, with calcareous bands and disseminated pyrite, dipping at more than 40^{o} in core 11 (4684-87 ft; 1427.7-28.6 m), which Gerrard (1964a) compared with the Devonian in Birkhead No. 1, exemplified in core 5 at 5136 feet (1565.4 m). De Jersey (1962) and Evans (1962a) obtained spores from the Devonian sequence in the Birkhead well, but the core from the Westbourne well yielded only carbonized residues, without spores. The lithology of the basal shale appears to be closer to that of the Timbury Hills Formation, which forms effective basement to

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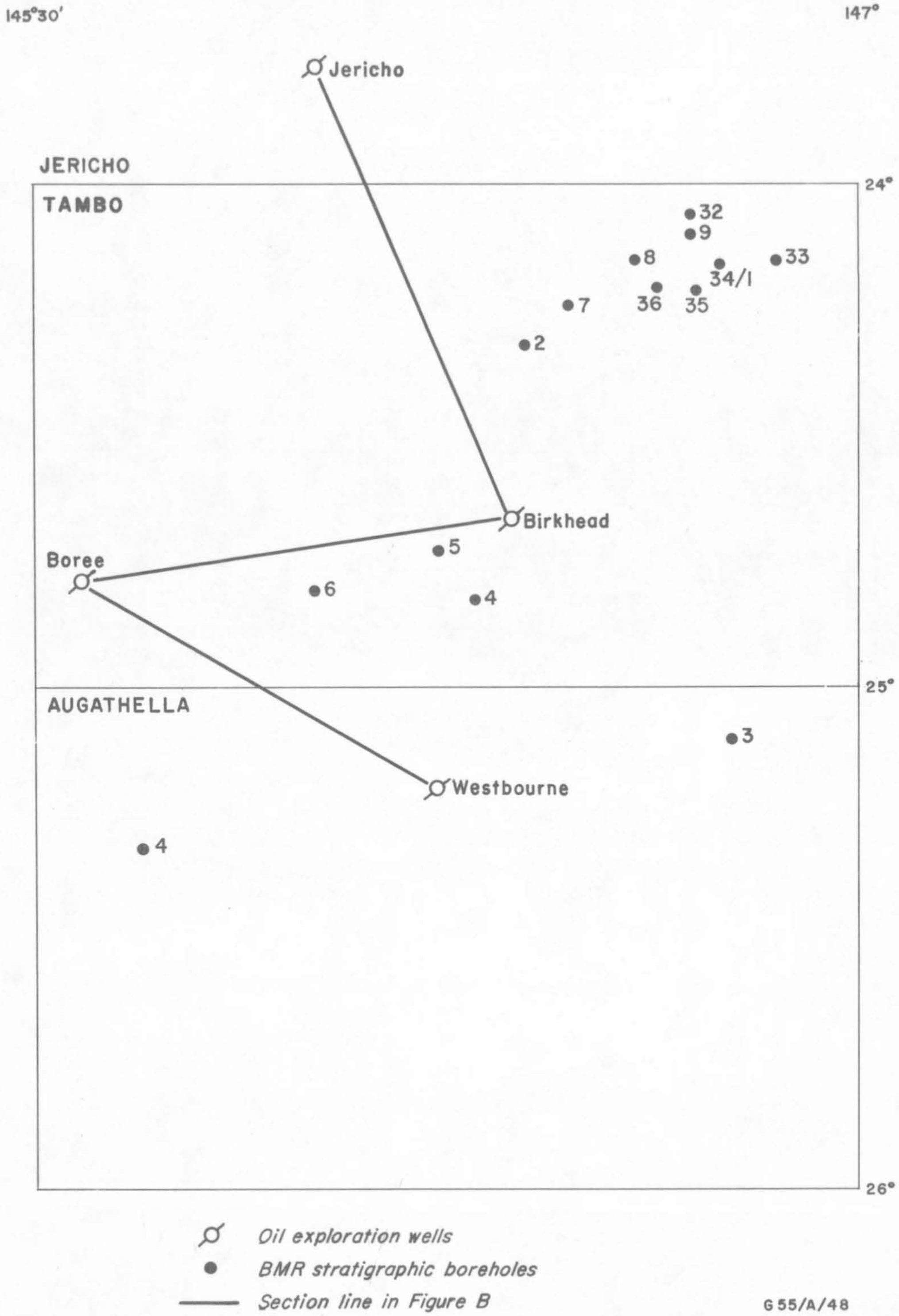

Fig. A. Approximate locations of wells and boreholes.

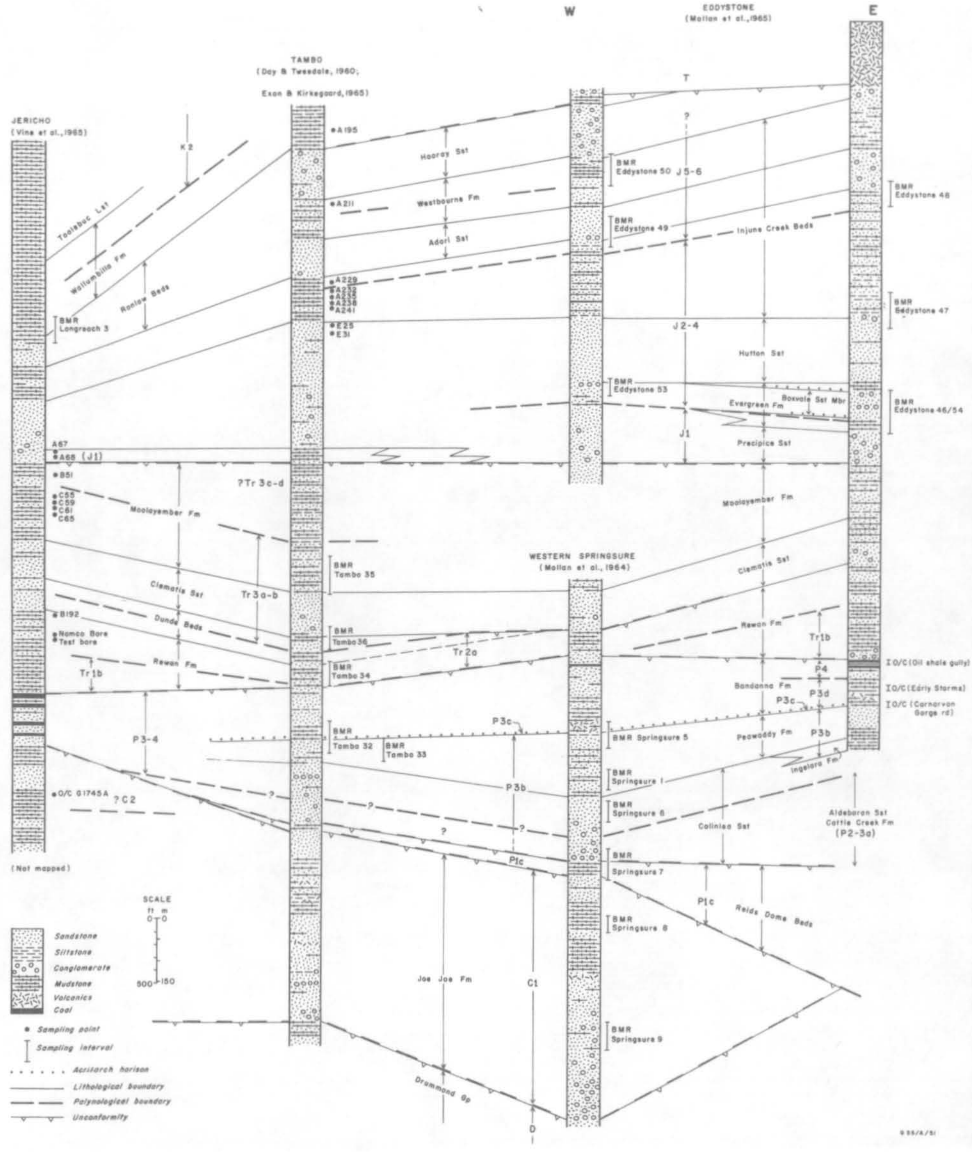

Fig. B. Stratigraphic correlations.

many wells farther east, than to the Devonian in the Birkhead and Boree wells. Sediments referred to the Timbury Hills Formation in Pickanjinnie No. 2 (Mary E. White, pers. comm.) in the Surat Basin, and in Purbrook No. 1 (Woods, in Minad, 1963) in the Bowen Geosyncline, have yielded Devonian plant remains. If all rocks ascribed to the Timbury Hills Formation are of Devonian age, considerable change in induration and attitude must take place across a zone between the western part of the Tambo and eastern parts of the Eddystone and Springsure Sheet areas. The apparent contrast in attitude between pre-Permian rocks in the Boree and Westbourne wells may be an expression of this change. Alternatively, the basal part of the section in the Westbourne well could be pre-Devonian.

LOWER/UPPER(?) DEVONIAN

Lower or Middle Devonian sediments of the Adavale Basin were encountered in the Boree and Birkhead wells. Gerrard (1964b) supposed that the arkose at the base of Boree No. 1 was as old as Silurian, although there is no palaeontological evidence to support this view. De Jersey (in Gerrard, 1964b) was unable to extract recognizable microfloras from core 21 (7967-77 ft; 2428.3-31.4 m) and core 22 (8231-40 ft; 2508.8-11.6 m) in the succeeding sandstone and carbonate section, below the halite 'Boree Formation' (see Gerrard, 1964b), but Jones (in Gerrard, 1964b) identified conodonts of probable Lower Devonian age within them. De Jersey extracted an abundant, well preserved, and diverse microflora from core 17 (6206 ft; 1891.6 m), including Archaeotriletes and Ancyrospora, and concluded that it was of Lower or Middle Devonian age, possibly younger than sections below about 8000 feet (2400 m) in the Etonvale No. 1 well, that is, to lithological unit D3 or younger in the Etonvale Formation (Lewis & Kyranis, 1962; Heikkila, 1965). De Jersey (in Gerrard, 1964b) recorded a small microflora from core 10 (4776-88 ft; 1455.7-59.3 m) in Boree No. 1, which, because of the presence of Chomotriletes sp., he thought to be basal Upper Devonian in age, comparable with the D2 horizon of the Etonvale Formation. Heikkila (1965) compared the varicoloured sandstone-shale section, above the 'Boree Formation' in Boree No. 1, with units D1-2 of the Etonvale Formation, and the Buckabie Formation, allowing it to be as young as Upper(?) Devonian, a view still consistent with the palynological evidence.

De Jersey (1962) recognized a Devonian microflora in Birkhead No. 1 (core 5 at 5136-41 ft; 1565.4-67 m) which included Archaeozonotriletes and abundant Radiaspora sp., which by their state of preservation were compared with spores in unit D2 of the Etonvale Formation (Lewis & Kyranis, 1962; Heikkila, 1965). Evans (1962a) recognized 'pre-Permian (?)' spores on the basis of their state of preservation from cuttings at 5000 to 5002 feet (1524-24.6 m) and 5035 to 5045 feet (1534.6-37.7 m) in the Birkhead well, which should now be regarded as Devonian in age. Although positive evidence of Devonian spores above this level in the Birkhead well is lacking (in spite of an examination of a number of cuttings which consisted mostly of cavings), the top of the Devonian is taken on lithological and electric log evidence at about 4450 feet (1335 m).

These observations leave some doubt about the correlation between the Devonian sequences in the Birkhead and Boree wells, but they favour the suggestion that the carbonate sequence in the Birkhead well may at least be younger than the 'Boree Formation'.

In both wells, the Devonian is unconformably overlain by Upper Carboniferous strata of the Joe Joe Formation.

UPPER CARBONIFEROUS/LOWER PERMIAN

Palynological divisions of the Upper Carboniferous and Permian sections in the north-eastern Eromanga Basin, particularly in the Longreach area, were outlined by Evans (1964b) and are here expressed in Evans' (1967) palynological stages.

Stage 1 (unit C1)

Evans (1962a) referred Birkhead No. 1, core 4 (3600 ft; 1097.3 m) to an 'early Permian' age. Re-examination of this core led to the recognition of the assemblage listed in Table A. Because of its content of Kraeuselisporites sp. 35, Vallatisporites sp. and aff. Dictyototriletes sp. 43, common Punctatisporites sp. 7, and an apparent lack of striate saccate pollen grains, the core is considered to be of Stage 1 age. This age is extended to the interval 3400 to 4450 feet (1036.3-1356.4 m) in which Grissett (1957) recorded sandstone and conglomerate composed mainly of volcanic material, and the boundaries of which are chosen from electric logs.

A Stage 1 assemblage occurred in Boree No. 1 core 8 (4355 ft; 1327.4 m) (Evans, in Gerrard, 1964b); this has been redetermined here as:

Punctatisporites gretensis (sp. 5)

Calamospora (sp. 4)

Retusotriletes diversiformis (sp. 6)

Punctatisporites (sp. 7)

Perinotriliti (sp. 10)

Verrucosisporites (sp. 173)

Verrucosisporites cf. (sp. 171)

Verrucosisporites (sp. 30)

Vallatisporites (sp. 37)

The assemblage is distinguished by the apparent absence of saccate pollen grains. It was unfortunately previously referred to unit P1a, a manuscript name used before the full sequence was recognized. The assemblage closely resembles what now is recognized under the term Stage 1 (Evans, 1964b, 1967).

In the Birkhead and Boree wells, and farther east in outcrops on the Fairview Anticline, Stage 1 is unconformably overlain by late Permian (Stage 4-5) sediments.

LOWER PERMIAN

Stages 3-4 (units P1c-P2)

Small pockets of Reids Dome Beds, equated with Stage 3 (unit P1c), have been identified in the Springsure and Tambo areas (Mollan, Exon, & Kirkegaard, 1964; Exon & Kirkegaard, 1965), but they are not present in the Birkhead or Boree wells. Development of Stage 3 coincides with the initial growth of the Denison Trough, when the thick deposits of the coal-bearing Reids Dome Beds were formed. No corresponding trough is yet known to have formed in the Galilee Basin and, unless the structures were formed in Stage 3 time, with deposition around their flanks, sediments of Stage 3 age are confined to the more northerly and westerly parts of the Galilee Basin. There was a general shrinkage in the area of deposition during this period.

LOWER/UPPER PERMIAN

Stages 4-5 (units P3a-P3-4)

The marine Permian of the Denison Trough was initially subdivided on the basis of spores and microplankton into units P2 and P3a-d. The definition and stratigraphic significance of unit P3a, within Stage 4, are still under discussion, but the base of unit

P3b is defined by the appearance of Dulhuntyispora parvithola (sp. 123) (B. & H.) and associated forms such as Anapiculatisporites ericianus (sp. 115) (B. & H.) and Acanthotriletes uncinatus (sp. 114) (B. & H.). Unit P3b is easily recognized and is now the base of Stage 5 (Evans, 1967). In the Denison Trough unit P3b commences near the top of the Aldebaran Sandstone. It contains characteristic microplankton and is overlain by unit P3c, consisting of a swarm of the acritarch Baltisphaeridium sp. 360*, found at the base of the Black Alley Shale. Unit P3d, still within Stage 5, is characterized by a species of Veryhachium. It includes the rest of the Black Alley Shale, but was not identified in the Bandanna Formation west of the Denison Trough until BMR Tambo No. 9 was drilled in the northeastern part of the Sheet area (p.88). Unit P4, which constitutes the highest interval of Stage 5, lacks microplankton at most points, and is marked by a proliferation of striate, disaccate pollen grains, and rare spores. Apart from this change in the abundance of major groups, and the absence of microplankton, only a few potential divisors of P3 and P4 are yet known. Evans (1964b) thus combined units P3 and P4, which subsequently became Stage 5 (Evans, 1967), in order to express the palynology of sections above the Joe Joe Formation and Reids Dome Beds in the Galilee Basin.

Unit P3c is the most widespread acritarch horizon in the sequence. Firmly identified at the base of the Bandanna Formation (base of the Black Alley Shale) in outcrop on the southern nose of Reids Dome, it has been found in the Springsure Sheet area (BMR Springsure No. 5) at the same stratigraphical position, immediately above the Mantuan Downs Productus horizon on the Springsure Shelf. In the Tambo Sheet area unit P3c was recovered from cuttings at 130 to 140 feet (39.6-42.7 m) (presumably Peawaddy Formation) in Tambo BMR No. 32 as well as in cuttings at 3250 feet (990.6 m) (Peawaddy Formation) in the Birkhead well (Table A). However, neither the sample from Tambo BMR No. 33, nor the core sample at 182 feet (55.5 m) from Tambo BMR No. 32, both from the Peawaddy Formation, yielded microplankton. Cuttings at 140 to 150 feet (42.7-45.7 m) in Tambo BMR No. 32 (P3b) yielded acritarchs, but these include contaminants from higher (P3c) levels. Cuttings between 1650 and 1710 feet (502.9-21.2 m) in Jericho No. 1, from an interval which Benedek (1965) regarded as the Peawaddy Formation, yielded rare acritarchs (Micrhystridium and Veryhachium). The brackish or marine character of the Peawaddy Formation thus seems to be lessening westwards, but more control points are needed before a positive assessment of this facet can be made.

Lithological similarity between the Bandanna Formation of Birkhead No. 1, and the sections from 3785 to 4009 feet (1153.6-221.9 m) in Boree No. 1 and 1300 to 1588 feet (396.2-484 m) in Jericho No. 1, led to an examination of cuttings from the base of the latter sections for Baltisphaeridium sp. 360; none was found. The sandstone between 3250 and 3400 feet (990.6-1036.3 m) in the Birkhead well, of presumed P3b age, also seems to have no counterpart in Boree No. 1, and it appears that P3b and P3c sediments could be overlapped in a southwesterly direction across the Galilee Basin.

Evans (in Galloway & Ingram, 1967) was the first to find microplankton (acritarchs) associated with unit P3d microfloras west of the Denison Trough, where they are restricted to the Black Alley Shale (Evans 1964b, 1966b). The Black Alley Shale on the Springsure Shelf, as seen in Springsure BMR No. 5, does not appear to contain these fossils. The Black Alley Shale in outcrop or near surface in the Tambo Sheet area has not been examined, although subsurface samples in the Birkhead, Boree, and Westbourne wells did not yield microplankton. Sediments younger than P3c were identified in BMR Tambo No. 9, which commenced in the Black Alley Shale and entered the Peawaddy Formation. Two samples were examined. Core 1 (Table B) yielded an abundance of spores, pollen grains, and occasional algae. Spinose acritarchs were not observed. The variety

*The system of coding palynomorph species now employed in the BMR supersedes previously used numerical codes. Baltisphaeridium sp. 360 = Micrhystridium sp. 3 of earlier reports.

of spores relative to pollen grains is suggestive of a P3d rather than a P4 age, in keeping with the regional age of the Black Alley Shale. However, the lack of acritarchs precludes firm identification of the zone and contrasts strongly with the Black Alley Shale intersected by the nearby BMR Tambo No. 1, which in core 3, at 161 feet 10 inches (49.32 m), contained abundant Veryhachium sp. 3, the diagnostic component of unit P3d. Spores and pollen grains from core 2 in BMR Tambo No. 9 (Peawaddy Formation) were relatively common but diluted with abundant micronitic material. No acritarchs could be seen. The spores listed in Table B confirm a Stage 5 (P3b-P4) age (Evans, 1967) for the Peawaddy Formation in the Tambo Sheet area. The presence of the unit P3d microfossils in the Blackwater Group in the Tambo Sheet area may now be interpreted:either there is a lateral facies change westwards which brings a lithology of Blackwater Group type into the Tambo Sheet area at an earlier time than in the region of the Denison Trough; or the marine or brackish facies, in which the microplankton thrived, briefly returned to the Tambo area later than its final withdrawal from the Denison Trough. The palynology of the subsurface Carboniferous and Permian in the Galilee Basin and Springsure Shelf is treated in more detail by Evans (1966b,e).

LOWER TRIASSIC

The Lower Triassic of the Bowen Geosyncline is divisible into four units - Tr1a, Tr1b, Tr2a, and Tr2b (Evans, 1965). The lowest of these (Tr1a) has not yet been recognized outside the Denison Trough. The succeeding unit (Tr1b) is widespread across at least the southern half of the geosyncline. It is represented in the Galilee Basin by only one sample from Maranda No. 1 (core 6 at 2073 ft; 631.8 m) where 'Trizonaesporites' sp. 258, and fairly common Striatiti sp. 262 occur, apparently in the absence of Densoisporites (al. Lundbladispora) playfordi (Balme) (sp. 243). This core was cut about 220 feet (67 m) above the base of the Rewan Formation. From thickness considerations, the unit may occur in the Galilee and perhaps in the Jericho Sheet areas (Evans, 1966b), although it is apparently missing from the Tambo and perhaps the Springsure Sheet areas.

Units Tr2a-b

Unit Tr2a is the most widespread division of the Lower Triassic west of the Bowen Geosyncline. Recognized by its content of Densoisporites playfordi (sp. 243) and an increased abundance of Taeniaesporites spp., it overlaps older divisions of the Lower Triassic in the Tambo Sheet area. In Tambo BMR No. 34 unit Tr2a rests directly on Permian sediments. The basal core from Tambo BMR No. 34 yielded a (?) Quadrisporites horridus (sp. 211) Hennelly and rare 'Trizonaesporites' (sp. 258), suggesting that basal Tr2a is represented there. Younger horizons in the zone have been sampled from higher in Tambo BMR No. 34, from Jericho No. 1, the Namco bore and other test bores in the Jericho Sheet area, and Maranda No. 1 in the Longreach Sheet area. However, in association with older Lower Triassic units, unit Tr2a cuts out farther south in the Tambo Sheet area. Where evidence is available, unit Tr2a is succeeded by unit Tr3. Unit Tr2b has not yet been recognized in the Galilee Basin, but this may be due to collection failure. Whether or not the unconformity between unit Tr3 and pre-Triassic strata in the southern part of the Sheet area and Longreach Sheet area represents a regional hiatus in the Galilee Basin, or merely an extension of the transgressive phase initiated in Tr2a time, cannot be ascertained. The Dunda Beds, which are interposed between Rewan Formation of Tr2a age and the Clematis Sandstone of Tr3 age in the northern portion of the Galilee Basin, are apparently not present in Maranda No. 1 in the Longreach Sheet area, or east of the Birkhead structure (N.F. Exon, pers. comm.). This formation is not merely a facies variant of the Rewan Formation, as their Tr3 age in Tambo BMR No. 36 indicates, and may comprise sediments deposited during a generally regressive phase between Tr2a and Tr3 times. Unit Tr2b may be found within the base of the Dunda Beds.

The transgressive character of unit Tr2a is well illustrated by the abundant content (18 % of a count of 300) of acritarchs Veryhachium cf. V. reductum reductum (sp. 270) de Jekhowsky and Micrhystridium sp. 273 in Jericho No. 1 (core 1 at 1212 ft; 369.4 m), which is probably indicative of brackish or marine conditions of sedimentation. Rare specimens of undifferentiated species of Veryhachium also occur in Tambo BMR No. 34 (cuttings from 70-80 ft; 21.3-24.4 m). Spasmodic occurrences of relatively rare acritarchs are known from older Lower Triassic sections in the Bowen Geosyncline, but nothing as abundant as the Jericho collection of Lower Triassic acritarchs has previously been found in Australia in other than the Perth and Canning Basins. The abundant Taeniaesporites spp. and the presence of Densoisporites playfordi link unit Tr2a with the Lower Triassic (Otoceratan) Kockatea Shale Taeniaesporites assemblage of the Perth Basin (Balme, 1963), the macrofauna of which (Dickins & McTavish, 1963) is in turn comparable in certain aspects with that found in the Maryborough Basin (Denmead, 1964). The Lower Triassic of Tr2a age thus appears to have been a period of at least ephemeral marine transgression in both eastern and western Australia, and the acritarchs in the Jericho well are perhaps a reflection of this event. Other Tr2a acritarch and perhaps macrofossil occurrences in the eastern Australian Triassic basins, particularly the Bowen Geosyncline, may be expected.

MIDDLE/UPPER TRIASSIC

Units Tr3a-d

It has long been recognized that unit Tr3, characterized by an abundance of Alisporites spp., is well represented in the Bowen Geosyncline; it is the most extensive Triassic unit in the Galilee Basin, and overlaps older sediments to rest on the Permian in the Tambo Sheet area. It has been identified in Tambo BMR No. 35 and No. 36 and in other borehole sections in the region (Evans, 1966b). Lists of the microfloras from these sections and concurrent studies in the Bowen Geosyncline led to the subdivision of unit Tr3 (Evans, 1965) on the basis of the distribution of species of Aratrisporites spp, and Duplexisporites gyratus Playford & Dettmann.

A succession of species of Aratrisporites begins to appear as early as unit Tr2a with A. coryliseminis (sp. 249) Klaus, followed by A. sp. 252 (?= A. strigosus Playford) in Tr2b and, restricted to the unit, A. tenuispinosus (sp. 250) Playford and A. banksi (sp. 248) Playford in Tr3b. Evans (1965) thought that Aratrisporites died out before the introduction of Duplexisporites gyratus, leaving a section termed Tr3c below the base of Tr3d, marked by the first appearance of D. gyratus. However, subsequent information from the Leigh Creek area of South Australia (Playford & Dettmann, 1965) showed that A. coryliseminis, A. flexibilis P. & D., and A. paenulatus P. & D. occur in association with D. gyratus, and Evans' stratigraphic division Tr3c is not acceptable as defined. Consequent investigation led to the confirmatory discovery of A. cf. A. tenuispinosus with D. gyratus in Birkhead No. 1 (cuttings at 1700 ft; 518.2 m). Unit Tr3c is consequently linked with Tr3d and the composite Tr3c-d defined as a sequence beyond the end of A. banksi (sp. 248), and including the first appearance of D. gyratus.

Unit Tr3a starts at least in the top of the Dunda Beds of Tambo BMR No. 36, and continues into the Clematis Sandstone, and extends into the lower parts of the Moolayember Formation. No acritarchs have been discovered in unit Tr3 in the Galilee Basin, although they occur at several points in the Bowen Geosyncline.

BMR Tambo No. 8 was drilled through the Triassic Dunda Beds and entered the Rewan Formation. Little of the two cores from the hole was suitable for examination, and all the samples examined were unfossiliferous.

BMR Tambo No. 7 commenced in the Precipice Sandstone and entered the Moolayember Formation. Samples were collected for examination to test the suggestion that rocks associated with Jurassic palynological unit J1 developed the character of the Moolayember Formation in the Tambo Sheet area (Evans, 1966b). However, samples from cores 1 and 2 (92-246 ft 5 in; 28-74.8 m) failed to yield any palynomorphs and the question remains unsolved.

SURAT AND EROMANGA BASINS

JURASSIC

Unit J1

Unit J1, marked by the introduction of Classopollis in the pollen sequence, commences above the unconformity between the Moolayember Formation and Precipice Sandstone in the Surat Basin. It has been located in the Precipice Sandstone of Tooloombilla No. 1 (Evans & Hodgson, 1965) and BMR Tambo No. 2, as well as in the lower Evergreen Formation, below the Boxvale Sandstone Member in Taroom BMR No. 46 and No. 54, immediately east of the Eddystone Sheet area. It was identified in Boree No. 1 (sidewall core at 3228 ft; 983.9 m) in the western part of the Tambo area and probably exists in the Westbourne No.1 section (Evans, 1966b). It occurs in the Birkhead No. 1 well (cuttings at 1400 ft; 426.7 m), below what is thought to be the Precipice Sandstone, an anomaly briefly mentioned by Evans (1964a). It may be that finer-grained sediments below the main sandstone bench in the area are also of Jurassic age (Evans, 1966b). N.F. Exon (pers. comm.) has noted how the Precipice Sandstone trends into a silty facies along the strike in the Tambo Sheet area, a feature perhaps related to the palynological observations.

Existence of a considerable hiatus between units Tr3c-d and J1 in the area is still postulated, as there is no evidence of the presence of correlates of the Ipswich Coal Measures and Bundamba Sandstone of the Ipswich-Clarence Basin.

Unit J2

The base of J2 is marked by the introduction of Tsugaepollenites segmentatus (Balme) and is accompanied by a brief appearance of acritarchs in the Surat Basin (Evans, 1962b, 1964a), immediately above the Boxvale Sandstone Member of the Evergreen Formation with the 'oolite horizon' (= Westgrove Ironstone Member). However, close sampling of Taroom BMR No. 46 and No. 54 has shown that there are two horizons of acritarch swarms, one above and one below the Boxvale Sandstone. The upper zone, as previously recognized, is associated with the Westgrove Ironstone Member, in that acritarchs appear immediately below and at the top of the member. The lower zone occurs immediately below the Boxvale Sandstone. The intermediate bench of finer material in the Boxvale Sandstone Member, mapped in outcrop (Mollan, Exon, & Forbes, 1965), cannot be identified in Taroom BMR No. 46 and No. 54, and there is some doubt whether the mudstone and very fine sandstone containing the lower acritarch zone in fact represents this intra-Boxvale interval. Also, acritarchs may occur within the sandy facies of the Boxvale Sandstone. The existence of two specifically distinguishable acritarch developments within the Evergreen Formation is useful in detecting the relative ages of sandstones within the formation.

Core 1 in BMR Tambo No. 2 appears to have been taken near the base of unit J2, but no sign of acritarchs was found in the residue. The westerly limit of the acritarch swarms must occur in the Eddystone Sheet area between Crystalbrook No. 1 (6.5 % at 350-60 ft; 106.7-9.7 m) and Eddystone BMR No. 53 (no acritarchs in several samples from the Westgrove Ironstone Member). No trace of the acritarchs found in the Evergreen has yet been recorded in the Eromanga Basin.

Units J5-6

Microfloras of J5-6 age are known from the upper part of the Birkhead Formation, Westbourne Formation, and Hooray Sandstone of the eastern Eromanga Basin (Evans, 1966a,b). The units were also recognized in microfloras from the Injune Creek Group, Gubberamunda Sandstone, and Orallo Formation in the Surat Basin (Evans, 1966a; Burger, 1968a). An attempt to separate a new unit J6 within the interval by the first appearance of Aequitriradites spp., noticed as early as the Gubberamunda Sandstone in AAO No. 1 (Roma), was unsuccessful because of the rarity of the nominate fossil. In BMR Tambo No. 5 undifferentiated J5-6 microfloras were recovered from core 5 (Hooray Sandstone) and core 9 (Westbourne Formation). Identical assemblages were also recognized in BMR Jericho No. 9 (Westbourne Formation and basal part of the Hooray Sandstone) as well as in core 14 from BMR Augathella No. 3 (Westbourne Formation; see Table E).

CRETACEOUS

Units K1a-b

The earliest K1a microfloras, characterized by the co-occurrence of Murospora florida and Cicatricosisporites spp., were recorded from the uppermost Orallo Formation in the Surat Basin (Burger, 1968a). Unit K1a is known to extend upwards as high as the base of the marine section of the Bungil Formation. Basal K1 microfloras were also recorded from the Hooray Sandstone in the eastern Eromanga Basin (Evans, 1966b) below the marine Cretaceous. Undifferentiated K1a-b microfloras were identified from the Hooray Sandstone and the overlying basal marine Cretaceous in BMR Tambo No. 5, but insufficient spore recovery prevented positive recognition of unit K1a. Initial examination of BMR Augathella No. 3 (core 1, Wallumbilla Formation; MFP4383) led to recognition of unit K1b for its microflora. Subsequent detailed re-examination of this spore interval in various borehole sections in the Surat Basin opened the possibility of a K1a age for the assemblage as well. The associated microplankton indicated the Dingodinium cerviculum Dinoflagellate Zone. The presence of Crybelosporites stylosus, together with some microplankton species (Canningia n. sp. Evans, 1966c; Micrhystridium sp.), forms a combination which is commonly encountered in the marine Minmi Member of the Bungil Formation farther southeast.

From these data a relationship of the Hooray Sandstone (eastern part of the Eromanga Basin) to the formations of the Surat Basin emerges, which is shown in Table F. This correlation is almost identical with that resulting from Evans' (1966b) palynological studies in the Longreach, Tambo, and Taroom Sheet areas. There are certain indications that the boundary between the lower and upper parts of the Hooray Sandstone, where recognized, should be correlated with some level in the upper part of the Bungil Formation in the Roma-Mitchell area.

Units K2

The spore zonation in the interval of the K2 units, beginning with the first appearance in the spore sequence of Coptospora paradoxa and Microfoveolatosporis canaliculatus (Evans, 1966a; Burger, 1968b,c), is at present being studied in more detail in connexion with recent information on the microfloras from the central and northern parts of the Eromanga Basin as well as the Surat area in the central Surat Basin. Although Coptospora paradoxa was not encountered in the microfloras from BMR Tambo No. 6, it is known to occur in pre-Toolebuc Limestone horizons in the Longreach Sheet area (Burger, 1968b). The presence in BMR Tambo No. 6, close to the Toolebuc Limestone (core 1; MFP4379), of Microfoveolatosporis canaliculatus and Pilosisporites grandis, reported by Dettmann

(1963) only from her Paradoxa Assemblage and encountered in Queensland only in K2 microfloras (Burger, 1968b,c), strongly favours a K2 age for assemblage MFP4379. The presence of (?) Dictyotosporites speciosus and tricolpate angiospermous pollen grains suggests an uppermost K2a to lowermost K2b age (Burger, 1968b,c).

BMR Augathella No. 4 (core 2) contains besides Coptospora paradoxa various types of smooth-walled and ornamented tricolpate pollen grains. Identical microfloras were also recovered from the Winton Formation in WOL No. 1 and No. 2 (Warbreccan) and provisionally attributed to the Upper Cretaceous (Cenomanian ?; Evans, 1966d). Palynological criteria for the spore-pollen zonation of the Upper Cretaceous in Australia have been discussed in Dettmann & Playford (1969). At present this zonation is not applied to the Winton Formation microfloras, as they appear to be intermingled with older Cretaceous microfossils, probably by reworking of sediment. Moreover, data from the Winton Formation are too scarce to justify far-reaching conclusions from the microfossils recovered.

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TABLE A : MICROFOSSIL DISTRIBUTION CHART - SPL BIRKHEAD NO. 1 AND TAMBO BMR NO. 32 AND NO. 33

Microfossil	GAB= Field Locality / MFP= Sample registration number	SPL 1 (BIRKHEAD)					BMR33		BMR32	
	Age	C1	P3c	P3-4					P3b	P3c
	Sample	MFP1112 Core, 3600'	MFP1977 Cuttings, 3250'	MFP1976 Cuttings, 3150'	MFP1975 Cuttings, 3050'	MFP1116 Cuttings, 2900'	MFP3573 Core 1, 84½'	MFP 3570 Core 1, 186'	MFP3572 Cuttings, 140-50'	MFP3571 Cuttings, 130-40'
Leiotriletes sp.	1	-	-	-	-	-	-	-	-	-
Punctatisporites sp.	3	+	-	-	-	-	-	-	-	-
Calamospora sp.	4	+	-	-	-	-	-	-	-	-
Punctatisporites sp.	7	+	-	-	-	-	-	-	-	-
Granulatisporites sp.	8	+	-	-	-	-	-	-	-	-
Perinotriliti sp.	10	+	-	-	-	-	-	-	-	-
aff. Retusotriletes sp.	12	+	-	-	-	-	-	-	-	-
Rugulatisporites sp.	22	+	-	-	-	-	-	-	-	-
Kraeuselisporites sp.	35	+	-	-	-	-	-	-	-	-
Vallatisporites sp.	37	+	-	-	-	-	-	-	-	-
aff. Dictyototriletes sp.	43	+	-	-	-	-	-	-	-	-
Monosacciti sp.	44	+	-	-	-	-	-	-	-	-
Parasaccites sp.	50	+	-	-	-	-	-	-	-	-
Parasaccites sp.	51	+	-	-	-	-	-	-	-	-
Calamospora sp.	58	+	-	-	-	-	-	-	-	-
Cingulati sp.	69	+	-	-	-	-	-	-	-	-
Cyclogranisporites sp.	100	+	-	-	-	-	-	-	-	-
aff. Cristatisporites sp.	174	+	-	-	-	-	-	-	-	-
Punctatisporites gretensis	5	+	-	+	-	-	-	-	-	-
Retusotriletes diversiformis	6	+	+	+	-	-	-	-	-	+
Dulhuntyispora dulhuntyi	122	-	+	-	-	-	-	+	-	+
Vitreisporites sp.	135	-	+	-	-	-	-	-	+	-

Striatoabietites sp.	149	-	+	-	-	-	-	-	-	-
Striatopodocarpites sp.	210	-	+	-	-	-	-	-	+	+
Baltisphaeridium sp.	360	-	c	-	-	-	-	-	+	c
Micrhystridium spp. undiff.	-	-	+	-	-	-	-	-	+	+
Veryhachium sp.	361	-	+	-	-	-	-	-	-	+
Microfoveolatispora trisina	372	-	+	+	-	-	-	-	+	-
Dulhuntyispora parvithola	123	-	+	-	+	-	-	-	+	+
Vesicaspora sp.	137	-	+	+	+	-	-	-	+	+
Protohaploxypinus amplus	147	-	+	+	+	-	+	+	-	+
Protohaploxypinus sp.	148	-	+	+	+	-	+	+	-	+
'Marsupipollenites' sinuosus	151	-	+	+	+	-	-	-	-	-
Marsupipollenites triradiatus	152	-	+	+	+	-	+	+	+	+
Leiotriletes directus	207	-	+	+	+	-	+	-	-	+
Anapiculatisporites ericianus	115	-	+	+	-	+	-	+	+	+
Kraeuselisporites apiculatus	127	-	+	+	+	+	-	+	+	-
Vesicaspora ovata	138	-	+	+	+	+	+	+	+	+
Parasaccites sp.	190	-	+	-	-	+	-	-	-	-
aff. Gnetaceaepollenites sp.	208	-	+	-	+	+	-	-	-	+
Granulatisporites sp.	110	-	-	+	-	-	-	-	-	-
Striatoabietites sp.	209	-	-	?	-	-	-	-	+	-
Baculatisporites sp.	109	-	-	+	-	+	+	-	-	+
Lophotriletes tereteangulatus	113	-	-	-	+	-	-	-	-	+
Limitisporites sp.	142	-	-	-	+	-	-	-	+	+
Protohaploxypinus cf. P. limpidus	146	-	-	-	+	-	+	?	-	+
Ginkgocycadophytus vetus	154	-	-	-	+	-	-	-	-	-
Striatoabietites cf. S. multistriatus	150	-	-	-	+	+	+	+	-	+
Monosaccites sp.	157	-	-	-	-	+	+	-	+	+
Granulatisporites micronodosus	111	-	-	-	-	-	+	-	-	-
Conbaculatisporites sp.	112	-	-	-	-	-	+	-	-	-
Protohaploxypinus sp.	144	-	-	-	-	-	+	-	-	-
Acanthotriletes uncinatus	114	-	-	-	-	-	-	?	-	+
Striatopodocarpites cancellatus	143	-	-	-	-	-	-	+	+	+
Bascanisporites undosus	139	-	-	-	-	-	-	+	-	-
Alisporites sp.	140	-	-	-	-	-	-	?	-	-
Platysaccus sp.	141	-	-	-	-	-	-	+	-	-
aff. Ovalipollis sp.	136	-	-	-	-	-	-	+	+	-
Perinotriliti sp.	156	-	-	-	-	-	-	+	+	-

c, common

TABLE B : MICROFLORAS FROM BMR TAMBO NO. 9

Palynomorphs	MFP4274 (core 1 93'6"-94')	MFP4275 (core 2 163'2")
Phyllothecotriletes nigritellus	x	x
Deltoidospora directa	x	x
Conbaculatisporites sp.	x	x
Baculatisporites sp.	x	-
Granulatisporites micronodosus	x	x
Lacinitriletes trisinus	x	x
Lophotriletes tereteangulatus	x	x
Didecitriletes ericianus	x	x
D. uncinatus	x	-
D. aff. dentatus	x	-
Microreticulatisporites bitriangularis	x	-
Indospora sp.	x	-
Lycopodiumsporites sp.	x	-
Kraeuselisporites spp.	x	x
Dulhuntyispora parvithola	x	-
Striatopodocarpidites cancellatus	x	x
Protohaploxypinus amplus/sewardi	x	x
Vesicaspora ovata	x	x
Striatoabietites multistriatus	x	x
Alisporites sp.	x	-
Gnetaceaepollenites sinuosus	x	-
Peltacystia sp.	x	-
Circulisporites sp.	x	-
Schizosporis calculus	x	-
Welwitschiapites ?	-	x
Marsupipollenites triradiatus	x	x
Barakarites rotatus	-	x
Parasaccites spp.	-	x
Bascanisporites undosus	-	x

TABLE C : RELATIONSHIP OF ROCK UNITS TO SPORE ZONATION
IN BMR STRATIGRAPHIC BOREHOLES IN THE TAMBO SHEET AREA

Borehole	Core	Depth	Sample No. (MFP)	Formation	Age	Unit	Remarks
	1	123'5"	4379)		Albian	K2a	M
6	2	133'4"	4380)	Toolebuc Lst	"	"	LM3
	3	149'	4381)	equivalent	"	"	LM
	1	78'	4181)		Neocomian	K1(a?)	
	2	88'	4182)	Lower part	"	"	M
5	3	95'	4183)	of Hooray Sst	"	"	L
	5	122'	4209)		U. Jurassic	J5-6	L
	9	275'5"	4211	Westbourne Fm	"	"	
4	1	277'4"	3982	Westbourne Fm	Jurassic	J5-6	A
	1	87'2"	3986	Boxvale Sst Mbr	L. Jurassic	J2	
2							
	3	210'	3987	Precipice Sst	"	J1	
7				See text			Barren
8				See text			Barren
	1	56'3"	3983	Rewan Fm	Triassic		Barren
1	2	121'	3984)	Blackwater Gp	Permian	P3d-4	
	3	161'10"	3985)		"	P3d	A
	1	93'6"-94'0"	4274	Black Alley Shale	Permian	P3d	
9							
	2	163'2"	4275	Peawaddy Fm	"	P3b-4	

Remarks: L, low spore recovery
M, marine microplankton
3, Odontochitina operculata Dinoflagellate Zone
1, Dingodinium cerviculum Dinoflagellate Zone
A, Acritarchs.

TABLE D : MICROFOSSIL DISTRIBUTION CHART,

TAMBO BMR 34, 35, AND 36

Borehole		34		36	35
Sample No. (MFP)		3589	3588	3575	3574
Depth (ft)		149	70-80	70-80	217½
Palynological unit		Tr2a		Tr3a	Tr3b
Striatiti sp.	84	?	-	-	-
Quadrisporites horridus	211	?	-	-	-
Cyathidites sp.	218	x	-	x	x
Cyclogranisporites sp.	224	x	-	-	-
Concavisporites sp.	237	x	-	-	-
Cingutriletes sp.	245	x	-	-	-
'Trizonaesporites' sp.	258	x	-	-	-
Verrucosisporites sp.	352	x	-	-	-
Retusotriletes diversiformis	6	?	?	-	-
Todisporites sp.	219	x	x	-	-
Zebrasporites sp.	239	x	x	-	-
Lundbladispora playfordi	243	x	x	-	-
Kraeuselisporites sp.	246	x	x	-	-
Punctatosporites sp.	253	x	x	-	-
Polypodiisporites ipsvichiensis	255	x	x	-	-
Striatites sp.	261	x	?	-	-
Striatiti sp.	262	x	x	-	-
Taeniaesporites cf. T. obex	263	x	x	-	-
Alisporites sp.	277	x	x	c	c
Lundbladispora brevicula	353	x	x	-	-
Cyclogranisporites sp.	222	-	x	x	-
Distalanulisporites sp.	242	-	x	-	-
Platysaccus queenslandi	278	-	x	-	-
Vitreisporites pallidus	344	-	x	-	-
Veryhachium sp. undiff.	-	-	x	-	-
Perinomonoliti sp.	309	-	-	x	x
Aratrisporites sp.	249	-	-	-	x
Conbaculatisporites sp.	294	-	-	x	x
Alisporites sp.	276	-	-	x	-
Calamospora sp.	221	-	-	x	-
Apiculati sp.	231	-	-	?	-
Aratrisporites sp.	252	-	-	x	-
Alisporites sp.	300	-	-	x	-

x, present

c, common

TABLE E : RELATIONSHIP OF ROCK UNITS TO SPORE ZONATION
IN BMR STRATIGRAPHIC BOREHOLES IN THE AUGATHELLA SHEET AREA

Borehole	Core	Depth	Sample No. (MFP)	Formation	Age	Unit	Remarks*
4	1	89'10"	4412	Winton Fm	U. Cretaceous?	Ku?	L
	2	97'	4386	" "	" "	"	
	1	63'4"	4382	Wallumbilla Fm	Aptian	K1a	LM1
	1	67'9"	4383	" "	"	"	M1A
3	3	81'10"	4384	U. part of Hooray Sst	?		L
	11	214'4"	4385	L. part of Hooray Sst	Neocomian	K1a?	
	14	378'	4387	Westbourne Fm	U. Jurassic	J5-6	

* See Table C for explanation

TABLE F : CORRELATION OF JURASSIC-CRETACEOUS FORMATIONS IN QUEENSLAND

Age	Unit	Tambo-Augathella Area	Roma-Mitchell Area	
Cretaceous	K1b	Wallumbilla Fm (lower part)	Wallumbilla Fm (lower part)	
	K1a		Bungil Fm	Minmi Mbr
		Hooray Sst	Mooga Sst	
Jurassic	J5-6		Orallo Fm + Gubberamunda Sst	
		Westbourne Fm		

APPENDIX 2

AUTHORS' FORMATION PICKS IN OIL EXPLORATION WELLS

	Alliance Jericho No. 1	SPL Birkhead No. 1	Amoseas Boree No. 1	Phillips-Sunray Bury No. 1	Phillips-Sunray Carlow No. 1	Amoseas Westbourne No. 1	Amoseas Balfour No. 1	Amoseas Cunno No. 1
Ground Level (ft)	1,282	1,556	1,094	1,077	920	1,231	1,479	1,796
Total Depth (ft)	9,142	5,185	8,781	9,004	12,028	4,867	5,560	2,828
Tertiary	0- 150						0- 110	
Mackunda Formation			0- 125	0- 180	0- 600?			
Allaru Mudstone			125- 623	180- 860	?600- 1,200			
Toolebuc Limestone			623- 640	860- 880	1,200- 1,216			
Coreena Member			640- 729	880-1,320	1,216- 1,300?	0- 380		
Doncaster Member			729-1,448	1,320-1,955	?1,300- 2,048	380- 902	110- 583	
Hooray Sandstone			1,448-1,735	1,955-2,210	2,048- 2,454	902-1,279	583-1,083	
Westbourne Formation			1,735-1,981	2,210-2,470	2,454- 2,785	1,279-1,651	1,083-1,453	
Adori Sandstone			1,981-2,149	2,470-2,673	2,785- 2,878	1,651-1,880	1,453-1,655	
Birkhead Formation		0- 516	2,149-2,454	2,673-3,094	2,878- 3,338	1,880-2,240	1,655-2,140	
Hutton Sandstone		)	)	)	)	)	2,140-2,782	0- 948
Evergreen Formation		) 516-1,220	) 2,454-3,356	) 3,094-3,865	) 3,338- 3,980	) 2,240-3,210	2,782-3,121	948- 953
Precipice Sandstone		)	)	)	)	)	3,121-3,398	953-1,205

UNCONFORMITY

	Alliance Jericho No. 1	SPL Birkhead No. 1	Amoseas Boree No. 1	Phillips-Sunray Bury No. 1	Phillips-Sunray Carlow No. 1	Amoseas Westbourne No. 1	Amoseas Balfour No. 1	Amoseas Cunno No. 1
Moolayember Formation	150- 572	1,220-1,920			3,980-4,205	3,210-3,884	3,398-3,882	1,205-2,085
Clematis Sandstone	572- 900	1,920-2,340	3,356-3,786	3,865-4,280	4,205-4,561	3,884-4,320	3,882-4,391	2,085-2,440
Dunda Beds	900-1,142	2,340-2,615						
Rewan Formation	1,142-1,300	2,615-2,860				4,320-4,484		
Upper Permian	(1,300-1,890)	(2,860-3,400)	3,786-4,009	4,280-4,600	4,561-4,800	4,484-4,605		
Bandanna Equivalent							4,391-4,550	2,440-2,625
Blackwater Group		2,860-2,930						
Black Alley Shale	1,300-1,590	2,930-3,240						
Colinlea Sandstone	1,698-1,890	3,240-3,400						
Peawaddy equivalent	1,590-1,698						4,550-4,597	2,625-2,781
Joe Joe Formation	1,890-5,507	3,400-4,460	4,009-4,457	4,600-5,264	4,800-5,546		4,597-5,481	
UNCONFORMITY								
Lower Carboniferous	5,507-9,142							
Star of Hope? + Telemon Formation	5,507-8,870							
Lower (?) Telemon	8,870-9,040							
Basal (?) Telemon	9,040-9,142							
Etonvale Formation		4,460-5,185	4,457-7,961	5,264-7,738		4,605-4,867		
Shale-Siltstone Member			4,457-4,982		5,546-6,202			
Sandstone Member			4,982-6,298	5,264-5,824	6,202-6,440			
Boree Salt Member			6,298-7,961	5,824-7,738				
UNCONFORMITY								

	Alliance Jericho No. 1	SPL Birkhead No. 1	Amoseas Boree No. 1	Phillips-Sunray Bury No. 1	Phillips-Sunray Carlow No. 1	Amoseas Westbourne No. 1	Amoseas Balfour No. 1	Amoseas Cunno No. 1
Log Creek Formation								
Bury Limestone Member			7,961-8,545	7,738-8,814				
Sandstone Member					6,440- 7,053			
Shale Member					7,053-11,230			
Gumbardo Formation			8,545-8,781	8,814-9,004	11,230-12,028			
UNCONFORMITY								
Silurian (?) Porphyry							5,481-5,560	2,781-2,828

APPENDIX 3

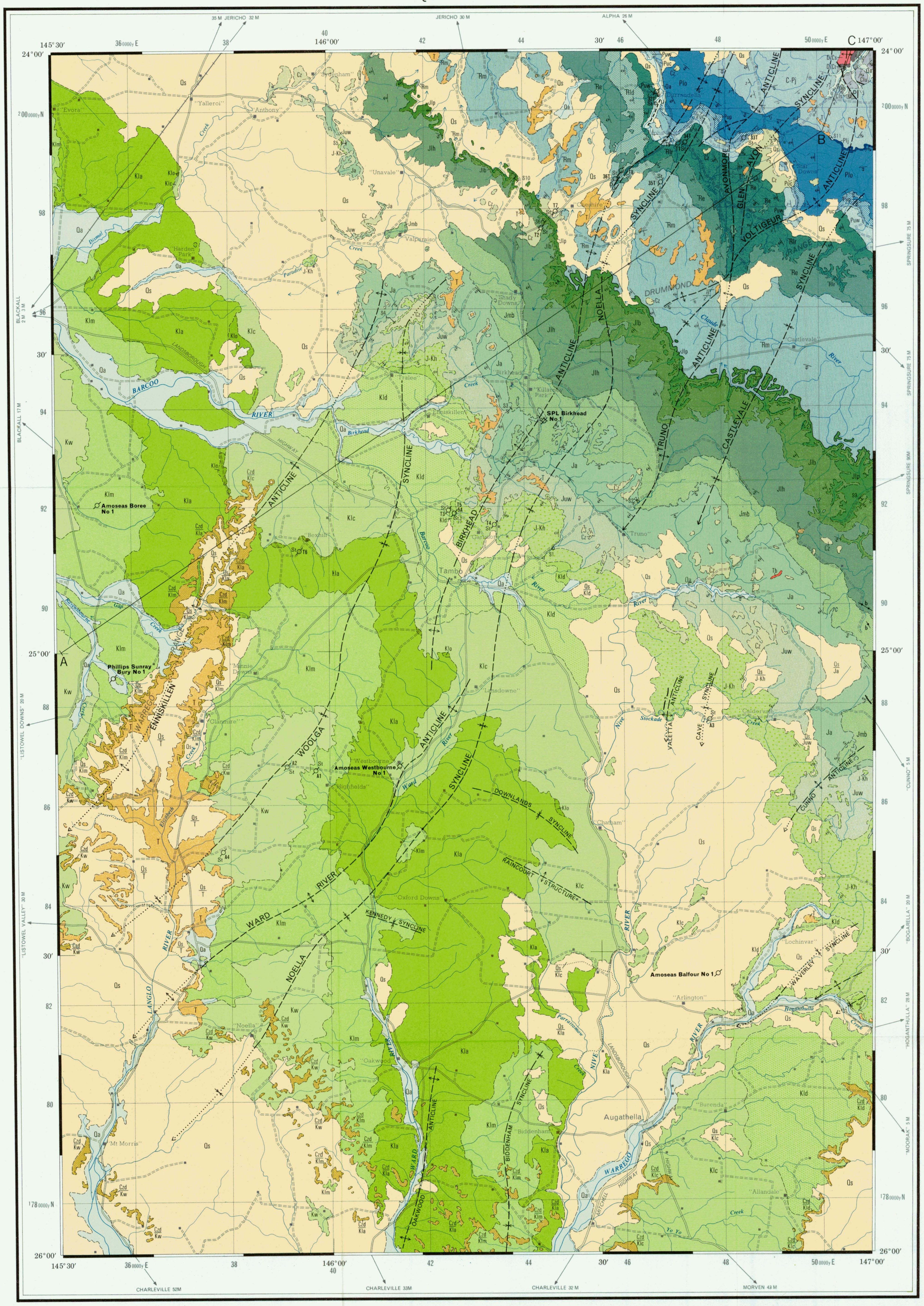
BMR STRATIGRAPHIC BOREHOLES

Hole	Year	Total Depth (ft)	Units	Grid Reference
BMR Tambo No. 1	1965	175	Rewan Fm, Blackwater Gp	472994
BMR Tambo No. 2	1965	224	Hutton Sst, Boxvale Sst Mbr, Precipice Sst	444977
BMR Tambo No. 3	1965	95	Doncaster Mbr	425920
BMR Tambo No. 4	1965	239	Westbourne Fm	434917
BMR Tambo No. 5, 5A	1966	278	Doncaster Mbr, Hooray Sst, Westbourne Fm	425919
BMR Tambo No. 6	1966	210	Allaru Mdst, Coreena Mbr	394911
BMR Tambo No. 7	1966	251	Precipice Sst, Moolayember Fm	446979
BMR Tambo No. 8	1966	217	Dunda Beds, Rewan Fm	460987
BMR Tambo No. 9	1966	172	Blackwater Gp, Black Alley Shale, Peawaddy Fm	468994
Tambo BMR No. 32	1964	250	Black Alley Shale, Peawaddy Fm, Colinlea Sst	467003
Tambo BMR No. 33	1964	180	Peawaddy Fm, Colinlea Sst	484995
Tambo BMR No. 34	1964	215	Rewan Fm	472994
Tambo BMR No. 35	1964	306	Moolayember Fm, Clematis Sst	468985
Tambo BMR No. 36	1964	169	Moolayember Fm, Clematis Sst, Dunda Beds	458985
BMR Augathella No. 1	1966	104	Mackunda Fm	396867
BMR Augathella No. 2	1966	153	Winton Fm	391868
BMR Augathella No. 3	1966	387	Doncaster Mbr, Hooray Sst, Westbourne Fm	478877
BMR Augathella No. 4	1966	177	Winton Fm	378851

GEOLOGICAL MAP

TAMBO-AUGATHELLA AREA

QUEENSLAND



Reference

CAINOZOIC	QUATERNARY			Qa	*Alluvium*
				Qs	*Sand, gravel, soil*
				Cz	*Poorly consolidated clayey sandstone*
				Czd	*Deep weathering profile*
	TERTIARY			T	*Well-bedded clayey sandstone and conglomerate; some with siltstone, mudstone*
				Tb	*Olivine basalt flows*
MESOZOIC	LOWER TO UPPER ? CRETACEOUS	Rolling Downs Group, Manuka Sub-Group	Winton Formation	Kw	*Labile sandstone; siltstone; mudstone, in part calcareous; minor coal*
	LOWER CRETACEOUS	Rolling Downs Group, Manuka Sub-Group	Mackunda Formation	Klm	*Fine labile sandstone; siltstone; mudstone, in part calcareous; coquinite*
		Rolling Downs Group, Wilgunya Sub-Group	Allaru Mudstone	Kla	*Mudstone, minor siltstone, in part calcareous; minor limestone*
			Toolebuc Limestone	Klo	*Concretionary limestone, calcareous shale*
			Wallumbilla Formation Coreena Member	Klc	*Mudstone; siltstone; fine labile to sublabile sandstone, in part calcareous; coquinite, intraformational conglomerate*
			Doncaster Member	Kld	*Mudstone, siltstone; glauconitic sandstone lenses*
	UPPER JURASSIC TO LOWER CRETACEOUS		Hooray Sandstone	J-Kh	*Cross-bedded clayey quartzose to sublabile sandstone, pebbly in part; conglomerate, siltstone*
	UPPER JURASSIC	Injune Creek Group	Westbourne Formation	Juw	*Siltstone, mudstone, very fine quartzose to sublabile sandstone*
	MIDDLE TO UPPER JURASSIC		Adori Sandstone	Ja	*Cross-bedded sublabile to labile sandstone; pebbly in part; siltstone*
	MIDDLE JURASSIC		Birkhead Formation	Jmb	*Sublabile to labile sandstone, calcareous in part; carbonaceous siltstone and mudstone, minor coal*
	LOWER JURASSIC		Hutton Sandstone	Jlh	*Clayey quartzose to sublabile sandstone; siltstone*
			Evergreen Formation Boxvale Sandstone Member	Jlb	*Cross-bedded quartzose sandstone, pebbly in part; siltstone*
			Precipice Sandstone	Jlp	*Cross-bedded quartzose sandstone, pebbly in part; siltstone*
	MIDDLE TO UPPER TRIASSIC		Moolayember Formation	Ꞧm	*Siltstone, mudstone, quartzose to lithic sandstone, calcareous in part*
			Clematis Sandstone	Ꞧe	*Cross-bedded quartzose sandstone, minor pebbly sandstone and siltstone*
	LOWER TRIASSIC		Dunda Beds	Ꞧld	*Quartzose to sublabile sandstone, siltstone*
			Rewan Formation	Ꞧlr	*Sublabile to labile sandstone; grey, green and red siltstone and mudstone*
PALAEOZOIC	UPPER PERMIAN		Blackwater Group	Puw	*Labile sandstone, calcareous in part; carbonaceous siltstone and mudstone, minor coal, fossil wood*
			Black Alley Shale	Puc	*Carbonaceous mudstone, siltstone; minor white claystone, bentonitic claystone*
			Peawaddy Formation	Pup	*Quartzose to sublabile sandstone, carbonaceous siltstone and mudstone*
	LOWER PERMIAN		Colinlea Sandstone	Plo	*Cross-bedded quartzose to sublabile sandstone; conglomerate; minor siltstone*
			Reids Dome Beds	Plj	*Siltstone and sandstone*
	UPPER CARBONIFEROUS TO LOWER PERMIAN		Joe Joe Formation	C-Pj	*Siltstone, sandstone, conglomerate, shale; minor tuff*
	LOWER CARBONIFEROUS	Drummond Group	Ducabrook Formation	Clu	*Lithic sandstone, siltstone and shale, some tuffaceous minor tuff*
			Star of Hope Formation	Cls	*Lithic sandstone, siltstone and shale, some tuffaceous; tuff*
			Raymond Formation	Clr	*Quartzose to sublabile sandstone, pebbly sandstone, minor conglomerate*
	UPPER DEVONIAN TO LOWER CARBONIFEROUS		Telemon Formation	D/Ct	*Lithic sandstone, siltstone and shale, some tuffaceous; lithic tuff, agglomerate and conglomerate, ash flows; minor limestone*
			Silver Hills Volcanics	D/Cs	*Basalt, trachyte, rhyolite*

Geological boundary

Anticline, showing plunge

Syncline, showing plunge

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

Important regional unconformity — base of Jlp

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

Strike and dip of strata

Dip <5°, *Dip 5–15°*, *Dip 15–45°*, *Horizontal strata* — *air-photo interpretation*

Dyke; b – basalt

S5 *Measured section*

S1 *Measured type section*

Abandoned well with show of gas

Dry hole, abandoned

St T1 *BMR shallow stratigraphic drill hole Tambo No 1*

St A1 *BMR shallow stratigraphic drill hole Augathella No 1*

Highway

Road

Vehicle track

Railway with station

Town

Homestead

Building

Published by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Bureau of Mineral Resources from aerial photographs and information supplied by the Division of National Mapping, Department of National Development and the Royal Australian Survey Corps. Commonwealth aerial photography; complete vertical coverage at 1:46,000 scale
Transverse Mercator Projection

Scale 1:500,000

10 0 10 20 30 MILES

10 0 10 20 30 40 50 KILOMETRES

GREY NUMBERED LINES INDICATE THE 20,000 YARD TRANSVERSE MERCATOR GRID, ZONE 7 (AUSTRALIA SERIES)

Geology, 1964-65, by N. F. Exon, M. C. Galloway (BMR), and D. J. Casey, A. G. Kirkegaard (GSQ)
Compiled, 1965-66, by N. F. Exon, E. H. J. Feeken
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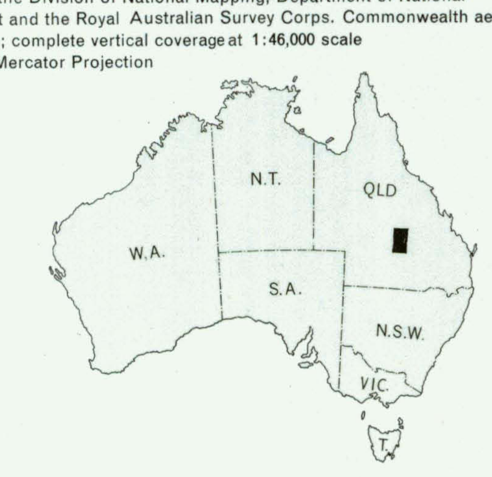
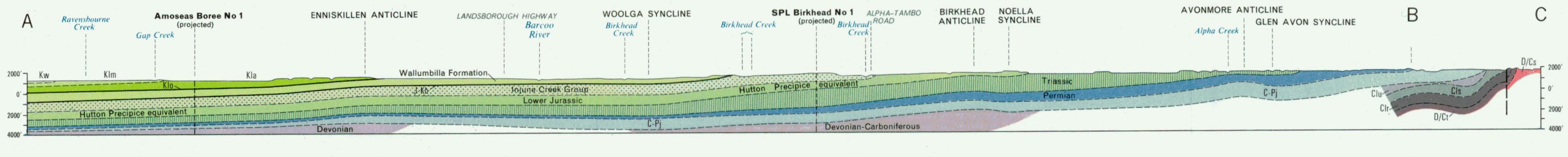


Section

Folding schematic
Cainozoic sediments omitted from section
Scale: $\frac{V}{H} = 4$



FIRST EDITION 1970

TAMBO–AUGATHELLA AREA

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