REPORT 140

THE POST-PALAEOZOIC ROCKS OF THE WARWICK 1:250000 SHEET AREA, QUEENSLAND AND NEW SOUTH WALES

N. F. Exon, R. F. Reiser, D. J. Casey, and R. L. Brunker

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SUMMARY

In 1968 the exposed Mesozoic and Palaeozoic rocks of the Warwick 1:250 000 Sheet area were mapped and a brief subsurface study was made. The area forms part of the western side of the Mesozoic Ipswich-Moreton Basin, also known as the Clarence-Moreton Basin; this Report follows the Geological Survey of Queensland nomenclature: Ipswich Basin for pre-Bundamba (early Triassic) and Moreton Basin for Bundamba and younger (late Triassic and Jurassic) sequences. The basin is bounded on the west by the northern end of the Palaeozoic Texas High. Palaeozoic sediments floor the basin and crop out on the eastern and western sides. The Palaeozoic basement surface dips gently away from the Texas High to the north and east. A maximum thickness of 2500 m of virtually flat-lying Mesozoic sediments has been drilled in exploratory wells in the central part of the basin, which lies along the eastern margin of the Sheet area.

The Ipswich-Moreton Basin is generally a simple structure, but there has been considerable post-depositional faulting and folding in the eastern part of the Sheet area. A major structure connects the South Moreton Anticline in the north, via the Grevillia and Toonumbar Anticlines, to the East Richmond Fault. The Mount Barney and Mount Alford Anticlines are associated with Tertiary intrusions.

The Mesozoic sequence is essentially conformable, with continental sediments onlapping the Texas High. The Triassic sequence is largely coal measures and volcanics. The lower part of the Jurassic sediments consists of fluviatile arkose (Ripley Road and Marburg Sandstones) derived from the Texas High. The Marburg Sandstone grades upwards into the Walloon Coal Measures, which contain considerable andesitic volcanic debris. They are overlain in the north by the labile sandstones of the Woodenbong Beds which grade laterally southwards into the quartzose Kangaroo Creek Sandstone; these may have been derived from the same source by southeast-flowing streams. The Upper Jurassic Grafton Formation, which is lithologically similar to the Walloon Coal Measures, is the youngest Mesozoic unit.

The present shape of the basin probably developed in Cretaceous and early Tertiary time, and the faulting and folding in the east belong to that period. The Oligocene-Miocene Main Range Volcanics and Lamington Volcanics, which are up to 1000 m thick in the Sheet area, unconformably overlie the exposed Jurassic units. They are mainly basalt, but trachyte is common in the Main Range Volcanics, and rhyolite in the Lamington Volcanics. Since the Miocene, erosion has continued at a rapid rate and much of the volcanic sequence has been stripped. In some areas erosion has exposed the underlying intrusive masses, which consist of acid to basic bosses, plugs, sills, and dykes; the Mount Barney and Mount Alford intrusive complexes, in particular, have a complicated geological history.

The great spread of Tertiary volcanics has hampered petroleum exploration in this part of the Ipswich-Moreton Basin, and aeromagnetic and seismic surveys cover only part of the area. Four wells have been drilled and only small hydrocarbon shows were recorded. The main targets are sandstone beds in the Triassic-Jurassic Bundamba Group, but most have poor permeability.

INTRODUCTION

A joint field survey of the post-Palaeozoic rocks of the Warwick 1:250 000 Sheet area was undertaken in 1968-69 by the Bureau of Mineral Resources (BMR), the Geological Survey of Queensland (GSQ), and the Geological Survey of New South Wales (GSNSW).

Mesozoic sediments in the Warwick Sheet area form part of the western marginal area of the Ipswich-Moreton Basin. They onlap the Palaeozoic Texas High, which occupies the southwestern half of the Sheet area. Correlation of the basal units has been complicated by the effects of depositional conditions at the margin of the basin; folding and faulting have affected the sequence towards the centre of the basin in the east of the Sheet area. Numerous Tertiary intrusions have invaded the Mesozoic sediments, and remnants of an extensive Tertiary basalt sheet cap much of the high country. The mapping has enabled the merging of the geology of the New South Wales and Queensland parts of the Ipswich-Moreton Basin. The results of the mapping were outlined in a BMR unpublished Record (Exon et al., 1969), of which this Report is an updated version, and additional details about the Lamington Volcanics were given by Exon (1972a). The Palaeozoic rocks of the Texas High are described by Olgers & Flood (1970; 1974). Explanatory Notes on the Warwick, Goondiwindi, and Dalby 1:250 000 Sheet areas are by Olgers (1972), Senior (1974), and Mond (1974) respectively. The detailed geology of the adjacent Dalby-Goondiwindi 1:250 000 Sheet areas is described by Exon et al. (1972). Shallow stratigraphic drilling in the eastern Surat Basin is outlined in Exon (1972b).

The Darling Downs area is devoted to grain growing and mixed farming. Farms are generally small, and even smaller farms are the rule east of the Main Range in Queensland, where dairying is the staple industry. Crops such as potatoes and onions are grown in irrigated areas, and fodder crops are grown extensively, often for sale. In rugged areas at the foot of the Main Range fat cattle raising is the main activity.

The main centres of population are Warwick (population 10 000), Allora, and Killarney on the Darling Downs, and Woodenbong and Kyogle in northern New South Wales. Small hamlets are common.

Access is easy, except for an area of forest west of Kyogle. Warwick lies on the Cunningham Highway, a sealed road linking Brisbane with southwestern Queensland. The Mount Lindesay Highway, also sealed, provides ready access to the eastern part of the Sheet area. Main roads are generally sealed, and formed roads abound. In forestry areas the main tracks are typically good, but some secondary tracks are suitable only for four-wheel-drive vehicles, even in dry weather.

Rainfall ranges from 750 mm on the plains in the northwest to 1500 mm in the McPherson Ranges near the coast. Water is stored in dams and earth tanks, and shallow water-bores are abundant, especially in areas of deep alluvium.

Details of five shallow stratigraphic holes drilled during the season and their grid references are given in Appendix 4. Graphic logs are shown in Figures 4, 6, and 7. Cores and cuttings are stored at the Bureau of Mineral Resources Core and Cuttings Laboratory, Fyshwick, A.C.T. Localities given in brackets thus (480420) refer to the 10 000-yard military grid shown on the Preliminary Edition of the Geological Sheet.

Crook's (1960) classification of arenites is used. The Wentworth Scale has been followed for grainsize terminology (Pettijohn, 1957; Fig. 5).

PHYSIOGRAPHY

The Warwick Sheet area (Fig. 1) lies across the Great Dividing Range; subsidiary divides include Herries Range, McPherson Ranges, and Richmond Range. These separate the area into five drainage systems: the Condamine and Dumaresq-Macintyre Rivers join the Darling River, and the Logan, Richmond, and Clarence Rivers flow into the Pacific Ocean. The larger rivers and many creeks in the east are perennial.

The area has been divided into the physiographic units shown in Figure 2, and consists of two independent provinces: the Palaeozoic massif in the southwest, and the rapidly eroding Mesozoic-Tertiary sequence in the northeast. The steeply dipping indurated sediments and the granite batholiths of the Texas High in the southwest form hilly country (maximum height 1400 m) with radial drainage. The absence of Triassic sediments and the presence of Jurassic stream sediments in present-day valleys, but not at high level, suggest that this is a mature area which has probably changed little since late Palaeozoic time. The following description is given of the five physiographic units of the Mesozoic-Tertiary province.

A mass of more than 900 m of Oligocene-Miocene volcanics (*volcanic plateaux*) has transformed the topography of the Ipswich-Moreton Basin, the land surface of which originally sloped steadily northeastwards away from the Texas High, parallel to the present-day dip of the sandstone mesa country. The Mount Warning shield volcano, immediately east of this area, poured out a mass of basalt and rhyolite which flowed away from the cone. Nearest the volcano, in the McPherson Ranges, the present-day elevation of the highest volcanics is 1200 m; at Beaudesert and Kyogle it is less than 150 m.

At much the same time intermediate and basic volcanics of the Main Range Volcanics forced their way through the soft sediments of the Walloon Coal Measures between Boonah and Urbenville, where the surface sloped westward, presumably as a result of the easterly uplift which formed the South Moreton Anticline in late Mesozoic or early Tertiary time. The highest point of the volcanic sequence is 1329 m at Mount Roberts in the east; the average elevation in the west is less than 900 m. Since the Miocene, the volcanics have been deeply dissected, and removed from some areas. Flows of differing resistance have given rise to spectacular cliffs. The Clarence and Richmond River systems were diverted to the south by the volcanic piles.

Erosion east of the Main Range has removed much of the soft Walloon Coal Measures and has exposed resistant intermediate intrusives which form jagged pinnacles rising 300 m and more above the rolling Walloon plain, which has an average elevation of 300 m (*rolling country with abundant volcanic plugs*). Mount Barney, the highest of these intrusive peaks, has an elevation of nearly 1500 m.

In the southeast the shallow-dipping, moderately resistant sandstone of the Kangaroo Creek Sandstone and the Marburg Sandstone has been eroded to form mesas and shallow dip-slopes (*sandstone mesa country*), the land surface having an average elevation of 300 m. The outcrop area of the intervening Walloon Coal Measures, although of fairly low local relief, is more elevated as it was protected until recently by a Tertiary basalt cap.

The elevation and relief on the Marburg Sandstone diminish northwestwards down the Condamine River, and the sandstone mesas give way to plains with scattered dip-slopes (*low relief sandy country*). The Condamine alluvium is included in this unit.

The unresistant Grafton Formation in the southeast has been strongly eroded and forms undulating country with elevation generally below 150 m (*low relief clayey country*).

PREVIOUS INVESTIGATIONS

Geological

Previously published work is listed in the References and brief summaries are given in Exon et al. (1969). The main publications are summarized below.

Cameron (1907) provided a general stratigraphic framework for the Mesozoic rocks of the Ipswich-Moreton Basin, which has persisted with minor modification till the present day. He proposed a threefold subdivision of the 'Trias-Jura system' of southeastern Queensland: the basal coal-productive Ipswich beds; the Bundamba beds which he regarded as having either a faulted or an uncon-

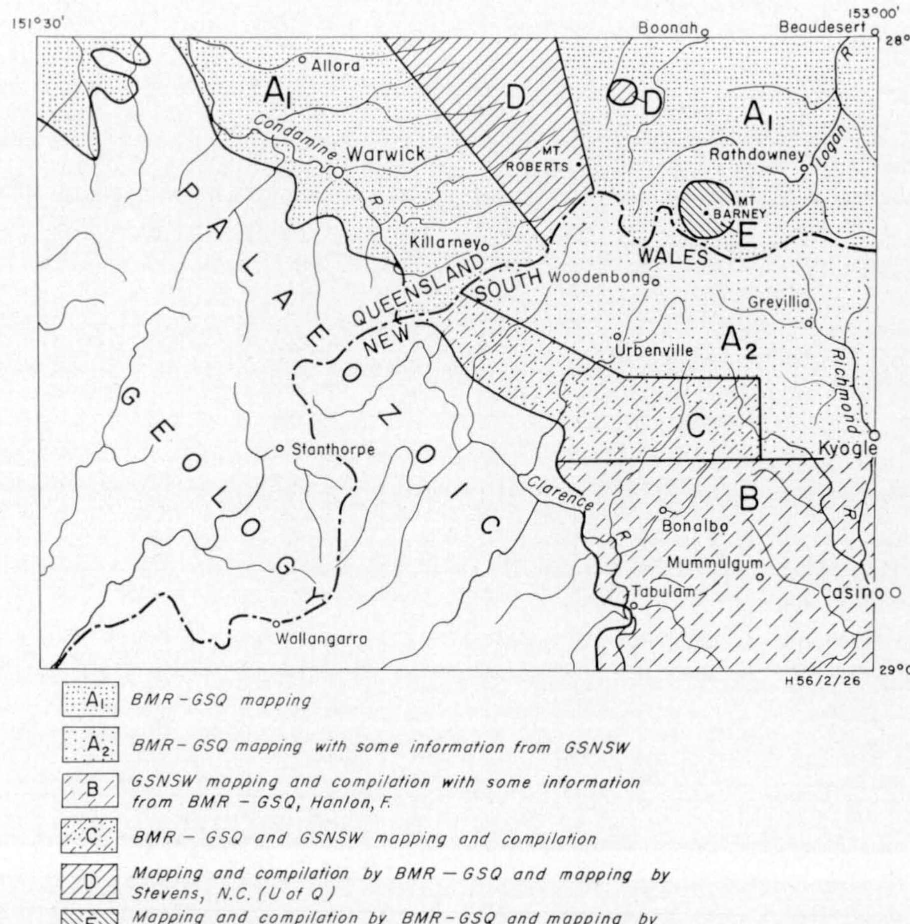

Fig. 1. Main source of geology.

formable upper contact with the overlying Walloon beds; and the coal-productive strata of the Walloon area. Cameron was the first to recognize the existence of the two separate coal measures, and the fact that the Darling Downs coal occurred in the upper coaly sequence. He also made the first reference to a southward-plunging anticline affecting the Mesozoic strata, the Trias-Jura Anticline which is now called the South Moreton Anticline.

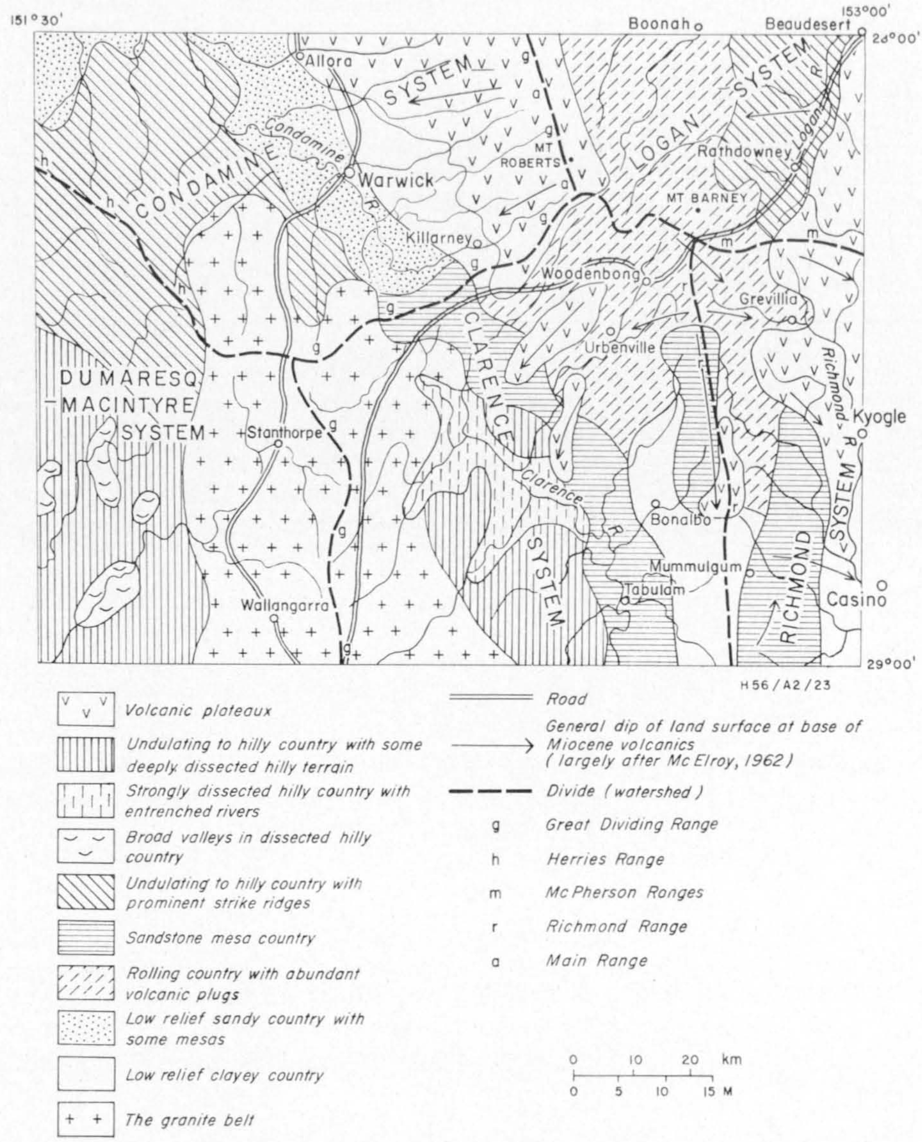

Fig. 2. Physiography.

Jensen (1909b) described Mounts French, Edwards, Greville, and Alford as rhyolitic plugs of independent denuded volcanics, and the Mount Barney-Mount Maroon area was mapped as rhyolite; he postulated post-Cretaceous faulting to explain the Main Range scarp.

Marks (1911) discussed the current theories on the age of igneous activity in the area, and concluded that there were rocks younger than Trias-Jura at Clifton, and that the eastern part of the McPherson Ranges was undoubtedly Trias-Jura.

On the basis of geomorphology, Wearne & Woolnough (1911) concluded that the shape of the Main Range around Cunninghams Gap was explicable only by invoking the two-stage uplift of a basaltic peneplain. They suggested two periods of igneous activity in the area: the first, believed to be in the Trias-Jura, gave rise to the normal trachytes of the Main Range, Mount Edwards, and Mount Flinders, and to the basalts of the Main Range near Cunninghams Gap; the second, in the Tertiary, gave rise to the more alkaline trachytes of Mounts French and Greville, to the rhyolites of Mounts Maroon and Barney, and to the basalts of the Toowoomba Range.

Richards (1916) recognized three major subdivisions of the volcanic rocks of southeastern Queensland: a lower unit, comprising widespread basic and sub-basic rocks, a middle unit comprising rhyolite, trachyte, and their glassy and fragmental representatives, and an upper unit of basic and sub-basic rocks. He adduced a post-Walloon age for these rocks, and suggested correlation with the Cainozoic rocks of Victoria and New South Wales.

Morton (1923) mapped the northeastern part of the Warwick Sheet area as part of a larger survey, and his conclusions agree closely with those of the present investigation. He was the first to detail the position and form of the South Moreton Anticline. His description of the Bundamba Series and its areal extent correspond with those of the Marburg Sandstone of present mapping, and his Walloon Series is the same as our Walloon Coal Measures.

Richards, Bryan, & Whitehouse (1932), in describing the geology of the Mount Barney complex, recorded the presence of two series of sedimentary strata: an older, steeply dipping, marine series, tentatively correlated with the *Pustula* beds of the uppermost Lower Carboniferous of central Queensland, and a younger gently dipping series containing fossil wood.

Sussmilch (1932) discussed the geomorphology of the Moreton district, including all of the Queensland part of the Sheet area east of Warwick. On geomorphological grounds he advocated faulting as the explanation of the Main Range scarp. In contrast with Wearne & Woolnough (1911), he regarded the lava and tuff peaks of the Cunninghams Gap area as mountains of accumulation along a north-south line of fracture.

Reeves (1936) examined the South Moreton Anticline as a possible structural trap for oil or gas and concluded that the numerous intrusions, and the consequent highly disturbed nature of the beds along the crest of the fold, would militate against the effective sealing of reservoir beds. His treatment of the general geology followed Morton (1923), except that he reported tuffaceous sediments in the upper part of the Walloon Series. He deduced that much of the sediment from this part of the Walloon Series was derived from volcanic rocks, and that, therefore, volcanic activity referred to as Tertiary began in Jurassic time.

Stephenson (1954, 1956, 1959), describing the Mount Barney complex, dealt mainly with the igneous rocks but also gave the first detailed account of the sedimentary section. He proposed the name Ballow Group for all the Mesozoic rocks of the area. On floral evidence, he assigned the lowest units, the basal Yamahra Conglomerate and the associated Portal Creek Volcanics, to the Triassic. A Triassic age was also implied by Hill (1960), who suggested the possible correlation of these units with the Ipswich Coal Measures. Present evidence suggests lithological correlation, at least, of the Portal Creek Volcanics with undoubted Triassic volcanics encountered in Queensland American The Overflow No. 1 well. The other members of the Ballow Group can be correlated with the Ripley Road-Marburg sequence elsewhere.

McElroy (1962) mapped part of the New South Wales segment of the Ipswich-Moreton Basin, and summarized existing knowledge. His regional map is broadly similar to our own and his regional geological framework has been only slightly modified. This Report makes extensive use of his data.

Green & Irving (1958) found that palaeomagnetism provided a basis for differentiating the Older and Newer Volcanics of Victoria and used the method with other Cainozoic volcanics. They correlated the Toowoomba basalts (continuous with those of the Cunninghams Gap area) with the Newer Volcanics of Upper Tertiary or Quaternary age.

Webb, Stevens, & McDougall (1967) obtained potassium-argon ages of whole-rock and mineral samples from the extrusives and near-surface intrusions of the Moreton district. They showed that volcanic activity occurred during the early Miocene and late Oligocene, with the most widespread phase between 26 and 22 m.y. ago. During this time the lavas of the Main Range and Mount Warning area were extruded and the rhyolite and trachyte intrusions of the southwest Moreton district were emplaced. Potassium-argon dating on three samples from the Tweed volcanic sequence in New South Wales (McDougall & Wilkinson, 1967) indicated an early Miocene age for the Lismore Basalt of McElroy (1962).

Stevens (1959 and 1962) described ring-dykes at Mount Alford and at Minto Crags and detailed the petrology and geochemistry. He proposed the name Mooggerah Sandstone for a unit which underlies the Walloon Coal Measures and which has been dragged up by the Alford intrusion; it is here included in the Marburg Sandstone.

McTaggart (1961) discussed the volcanic rocks extending from Mount Warning to as far west as Mount Barney. Although parts of his accompanying map were confirmed by the present mapping, his correlations were based on little evidence.

Stevens (1965) discussed the volcanic rocks of southeast Queensland. He proposed the name Main Range Volcanics for the near-horizontal Tertiary volcanic rocks in the area and described three members within the formation: Spicers Gap Trachyte Member, Swanfels Trachyte Member, and Steamers Trachyte Member. His boundaries have been used in part on the accompanying map.

Maffi (1968) prepared a photo-interpretation of the Warwick Sheet area before the present joint field survey began.

Geophysical

Two geophysical surveys have been carried out in the area, both in New South Wales for Mid-Eastern Oil. A reconnaissance seismic reflection survey was made south and east of Bonalbo (Warner, 1963). The location of lines was hampered by the presence of basalt in many areas. Reflection quality varied and reflectors contoured were a 'Basal Mesozoic Phantom Horizon' and a 'Shallow Mesozoic Phantom Horizon'. At least 2500 m of Mesozoic sediments northwest of Casino were indicated by the data, and the drilling of Mid-Eastern Kyogle No. 1 and Sextonville No. 1 confirmed the thick section.

An aeromagnetic survey (Zarzavatjian, 1965) was carried out over most of the Mesozoic sequence in New South Wales. By flying at 3000 m the distorting effect of the basalts was minimized and acceptable depth-to-basement data obtained, suggesting a maximum depth to basement of 3200 m immediately east of Mummulgum.

Exploratory drilling for petroleum

Exploratory drilling in and near the Warwick Sheet area is summarized in Table 1; all wells were subsidized, and all were abandoned.

PALAEOZOIC ROCKS

The Texas High was a topographically high area throughout the Mesozoic; streams carried the erosion products into the surrounding low areas, and local valley-fill Mesozoic sediments have been preserved on the Texas High. Most sedimentary and volcanic rock types of the Texas High are found as pebbles in the lower Mesozoic sequence, whose matrix was derived from granitic debris. The following discussion of the Palaeozoic rocks is drawn largely from Olgers & Flood (1974).

Granite of Texas High

The granite belt of southern Queensland and northern New South Wales extends from west of Warwick to south of Wallangarra. The granites are largely normal massive Permian granites and granodiorites. In general they are separated from the Mesozoic sediments by intervening Palaeozoic sediments or volcanics. However, modern streams near the edge of the Texas High contain mainly granitic debris and the ancient streams probably did likewise.

Palaeozoic sediments and volcanics of Texas High

The generally tough resistant Devonian, Carboniferous, and Permian rocks break down to cobble and pebble-size debris which was incorporated in the Mesozoic sediments deposited near the Texas High. Devonian intermediate volcanics, limestone, chert, and shale crop out near Silverwood. Carboniferous sandstone, mudstone, limestone, and minor volcanics crop out extensively in the northwest and west, and there is a smaller body north of Drake. These steeply dipping beds form strike ridges and are deeply incised. Highly sheared zones are phyllitic and unresistant and have aided erosion. Permian agglomerate, tuff, rhyolite, mudstone, sandstone, and conglomerate are widespread in the Drake area, and there are some small Permian fault blocks in the Silverwood area.

Neranleigh-Fernvale Group

The Neranleigh-Fernvale Group crops out widely in the Moreton District (Hill & Tweedale, 1955) and along the New South Wales coast (McElroy, 1962). It forms a major part of the basement on the northern and eastern side of the

Ipswich-Moreton Basin, but does not crop out in the Warwick Sheet area. The group is heterogeneous, containing banded shale and chert, radiolarian jasper, siltstone, greywacke, and limestone. Phyllitic siltstone and shale and siliceous sandstone are common in New South Wales.

Palaeozoic of Sextonville No. 1 well

The basal indurated sequence in Mid-Eastern Sextonville No. 1 was tentatively assigned to the Carboniferous (Perryman, 1964). The top 15 m of tight, hard pebbly sandstone is underlain by 60 m of fine-grained quartz keratophyre which is interpreted as a flow. The remaining 120 m of tough siltstone and shale is generally laminated and somewhat deformed, and contains scattered pebbles and cobbles of volcanic and siliceous rocks. The sequence is probably part of the Texas High sequence, which is less than 32 km away; lithologically it is most similar to Permian rocks.

MESOZOIC ROCKS (Table 2)

Ipswich Coal Measures (including Triassic volcanics)

The Ipswich Coal Measures consist of about 1300 m of freshwater shale and sandstone, some coal-bearing, together with conglomerate, breccia, tuff, and basalt (Denmead, 1955). In outcrop the Ipswich Coal Measures contained a rich fossil flora of Middle and Upper Triassic age (Jones & de Jersey, 1947; Hill et al., 1965) and two prolific insect horizons (Hill et al., op. cit.). They do not crop out in the Sheet area but are widespread in the subsurface (Fig. 3). They are correlated with the Nymboida Coal Measures of New South Wales, but the earlier Queensland name is used.

Figure 3 shows that the coal measures consist largely of a mixture of shale, siltstone, sandstone, conglomerate, and coal. In some wells the lower part of the sequence contains abundant volcanics which are presumably correlates of the Brisbane Tuff and the Chillingham Volcanics. They consist of altered red and green basalt, andesite, trachyte, and tuff in Queensland American The Overflow No. 1, where they are well developed. The volcanic sequence in Phillips Swan Creek No. 1 is largely dark green-grey and orange hard massive tuff grading to agglomerate, with varicoloured volcanic rock fragments, quartz, feldspar, and mafic minerals in an ashy, in places siliceous, matrix; the sequence also includes some shale, and tuffaceous sandstone. In Burmah Oil Co. Clifden No. 1 volcanics are abundant throughout the sequence. The volcanics in Mid-Eastern Sextonville No. 1 are probably Tertiary sills rather than Triassic volcanics.

Triassic Rocks of Mount Barney

On the northern flank of Mount Barney two Triassic sequences containing the Middle to Upper Triassic plant *Dicroidium odontopteroides* dip northwards at an average of 30°. On the eastern flank the corresponding sequences are overturned and dip westwards. The area was mapped by Stephenson (1959, 1960) and his boundaries have been generalized on the accompanying map. The following discussion is based on his work.

TABLE 1. EXPLORATORY DRILLING

Well	*Sheet Area (Year completed)*	*Total Depth (feet)*	*Hydrocarbon Shows (Intervals of shows)*	*Reference*
Queensland American The Overflow No 1	Ipswich (1960)	2993	Minor hydrocarbon shows related to coal seams (Ipswich Coal Measures)	Queensland American Oil Co (1963)
Mid-Eastern Kyogle No 1	Warwick (1963)	8170	Oil in SWC from 2770′. Oil in DST (3735′-3752′) (Upper and lower parts of Bundamba Group)	Relph (1963)
Burmah Oil Co Clifden No 3	Grafton (1963)	7505	No shows	Burmah Oil Co (1963)
Mid-Eastern Sextonville No 1	Warwick (1964)	7315	Minor gas shows (Bundamba Group)	Perryman (1964)
Phillips-Sunray Swan Creek No 1	Warwick (1965)	1662	No shows	Kyranis & Patterson (1966)
Australia Cities Service Tullymorgan No 1	McLean (1965)	7582	Some higher hydrocarbons in DST (3641′-3741′) (Bundamba Group)	Boisvert & Williams (1965)
Clarence Oil Hogarth No 1	Warwick (1968)	3996	No shows	Hanlon (1968)

The lower sequence, the Yamahra Conglomerate, is more than 150 m thick and rests unconformably on Carboniferous rocks. It consists of quartzose sandstone and conglomerate with boulders of metaquartzite and chert up to 0.3 m across. Overlying it is 15 to 90 m of Triassic basic lava and tuff. The Triassic sequence is then interrupted by a Tertiary trachytic sill which is overlain by an upper sedimentary sequence consisting of 150 m of quartzose sandstone, light in colour and with clay cement, and black carbonaceous shale. These Triassic rocks were included in Stephenson's Ballow Group, the upper (Jurassic) part of which is here assigned to the Marburg Sandstone and Walloon Coal Measures.

B. Houston (GSQ, pers. comm.) has suggested that the Triassic volcanics in the middle of this sequence are similar to those penetrated in the lower part of Queensland American The Overflow No. 1 some 40 km to the north. They can probably be correlated with the Brisbane Tuff of the Ipswich Coal Measures.

Bundamba Group

The name 'Bundamba' has sometimes been incorrectly restricted to a particular type of sandstone (massive, cross-bedded, quartzose, light-coloured) which makes up only part of the interval between the Ipswich and Walloon Coal Measures. Staines (1964) formally defined the lowest three formations in the Bundamba Group — the Aberdare Conglomerate, the silty Raceview Formation, and the massive Ripley Road Sandstone. He pointed out the difficulty of fixing the upper limit of the Bundamba Group:

> 'In the Rosewood area, "the Walloon Coal Measures conformably succeed the Marburg Sandstone, the junction being taken as the top of the highest bed of conglomerate or pebbly sandstone in the latter formation" (Cameron & de

Jersey, 1960, p. 291). The top of the Marburg Sandstone is thus explicitly defined. It then appears that the upper limit of the Marburg Sandstone, being contiguous with the base of the Walloon Coal Measures, is also the upper limit of the Bundamba Group.'

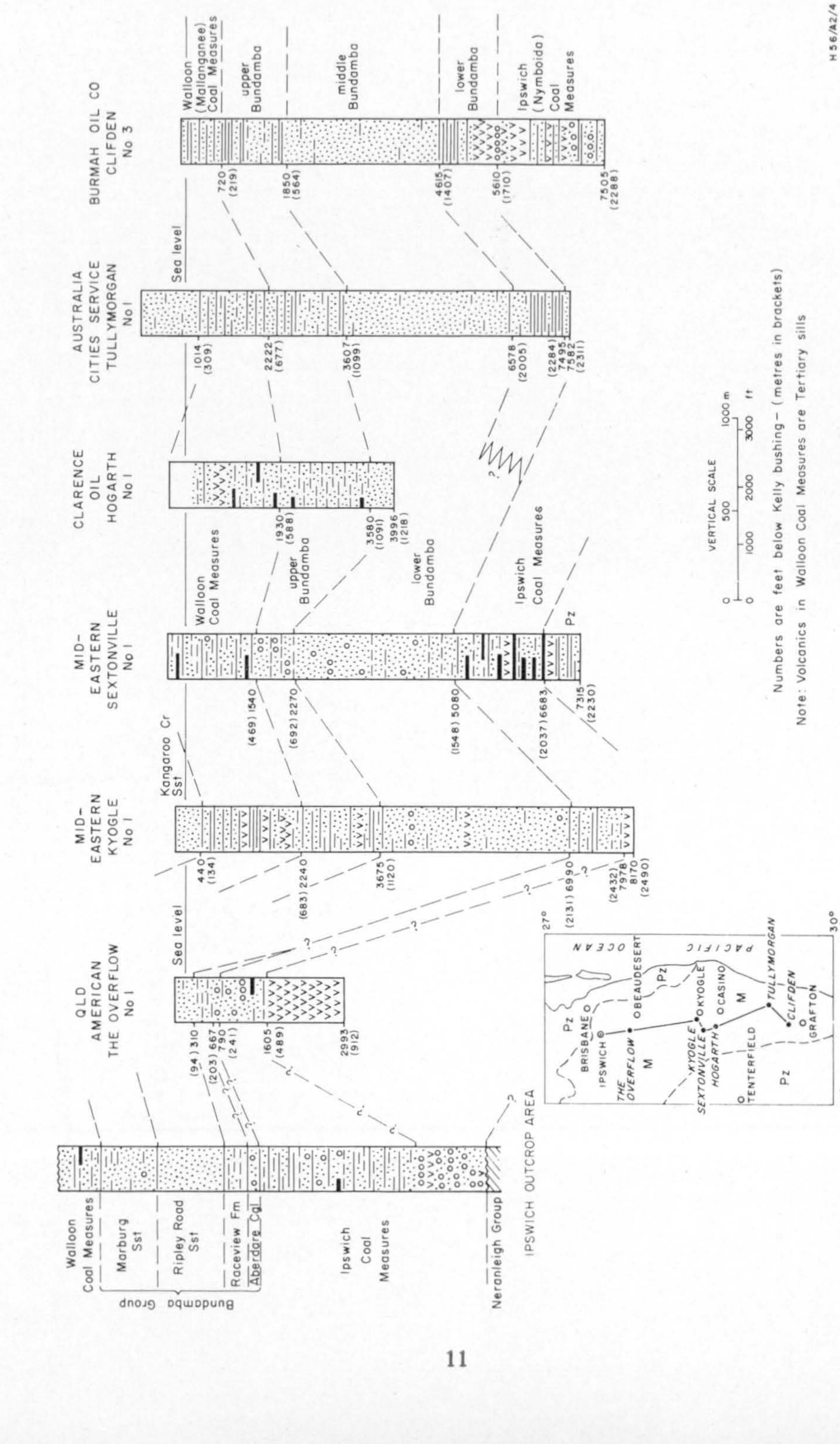

Fig. 3. Correlation of oil wells.

TABLE 2. MESOZOIC STRATIGRAPHY

Age	*Rock Unit and Map Symbol*	*Thickness (m)*	*Distribution*	*Lithology*	*Palaeontology*	*Relationships*	*Origin*
UPPER JURASSIC	Grafton Formation Jg	About 150	Small isolated areas in far SE	Lithic sandstone, siltstone, mudstone	*Taeniopteris spatulata* (McElroy, 1962) microflora, *Hystrichosphaeridium* (Exon et al., 1969)	Conformable on Kangaroo Creek Sandstone	Fluvial; possibly partly marine
	Kangaroo Creek Sandstone Jk	180	Large area in SE; isolated areas E of Bonalbo	Medium to coarse white and cream quartzose sandstone; in places pebbly. Minor feldspathic quartzose sandstone		Apparently conformable on Walloon Coal Measures. Equivalent to part of Woodenbong Beds	Fluvial
	Woodenbong Beds Js	300	Between Mt Barney and Bonalbo; smaller areas W of Mt Barney	Feldspathic sandstone, siltstone	Fragments of fossil wood	Youngest unit in Queensland part of Basin. Conformable on Walloon Coal Measures. Equivalent to Kangaroo Creek Sandstone and possibly also to Grafton Formation	Fluvial and lacustrine

Table 2 continued

Age		*Rock Unit and Map Symbol*	*Thickness (m)*	*Distribution*	*Lithology*	*Palaeontology*	*Relationships*	*Origin*
MIDDLE TO UPPER (?) JURASSIC		Walloon Coal Measures Jw	200	Continuous belt in centre of basin	Fine clayey lithic sandstone, light grey mudstone, siltstone, thin coal seams	Plants (White, 1969); Dinosaur footprints	Conformable on Marburg Sandstone. Contact transitional Intruded by Tertiary volcanics	Fluvial, lacustrine and paludal
LOWER JURASSIC	BUNDAMBA GROUP R — Jb	Marburg Sandstone Jlm	300 to 600 in W; probably thicker in NE	Narrow belt along W margin of basin, and in NE	Fine, medium and coarse feldspathic sandstone, pebbly sandstone, arkosic sandstone, polymictic conglomerate	Labyrinthodont fragment (Whitehouse, 1955); spores (de Jersey, 1963); plants (White, 1969); *Hystrichosphaeridium* (Exon et al., 1969)	Unconformable on Palaezoic rocks in W; conformable on Ripley Road Sandstone in centre of Ipswich-Moreton Basin	Fluvial; possibly partly marine
UPPER TRIASSIC TO LOWER JURASSIC		Ripley Road Sandstone Jlr	About 300	Two small areas in NE, and in core of South Moreton Anticline	White fine to coarse quartzose to feldspathic sandstone	Spores	Probably conformable on Aberdare Conglomerate	Fluvial; point-bar beds
UPPER TRIASSIC		Aberdare Conglomerate and Raceview Formation Tr	Average 30 in Ipswich area	Subsurface only	Polymictic conglomerate, sandstone, siltstone; carbonaceous shale in type area (Ipswich Sheet)		In type area unconformable on Ipswich Coal Measures	Elsewhere of fluvial origin

Table 2 continued

Age		*Rock Unit and Map Symbol*	*Thickness (m)*	*Distribution*	*Lithology*	*Palaeontology*	*Relationships*	*Origin*
MIDDLE TO UPPER TRIASSIC	IPSWICH COAL MEASURES	Tri	300± in Kyogle 1; 500± in Sextonville 1	Subsurface only	Shale, silt-stone, sand-stone, con-glomerate, coal	Rich flora in Ipswich area (Hill, Playford, & Woods, 1965)	Transitional from volcanics; unconformable on Palaeozoic rocks	Fluvial and lacustrine
		Trv	60+ in Kyogle 1; 150+ in Swan Creek 1	Subsurface only: Kyogle 1 and Swan Creek 1 and possibly in Sextonville 1 (6 732′-6 920′)	Acid to basic volcanic rocks including flows and pyroclastics (Kyogle 1). Dark green crystal-lithic tuff and minor black shale (Swan Creek 1). Quartz keratophyre (Sextonville 1)		Unconformable on Palaeozoic. Probably equivalent to volcanics in unit Trb	Probably mainly terrestrial
		Trb	Up to 400	Small outcrops E and N of Mt Barney	Conglomerate, basic lava, tuff, quartz-ose sandstone, black carbon-aceous shale	*Dicroidium odontopter-oides*	Unconformable on Mt Barney Beds	

Cameron's definition of the Bundamba Group as the interval between the Ipswich and Walloon Coal Measures is accepted in this Report, and the Marburg Sandstone is treated as a formation of the Bundamba Group. De Jersey (1971) showed that there are marked facies changes within the Bundamba Group even in the Ipswich area; the basal part of the Marburg Sandstone is considerably older in the Ipswich area than near Lowood, about 15 km farther north. Therefore, widespread diachronism of formation boundaries may be expected over the whole basin.

The terms 'Tabulam Beds' and 'Tabulam Group' were initially used (Lloyd & Whiting, 1940; Lloyd & Rayner, 1946; David, 1950; McElroy, 1962) for a Triassic-Jurassic sedimentary sequence between Triassic and Jurassic coal measures in the Ipswich-Moreton Basin in New South Wales. McElroy (op. cit.) divided the Tabulam Group into the Bundamba Group and Marburg Formation, correlating them with similar sequences in Queensland. More recent GSQ mapping in the Ipswich-Moreton Basin has indicated that the Bundamba Group and Marburg Formation of New South Wales are not equivalent to the same-named units in Queensland.

The two upper formations of the Bundamba Group, which crop out in the Sheet area, are discussed below. The Aberdare Conglomerate and the Raceview Formation (the two lower units of the Bundamba Group) do not crop out in the area but both probably occur in Queensland American The Overflow No. 1, 8 km north of the Sheet boundary (Fig. 3). In the type area near Ipswich the Aberdare Conglomerate consists of polymictic conglomerate, sandstone, siltstone, and thin carbonaceous shale beds. The Raceview Formation consists of sandstone, siltstone, shale (some carbonaceous), and a few thin coal seams. The Aberdare Conglomerate is 1.5 to 35 m thick and the Raceview Formation 95 to 160 m thick (Staines, 1964).

De Jersey (1970, p. 22) examined assemblages from NS272, a Queensland Mines Department drill hole in the Ripley Road area, and put forward various lines of evidence that support each other in indicating a late Triassic age for assemblages from the Aberdare Conglomerate and Raceview Formation; within the late Triassic the evidence now available favours a Norian or Rhaetian, rather than a Carnian, age.

In the subsurface in the New South Wales part of the Moreton Basin (Fig. 3), the Bundamba Group can be separated from the Ipswich and Walloon Coal Measures, but it is difficult to relate its subdivisions to the outcrop formations. This is also the situation in outcrop on the eastern side of the basin in the Tweed Heads Sheet area (G. Tweedale, pers. comm.). In all exploration wells a subdivision can be made into an upper finer-grained part and a lower coarser-grained part, which are possibly equivalent to the Marburg Sandstone and the Ripley Road Sandstone of outcrop. It could also be argued that the lowermost fine-grained part of the group in Tullymorgan No. 1 and Clifden No. 3 wells near Grafton is an equivalent of the Aberdare-Raceview sequence in the Ipswich area, but the density of drilling has not been great enough to substantiate these tentative correlations. In addition, consideration must be given to the outcrop pattern on the western side of the basin, including the Grevillia and Toonumbar Anticlines, where the sequence mapped as Marburg Sandstone consists of an upper comparatively well bedded finer-grained sequence and a lower comparatively poorly bedded, coarser-grained sequence. On the western edge of the basin the lower sequence is arkosic sandstone, but in the two anticlines it is quartzose to feldspathic sublabile sandstone. It is tempting to regard the lower sandstone sequence in the anticlines as Ripley Road Sandstone, but it shows too much bedding to be typical of that unit; furthermore, similar sandstone in the lower part of the Marburg Sandstone crops out in the northern part of the sheet area. R. Helby (GSNSW) has described microfloras from the sandstone of the Toonumbar Anticline as of Marburg age.

Although the subdivision in the wells and the anticlines may represent Marburg and Ripley Road Sandstones, the true boundary may be somewhat lower. On the western side of the basin the arkosic sequence is unlike either sandstone. As similar arkose rock types are interbedded with definite Marburg sediments higher in the sequence, and as the Ripley Road Sandstone is generally less feldspathic than the Marburg Sandstone, it was decided to include the arkosic sequence in the Marburg Sandstone. With more detailed work the arkosic sequence could be mapped as a separate unit.

Recent palynological work based on the GSQ core-drilling program in the Ipswich area suggests that the Triassic-Jurassic boundary lies within the Ripley Road Sandstone (de Jersey, 1971a).

Ripley Road Sandstone (Staines, 1964)

In the type area south of Ipswich the Ripley Road Sandstone is a white, fine to coarse massive sandstone composed mainly of quartz with some weathered feldspar and a kaolin matrix. However, continuous coring in the type area has shown that it is a feldspathic sandstone.

In the Warwick Sheet area the Ripley Road Sandstone crops out in a narrow belt about 1 km wide in the axis of the South Moreton Anticline, and in a valley along Allans Creek farther west. As exposed in weathered outcrop, it is dominantly a massive, friable, medium to coarse, white to light brown, quartzose to feldspathic sublabile sandstone with a clayey matrix; it contains subordinate beds of fine-grained sandstone and a few thin pebble beds with pebbles of acid and basic volcanics and quartz. Planar cross-bedding with large sets is common; current directions are consistently to the north. There is gradation within some sets from very coarse to fine grained. In Queensland American The Overflow No. 1 (Fig. 3) an incomplete section of 90 m of the Ripley Road Sandstone was penetrated, whereas in the type area a thickness of up to 370 m was estimated (Freytag, 1963).

The boundary between the Ripley Road Sandstone and the Raceview Formation was not observed in the Warwick Sheet area. In the Ipswich Sheet area Staines (1964) noted that the Marburg-Ripley Road boundary is vague; Freytag (1963) found sandstones transitional between Ripley Road and Marburg Sandstones, and Pearce (1964) did not identify the Ripley Road Sandstone.

Macrofossils were not collected in the area. Two continuously cored stratigraphic holes were drilled in the Bundamba Group by GSQ near the type section of the Ripley Road Sandstone, and palynological study of these and other holes (de Jersey, 1971a) showed that the Ripley Road Sandstone, previously regarded as wholly Upper Triassic, ranges up into the lowermost Jurassic. In European terms, the Triassic-Jurassic boundary has not been precisely determined in Australia, where the appearance of *Classopolis* is regarded as the start of the Jurassic. De Jersey (op. cit.) has shown that the Ripley Road Sandstone is, in large part, older than the wholly Jurassic Helidon Sandstone, its correlate in the western part of the Ipswich Sheet area.

MARBURG SANDSTONE (REID, 1921; HILL, 1953)

The Marburg Sandstone crops out extensively in the Warwick Sheet area. It conformably overlies the Ripley Road Sandstone in the South Moreton Anticline, and unconformably overlies Palaeozoic basement surrounding the Texas High. It also crops out in the faulted Swan Creek Anticline, in several small culminations farther north, and in the Grevillia and Toonumbar Anticlines. It forms a fairly rugged topography of dip-slopes in the South Moreton Anticline and a more subdued topography elsewhere.

South Moreton Anticline Area. In the northeast, near the type area, the Marburg Sandstone consists dominantly of fine to very fine feldspathic sublabile to labile sandstone which is thickly to very thickly bedded. It is commonly hard and well bedded. Locally, massive medium to coarse sandstone ranges from quartzose to labile. Pebble lenses are common, and in places isolated pebbles scattered through the fine-grained sediments include acid and basic volcanics, low-grade metamorphics, and quartz. Although sandstone is the characteristic rock, significant amounts of fine sediments are present, especially in the upper part of the formation.

Pearce (1964) divided the Marburg Sandstone into upper (Innisplain) and lower (Kooralbyn) members. He defined the Innisplain as an interbedded sequence of very fine-grained sandstone, siltstone, and mudstone up to 240 m thick, sandstone being the most common. In the present regional survey the subdivisions were not mapped, although the finer upper section was noted; the siltstone is mainly thin-bedded, with some very resistant beds of ironstone, and the olive brown thin-bedded mudstone is mainly very weathered.

Variations in dip across the section in the northeast prevented an accurate estimate of thickness. Pearce (1964), Morton (1923), and Reid (1922) all suggested a minimum thickness of 1200 m, and this was confirmed by the present survey. Thus, it is possible that most of the subsurface Bundamba Group in the southern part of the Sheet area is Marburg Sandstone. GSQ stratigraphic drilling has shown the thickness in the type area to be about 300 m (de Jersey, 1971b), so the unit thickens greatly southward into this Sheet area.

A reconnaissance of the type area carried out jointly with A. Carr (Coal Section, GSQ) revealed the following criteria for differentiating the Ripley Road and Marburg Sandstones in outcrop:

Ripley Road Sandstone

- Generally coarser-grained
- White to light brown
- Massive and friable with patches of assorted pebbles generally in hard dark brown rock
- Weathers more readily and produces fairly gentle slopes

Marburg Sandstone

- Generally finer-grained
- Generally dark brown
- Usually thick-bedded with some resistant well developed bedding
- More resistant to erosion and forms rugged topography
- Near base is distinctive fine-grained greenish brown sandy siltstone with feldspar grains

An examination of GSQ cores from the type area showed that the differences between the Ripley Road and Marburg Sandstones are more apparent in weathered outcrop than in the subsurface. In the subsurface the Ripley Road Sandstone is generally medium to coarse feldspathic sandstone. Similar but generally finer-grained sandstone predominates in the Marburg Sandstone. The presence of siltstone and pebbly beds helps to differentiate the Marburg Sandstone. The boundary between the two units is transitional over about 100 m.

Texas High Area. Around the Texas High in both the Warwick and the adjacent Goondiwindi Sheet areas, the oldest Mesozoic sediments have been assigned to the Marburg Sandstone.

East of the Texas High an arkosic sequence up to 150 m thick sitting directly on basement consists of thickly bedded to massive sandstone and polymictic conglomerate with high-angle cross-bedding prominent in some beds. The sandstone and the matrix of the conglomerate are largely medium to coarse and feldspathic, indicating derivation from the granites farther west. The angular feldspars suggest rapid erosion of the hinterland and depositions from streams (Pl. 1a).

The polymictic conglomerate is most abundant in present-day valleys as valley-fill sediment. It is well exposed in cuttings on the New England Highway south of Warwick, where the clasts are mostly comparable with nearby Palaeozoic rocks and consist of black, grey, and green chert, silicified sandstone, carbonaceous siltstone, quartz, porphyritic acid volcanics, and minor granite. The conglomerate and the interbedded fine to coarse arkosic sandstone are point-bar beds; soft siltstone beds and pods (Pl. 2) represent quieter deposition on top of the point bar.

In the Leyburn area in the northwest true conglomerate is rare, although polymictic arkosic pebbly sandstone is quite common (Fig. 4). The dominant rock type is thickly bedded cross-bedded feldspathic sandstone. Basal beds in areas of phyllitic Palaeozoic rocks south of Leyburn are virtually unworked lithic sandstone consisting almost entirely of phyllite and quartz fragments (the latter from veins in the Palaeozoics), commonly overlain by well bedded, fine-grained quartzose sandstone resembling typical Boxvale Sandstone in the Surat Basin (Mollan et al., 1972). These beds contain plant roots in situ and well preserved fronds (Appendix 3).

Between Warwick and Tabulam the conglomeratic arkosic sequence is well developed. Southwest of Avondale homestead outcrops of massive conglomerate up to 100 m thick contain clasts (Pl. 1b) dominated by Palaeozoic acid porphyries, quartzite, silicified fine-grained labile sandstone, and also include basalt, crystalline tuff, schist, ironstone, and intraformational arkose blocks; fossil logs, some replaced by clay and others by ironstone, are common. The maximum cobble size noted was 30 cm and the average size for the largest outcrop (45 m thick) is about 15 cm; the average size for all beds is about 5 cm. Most clasts are angular, but the sharper angles have been commonly blunted.

These basal units of the Marburg Sandstone were deposited by streams draining the Texas High. Their matrix was derived largely from the granitic hinterland, and the high-relief Palaeozoic areas crossed by the streams shed coarser material. The coarsest sediments were probably deposited during major floods. Massive tree trunks found in places in the sequence, especially near Warwick, are up to 10 m long and 1 m in diameter.

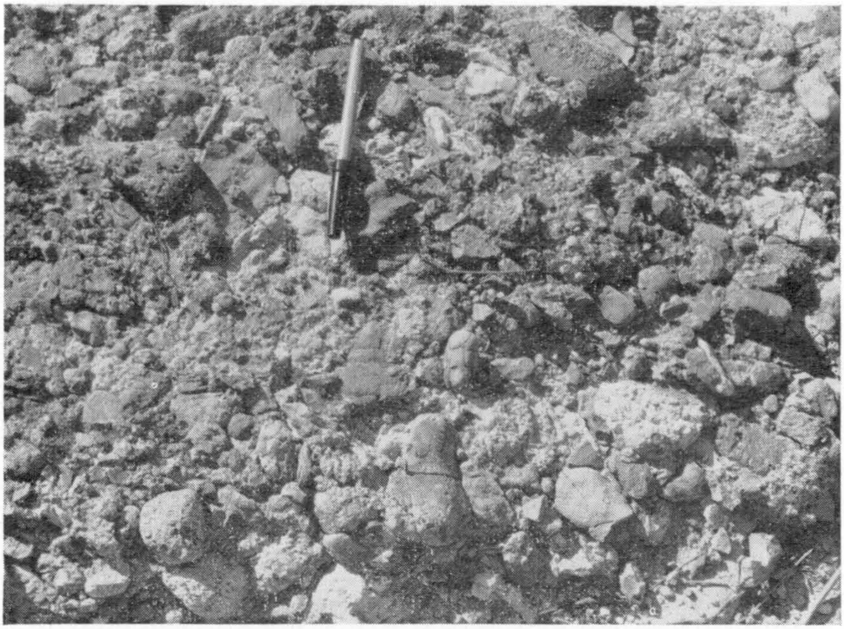

Plate 1a. Polymictic conglomerate in creek near b., south of Lower Acacia Creek township. Basal Marburg Sandstone.

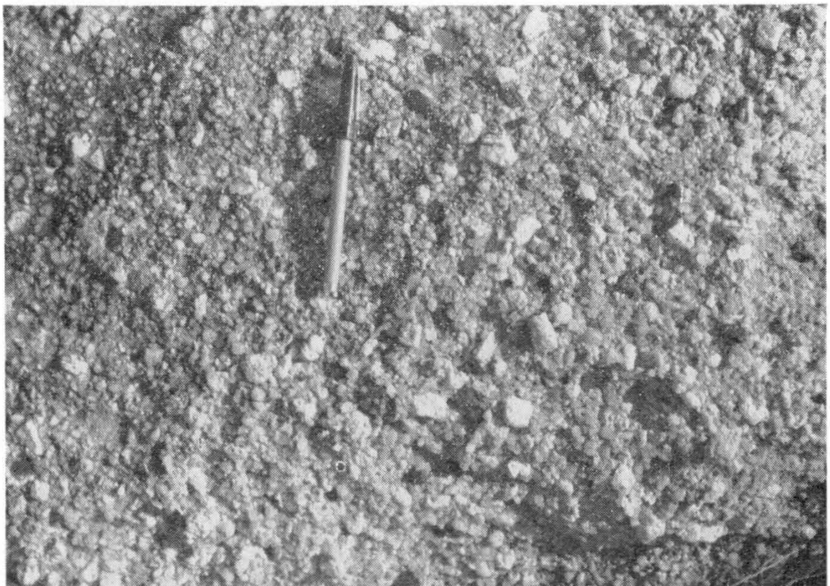

Plate 1b. Feldspathic grit in creek crossing south of Lower Acacia Creek township (grid ref. 536470). Basal Marburg Sandstone.

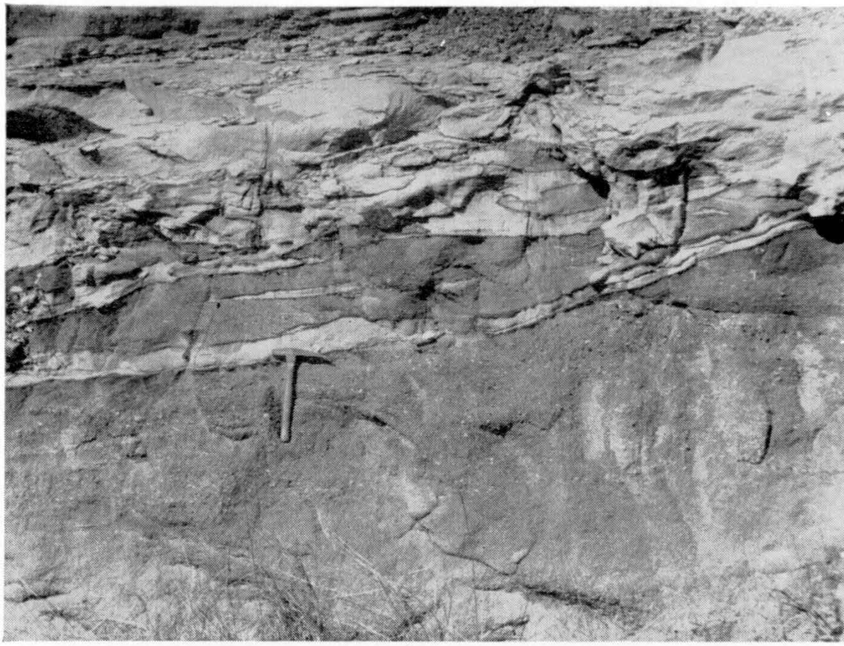

Plate 2a. Coarse sandstone in lower point bar with siltstone in upper point bar. Road cutting on New England Highway south of Warwick (grid ref. 505512). Basal Marburg Sandstone.

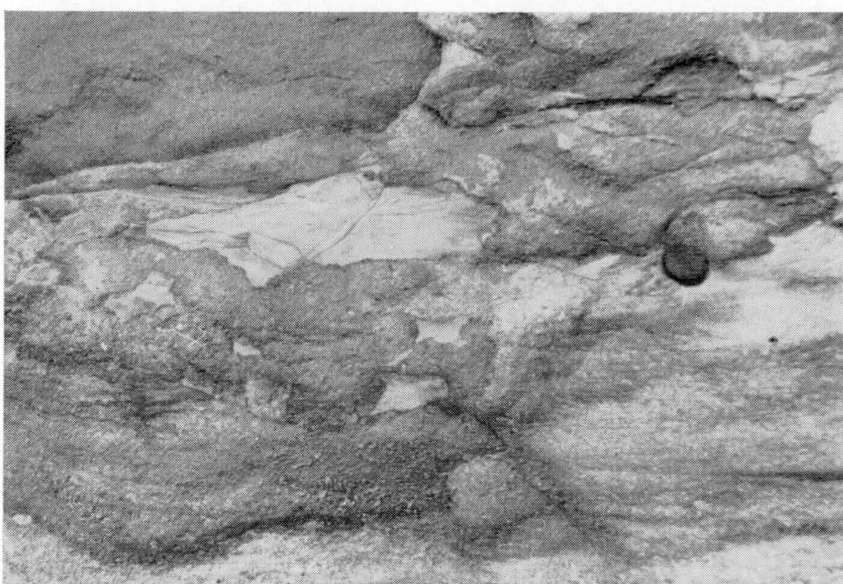

Plate 2b. Close-up of siltstone fragments included in sandstone at same locality. Basal Marburg Sandstone.

Plate 3. Low-angled cross-bedding in well bedded sandstone in upper Marburg Sandstone. In quarry north of Warwick (grid ref. 506515).

The coarse clastics are overlain by about 250 m of fine to coarse, generally labile sandstone, and some siltstone, especially towards the top. This sequence is similar to the Marburg Sandstone in the type area. The sandstone varies from greenish or yellowish grey when labile, to buff when sublabile, to quartzose. It averages about 35 percent quartz, 20 percent orthoclase and albite, 25 percent rock fragments (fine-grained sediments and volcanics), 15 percent clay matrix, and minor iron minerals, muscovite, and biotite. This composition suggests a more mature type of sediment, but with the same origin as the arkose because the resistant rock fragments have increased in proportion; mudclasts and small pieces of fossil wood are common. One particularly massive sandstone sequence, which serves as a marker, can be identified from south of Tabulam north to the State border; it is generally associated with fossil logs, pebbles, and cobbles, and presumably represents widespread flooding.

The upper Marburg Sandstone sequence varies from well to poorly bedded. Cross-bedding varies from low-angled and minor to torrential and dominant (Pls 3, 4). The more quartzose sandstone from the upper sequence near Warwick has been used for ornamental stone. In the southern part of the Sheet area the Marburg Sandstone is generally thickly bedded and cross-bedded, although there are some thinner and well bedded sandstones. The sandstone is generally greenish brown and labile, and polymictic pebbles are abundant at the bases of some beds. The sequence includes siltstone beds up to 10 m thick.

Grevillia and Toonumbar Anticlines. The Marburg Sandstone in these anticlines is 30 to 40 km from the Texas High. In the Grevillia Anticline it consists of two sequences. The upper 150 m consists of well bedded greenish brown fine to medium labile sandstone and siltstone. The lower 150 m consists of thickly bedded and strongly cross-bedded, fine to coarse, feldspathic sublabile sandstone, which is pebbly in part, with some fossil wood; the sand grains are angular, and the pebbles consist of quartz, quartzite, and acid volcanics.

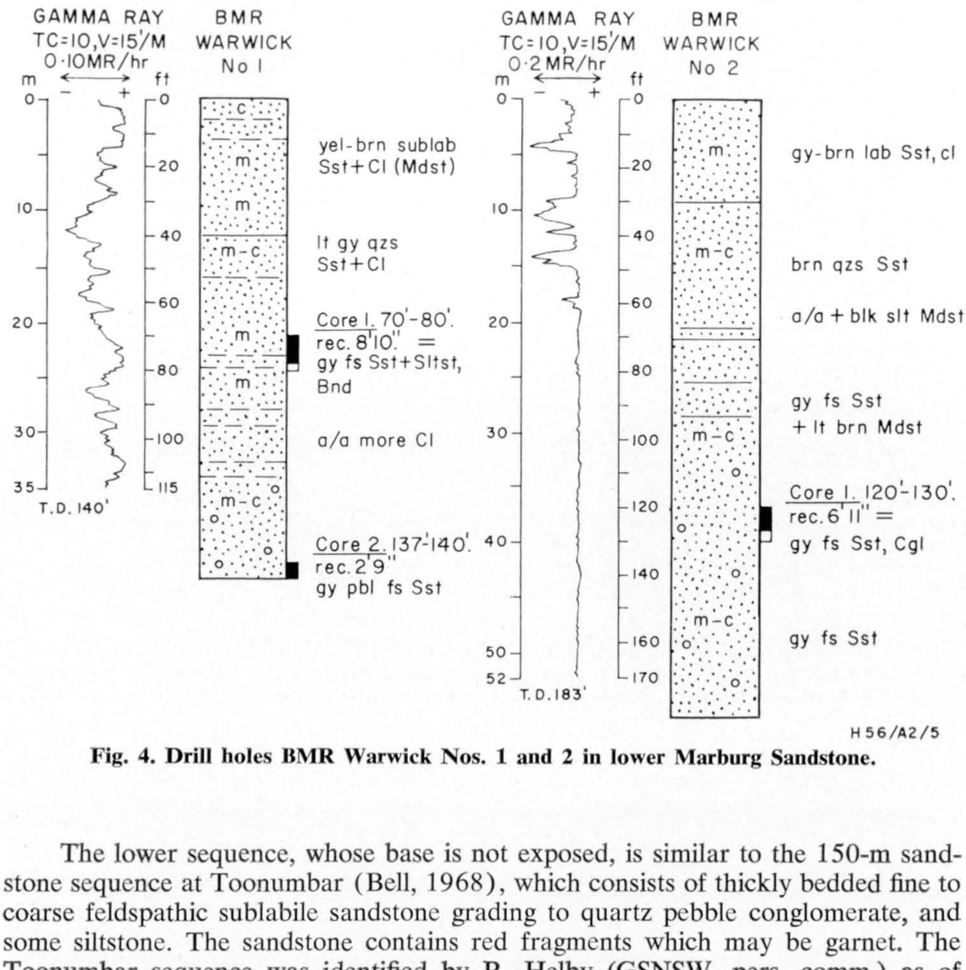

Fig. 4. Drill holes BMR Warwick Nos. 1 and 2 in lower Marburg Sandstone.

The lower sequence, whose base is not exposed, is similar to the 150-m sandstone sequence at Toonumbar (Bell, 1968), which consists of thickly bedded fine to coarse feldspathic sublabile sandstone grading to quartz pebble conglomerate, and some siltstone. The sandstone contains red fragments which may be garnet. The Toonumbar sequence was identified by R. Helby (GSNSW, pers. comm.) as of Marburg Sandstone age on the basis of palynology, and his interpretation is supported by lithological correlation.

Environment of Deposition. The Marburg Sandstone was deposited by streams radiating from the Texas High; even in the northern part of the Moreton Basin derivation is from the south (Swindon, p. 290 *in* Hill & Denmead, 1960). The general lack of marine organisms suggests that it is a dominantly freshwater unit, although it may be marine or deltaic in part. The presence of *Hystrichosphaeridium* in the upper part of the formation in BMR Warwick No. 4 (Fig 6), and carbonaceous and pyritic sandstone indicate a period of quiet marine deposition. There was a marked change in the hinterland in early Jurassic time to give the high-energy deposition of the basal sequence around the Texas High, whereas there had been only slow Triassic deposition farther into the basin. This could have been related to a change of climate, or to uplift of the Texas High. As time

SYMBOLS

LITHOLOGY

Coal

Sandstone

vf	*Very fine*	*0·06–0·12 mm*
f	*Fine*	*0·12–0·25 mm*
m	*Medium*	*0·25–1·0 mm*
c	*Coarse*	*1·0–2·0 mm*

Quartzose sandstone >90% clasts quartz
Sublabile sandstone 75–90% clasts quartz
Labile sandstone <75% clasts quartz

Conglomerate

Siltstone

Mudstone, shale

VVVV VVVV *Volcanics*

Unconformity

BEDDING STRUCTURE

Very thick	*> 100 cm*
Thick	*30–100 cm*
Medium	*10–30*
Thin	*1–10 cm*
Laminated	*< 1 cm*
Crossbedded	
Crosslaminated	

FOSSILS

Dinoflagellates

Ø *Barren of spores and pollens*

JURASSIC SPORE DIVISIONS

J2

J4

J5–6

CORE

Recovery

No recovery

( ) Surrounding symbol mean weakly developed or rare

ABBREVIATIONS

a/a	as above	low	lower
Bdg	bedding	lt	light
blk	black	m	medium
Bnd	band	Mdst	mudstone
brn	brown	Mi	mica
C	coal	MR	milliroentgen
c	coarse	mV	millivolt
carb	carbonaceous	Ωm	ohm metre
Cgl	conglomerate	pbl	pebbly
Cl, cl	clay (ey)	qzs	quartzose
dk	dark	rec.	recovery
f	fine	slt	silty
fe	ferruginous	Sltst	siltstone
Frag	fragments	Sst	sandstone
fs	feldspathic	sublab	sublabile
gn	green	TC	time constant
Grn	garnet	tn	thin
gy	grey	up	upper
hr	hour	V	velocity
lab	labile	vf	very fine
li	lithic	yel	yellow

M(C) 31

Fig. 5. Symbols and abbreviations used on lithological logs.

passed the streams approached equilibrium and fine-grained sediments were laid down in point bars and backswamps.

Thickness. No reliable measurements have been made in the Sheet area, but thicknesses between 300 and 600 m are indicated by outcrops around the Texas High; the formation is thicker in the subsurface and in outcrop in the northeast (up to 1200 m).

Age. Whitehouse (1955) suggested an Upper Triassic age for the Marburg Sandstone, based on the identification of a jawbone fragment of a labyrinthodont, *Austropelor wadleyi,* by Longman (1941). However, palynological studies of samples from the formation in the Ipswich area have shown that it is Lower Jurassic (de Jersey, 1963, who suggested that the bone fragment could be a reworked fossil from the Triassic).

Plants collected by the present party (White, 1969) suggested a Jurassic to Lower Cretaceous age for Marburg Sandstone sediments south of Warwick (505491); a Triassic or Jurassic age for sediments south of Mount Barney (581489); and a Jurassic age for sediments from Durikai (466503), which is documented in Appendix 3 by Gould, who suggests an upper Liassic age for the flora. A J4 spore assemblage (Lower or Middle Jurassic) and a post-J2 spore assemblage (Lower Jurassic or younger) were obtained from BMR Warwick No. 4 in the uppermost part of the formation (Burger, Appendix 2). Thus the unit is probably almost entirely Lower Jurassic.

WALLOON COAL MEASURES

The history of the Walloon Coal Measures is discussed by Whitehouse (1955), Cameron et al. (pp. 287-8 *in* Hill & Denmead, 1960), and Gould (1968). Whitehouse (1955) designated a type area near the township of Walloon where the coal measures are about 200 m thick, and drilling showed that they consist of light grey mudstone, siltstone, fine-grained clayey lithic sandstone, thin coal seams, and an upper bed of medium-grained sandstone more than 30 m thick. The clayey sandstone, which has a montmorillonitic matrix, disintegrates rapidly and outcrops are rare. In the subsurface the sandy proportion varies greatly from hole to hole.

In the eastern half of the Sheet area the Walloon Coal Measures cover a large area within the Moreton Basin. Where undisturbed and unprotected, they form rolling country with virtually no outcrop. In the northeast they are intruded by sills, dykes, and plugs of Tertiary igneous rocks which dominate the landscape and increase the relief; but few intrusions appreciably affect the dip. Elsewhere in the Warwick Sheet area the coal measures are commonly overlain by Tertiary flows which form a hard capping.

The rock types in the Sheet area are similar to those in the type area, and the greater relief causes more outcrop, particularly sandstone. The matrix of the sandstone, although generally clayey, is often calcareous, and concretions are common; when not originally calcareous, or when leached, the sandstone is friable.

In the northeast (e.g. Mount Barney area) the lower 400 m of section consists largely of well bedded carbonaceous mudstone and siltstone, and some thinly bedded fine-grained greenish brown lithic sandstone, coaly mudstone, and coal. Sandstone is more common in the upper 200 m of the total sequence; it is medium-grained, thickly bedded, cross-bedded, and greenish grey, and contains abundant andesitic rock fragments and subordinate feldspar; coaly grains and

Plate 4a. Well bedded sandstone in eastern flank of South Moreton Anticline (grid ref. 605506). Marburg Sandstone.

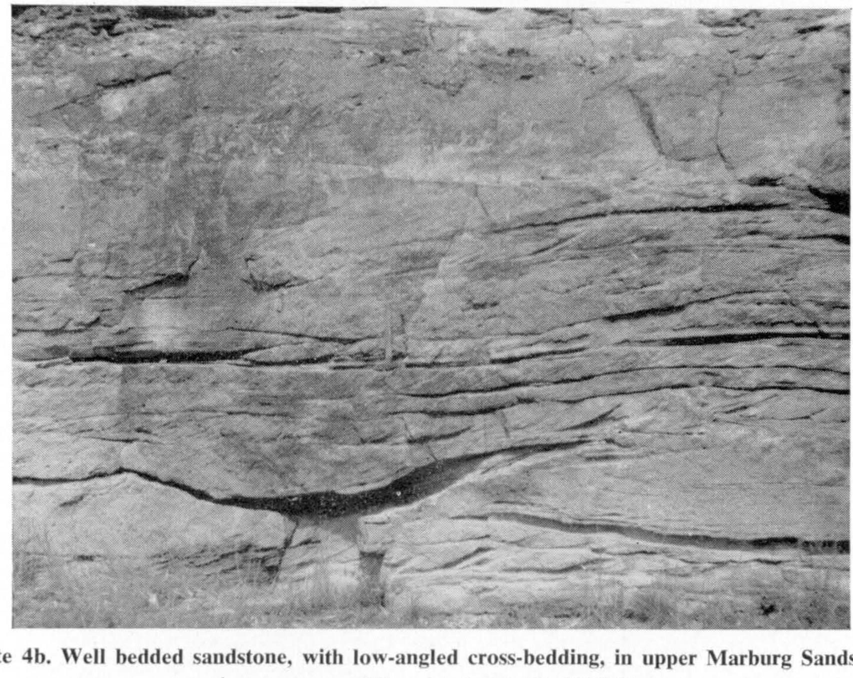

Plate 4b. Well bedded sandstone, with low-angled cross-bedding, in upper Marburg Sandstone in quarry near Warwick (grid ref. 512504).

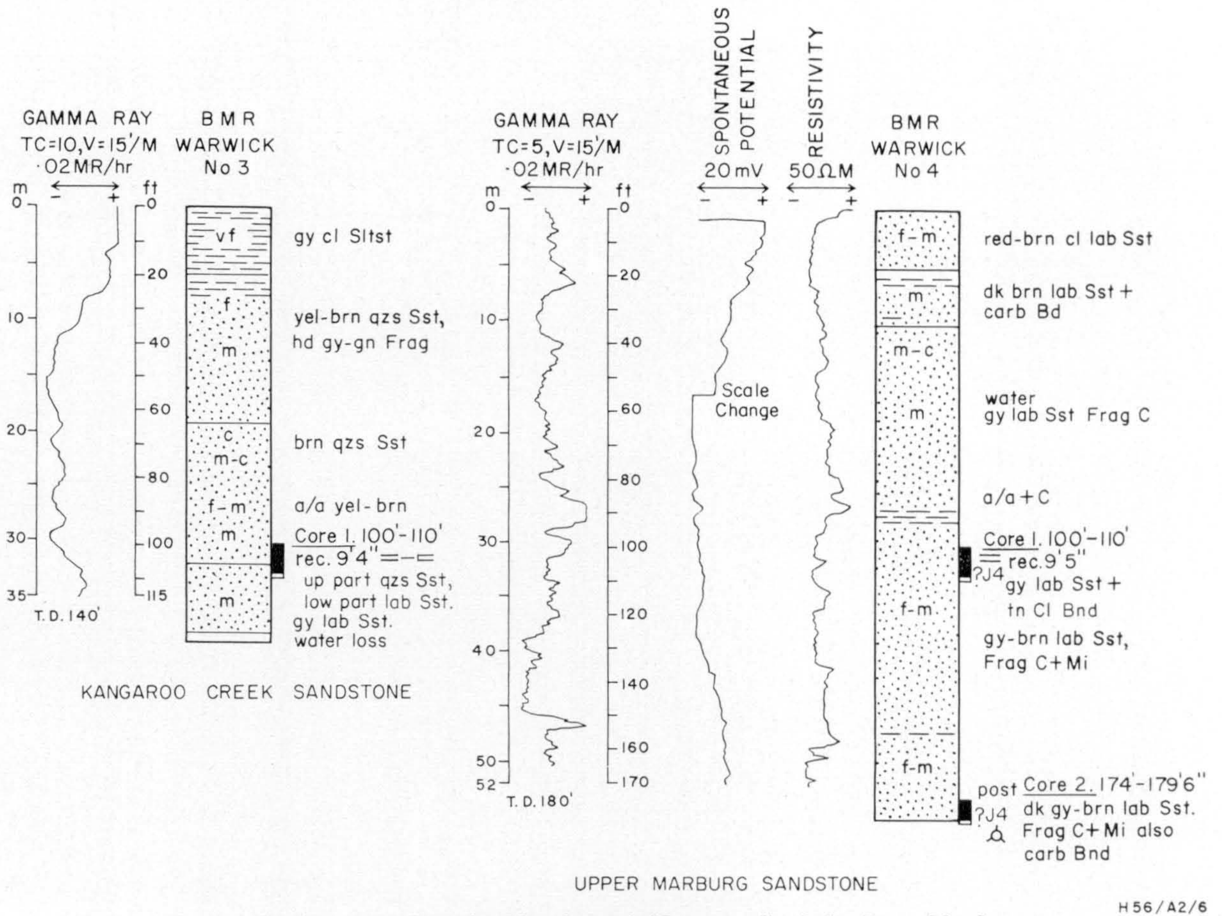

Fig. 6. Drill holes BMR Warwick Nos. 3 and 4; Kangaroo Creek Sandstone No. 3; upper Marburg Sandstone No. 4.

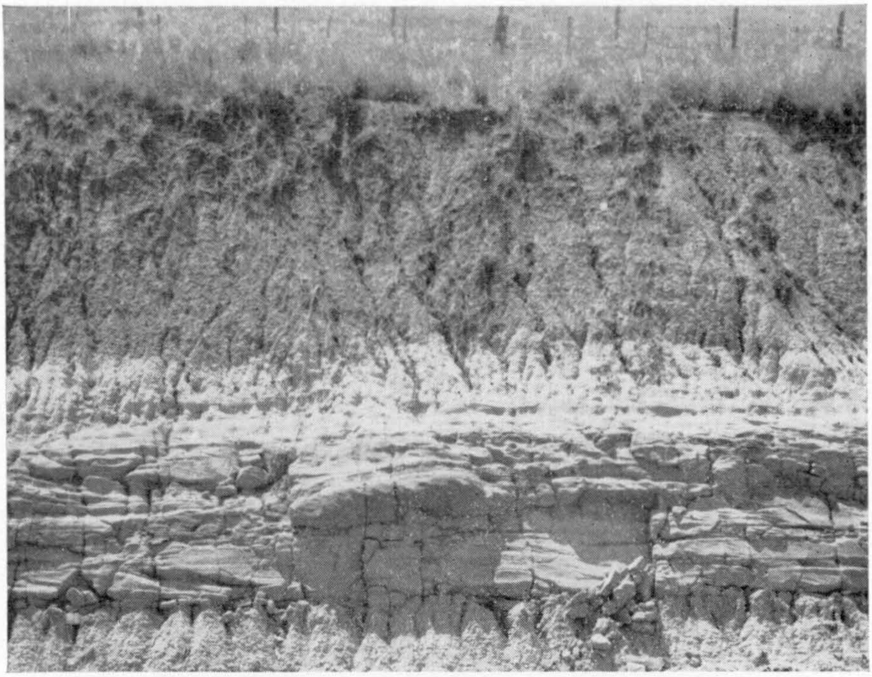

Plate 5a. Typical sandstone and siltstone in railway cutting near Beaudesert (Ipswich 1:250 000 Sheet area, grid ref. 607527). Walloon Coal Measures.

Plate 5b. Poorly bedded cross-bedded sandstone with some calcareous lenses in creek north of Warwick (grid ref. 512506). Walloon Coal Measures.

lenses are common in some beds. In the southeast a similar sequence contains volcanic and sedimentary pebbles, and small pieces of fossil wood scattered through some sandstone beds.

West of the Main Range Volcanics, siltstone and mudstone still predominate, but thick sandstone beds are exposed in places. A particularly good outcrop about 20 m thick, in a small creek north of Warwick (512507), varies from medium-grained sandstone to lithic grit; it is poorly to thickly bedded, cross-bedded in part, generally calcareous with calcite concentrated in more resistant lenses and concretions (Pl. 5b), and is generally brown or greenish brown; some beds contain clay clasts. In this section the sandstone consists mainly of andesitic rock fragments with less than 10 percent of quartz, albite, and sedimentary rock fragments, and with abundant clay matrix or calcareous cement. The clay matrix is derived, in part at least, from weathering of rock fragments in situ. Iron ore, muscovite, and biotite are minor constituents.

The Walloon Coal Measures conformably overlie the Marburg Sandstone and the contact is transitional; in the type area the top of the highest bed of conglomerate or pebbly sandstone is taken as the top of the Marburg Sandstone. Marburg-type sandstone persists in the basal Walloon Coal Measures, and abundant carbonaceous siltstone and mudstone are present in the upper part of the Marburg Sandstone.

In the northeast the boundary is quite distinct. The resistant sandstone beds of the Marburg Sandstone form high country near the South Moreton Anticline and contrast with flatlands developed on the Walloon Coal Measures. Lithological distinctions in outcrop may be more apparent than real, as benches of resistant Marburg sandstone are separated by intervals of poor or no outcrop, reflecting less resistant, more Walloon-like, sediments. The Marburg sandstone beds are typically deep green, very fine to fine, feldspathic sublabile to feldspathic, with minor lithic fragments; whereas Walloon sandstone is typically very lithic, commonly with a high content of coaly fragments and subordinate feldspar. In the southeast the boundary is transitional, generally without major changes in topography or lithology.

West of the Main Range Volcanics the boundary can be mapped relatively easily: the Walloon Coal Measures underlie black soil whereas the Marburg Sandstone underlies orange or brown clayey sandy soil. This change coincides with the change from the Marburg Sandstone to the poorly outcropping calcareous mudstone, siltstone, and fine-grained sandstone of the Walloon Coal Measures. Generally, Walloon sandstone contains black lithic fragments whereas Marburg sandstone does not. There is commonly a difference in photo-pattern at the boundary, but this can be obscured by black soil moving downslope.

The Walloon Coal Measures were deposited in swamps by low-energy streams, and in lakes; coal accumulated in backswamp areas. The abundance of fresh andesitic rock fragments, and the presence of montmorillorite as matrix and in discrete beds indicate that there was andesitic volcanism in the hinterland which provided much of the debris. Tuff and similar sediments of the same age in the Surat Basin (Exon & Duff, 1968) suggest widespread volcanism at the time. In the type area (Hill & Denmead, 1960, p. 290) deposition was from north-flowing currents. As in Marburg time, the Texas High was apparently the main source of streams that radiated from it; we took some cross-bedding readings which support this view.

High-volatile, generally non-coking, bituminous coal has been mined at Bonalbo and Tannymorel, but the mines have closed. Working seams were generally 1 to 4 m thick (Gould, 1968) but in places were thicker.

The sequence in the Sheet area is thicker than the 200 m of the type area in the north. We estimated a thickness of 450 m at Mount Barney, and the formation is 550 m thick in Mid-Eastern Kyogle No. 1 (Fig. 3) in the middle of the basin. It thins southwards to 360 m in Australia Cities Service Tullymorgan No. 1 near Maclean, and in the far south near Nymboida (McElroy, 1962) it is 120 to 200 m thick. The formation is therefore thickest in the centre of the depositional basin.

Plant leaves and stems are very abundant. Plants collected during the present survey are of Jurassic to Lower Cretaceous age (White, 1969). De Jersey & Paten (1964) assigned a Middle Jurassic age to the sequence in the type area. McElroy (1962) recorded two spore assemblages from the Bonalbo Colliery which were identified by J.P.F. Hennely as Upper Jurassic. Burger (Appendix 2) obtained a typically Jurassic flora of Evans' (1966) division J4 which is Middle Jurassic. Thus, most of the unit is Middle Jurassic, but it may range into the Upper Jurassic

WOODENBONG BEDS (new name)

The Woodenbong Beds are named after the township of Woodenbong in northeastern New South Wales. Their main areas of exposure are north of Woodenbong, around Capeen, and west of Kyogle, and scattered outcrops extend some 50 km northwest from Kyogle.

They are well exposed in the general area north of Woodenbong along the west-northwesterly-trending Great Dividing Range between longitudes 152°30′ and 152°21′E and latitudes 28°17′ and 28°21′S. Particularly good exposure is present above the top of the Walloon Coal Measure on the forestry road at 152°35′50″E, 28°20′20″S, westward to the base of the Tertiary basalt on the eastern side of Mount Clunie at 152°32′00″E, 28°18′50″S.

North of Woodenbong the lower part of the beds consists largely of massive to medium-bedded, pale grey, fine to coarse, cross-bedded labile sandstone with minor dark lithic grains, and some carbonaceous partings and small pieces of fossil wood. ripple-marked siltstone lenses are common; the ripple marks and cross-bedding suggest current flow to the east. Above the basal section outcrop is poor, but the beds appear to consist of more than 50 percent fine to medium feldspathic sandstone; siltstone, carbonaceous mudstone, and minor coal make up the rest of the sequence.

The beds are lithologically similar throughout their outcrop, although they contain more lithic grains and more feldspar in the north than in the south. Southwards, near Old Bonalbo, they grade laterally into the more quartzose Kangaroo Creek Sandstone. North of Woodenbong the beds are heavily leached and appear superficially to be sublabile; fresher outcrops show that they are labile. In hills near Capeen (e.g. road towards Dome Mountain, road over Richmond Range) good outcrop shows that the sequence is predominantly sandstone. Near the southern limit of the Woodenbong Beds a basal medium to coarse sandstone sequence perhaps 15 m thick (e.g. 577457) varies from labile to apparently quartzose — a rock type transitional between typical Woodenbong

Beds and Kangaroo Creek Sandstone. McElroy (1962) mapped the beds in this southern area as part of the Kangaroo Creek Sandstone (although he included those near Woodenbong in the Walloon Coal Measures). However, overlying the basal sequence is about 150 m of unresistant labile sandstones quite unlike those of the Kangaroo Creek Sandstone; some of them are greenish and contain numerous lithic grains. Minor pebbly and gritty bands persist throughout the sequence.

The Woodenbong Beds conformably overlie the Walloon Coal Measures and are unconformably overlain by Tertiary volcanics. They are lateral equivalents of the Kangaroo Creek Sandstone and probably of part of the overlying Grafton Formation. The conformable contact with the underlying Walloon Coal Measures is obvious in most areas. It is possible that the Woodenbong Beds were originally continuous with the upper part of the Injune Creek Group in the Surat Basin (Exon et al., 1972), and that structural movements and erosion have left a gap of 200 km to the Springbok Sandstone in the Millmerran area. Alternatively there may have been no deposition on the high connecting the Yarraman Block and the Texas High. We have no palynological data from the Woodenbong Beds as a basis for comparison with the Surat Basin sequence, but it is possible that the lower sandstone part of the beds is comparable with the Springbok Sandstone, and the upper finer-grained part with the Westbourne Formation. The thickness is not accurately known but probably exceeds 400 m.

The beds were deposited by streams and in lakes; their provenance was probably largely granitic and from the Texas High area. Intermediate volcanic grains may represent contemporary andesitic volcanism to the north. Cross-bedding readings suggest deposition from streams flowing east and southeast.

The Woodenbong Beds are underlain by the Middle to Upper Jurassic Walloon Coal Measures, and are equivalent to the Upper Jurassic Kangaroo Creek Sandstone, and probably to the lower part of the Grafton Formation, which is also Upper Jurassic; therefore they are probably entirely Upper Jurassic.

KANGAROO CREEK SANDSTONE

The names 'Kangaroo Creek Series' and 'Kangaroo Creek Stage' were proposed (Lloyd & Whiting, 1940; Lloyd, 1950) for the sandstone which forms escarpments up to 90 m high along Kangaroo Creek near Nymboida (the type area). The unit was redefined as Kangaroo Creek Sandstone by McElroy (1962) in the following terms:

> 'The dominant rock type (indeed, almost the only rock type) of the formation typically consists of medium to coarse, glistening white and cream sandstone of saccharoidal texture. Thin bands and lines of quartz pebbles are distributed sparsely throughout the formation.'

In thin section quartz constitutes 80 to 85 percent of the rock, silty rock fragments, chert, and feldspar 3 to 4 percent, and clay matrix the remainder; zircon, rutile, garnet, tourmaline, and monazite are present in small quantities. By Crook's (1960) classification it is quartzose sandstone.

McElroy (1962) mapped the formation right around the basin from south of Woodenbong to the Grafton area, and thence north to the Nimbin area, but we

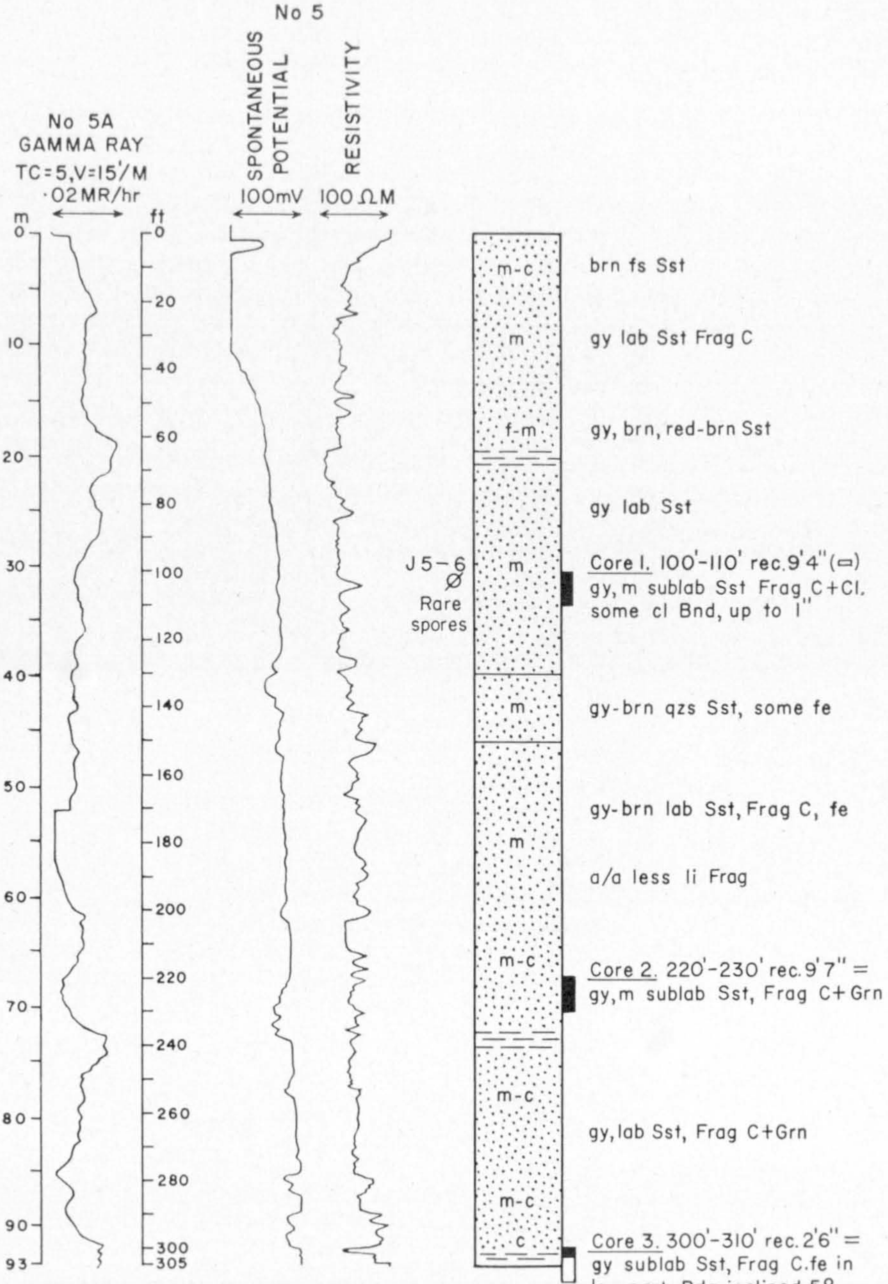

Fig. 7. Drill holes BMR Warwick Nos. 5 and 5A, Grafton Formation. Both holes drilled at the one site.

have mapped the feldspathic sandstone near Woodenbong separately as the Woodenbong Beds. The facies boundary shown on the geological map is arbitrary and marks roughly the southernmost extent of dominantly feldspathic sandstone; south of it quartzose and feldspathic sublabile sandstone predominates, although some labile sandstone was encountered in BMR Warwick No. 3 (Fig. 6).

The Kangaroo Creek Sandstone is a cliff-forming unit, at least in the lower part. It is typically exposed along the Mallanganee-Casino road where it is about 180 m thick. The lower third of the sequence consists of thickly bedded cross-bedded, fine to coarse, white to buff, quartzose to feldspathic sublabile sandstone. It contains minor dark lithic grains, isolated potash feldspar grains, and quartz grains which display crystal faces. The rather rare pebble bands consist largely of quartz, quartzite, phyllite, chert, and acid porphyry. Non-outcropping bands may represent more labile sandstone. The upper part of the sequence is much less resistant and consists largely of fine-grained feldspathic sublabile sandstone, grading to feldspathic sandstone in some beds.

The Kangaroo Creek Sandstone overlies the Walloon Coal Measures with apparent conformity in the Sheet area, although McElroy (op. cit., p. 42) believes that farther south there is an angular unconformity of several degrees. The East Richmond Fault, which follows the contact in the Mummulgum area, confuses the relationship in one of the best outcrop areas.

The Kangaroo Creek Sandstone is a fluviatile unit for which the Texas High undoubtedly remained the source of the detritus, but the overall change southwards to a thinner more quartzose sandstone indicates deposition from southeast-flowing streams. In the northern part of the outcrop area the Kangaroo Creek Sandstone is more than 300 m thick. In Mid-Eastern Kyogle No. 1, 135 m of Kangaroo Creek Sandstone was penetrated and there is a considerable thickness of the unit above the well head; the total thickness is estimated to be about 250 m. In the southern part of the Warwick Sheet area Hanlon (1968) estimated a thickness of 180 m. In the type area it is about 150 m thick.

A core sample from Mid-Eastern Kyogle No. 1 yielded the only identified fossil, the spore *Lycopodiamsporites rosewoodensis,* which indicates a post-Middle Triassic age. The Kangaroo Creek Sandstone overlies the Middle to Upper Jurassic Walloon Coal Measures, underlies the Upper Jurassic Grafton Formation, and is therefore Upper Jurassic.

Grafton Formation

The terms 'Grafton Beds' (Lloyd & Rayner, 1946) and 'Grafton Stage' (*in* David, 1950) were proposed for a sequence of poorly outcropping sandstone, siltstone and mudstone extending along the axial zone of the Clarence Basin from south of Grafton to north of Casino. McElroy (1962, p. 45) renamed the unit, which has no designated type section, as Grafton Formation and described it as largely siltstone and claystone with some soft, poorly cross-bedded sandstone. In thin section (McElroy, op. cit., p. 47) the clayey lithic sandstone contains quartz and rounded chert, with minor feldspar and abundant clay matrix; subrounded zircon predominates over a rutile in the heavy-mineral fraction. BMR Warwick No. 5 stratigraphic hole (Fig. 7) penetrated 95 m of fine to coarse grey sublabile to labile sandstone with angular clasts and minor siltstone and clay; garnet and coal grains and clay clasts are abundant in some beds.

TABLE 3. CAINOZOIC STRATIGRAPHY

	Age	*Rock Unit and Map Symbol*		*Distribution*	*Lithology*	*Relationships*
QUATERNARY			Qs	Small area 15 km N of Warwick	Sand	Unconformable on Walloon Coal Measures or Tertiary basalt
QUATERNARY			Qa	Along major rivers	Sandy alluvium. Vertebrate remains in Knapps Creek (Woods, 1960)	Unconformable on older rocks
QUATERNARY	Pleistocene		Qpc	Along Condamine River and tributaries	Sandy alluvium up to 30 m thick. Vertebrate remains (Woods, 1960; Bartholomai & Woods, 1968; Bartholomai, 1969)	Unconformable on older rocks
LATE OLIGOCENE TO EARLY MIOCENE	22-24 m.y. (Webb et al., 1967)	Main Range Volcanics	Tmm	NNW belt up to 20 km wide and 50 km long in N	Alkali-olivine basalt, minor pyroclastics and sediments including lithic sandstone and mudstone (up to 750 m thick)	Unconformable on Walloon Coal Measures and Marburg Sandstone Extruded from fissures (Tmo) along and E of Main Range
LATE OLIGOCENE TO EARLY MIOCENE		Main Range Volcanics	Tmt	Narrow belts within area of outcrop of Main Range Volcanics	Trachyte (up to 165 m thick)	Flows interbedded with basalts (Tmm) and extruded from vents exposed east of Great Dividing Range (Tmp). Equivalent to trachyte sills (Tms) in Walloon Coal Measures
LATE OLIGOCENE TO EARLY MIOCENE		Main Range Volcanics	Tmo	Small isolated outcrops along eastern flank of Great Dividing Range	Dolerite	Sills and dykes intruding Permian at Tooloom and Walloon Coal Measures east of Great Dividing Range. Vents to Main Range Volcanics
LATE OLIGOCENE TO EARLY MIOCENE	22.6-22.9 m.y. (McDougall & Wilkinson, 1967)	Lamington Volcanics	Tml	Belt up to 25 km wide along most of eastern boundary of Sheet area	Mainly basalt, some bedded rhyolite, rhyolitic pyroclastics, sediments	Unconformable on Ipswich-Moreton Basin sequence. A small part of Mount Warning volcanics, vent 25 km to E
LATE OLIGOCENE TO EARLY MIOCENE		Lamington Volcanics	Tmr	Irregular belts of outcrops near eastern Sheet boundary and Mt Lindesay	Cliff-forming agglomerate and brecciated rhyolite overlain by argillaceous sandstone and polymictic conglomerate (thickness: 3-60 m)	Interbedded in Lamington Volcanics. Previously mapped as Hillview Rhyolite and Chinghee Conglomerate (McTaggart, 1961)

Table 3 continued

	Age	*Rock Unit and Map Symbol*	*Distribution*	*Lithology*	*Relationships*
LATE OLIGOCENE TO EARLY MIOCENE	At Tabulam 23.6 m.y. (McDougall & Wilkinson, 1967)	Tmb	Small areas in N between Main Range Volcanics and Lamington Volcanics. Larger areas in SE both E and W of Bonalbo	Basalt	Unconformable on Mesozoic sediments, mainly Walloon Coal Measures. Equivalent to basalts of Main Range or Lamington Volcanics
	22.5-25 m.y. (Webb et al., 1967)	Tmp	Peaks in NE including Mts Greville, Alford, Edwards, Barney, Moon, and Focal Peak; peaks around Woodenbong including Night Cap, North and South Obelisk, Edinburgh Castle, Bald Knob, and Glassy Mountain	Mainly trachyte; some rhyolite (e.g. Mt Moon) and granophyre (Mts Barney & Alford)	Plugs intruding Ipswich-Moreton Basin sequence. Vents for trachyte flows in Main Range Volcanics (Tmt), and sills and dykes in Mesozoic strata (Tms, Tmd)
		Tms	Small isolated areas in axial part of basin from Bonalbo to northern boundary	Mainly trachyte; some rhyolite (e.g. Mts Gillies, Maroon, Toowoonan)	Sills in Walloon Coal Measures. Related to plugs (Tmp), and trachyte flows in Main Range Volcanics (Tmt)
		Tmd	Three small areas S and SW of Woodenbong and one 20 km NNW of Mt Barney	Mainly trachyte	Dykes mainly in Walloon Coal Measures. Related to plugs (Tmp) and sills (Tms)

The Grafton Formation conformably overlies the Kangaroo Creek Sandstone. Although the contact is gradational, the quartzose to feldspathic sublabile Kangaroo Creek Sandstone is generally quite distinctive from labile Grafton Formation sandstone. The upper Woodenbong Beds may be equivalent to the Grafton Formation as the grey sandstone in BMR Warwick No. 5 is not unlike sandstone high in the Woodenbong Beds. However, the feldspathic Woodenbong Beds contain very few lithic sandstones, and no tough green sandstone which typifies the Grafton Formation in outcrop.

The Grafton Formation is probably a fluviatile unit in the Sheet area. As the siltstone-mudstone sequence farther south suggests lake sediments, derivation from a northerly source is likely, probably from the Texas High in the northwest; the abundant andesitic rock fragments suggest some contemporary volcanism, and the presence of *Hystrichosphaeridium* in BMR Warwick No. 5 indicates a marine incursion.

The maximum thickness of the unit is probably approached in Clarence Grafton No. 2 bore (McElroy, op. cit., p. 45) where it is 270 m thick. In the Sheet area it is probably less than 150 m thick.

The Grafton Formation is unconformably overlain by Oligocene-Miocene basalt and in some places is very hard near the contact, suggesting heat-induced recrystallization of the calcareous matrix. It contains *Taeniopteris spatulata,* a Jurassic to Lower Cretaceous plant (McElroy, op. cit.). From cuttings in BMR Warwick No. 5A, Burger (Appendix 2) obtained a microflora of Upper Jurassic rather than Lower Cretaceous age, which he has assigned to Evans' (1966) spore unit J5-6. It is thus probably Upper Jurassic and is the youngest Mesozoic unit in the Ipswich-Moreton Basin.

OLIGOCENE-MIOCENE IGNEOUS ROCKS

There was widespread igneous activity in southeast Queensland and northeast New South Wales in late Oligocene-early Miocene time. In the Main Range and McPherson Ranges areas, the extrusive products of this volcanism dominate the landscape. Intrusive igneous rocks in the form of bosses, plugs, sills, and dykes crop out between Boonah and Woodenbong. The Main Range Volcanics, which consist of alkali-olivine basalt and some trachyte, were poured out from local vents near the present-day Main Range, and were largely deposited to the west on a westerly slope. The subalkaline basalts of the Lamington Volcanics were extruded from vents at Mount Warning, and the associated rhyolites from local vents through the basalts. Erosion later stripped the basalts from the centre of the area and revealed the intrusions, which are confined to the outcrop area of the Walloon Coal Measures. Numerous intrusions probably underlie the basalts in the remainder of the area.

Table 4 lists the results of potassium-argon dating of the igneous rocks and Table 3 their stratigraphy. The rock types of the various intrusions and extrusions are shown in Figure 1 in Exon (1972a).

INTRUSIONS

The numerous intrusive masses, mostly plugs, dykes, and sills, in the north-eastern part of the Sheet area, and their relationship to pre-Tertiary rocks are shown on the geological map. Most of the Queensland intrusions were described by Richards (1916); the Mount Barney Central Complex by Stephenson (1954, 1956, 1959, 1960); and the Mount Alford Ring Complex by Stevens (1959, 1960, 1962). Less work has been done in New South Wales, and little has been published apart from McElroy (1962).

The distribution of rock types and the dating results (Table 4) suggest that emplacement of the alkali suite of trachyte, comendite, and microsyenite west of Rathdowney began slightly before that of the acid rhyolites and granophyres related to the Mount Barney and Mount Alford Complexes. However, both the times of emplacement and the rock types probably overlapped. Intrusion of dolerite, basalt, and teschenite, on the evidence of the extrusives in the Main Range Volcanics, probably continued longer than that of the more acid suites and started earlier. The extrusive equivalents of the microdiorite, diorite, and andesite cannot be separated from the basalt in the field and the date of their intrusion, although confined to the general period of volcanism, is uncertain. The intrusions are largely confined to the outcrop area of the unresistant Walloon Coal Measures, although the main acid complexes (Mount Barney and Mount Alford) dragged the more resistant Marburg Sandstone to the surface.

Mount Barney Central Complex (Stephenson, 1959, 1960)

The rocks of the complex range from acid granophyres to tholeiitic dolerites. Their intrusive history can be related to five successive centres of activity, aligned east-west. The complex has updomed the Walloon Coal Measures and exposed the underlying Marburg Sandstone and Triassic and Carboniferous sediments. Inside a circular line of flexure, dips of 20-40° away from the intrusions are common; outside the line, dips are normally shallow.

Mount Alford Ring Complex (Stevens, 1959, 1960, 1962)

The situation is generalized on the geological map. The complex consists of a central boss of porphyritic microdiorite, with closely associated granophyre, intruding steeply dipping Marburg and Walloon sediments which were dragged up during intrusion. Ring dykes of rhyolite and trachyte intruded the upturned Marburg sediments, and andesite invaded the central boss. Sills of rhyolite extend northwards from the outermost ring dyke. The central boss and the outer zone of ring dykes were pierced by later dykes of rhyolite and trachyte. At about the same time breccia necks formed within and on the margin of the boss by explosive action. The latest phase of activity was a basaltic dyke swarm restricted to the ring complex.

Other intrusions. An almost complete ring dyke of alkaline rhyolite forms Minto Crags, southeast of the Mount Alford Ring Complex. Two other partial ring dykes, apparently trachytic, cropping out southwest of Urbenville and near Capeen, were identified as ring dykes largely on the basis of the photo-pattern.

TABLE 4. POTASSIUM-ARGON DATING

Subdivision	*Age (m.y.)*	*Comments*
Alkali trachyte intrusives of central area	25-24*	Mt Edwards was only trachyte dated within Sheet area
Acid intrusions of central area	23.5-22.5*	One sample from each of Mts Alford, French, Barney, Gillies
Main Range basalts	24-22*	Consistent decrease up sequence from basal flow; 4 samples in Mt Mitchell area
Mt Warning gabbro	22.4*	One sample
Mt Warning basalts	22-20*	Weathered, internally inconsistent; probably too young; 4 samples
Mt Warning basalts	22.9, 22.6†	More reliable, 2 samples
Tabulam basalt	23.6†	Not known if part of Main Range or Lamington Volcanics or neither

* Webb, Stevens, & McDougall, 1967
† McDougall & Wilkinson, 1967

In places trachytic plugs are surrounded by sills of similar composition, possibly intruded into the Jurassic sediments during injection of the plugs before the final vertical breakthrough which formed volcanic vents.

VOLCANICS

Most of the volcanics can be assigned either to the Main Range Volcanics (Stevens, 1965) west of a line connecting the Main Range and Woodenbong, or to the Lamington Volcanics (Bryan & Jones, 1945) east of Mount Barney. A longitudinal line through Bonalbo and Capeen may separate the two units in the south. The affinities of the small basalt cappings in the Mount Barney/Boonah area are not known; some may be late-stage products of the Mount Barney and Mount Alford complexes.

Main Range Volcanics

The Main Range Volcanics form a north-northwesterly belt of country sloping gently westwards from the Main Range to Allora and Killarney. Up to 1000 m of volcanics are exposed in the east, and flows dip gently, and thin, westwards. The area has been cut into ridges, with valleys more than 300 m deep, by westerly-flowing streams.

The fairly straight scarp led early workers to postulate a major fault along the escarpment, but Reid (1922) and Marks (1932) showed that there is no evidence of a fault and suggested that the scarp is due to stream erosion which is more active east of the divide.

The volcanics were largely extruded from fissures along and immediately east of the line of the Main Range; the fissures are represented by numerous basalt dykes and many trachytic sills and plugs. Stevens (1965) stated that the volcanics dip easterly and westerly at low angles away from a line close to the present divide. The pre-volcanic surface was irregular and the base of the volcanics varies greatly in elevation.

Stevens (1965) showed that the sequence is complex. The lower 300 m contains numerous trachyte sills up to 165 m thick, but the oldest flow is always basalt. The trachytes are discontinuous and lenticular, and occur at various levels; each flow had a local vent, and some plugs are exposed. The upper 600 m is entirely basaltic. On the basis of petrology and distribution, Stevens named three members of the Main Range Volcanics — Spicers Gap Trachyte, Swanfels Trachyte, and Steamers Trachyte; his boundaries have been generalized on the accompanying geological map. Only the leucotrachytes can be distinguished in the field, so they alone are shown on the map; in some places basalt alternates with trachyte. Stevens found rocks 'ranging from olivine basalts to rocks with the chemical composition of rhyolites'. Basalt is the most abundant rock type and overall the sequence is an alkali-basalt/trachyte suite typical of continental non-orogenic regions.

Lamington Volcanics

The Queensland portion of the Lamington Volcanics was first discussed by Richards (1916), who recognized a general threefold vertical subdivision into basalt-rhyolite-basalt. Bryan & Jones (1945) named them the Lamington Series and suggested a Pliocene age. The name Lamington Volcanics was first used by Stephenson et al. (p. 355 *in* Hill & Denmead, 1960). The volcanics consist predominantly of basalt with some interbedded rhyolite, rhyolitic pyroclastics, and sediments, and were mainly extruded from the Mount Warning shield volcano. The rocks have a maximum thickness of about 1100 m and form a shield volcano, the lavas extending in all directions for up to 55 km (Solomon, 1964). Spine-like supplementary vents of acid material — Egg Rock and Charrambomba Rock — were noted by Tweedale (1950) in the Binna Burra area. Solomon (1964) noted similar spines within the caldera.

McElroy (1962) found a threefold division south and east of the Warwick Sheet area and used the name 'McPherson Volcanics' for the sequence, but noted that Lamington Volcanics had priority. The lower 200 m basaltic sequence (the Lismore Basalt) is overlain by a rhyolitic sequence (Nimbin Rhyolite), which has a maximum thickness of 500 m near Nimbin; the upper basalt (Blue Knob Basalt) has a maximum thickness of 250 m, also near Nimbin.

The recent mapping (see also Exon, 1972a) indicates that rhyolite was emitted in different areas at different times, the earliest phase possibly being the Hillview Rhyolite and the Chinghee Conglomerate (McTaggart, 1961) between Hillview and Wiangaree. The Binna Burra Rhyolite (McTaggart, 1961) and the Nimbin Rhyolite (McElroy, 1962) are at a higher level but about 10 km farther east, and may be contemporaneous although spatially separated. The Mount Lindesay Rhyolite (McTaggart, 1961) exposed at Mount Lindesay and Mount Glennie (Glennies Chair) is a fourth body. It was impossible to establish their relationship to the rhyolites in the east in our regional mapping program, but the Mount Lindesay Rhyolite has a different origin from the eastern rhyolite because it thickens northwestwards.

The names Albert Basalt, Beechmont Basalt, Hobwee Basalt, Lismore Basalt, and Blue Knob Basalt have local application, but we have used the map symbol Tml for all the basalts of the Lamington Volcanics. As the volcanic sequence is not divisible in many places, we prefer the earlier name Lamington Volcanics to McTaggart's (1961) Lamington Group. A more detailed discussion of our findings in the Lamington Volcanics is given in Exon (1972a).

Hillview Rhyolite and Chinghee Conglomerate. McTaggart (1961) proposed these names for sequences in the Hillview type area, where the cliff-forming Hillview Rhyolite consists of agglomeratic tuff and brecciated rhyolite up to 60 m thick. The type section of the Chinghee Conglomerate (Table 5) was measured during the present study.

The Chinghee Conglomerate consists of alternating beds of argillaceous current-bedded sandstone and polymictic conglomerate which contains boulders up to 0.5 m across consisting of Palaeozoic sediments, rhyolite, and granophyre, the last being similar to that of the Mount Barney central stock. McTaggart stated that it everywhere overlies the Hillview Rhyolite, and reaches a maximum thickness of 30 m in the type area.

The Chinghee Conglomerate is regarded as a fluviatile sequence deposited during a period of acid volcanism. The Hillview Rhyolite, which is largely agglomerate, must have had its vent in the Hillview-Chinghee area, where the unit is coarsest.

The Hillview Rhyolite and Chinghee Conglomerate, which are interbedded outside the type area, are included in unit Tmr on the geological map. The unit thins steadily southwards from about 60 m near Cougal to about 30 m south of Mount Lion, and has a gentle southerly dip.

TABLE 5. TYPE SECTION OF THE CHINGHEE CONGLOMERATE

(Measured up cliffs in the type area near Hillview by D. J. Casey and R. F. Reiser)

Chinghee Conglomerate	
50-56 m	conglomerate, boulders up to 1 m, subangular; basalt and acid volcanics
46-50 m	basalt, probably infilling a valley in the conglomerate
39-46 m	conglomerate, boulders up to 1 m, subangular; basalt and acid volcanics
34-39 m	fine to coarse yellow tuffaceous sandstone, thick to well bedded, feldspathic; minor lenses of cobble conglomerate
31-34 m	fine-grained feldspathic sandstone with fine interbeds of tuff; some beds of pebble conglomerate 15-30 cm thick
27-31 m	generally coarse conglomerate with fragments up to boulder size, cobbles common; clasts of tuff, rhyolite porphyry and 'chert' of low sphericity, subangular, in a tuffaceous matrix
16-27 m	no outcrop
Hillview Rhyolite	
0-16 m	agglomerate of large angular boulder to cobble-sized clasts of tuff, containing feldspar and quartz crystals

Mount Lindesay Rhyolite. McTaggart (1961) introduced this name for the sequence of tuff, agglomerate, obsidian, and rhyolite that forms cliffs on Mount Lindesay and nearby Mount Glennie (Glennies Chair). On Mount Lindesay, Stephenson (*in* McElroy, 1962, p. 55) recorded 420 m of basalt overlain by 60 m of rhyolitic agglomerate and light-coloured tuff; above them is 180 m of cliffs containing rhyolite, local thin basalts, and acid pyroclastics at the base; the mountain is topped with 30 m of basalt. The sequence was originally co-extensive with the 120-m sequence at Mount Glennie. The two flows on Mount Glennie are more uniform, being largely white rhyolite with feldspar phenocrysts.

A dip to the south is visible on Mount Glennie, and the same beds are about 180 m higher on Mount Lindesay in the northwest. As the Mount Lindesay sequence is thicker and more agglomeratic as well as higher, the interpretation of Tweedale & Stephenson (p. 356 *in* Hill & Denmead, 1960) that Mount Gillies, 8 km farther north, was the vent for the Lindesay Rhyolite is accepted.

Both the original and the present distribution of the Lindesay Rhyolite are uncertain. Richards (1916) recorded sporadic cappings of acid volcanics on the McPherson Ranges between Mount Lindesay and Running Creek. We found no acid volcanics in situ in accessible areas north of Old Grevillia, but all the creeks contained abundant large cobbles and boulders of acid volcanics which range from very fine rhyolite to very coarse acid porphyries and must have been derived from the headwaters of the creeks.

The Basalts. Richards (1916) made the first detailed study of the basalts. Chemical analyses show that the Lamington Volcanics are less alkaline than the Main Range Volcanics; Webb et al. (1967) stated that the Lamington Volcanics are not typical tholeiites but are closer in composition to that suite than are the Main Range Volcanics.

The basalts range from glassy to coarsely porphyritic with phenocrysts normally of olivine or feldspar. Richards (1916) reported porphyritic andesite from the upper basalt sequence in the north. Vesicular and amygdaloidal basalts form scattered outcrops, and zeolite infillings are common. Basaltic agglomerate and tuff have been seen only in the lower part of the sequence and are rare.

Age: Webb et al. (1967) used K/Ar dating to obtain apparent ages of 22 to 20 m.y. for four samples. These dates were all younger than the biotite age of 22.5 to 23 m.y. obtained for the Mount Warning gabbro. They stated:

> 'The present evidence does not justify the conclusion that the volcanism in the Main Range began before that in the Mount Warning Shield. The results suggested that alkali olivine basalt magma and sub-alkaline magma were being extruded during the same interval from centres only 80 km apart'.

Dates on basalts from Fingal and Burleigh Heads (22.6 and 22.9 m.y. respectively) and an age of 23.6 m.y. from an olivine tholeiite near Tabulam (Main Range Volcanics?) were given by McDougall & Wilkinson (1967).

Sediments associated with the Main Range Volcanics

In several localities near Cunninghams Gap sediments interbedded with or overlying basalt are dominantly volcanolithic (both explosive debris and clasts derived from erosion of pre-existing basalts). A typical sequence, 12 m thick, in a creek bank at 540523 north of the Cunningham Highway comprised:

Top

Unit 8.	yellow, fibrous, low-density volcanic ash
Unit 7.	hard, well crystallized (?silicified) tuff with a conchoidal fracture cutting across crystals
Unit 6.	vesicular tuff, replaced laterally by coarse pebble sandstone
Unit 5.	hard grey mudstone interbedded with grey to white fine-grained sublabile to labile sandstone
Unit 4.	vesicular fine-grained tuff with quartz and feldspar pebbles
Unit 3.	pebbly sandstone and conglomerate overlying unit 2 with scour-and-fill structure; clasts largely intraformational in derivation, showing poor sorting and irregular shape
Unit 2.	fine-grained white tuff, with fine quartz and feldspar crystals and some medium feldspar
Unit 1.	fine-grained low-density tuff, with sand-size shards of volcanic glass and minor feldspar and quartz crystals.

The sequence suggests explosive volcanism during a lull in extrusive activity, and deposition in a lacustrine or fluviatile environment on a basalt surface.

QUATERNARY SEDIMENTS (Table 3)

The major accumulations of Quaternary sediments are related to the Condamine, Logan, Richmond, and Clarence River systems.

Condamine alluvium (Qpc)

The alluvium of the Condamine River system, especially its vertebrate content, has been discussed by Woods (1960), Bartholomai & Woods (1968), and Bartholomai (1972). Downstream from Dalby, Pliocene vertebrates are found in the Chinchilla Sand; the younger unit Qpc contains Pleistocene vertebrates along its length. Bartholomai (op. cit.) noted that an overlying veneer of Recent mud was about 1 m thick.

In the headwaters of the Condamine River Pleistocene vertebrates have been found at several localities, particularly in Freestone and Emu Creeks. The alluvium of the Condamine River, which is largely drawn from Palaeozoic sediments and granite and the Marburg Sandstone, is sandy and probably less than 30 m thick. The west-flowing tributaries contain unusually muddy alluvium derived from the basalt of the Main Range, the feldspathic Marburg Sandstone, and the muddy lithic sediments of the Walloon Coal Measures. Although some of the sediment exposed at the surface is Recent, most is probably Pleistocene.

Other alluvium (Qa)

Little is known about the alluvium of the other streams and it is shown on the map as undifferentiated Quaternary alluvium. Pleistocene vertebrates have been found only in Knapps Creek, a tributary of the Logan River near Tamrookum (Woods, 1960, p. 402).

The alluvium of the broad flood plain of the Logan River is thick and sandy, as shown by numerous water-bores along its length. Both it and the Richmond River alluvium probably contain extensive Pleistocene sediments. The Clarence River alluvium is narrower, but is very sandy. West of the river on the main road west from Tabulam, about 6 m above the present-day alluvium, consolidated river gravels at least 2 m thick are probably Pleistocene or older.

STRUCTURE

The Warwick Sheet area forms part of the western flank of the meridional Ipswich-Moreton Basin (Fig. 8). The basin structure is simple overall but is complicated in the Sheet area by several faults and related anticlines, the domes of the Mount Alford and Mount Barney intrusions, and Hogarth Dome.

Palaeozoic sediments and granites of the Texas High form the western margin of the basin and the basement throughout the Warwick Sheet area. The eroded surface of the basement rocks slopes from the Texas High to the north and east at an average of less than 0.5°, although it is somewhat steeper at the basin margin. The Mesozoic fill of the basin conforms to the basement structure. In the middle of the basin, on the eastern side of the Sheet area, Mid-Eastern Kyogle No. 1 penetrated 2500 m (Warner, 1963) of Mesozoic sediments, which seismic and aeromagnetic data (Zarzavatjian, 1965) suggest is about the maximum thickness.

The two cross-sections on the geological map illustrate the general structure as inferred from surface and subsurface data, but the widespread Miocene basalt cover has prevented geophysical work in most of the Sheet area and has obscured much of the pre-Tertiary outcrop.

In the north (Section A-B-C), Triassic and basal Jurassic sediments fill the centre of the basin but do not appear in outcrop on the western side of the basin. It seems more likely that this is due to an onlap relationship to the Texas High rather than to early Jurassic bevelling. The same situation applies in the south (Section D-E-F), where several holes were drilled and some seismic data are available.

The Tertiary intrusions of Mount Barney and Mount Alford have domed the surrounding Mesozoic sediments. Inside a line of flexure developed around the Mount Barney Complex dips are steep, but outside they are virtually flat. The Swan Creek and Maryvale Anticlines, in which dips are only shallow, are probably due to basement adjustment and associated faulting. The faulting on the western side of the Swan Creek Anticline is illustrated in Plate 6b.

The South Moreton Anticline, the related Grevillia and Toonumbar Anticlines, and the associated faults appear to have been caused by basement readjustment in pre-Miocene time. Hill (p. 6 *in* Hill & Denmead, 1960) stated that the main faulting occurred between the mid-Jurassic and the early Cainozoic, although some movement occurred in the late Triassic, and again in the Cainozoic when the Mesozoic structures were accentuated. The West Ipswich Fault, a major structural line trending south-southeast, affected the Walloon Coal Measures but not the Cainozoic rocks. In the Warwick Sheet area and immediately north of it Oligocene-Miocene basalts lying directly on the South Moreton and Grevillia Anticlines are undisturbed (Hill & Tweedale, 1955). Jorgenson & Barton (1966), from photogeological interpretation, suggested that the eastern edge of the Esk Trough, the West Ipswich Fault, and the South Moreton Anticline, all of which are aligned, were controlled by a single system of crustal weakness.

The South Moreton Anticline is an asymmetrical structure with a gently dipping western limb (2 to 5°), and a steeply dipping east limb (up to 70°) (Pl. 6a) which is sheared and faulted in places; culminations on the anticline are delineated by outcrops of the Ripley Road Sandstone. The Grevillia Anticline is only visible as a window in the Tertiary basalt and may be linked, under the basalt, to the South Moreton Anticline. Dips of 5 to 15° are visible on both flanks but no sign of faulting was seen in the small area of outcrop. The Toonumbar Anticline, farther south and on the same trend, is similar to the South Moreton Anticline in that it has a gently dipping western flank and a faulted eastern flank with dips up to 30°. The preferred interpretation is that all the resistant sandstone in the vicinity is part of the Marburg Sandstone. An alternative interpretation is that displacement of more than 300 m on the fault has brought the Kangaroo Creek Sandstone into juxtaposition with the Marburg Sandstone.

The East Richmond Fault (McElroy, 1962), the southerly continuation of the main line of structures, is a zone of faulting apparent on both seismic and aeromagnetic maps. Feather faulting, with azimuth approximately 200°, is evident in the Ghinnighi area. Maximum displacement down to the east is probably about 80 m in outcrop near Mummulgum, but seismic data suggest it is more than 150 m in the subsurface. Thus there probably was slow movement on the fault during the Mesozoic.

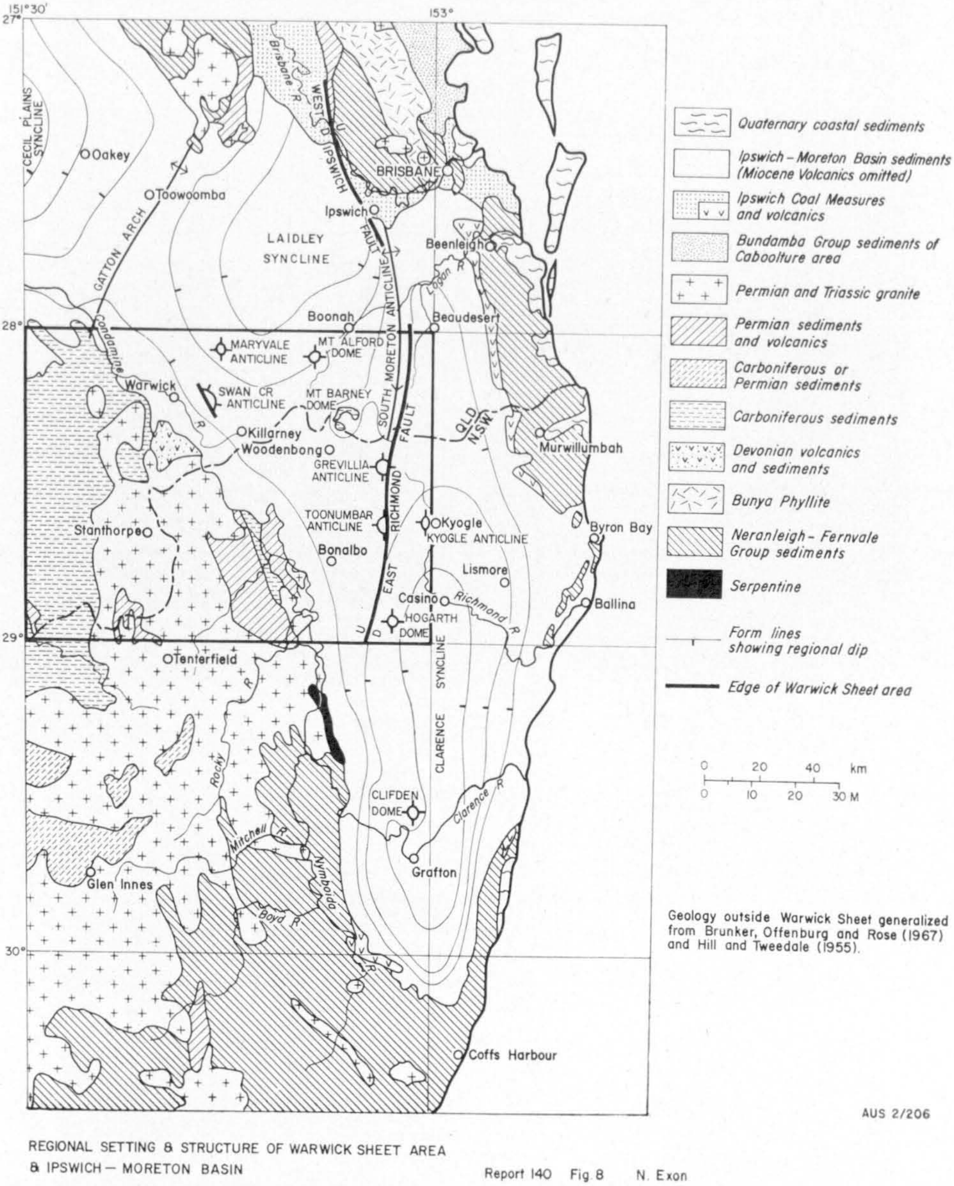

Fig. 8. Regional setting and structure of Warwick Sheet area and Ipswich-Moreton Basin.

Plate 6a. Steeply dipping and probably faulted Marburg Sandstone in eastern flank of South Moreton Anticline (grid ref. 605513).

Plate 6b. Faulted Marburg Sandstone on western side of Swan Creek Anticline. Looking south at roadside (grid ref. 524503).

The West Richmond Fault (McElroy, 1962) is a less obvious feature not apparent on the seismic map. McElroy (pp. 68-69) described shallow-dipping Walloon and Kangaroo Creek sediments at the same level on either side of a northern tributary of Gorge Creek (583437) and from this and other evidence in the vicinity he concluded that there is displacement of more than 200 m on the fault, with upthrow to the east.

The 8 km-wide upthrown area separating the East and West Richmond Faults in the Richmond Range area was named the Richmond Horst by McElroy (1962). Seismic and outcrop evidence suggests that the feature terminates southwards east of Bonalbo, although seismic data show that a platform with a faulted eastern side persists southwards (Section D-E-F). In the north the horst disappears under the basalt of the McPherson Ranges and cannot be traced beyond the basalt, and thus is only recognizable over 24 km.

In the south, and east of the East Richmond Fault, the Hogarth Dome is a broad gentle structure centred on Hogarth Trig. Station. Hanlon (1968) mapped it on the basis of structure contours in the Upper Jurassic sequence, and proved a culmination of 100 m; the structure was drilled in 1968 by Clarence Oil Hogarth No. 1.

GEOLOGICAL HISTORY

In early Triassic time the Texas High and the surrounding area were steadily eroded by streams to form a fairly flat surface, and possibly the Beenleigh Block farther east was also being eroded.

In mid-Triassic time the Ipswich Coal Measures accumulated in depressions, and bursts of volcanism contributed tuffs and flows. Periods of energetic stream deposition gave rise to beds of polymictic conglomerate. Similar sedimentation persisted to form the lower part of the Bundamba Group and the sediments gradually lapped farther onto the Texas High. In early Jurassic time the rate of erosion and deposition increased and the fluviatile arkosic sandstone of the Ripley Road Sandstone was laid down on top of the coal measures. The Marburg Sandstone overlapped the Ripley Road Sandstone, early beds being mostly coarse and arkosic, but finer-grained overbank and lacustrine sediments later became more important. The sea invaded low areas for short periods.

During the Middle Jurassic the Walloon Coal Measures were laid down in and near swamps and lakes; the large proportion of andesitic volcanic debris and the presence of bentonite suggest contemporaneous volcanism. Deposition of point-bar and channel sands by southeast-flowing streams gave rise to the labile Woodenbong Beds in the north and the quartzose Kangaroo Creek Sandstone in the south. The Jurassic ended with overbank, lake, and in small part marine, beds of the Grafton Formation. Abundant volcanic debris suggests contemporaneous volcanism. The accumulation of Mesozoic sediments reached more than 2500 m in places.

A long period of erosion was interrupted by a burst of tectonic activity during which a major structure, the South Moreton Anticline-East Richmond Fault, developed. Probably the Beenleigh Block was raised and the present basin was shaped at that time.

In late Oligocene-early Miocene time the Mount Warning volcano and other vents poured out a mass of volcanic material which formed a sheet more than 1000 m thick over large parts of the area. Basalt dominated, but more acidic flows and pyroclastics were also widespread. The larger acid bodies caused doming of the Mesozoic sequence, and a profusion of sills, dykes, and plugs was intruded.

Erosion has since been the major activity in the Sheet area, and Pliocene and Pleistocene sands containing vertebrate fossils were deposited along the major stream courses. Several thousand metres of volcanics and Mesozoic sediments were removed from the more active erosional areas. The underlying Oligocene-Miocene intrusions have been exposed south of Boonah, and in places rise more than 1000 m above the surrounding plain.

ECONOMIC GEOLOGY

WATER

by L. Stevenson, GSNSW, and D. J. Casey, GSQ

These notes have been compiled from water-bore data held by the Water Conservation and Irrigation Commission of New South Wales and the Irrigation and Water Supply Commission of Queensland. Appendix 5 summarizes the New South Wales borehole data, but only sketchy records are available from the Queensland part of the Sheet area. Most of the available information in Water Conservation and Irrigation Commission records has been provided from drillers' records, but records for many boreholes are incomplete and no comprehensive field borehole survey has been carried out.

All recorded New South Wales boreholes are in the eastern third of the Sheet area, east of the New England Tableland. Rainfall (over 600 mm) is normally adequate for pastoral purposes, and widespread use is made of surface catchments, and less of groundwater. Groundwater is used mainly for stock. Yields are 450 to 18 000 litres/hour but generally seem insufficient for irrigation; 87 boreholes are recorded in the New South Wales part of the Warwick Sheet area; water is derived from Quaternary alluvium in 43 percent of the boreholes, Tertiary alluvium in 1 percent, Tertiary basalt in 8 percent, and Jurassic-Cretaceous sediments in 13 percent; logs are not recorded for 36 percent.

In Queensland the rugged sandstone and basalt country away from the alluvial valleys has a relatively low stock-carrying capacity. Pastoralists obtain sufficient water for stock requirements from earth tanks and from surface water. Most streams rise in the McPherson or Liverpool Ranges and many are permanent.

Quaternary Alluvial Sediments. In New South Wales most boreholes have been sunk in shallow alluvium close to streams. Unconsolidated sediments average 10 m deep, with a maximum recorded 30 m, and consist of sand, sandy clay, gravel, and clay. Water is obtained mainly from the sand and gravel beds, and yields from boreholes and wells average 2250 litres/hour. One borehole had a reported yield of 18 000 litres/hour. Analyses of salt content have not been recorded, but the groundwater appears generally suitable for stock.

In Queensland the Irrigation and Water Supply Commission carried out a groundwater investigation of the Logan and Albert Rivers in 1959. Most work was done in the Tweed Heads Sheet area, but three lines, at Round Mountain, Tamrookum, and Hillview, were drilled across the alluvium in the Warwick Sheet area, the last one along Christmas Creek, a tributary of the Logan River. The holes were generally 18 to 24 m deep, the thickness of the alluvium, and pumping supplies of up to 65 000 litres/hour were obtained, the average being about 3300 litres/hour. Average solids content was about 500 ppm, which is suitable for irrigating most crops. Little use is made of this water as most irrigation farmers use surface water from the Logan River and its tributaries.

Tertiary Basalt. In New South Wales boreholes in basalt produce groundwater yields of 2250 to 4500 litres/hour, but there is no recorded information about the quality of the water. One borehole (grid ref. 613445) produced good-quality water from Tertiary alluvium below the basalt with a maximum yield of 5500 litres/hour.

Small springs are common at the basalt/sediment contact along the State border, but they tend to dry up during prolonged dry spells. The basalt/sediment contact could be a suitable target for groundwater away from the dissected margin of the basalt.

Jurassic-Cretaceous sediments. In New South Wales the Grafton Formation consists of labile sandstone and shale from which boreholes have provided yields of up to 2250 litres/hour. Boreholes drilled into the underlying Kangaroo Creek Sandstone have given yields of 900 to 6500 litres/hour, and yields from boreholes into the Walloon Coal Measures range up to 900 litres/hour. Recorded information concerning the quality of the groundwater from these units is not available.

In Queensland sandstone beds of the Marburg Sandstone and the Walloon Formation are not major sources of underground water because they are usually impermeable. The Ripley Road Sandstone is more permeable, but its outcrop is restricted and, because of the steep dips in the area, it would be too deep for economic exploitation.

COAL

The only significant coal in the area occurs in the Walloon Coal Measures.

Coal was worked 3 km east of Hendon railway station, 18 km north-northwest of Warwick, but no records are available. On Talgai station, 22 km north-northwest of Warwick, a 2.5 to 3 m seam of coal, contaminated with shale, was intersected in a water well.

East of Warwick, around Tannymorel, coal of Jurassic age has been discovered over an area of about 500 km². Many occurrences, such as those near the Swan Creek railway station 10 km east of Warwick, in the left bank of Emu Creek 5 km east of Emu Vale railway siding (Jack, 1892), and in bores in the Killarney area are apparently not of workable size. The deposit at Mount Colliery, 6 km east of Tannymorel, is the largest known in the Sheet area, and provided fuel for the local railway and for gasworks for many years. The coal occurs in lenticular seams within the Walloon Coal Measures. A seam, 70 cm to 1 m thick, was worked more or less continuously from 1887 until 1968, when the mine closed down because of decreasing local demand. The coal was predominantly a bright (perhydrous clarain), poorly cleated, brittle, pitch-like high-volatile, bituminous, non-coking coal with an ash content of 10 to 20 percent. Diamond drilling by the Department of Mines in 1960-61 suggested general deterioration of the seam eastwards from the workings (Hawthorne, 1962). Production records are not available for the years 1887 to 1907; total production reported for the years 1908 to 1967 was 1 218 000 tonnes.

High-volatile, bituminous non-coking coal was also mined at Bonalbo, but the mine has closed. The coal is interbedded with shale, and the proportion of coal to shale varies considerably over short distances. At the Bonalbo Colliery, the coal constituted only 74 percent of the working section.

The Jurassic coal measures of the Rosewood-Walloon field in the Ipswich Sheet area extend south and west to the McPherson and Main Ranges, where they are overlain by Tertiary volcanics. A little coal has been won in the Beaudesert area 1.5 km northeast of the Sheet margin. Outcrops of coal are widespread and in the south many seams are affected by intrusions. Marks (1910), Reid (1922), and Morton (1923) have discussed the area, but little interest has been shown in exploration for coal.

PETROLEUM

Petroleum exploration drilling is summarized in Table 1; and generalized lithological logs are presented in Figure 3.

Queensland American The Overflow No. 1, drilled on the South Moreton Anticline 8 km north of the Sheet area, penetrated 489 m of Lower Jurassic and Triassic sediments before entering volcanics of possible Triassic age. Small hydrocarbon shows were associated with coal seams. Phillips-Sunray Swan Creek No. 1, drilled on the Swan Creek Anticline near Warwick, penetrated a Lower Jurassic sequence overlying volcanics of possible Triassic age at 350 m, but no shows were recorded. The presence of unprospective volcanics at shallow depth has discouraged exploration in the northern part of the Sheet Area. No seismic work has been done in the north, presumably because of the great expanse of basalt and the abundant intrusive bodies in the Walloon Coal Measures.

Three wells drilled in the southeast have shown that a thick Mesozoic sedimentary succession is present with considerable porosity and permeability in places, and some hydrocarbon traces have been found. The seismic method has been used successfully in the area to delineate structures.

Mid-Eastern Kyogle No. 1, drilled in 1963 on a small anticline west of Kyogle in the axial part of the Ipswich-Moreton Basin, penetrated Jurassic and Triassic sediments to 2432 m. where it entered volcanics of possible Triassic age. Oil was found in sidewall cores in both upper and lower parts of the Bundamba Group. The upper part was generally very tight, but the section containing oil had moderate porosity and some permeability. The upper sequence of the lower part also contained oil in places, but the permeability was low. The lower sequence of the lower part had high porosity and permeability up to 57 millidarcies.

Mid-Eastern Sextonville No. 1, drilled in 1964 on the Richmond Horst farther west, penetrated Jurassic and Triassic sediments to 2037 m, where indurated Palaeozoic sediments were entered. In this well, which is closer to the (westerly) source of the sediments, the Bundamba sequence is coarser, tighter, and thinner than that in Kyogle No. 1. Minor gas shows were encountered in the lower part of the group.

Clarence River Basin Hogarth No. 1 was drilled in 1968 to 1218 m in Mesozoic sediments on a gentle dome farther south. The Bundamba sequence was generally tight and no hydrocarbon shows were recorded.

BENTONITE

Abundant montmorillonite and mixed-layer montmorillonite-illite occur in the Walloon Coal Measures (McElroy, 1962, p. 40) although kaolinite is the dominant clay mineral. A pure bentonite was found in Smithfield No. 3 Colliery, near Ipswich. We found outcropping bentonite beside the Brisbane-Warwick road in a 0.5-m seam, and smaller occurrences elsewhere. Bentonite is also abundant at some levels in the Jurassic of the Surat Basin (Duff & Milligan, 1967; Exon & Duff, 1968). It seems that volcanism of a type giving rise to bentonite was widespread in or near the Surat and Moreton Basins in Jurassic time, and the Walloon Coal Measures could contain significant bentonite deposits.

Building Materials

Sandstone from the Marburg Sandstone has been worked at several sites near Warwick and Yangan, 18 km east of Warwick (Ball, 1905; Richards, 1918; Wolff, 1957).

Clay

Only one clay deposit is currently held under lease in the Warwick district. The raw materials used are shale and clay shale, mined from a quarry 11 km from Warwick along the Stanthorpe road. This material is processed in Warwick to produce building bricks, paving tiles, and agricultural pipes. Clay deposits have been reported from Dalveen, 20 km north of Stanthorpe, Emu Creek and Emu Vale 22 km east of Warwick, Gladfield 24 km northeast of Warwick, Mount Leslie 6 km south-southwest of Killarney, the Tannymorel coal mine 6 km north of Killarney, the Glen mine 10 km southwest of Warwick, and Wheatvale 16 km west-northwest of Warwick (Houston, 1967).

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APPENDIX I

PETROGRAPHY OF ROCK SPECIMENS

by

N. F. Exon and J. Smart

About 60 thin sections of rocks, mostly from the Warwick Sheet area, were examined. Estimates of mineral percentages were made without the aid of point counting. Cards with more detailed descriptions, the thin sections, and the hand specimens, are held at the Bureau of Mineral Resources, Canberra.

(Field No.) *Registered No.* *(prefix 6858)*	*Grainsize*	*Quartz*	*Feldspar*	*Mica*	*Dark Minerals*	*Opaque Minerals*	*Phenocrysts (v.f. rocks)*	*Groundmass*	*Classification*	*Grid Reference*
PERMIAN GRANITE										
(106)	m.	15%	Orthoclase 50% Plagioclase 20%	Biotite tr.	Hornblende 10%	—	—		Hornblende granite	564413
(1018) 1269	m.	50%	Orthoclase 40% Plagioclase 8%	2%	—	—	—		Granite	560421
TERTIARY ACID AND INTERMEDIATE INTRUSIONS										
(91) 1007	f.	—	Abundant	Biotite tr. Chlorite 3%	Clinopyroxene 5%	Fe ore 2%	Potash Feldspar 15%	Most of rock	Microsyenite	570457
(1043) 1279	f.	2%	Potassic 80%			Magnetite/Hematite 7%	Holocrystalline	Feldspar-quartz intergrowths 10%	Microsyenite	564500
(1161) 1292	f. (large phenocrysts)						Potash feldspar 30% Magnetite hematite 5% Pyroxene tr.	Two feldspars 60% Fe ore 5%	Porphyritic trachyte	555483
(1162) 1293	f. (porphyritic)						Potash feldspar 30% Plagioclase 20% Clinopyroxene tr.	Two feldspars 40% Brown glass 15%	Porphyritic trachyte	556484
TERTIARY ACID AND INTERMEDIATE EXTRUSIONS										
(1148) 1291	v.f.						Glass, fine volcanics, feldspar, magnetite, ?ortho-pyroxene 30%	Glass, feldspar + augite, 70%	Flow banded trachyte	556475
(1037) 1310	f. (porphyritic)						?Anorthoclase, brown pyroxene 20%	Two feldspars, iron ore, pyroxene, tridymite infillings 80%	Trachyte	547486
(1030) 1311	f. (porphyritic)						Potash feldspar 8% ?Sodalite 2%	Two feldspars 80% Fe ore + ? augite 10%	Trachyte	545509

TERTIARY BASIC IGNEOUS ROCKS

(Field No.) *Registered No.* (*prefix* 6858)	*Grainsize*	*Plagioclase*	*Augite*	*Olivene*	*Opaque*	*Groundmass*	*Classification*	*Grid Reference*
(894) 1252	v.f. (porphyritic)	Labradorite, olivine 5%				Labradorite, augite, iron ore, olivine 95%	Microporphyritic basalt	513515
(907) 1255	v.f. (porphyritic)	Labradorite 10%				Labradorite, augite, olivine, iron ore 90%	Porphyritic basalt	508510
(938) 1258	v.f. (porphyritic)	Labradorite 10%		10%		Labradorite, augite, iron ore, olivine 80%	Basalt	532505
(972) 1262	v.f. (porphyritic)	Labradorite 10%				Labradorite, augite, iron ore 90%	Basalt	541494
(995) 1264	f.	90%	3%	tr.	Fe ore 2%	Glass 5%	Basalt	541500
(1018) 1268	f.	50%		5%		Dusty glass 30% Green glass 15%	Basalt	524518
(1007) 1273	v.f. (porphyritic)	Labradorite 20%				Labradorite, olivine iron ore, augite 80%	Basalt	527516
(1092) 1289C	glassy (phenocrysts)	Labradorite 5%	5%	tr.		Glass, partly devitrified 90%	Pitchstone	560491
(1183) 1295	m-c	Labradorite 30%	40%	25%	Fe ore 5%		Dolerite sill	549472

MARBURG SANDSTONE

(Field No.) *Registered No.* *(prefix 6858)*	*Grainsize*	*Quartz*	*Feldspar*	*Mica*	*Rock Fragments*	*Opaques*	*Matrix*	*Classification*	*Grid Reference*
(5) 1003	v.c.	50%	Potash 5%		f. sediments and acid volcanics 30%, quartzite 1%		Clay, limonite 10%	Lithic sandstone	531484
(17) 1004	v.c.	35%	Potash 20%	tr.	v.f. acid volcanics 30%	Fe Ore tr.	Clay 10%	Labile sandstone	537464
(18) 1005	m.	25%	Potash 10%	3%	f. sediments and acid volcanics (?) 55%	Fe Ore 1%	Silt 10%	Lithic sandstone	536470
(96) 1008	m.	25%	Potash and albite 15%	1%	f. sediments, quartzite, acid volcanics 45%	Fe Ore 4%	f. Sand 10%	Lithic sandstone	565445
(762) 1235	m.	80%				Fe Ore 5%	f. Sand 15%	Quartzose sandstone	458509
(764/1) 1237	m.	30%	Potash and albite 5%		f. sediments 20%	Fe Ore 5%	f. Sand, silt 40%	Lithic sandstone	459509
(820) 1242A	f.	45%	Potash and albite 15%	Biotite 5%	f. sediments 10%	Fe Ore 2%	f. Sand 25%	Labile sandstone	508494
(820) 1242B	m-c	60%	Potash, some albite 5%	Biotite tr.	v.f. sediments 15%	Fe Ore 2%	f. Sand 20%	Lithic sandstone	508494
(820) 1242C	m.	30%	Albite, some potash 30%		f. sediments 15%	Fe Ore 5%	f. Sand 20%	Labile sandstone	508494
(831) (1244	c.	45%	Potash 25%		Quartzite, f. acid volcanics 8%	Fe Ore 2%	f. Sand 20%	Feldspathic sandstone	Southwest Ipswich Sheet
(834) 1245	f.	40%	Potash 15%	Biotite 2% Muscovite tr.	Quartzite, f. acid volcanics 15%	Fe Ore 3%	f. Sand 30%	Labile sandstone	Southwest Ipswich Sheet
(903/1) 1254	f.	35%	Potash 30%		f. sediments and f. acid volcanics, 15%	Fe Ore 5%	f. Sand 20%	Labile sandstone	506514
(921) 1257	f.	30%	Potash, some albite 10%		f. sediments and f. acid volcanics 30%	Fe Ore 5%	f. Sand 25%	Lithic sandstone	522512

MARBURG SANDSTONE (CONTINUED)

(Field No.) Registered No. (prefix 6858)	*Grainsize*	*Quartz*	*Feldspar*	*Mica*	*Rock Fragments*	*Opaques*	*Matrix*	*Classification*	*Grid Reference*
(1011) 1266	m.	20%	Potash tr.		v.f. sediments and f. acid volcanics 70%	Fe ore tr.	Clayey 10%	Lithic sandstone	529518
(1021) 1270	c.	25%	Albite, some potash 20%	Biotite 2%	f. sediments 35%	Fe ore 3%	f. Sand 15%	Labile sandstone	568418
(1023) 1271	f.	20%	Potash, albite 20%	Muscovite 2%	f. sediments and f. acid volcanics 45%	Fe ore 5%	f. Sand 10%	Lithic sandstone	569417
Average (range)		35% (20-60)	20% (5-30)	Tr. 0-5)	25% (10-70)	Fe ore 2% (0-5)	15% (10-25)	Labile sandstone	

WEST IPSWICH SHEET — HEIFER CREEK SANDSTONE MEMBER OF MARBURG SANDSTONE

(Field No.) Registered No. (prefix 6858)	*Grainsize*	*Quartz*	*Feldspar*	*Mica*	*Rock Fragments*	*Opaques*	*Matrix*	*Classification*	*Grid Reference*
1275A	m.	10%	Potash 60%			Fe ore 5%	Clayey— f. Sand 15%	Arkose	517560
1275B	f.	60%	Orthoclase, some plagioclase 6%			Fe ore 4%	Sandy 30%	Sublabile sandstone	517560
1275C	m.	25%	Potash 35% Plagioclase 5%			Fe ore 5%	f. Sand 30%	Feldspathic sandstone	517560

WEST IPSWICH SHEET — HELIDON SANDSTONE IN WRIGHT'S QUARRY

(Field No.) Registered No. (prefix 6858)	*Grainsize*	*Quartz*	*Feldspar*	*Mica*	*Rock Fragments*	*Opaques*	*Matrix*	*Classification*	*Grid Reference*
1276B	m.	40%			Quartzite, v.f. acid volcanics (?) 20%	Fe ore 2%	Sandy, mica tr., feldspar tr.	Lithic sandstone	

Marburg Sandstone Discussion. These labile sandstones vary from feldspathic to lithic. The dominant feldspar is orthoclase. Rock fragments are weathered, but fine-grained sediments, acid volcanics and quartzite are identifiable. The sandy matrix largely represents broken-down lithic fragments and feldspar. The sandstones are generally subangular and well sorted for size. No uniform trend in composition within the formation can be seen. It is of interest that McTaggart's (1963) Heifer Creek Sandstone, described by him as siliceous, varies from arkose to quartzose sandstone. In fact there is little obvious difference between sandstones in the Heifer Creek Sandstone, Ma Ma Creek Sandstone, and Helidon Sandstone.

WALLOON COAL MEASURES

(Field No.) Registered No. (prefix 6858)	Grainsize	Quartz	Feldspar	Mica	Rock Fragments	Opaques	Matrix	Classification	Grid Reference
(826) 1243	c.	5%	Albite 2%		Andesite 15% Quartzite tr.		Ironstained clay replacing calcite and rock fragments 75%	Clayey lithic sandstone	522497
(900) 1253	m.	5%	Albite 20%	Muscovite tr.	Andesite 20%	Fe ore tr.	Calcite and some chlorite 55%	Calcareous labile sandstone	507515
(948) 1259	m.	5%	Albite 10%		Andesite 35%		Calcite 50%	Calcareous lithic sandstone	521504
(969/2) 1261	m.	10%	Albite 3%	Biotite tr.	Andesite and fine sediments 70%	Fe ore tr.	Clay 15% Iron ore 1%	Lithic sandstone	539492
(1055) 1282	m.	3%	Plagioclase 2%		Andesite 45%	Fe ore tr.	Calcite, clay replacing rock fragments 50%	Lithic sandstone	570497

WALLOON COAL MEASURES — WEST IPSWICH SHEET

1274	m.	5%	tr.		Andesite, minor fine sediments 35%	Fe ore 2%	Calcite 60%	Calcareous lithic sandstone	Ipswich 518554

KANGAROO CREEK SANDSTONE — WOODENBONG BEDS

(89) 1006	c.	80% (includes aggregates)	3% (? potash)	—	f. grained, probably metasediments 2%		Clay 5% Pore space 10%	Quartzose sandstone	568463
(115) 1009	c.	85% (includes aggregates)	Potash 1%	—	Quartzite 5%		Clay 5% Pore space 5%	Quartzose sandstone	Northern Grafton Sheet
(113) 1011	c.	85% (includes aggregates)	Potash 3%	—	f. grained, some acid volcanics 2%	Fe ore tr.	Clay 5% Pore space 5%	Quartzose sandstone	579414

GRAFTON FORMATION

(Field No.) Registered No. (prefix 6858)	Grainsize	Quartz	Feldspar	Mica	Rock Fragments	Opaques	Matrix	Classification	Grid Reference
(144) 1012(1)	m.	20%	10% (pseudomorphed by calcite)	—	?volcanics 10% v.f. sediments 25%		Chloritic (probably after calcite 35%	Calcareous lithic sandstone	604423
(144) 1012(2)	m.	20%			f. volcanics, some sst. 60%	Fe ore tr.	Degraded rock fragments	Pebbly lithic sandstone	604423
(144) 1012(3)	m.	30%	Potash and plagioclase, some calcite replacement 15%		Andesite 20% sediments or volcanics 10% Ferruginized? sediments 5%	Fe ore 1%	Chloritic, ironstained 20%	Calcareous lithic sandstone	604423
1272	m.	35%	Potash and plagioclase 10%	Muscovite tr. Biotite tr.	Andesite and v.f. ?sediments 30%		Chloritic 25%	Lithic sandstone	604423

APPENDIX 2

Palynology of Samples from Warwick Sheet Area

by

D. Burger

BMR Warwick No. 4. Stratigraphic Hole

Warwick No. 4 was drilled through the lower Walloon Coal Measures and the upper part of the Marburg Sandstone. Two cores were sampled, both of which yielded plant microfossils.

Sample 4933 from core 1 (depth 102′7″ — 8″) yielded the following stratigraphically significant forms:

Annulispora folliculosa
Applanopsis trilobatus & dampieri
Acanthotriletes pallidus
Leptolepidites verrucatus
Nevesisporites vallatus
Rugulatisporites ramosus

These forms have been widely observed from Jurassic strata in Queensland. The presence of *L. verrucatus* dates this assemblage as not older than spore unit J4 (Burger, 1968; also subsequent unpublished information). A younger age is considered improbable in view of the absence of *Contignisporites cooksonii* and *Murospora florida,* of which the first appearance is taken as the base of spore unit J5 (Evans, 1966; Burger, op. cit.). The absence of dinoflagellates and acritarchs, together with the presence of the freshwater alga *Botryococcus,* points to non-marine depositional environments.

Sample 4931 from core 2 (depth 177′0″ — 1″) produced the following forms:

Spores:

Annulispora folliculosa
Applanopsis dampieri
Ischyosporites marburgensis
cf. *Leptolepidites verrucatus*
Nevesisporites vallatus
Rugulatisporites ramosus

Microplankton:

cf. *Baltisphaeridium* sp.
aff. *Diconodinium* spp.
Hystrichosphaeridium spp.

This assemblage is very similar to the previous one and is therefore regarded as of similar age, although *L. verrucatus* was not identified beyond doubt. The microplankton species resemble certain forms that occur in higher Jurassic and Lower Cretaceous marine sediments in the Papuan area, of which the presence in J4 spore assemblages was hitherto unknown. A secondary (contaminated) origin must be regarded as a possibility. If the microplankton are to be regarded as in situ, then a (brief) marine incursion in the Moreton Basin must have occurred during J4 time; farther west, in the Surat Basin, there is no evidence of marine conditions.

Assuming that the mirofloras from cores 1 and 2 belong to spore unit J4, the strata involved can be compared, on the basis of their palynological age, with the upper part of the Hutton Sandstone and the lower part of the Birkhead Formation (and its equivalent, the Walloon Coal Measures) in the Surat and Eromanga Basins.

BMR Warwick No. 5A Stratigraphic Hole

Samples from cores and cuttings, taken from the Grafton Formation, eastern Warwick 1:250 000 Sheet area, were examined. The following results were obtained:

Cuttings (depth 90' - 100')	MFP 4894	Spore units J5-6
Core 1 (depth 103'8" - 9")	MFP 4880	Barren
Cuttings (depth 110' - 120'	MFP 4895	Very few spores

Sample 4894 yielded a microfloral assemblage that was poorly to moderately well preserved and contained among others the following species:

Leptolepidites verrucatus
Murospora florida
Nevesisporites vallatus
Contignisporites fornicatus
Staplinisporites caminus
Klukisporites cf. *scaberis*
Hystrichosphaeridium sp.

The presence of *C. fornicatus* and *M. florida* indicates that the microflora is not older than spore unit J5 (Evans, 1966), while the presence of *M. florida* and *N. vallatus* points to an age not younger than spore unit K la (Evans, 1966; Burger, 1973). The absence of such spores as *Cicatricosisporites australiensis, Crybelosporites tylosus* and *Cyclosporites hughesi* favours a Jurassic rather than a Cretaceous age. *S. caminus* is a common constituent of Jurassic assemblages and is very scarce in the Cretaceous. The microflora is therefore very likely of Jurassic age, belonging to spore units J5-6.

Microfloras of J5-6 age are known in the Surat and Eromanga Basins as early as the upper Birkhead Formation (Evans, 1966; Burger, 1968). The contact of units J6 and K la appears to be closely connected with the base of the Mooga Sandstone in the Surat Basin (Burger, 1968), so that sample 4894 may be regarded as the palynological equivalent of somewhere in the interval from the upper Birkhead Formation to close to the base of the Mooga Sandstone. The presence of *Hystrichosphaeridium* sp. suggests a marine environment.

Sample 4895 yielded a very few badly preserved, stratigraphically long-ranging spore types. Age determination on the basis of these forms is not possible.

Outcrop Sample, Wallaby Creek

Spores and pollen grains were recovered from a rock sample (sample 4792), consisting of pale grey mudstone, collected from an outcrop locality at Wallaby Creek (Grid ref. 554469) in the Walloon Coal Measures. It was possible, after gentle chemical treatment, to extract a microflora that was sufficiently rich and well preserved for detailed age determination.

From the microfossils recognized, the spore types that are regarded as stratigraphically important are listed below.

Classopolis spp.
Applanopsis dampieri
Inaperturopollenites turbatus
Polycingulatisporites cf. *P. crenulatus* (1 specimen)
Cadargasporites sp. (2 specimens)
Rugulatisporites ramosus
cf. *Duplexisporites gyratus* (1 specimen)
Leptolepidites verrucatus
Neoraistrickia truncata
Lycopodiumsporites rosewoodensis (1 specimen)
L. semimurus
Concavisporites jurienensis

These types form a typically Jurassic assemblage. The presence of *A. dampieri,* coupled with an absence of *Contignisporites* spp., restricts the palynological age to the interval of Evans' spore units J2-4 (Evans, 1966). The presence of *Leptolepidites verrucatus* indicates spore unit J4 (Burger, 1968), which was identified in various subsurface sections drilled in the Eromanga and Surat Basins. Microfloras of J4 age are only known from the upper part of the Hutton-Eurombah interval and from the lower part of the Birkhead Formation in the Surat Basin and their stratigraphic equivalents in the Eromarga Basin. Freshwater depositional environments are indicated by the presence of remains of the freshwater alga *Botryococcus.*

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APPENDIX 3

Report on Plant Fossils from Durikai, Southeastern Queensland

by

R. E. Gould

Data on fossil plants from the locality at Durikai have been given by Walkom (1921), Whitehouse (1932, p. xv; 1955, p. 7; and *in* Longman, 1941, p. 32), Tweedale (*in* Hill & Denmead 1960, p. 285), and Hill, Playford, & Woods (1966). Specimens of *Otozamites, Phlebopteris,* and *Sagenopteris* localized as 'near Thane', 'Talgai', or even 'Darling Downs, near Toowoomba', by Feistmantel (1879, 1881, 1890), Tenison Woods (1883), Etheridge (1888, 1890; and *in* Jack & Etheridge, 1892), and Walkom (1917a, b, 1921), may also have come from the beds at Durikai (or their lateral equivalents) which contain numerous impressions of these plants (e.g. see Whitehouse, 1955).

Determinations: (The plants are preserved as impressions, and hence accuracy of determinations is restricted.)

Phlebopteris alethopteroides Etheridge Jr, 1888. Figured by Etheridge (1888, 1890).

Phlebopteris sp. Fertile and infertile pedate fronds, smaller than *P. alethopteroides.*

Dictyophyllum sp. Infertile fragments of large frond; lamina divided at least 2/3 - 3/4 of way to midrib; vein meshes polygonal.

Cladophlebis sp. Infertile bipinnate fronds with straight pinnules.

Two species of undetermined fern fronds (one possible referable to *Coniopteris* sp.).

Sagenopteris nilssoniana (Brongniart) Ward, 1900. This species includes *S. rhoifolia* Presl, 1838 (Harris, 1932, p. 7). Figured by Tenison Woods (1883) and Hill et al. (1966).

Otozamites sp. or spp. Referable to *O. bengalensis* (Oldham & Morris) Seward, 1971, and (or) *O. feistmanteli* Zigno, 1881 (see Walkom, 1921).

Elatocladus-like shoots.

In addition, an undetermined fairly large bivalve was collected by J. D. Armstrong.

Age of the flora: Presence of *Phlebopteris, Sagenopteris,* and *Otozamites* is indicative of a Jurassic age (Whitehouse, *in* Longman, 1941, p. 32). *Dictyophyllum* ranges from Upper Triassic to Middle Jurassic. *Sagenopteris nilssoniana* occurs in the Liassic of Greenland (Harris, 1932), and similar forms occur in the Lower and Middle Jurassic of South America (Frenguelli, 1941; Menendez, 1957; Herbst, 1965). Harris (1937, p. 100) discussed the Queensland specimens referred to *S. rhoifolia* and considered a Liassic age probable. Fronds of *Dicroidium,* which range into the Rhaeto-Liassic (Townrow, 1966), are not found in the Durikai flora, which would thus be younger than the 'mixed' *Dicroidium* flora described from Cracow by Jones (1948); the Cracow locality is considered to be in the Precipice Sandstone (McTaggart, 1963a, b) of probable lower Liassic age (de Jersey & Paten, 1964). The fossil evidence thus points to an upper Liassic age for the plant-bearing strata at Durikai.

Horizon: Marburg Sandstone (N. F. Exon & R. F. Reiser, pers. comm.).

Materials The specimens available to the author included those of Tenison Woods (1883), Etheridge (1888), Walkom (1917b, 1921), and others collected by J. D. Armstrong, F. S. Colliver, A. Day, N. S. Foote, R. E. Gould, R. F. Reiser, and P. G. Telford.

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APPENDIX 4

Shallow Stratigraphic Drilling, Warwick Sheet Area, 1968

by

N. F. Exon

The Surat Basin party supervised the drilling of six holes in the Warwick Sheet area from 5 to 28 November 1968 using a Fox-Mobile rig, 400 feet of drill pipe, a ten-foot core barrel, and equipment for drilling with mud. A Widco portalogger with electric and gamma probes recovered logs from most holes.

Drilling

The drilling statistics are presented in the table. Logs of the holes are presented in the body of this Report. The holes were drilled to obtain lithological information and wireline logs of poorly exposed and weathered formations, and to obtain material for palynological investigation.

Hole No.	*Grid Ref.*	*Total Depth (feet)*	*Drilling (feet)*	*Coring (feet)*	*No. of cores*	*Core Recovery Actual (feet)*	*Core Recovery %*
Warwick 1	498507	140	127	13	2	12	93
Warwick 2	505494	183	173	10	1	7	70
Warwick 3	597423	130	120	10	1	9	90
Warwick 4	577417	180	164	16	2	15	94
Warwick 5	612420	60	60	0	0	0	—
Warwick 5a	612420	310	280	30	3	22	73
Total		1003	924	79	9	65	82

The program was moderately successful although suitable palynological material was rare (Appendix 2). Cores and cuttings were examined under a binocular microscope.

APPENDIX 5

Water-Bore Details — N.S.W. Part of Warwick Sheet Area

by

Miss L. Stevenson — GSNSW Hydrological Section

					BORE LOG		QUALITY	AQUIFER		
Map No.	*W.C. & I.C. No.*	*Year Sunk*	*Status*	*Depth of Bore (ft)*	*Interval (ft)*	*Summary of Log*	*Description*	*Depth (ft)*	*Supply (lph)*	*S.W.L. (ft)*
1	15860	—	—	84	—	No record available	—	—	—	—
2	15861	—	—	124	—	No record available	—	—	—	—
3	15867	—	—	21	—	No record available	—	—	—	—
4	15869	—	—	12	—	No record available	—	—	—	—
5	15868	—	—	11.5	—	No record available	—	—	—	—
6	11556	1956	—	50	0-50	Quaternary alluvium	—	27-33	1350	12
					0-24	Quaternary alluvium	—	20-24	—	—
7	24220	—	—	82	24-82	Mallanganee Coal Measures	—	42-42.5	—	—
						Coal Measures		53-60	—	—
								67-69	10000	6
8	13351	—	—	—	—	No log available	—	—	—	18
9	13347	—	Well	—	—	No log available	—	—	4500	0.5
10	12578	1956	—	35	0-35	Quaternary alluvium	Fresh	20-30	3400	20
11	16028	1957	—	40	—	No log available	—	23	16000	23
12	18495	—	—	60	0-60	Quaternary alluvium	—	49-60	3400	49
13	14090	1959	—	51	0-50	Quaternary alluvium	—	—	—	—
					51-52	Tertiary basalt	—	48-50	3300	35
14	14272	1957	—	69	0-69	Quaternary alluvium	—	60	1000	50
15	11570	1956	—	48	0-48	Quaternary alluvium	—	30-35	1350	5

Appendix 5 (continued)

					BORE LOG		QUALITY	AQUIFER		
Map No.	*W.C. & I.C. No.*	*Year Sunk*	*Status*	*Depth of Bore (ft)*	*Interval (ft)*	*Summary of Log*	*Description*	*Depth (ft)*	*Supply (lph)*	*S.W.L. (ft)*
16	16301	1959	—	105	0-15	Quaternary alluvium	—	—	—	—
					15-90	Tertiary basalt	—	—	—	—
					90-105	Tertiary honeycomb basalt	—	90	4500	3
17	26320	1967	—	60	0-48	Quaternary alluvium	—	—	—	—
					48-56	Weathered tertiary basalt	—	—	—	—
					56-60	Fresh tertiary basalt	—	45-63	4500-5500	30
18	27738	—	—	42	—	No log available	—	35	900	1
19	18125	1960	—	50	0-50	Tertiary basalt	—	27	4500	16
20	17661	—	—	30	—	No record available	—	—	—	—
21	16482	—	Abandoned	30	0-30	Quaternary alluvium	—	—	—	—
22	16481	—	—	95	0-95	Quaternary alluvium	—	—	—	—
23	13141	1952	—	40	0-40	Quaternary alluvium	Good	15-30	2700	10
24	17660	—	—	15	0-15	Quaternary alluvium	Brackish	—	—	—
25	11583	1954	—	53	—	No log available	Poor	45	2200	15
26	16437	1952	—	65	0-18	Quaternary alluvium	—	—	—	—
					18-65	Mallanganee Coal Measures	—	45-64	900	20
27	16438	1954	—	45	0-45	Quaternary alluvium	—	18-20	—	18
28	16436	1959	—	30	0-30	Quaternary alluvium	—	18-30	3200	18
29	11647	—	—	48	—	No log available	—	—	3850	—
30	16333	1952	—	45	0-45	Quaternary alluvium	—	14-30	—	14
31	12830	1957	—	59	0-59	Quaternary alluvium	—	50-59	2200	30
32	12643	1956	—	55	0-47	Quaternary alluvium	—	25-47	1100	24
					47-55	Kangaroo Creek Sandstone	—	—	—	—

Appendix 5 (continued)

Map No.	*W.C. & I.C. No.*	*Year Sunk*	*Status*	*Depth of Bore (ft)*	BORE LOG *Interval (ft)*	BORE LOG *Summary of Log*	QUALITY *Description*	AQUIFER *Depth (ft)*	AQUIFER *Supply (lph)*	AQUIFER *S.W.L. (ft)*
33	11737	1956	—	39	0-34	Quaternary alluvium	—	30-34	1800	29
					34-39	Tertiary basalt	—	—	—	—
34	11862	—	Well	7	0-7	Quaternary alluvium	—	7	—	1
35	11863	—	Well	11	0-11	Quaternary alluvium	—	11	—	1
63	11864	—	Well	7	0-7	Quaternary alluvium	Hard	7	Seepage	—
37	11567	1955	—	97	0-97	Kangaroo Creek Sandstone	—	87-93	1800	75
38	13013	1955	Abandoned	97		Quaternary alluvium	Medium	33-35	45	—
39	13295	1916	Well	43	0-42	Quaternary alluvium	—	—	—	—
					42-43	Tertiary basalt	—	43	2200	15
40	12639	1951	Well	37	—	No log available	—	—	—	19
41	15772	1955	—	76	0-76	Quaternary alluvium	—	70	2700	40
42	12844	1957	—	80	0-30	Quaternary alluvium	—	—	—	—
					30-80	Kangaroo Creek Sandstone	—	—	—	—
43	15758	1957	Failure	50	0-50	Quaternary alluvium	—	20	270	8
44	18114	—	Well	6	—	No record available	—	—	—	—
45	20032	1963	—	125	0-32	Quaternary alluvium	Liquid mud	24-32	—	3
					32-125	Kangaroo Creek Sandstone	—	62-70	6500	3
46	18189	1961	—	85	0-14	Tertiary basalt	—	—	—	—
					14-85	Tertiary alluvium	—	64-85	5500	3
47	27512	1967	—	70	0-39	Quaternary alluvium	—	—	—	—
					39-70	Basalt	—	60-70	2200	15
48	24208	1965	—	56	0-56	Alluvium	Good	20-56	1700	4
49	19928	—	—	60	—	No log available	—	—	1800	—

Appendix 5 (continued)

					BORE LOG		QUALITY	AQUIFER		
No. Map	*W.C. & I.C. No.*	*Year Sunk*	*Status*	*Depth of Bore (ft)*	*Interval (ft)*	*Summary of Log*	*Description*	*Depth (ft)*	*Supply (lph)*	*S.W.L. (ft)*
50	21609	—	—	172	0-20	Quaternary alluvium	—	—	—	—
					20-172	Kangaroo Creek Sandstone	—	—	550	20
51	21611	—	—	200	0-20	Quaternary alluvium	—	—	—	—
					20-200	Kangaroo Creek Sandstone	—	80	1100	20
52	21610	—	—	250	0-25	Quaternary alluvium	—	—	—	—
					25-250	Kangaroo Creek Sandstone	—	100	450	30
53	21689	—	—	60	0-60	Quaternary alluvium	—	60	2700	48
54	16552	1953	—	60	0-5	Quaternary alluvium	—	—	—	—
					5-60	Grafton Formation	—	55	450	30
55	22936	1965	—	81	—	No log available	—	8	9000	4
56	17307	—	—	20	—	No log available	—	18-20	30000	4
57	17839	1958	Failure	19	0-19	Quaternary alluvium	—	19	115	6
58	17841	1951	Well	25	0-25	Quaternary alluvium	—	15-17	340	10
								20-25	3850	10
59	26759	—	—	90	0-67	Quaternary alluvium	—	74-86	2200	55
					67-90	Mallanganee Coal Measures				
60	17876	1958	Spear point	16	0-16		Good drinkable water	8-16	19000	8
61	18128	1960	—	15.5	—	No record available	—	—	45000	—
62	16303	—	—	45	—	No record available	—	—	—	—
63	16308	—	—	12	—	No record available	—	—	—	—
64	16305	—	—	12	—	No record available	—	—	—	—
65	18138	1958	—	44	0-18	Quaternary alluvium	—	—	—	—
					18-44	Tertiary basalt	—	35-37	2700	8
66	12641	—	Well	—	—	No record available	—	—	—	—
67	12640	1915	Well	19	—	No log available	Good	—	1600	—

Appendix 5 (continued)

					BORE LOG		QUALITY	AQUIFER		
Map No.	*W.C. & I.C. No.*	*Year Sunk*	*Status*	*Depth of Bore (ft)*	*Interval (ft)*	*Summary of Log*	*Description*	*Depth (ft)*	*Supply (lph)*	*S.W.L. (ft)*
68	12801	—	Well	24	—	No record available	—	—	—	—
69	12800	—	Well	22	—	No record available	—	—	—	—
70	12802	—	Well	10	—	No record available	—	—	—	—
71	12803	—	Well	20	—	No record available	—	—	—	—
72	12500	—	Well	28	—	No record available	—	—	—	—
73	11999	1952	—	32	0-10	Quaternary alluvium	—	—	—	—
					10-32	Grafton Formation	Brackish	30	1800	20
74	18127	1961	—	40	0-24	Quaternary alluvium	—	—	—	—
					24-40	Grafton Formation	—	22-24	800	9
75	11993	—	Well	32	—	No record available	—	—	—	—
76	18126	1961	—	54	0-54	Quaternary alluvium	—	28-31	900	12
								48-53	2700	12
77	17813	—	—	62	0-60	Quaternary alluvium	—	—	—	—
					60-62	Grafton Formation	—	36-39	1100	15
78	13371	1957	—	201	0-20	Quaternary alluvium	—	—	—	—
					20-201	Grafton Formation	—	37-40	800	12
79	11996	—	—	54	0-54	Quaternary alluvium	—	46	550	10
80	11998	—	—	48	0-48	Quaternary alluvium	Stock	42	6300	12
81	11994	—	Well	30	—	No record available	—	—	—	—
82	13786	—	—	35	35	Quaternary alluvium	—	30-34	1800	—
83	11992	—	Well	—	—	No log available	Brackish	25	—	—
84	11997	—	—	37	0-37	Quaternary alluvium	Stock	15	45000	8
85	11995	—	—	18	0-18	Quaternary alluvium	—	—	—	—
86	22113	1916	Well	32	0-32	Quaternary alluvium	Stock	30-32	1350	12
87	21599	1957	—	62	0-62	Quaternary alluvium	—	—	1800	45

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Reference

- Geological boundary
- Facies boundary
- Anticline
- Plunge of minor anticline
- Fault (D, U indicate relative movement down, up)

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

- 40 Strike and dip of strata
- Prevailing strike and dip of strata
- Vertical strata
- Horizontal strata
- 80 Overturned strata
- Dip < 5° (air-photo interpretation)
- Dip 5°—15° (air-photo interpretation)
- Dip 15°—45° (air-photo interpretation)
- Dip > 45° (air-photo interpretation)
- Trend lines (air-photo interpretation)
- Joint pattern (air-photo interpretation)

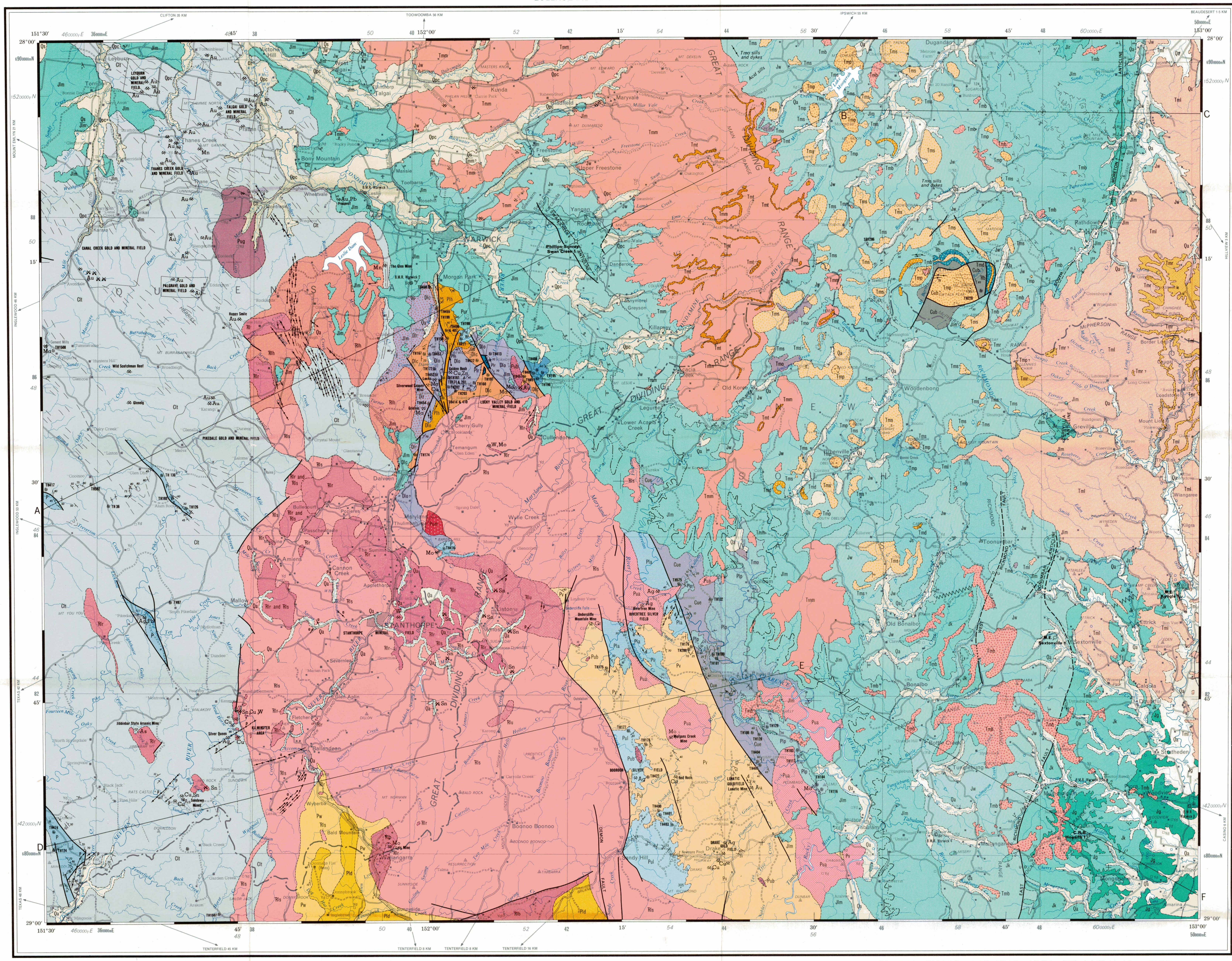
- Fossil locality—general
- TH 124 Macrofossil locality and field collection number
- SB 1286 Plant fossil locality and field collection number
- Fossil wood locality
- Fossil wood horizon
- Dyke or vein; a - aplite, d - diorite, p - porphyry, tr - trachyte

- Boundary of gold or mineral field
- Prospect
- Mine
- Mine not worked
- Quarry
- Quarry not worked
- Alluvial working not worked
- Ag Silver
- As Arsenic
- Au Gold
- C Coal
- Cu Copper
- Gt Graphite
- Ma Marble
- Mn Manganese
- Mo Molybdenite
- Pb Lead
- Sn Tin
- W Wolfram
- Zn Zinc

- Oil well, dry hole, abandoned
- St Stratigraphic hole

- Shallow water bore
- Dam on stream
- WH Waterhole
- Swamp

- Highway
- Road
- Vehicle track
- Railway with station and siding
- Telephone line
- Built up area
- "Montrosa" Homestead
- Building, hut or outstation
- Landing ground
- Yd Yard
- State boundary
- 204 Elevation in metres
- Trigonometrical station



Reference

CAINOZOIC	QUATERNARY		Qs	Sand
			Qa	Alluvium: sand, silt, mud, gravel.
	PLEISTOCENE		Qpc	Sandy alluvium of Condamine River, vertebrate fossils
	TERTIARY (MIOCENE)	Main Range Volcanics	Tmm	Alkali—olivine basalt, minor tuff, sandstone, mudstone
			Tmt	Trachyte
			Tmo	Dolerite sills and dykes
		Lamington Volcanics	Tml	Sub-alkali basalt, minor tuff and agglomerate
			Tmr	Agglomerate, rhyolite, mudstone conglomerate
			Tmb	Basalt
			Tmp, Tms, Tmd	Rhyolite, trachyte, granophyre; minor diorite and andesite. Tmp—plug; Tms—sill; Tmd—dyke
MESOZOIC	UPPER JURASSIC	Grafton Formation	Jg	Lithic sandstone, siltstone, mudstone
		Kangaroo Creek Sandstone	Jk	Quartzose to feldspathic sublabile sandstone
		Woodenbong Beds	Js	Medium feldspathic to feldspathic sublabile sandstone, siltstone
	MIDDLE TO UPPER JURASSIC	Walloon Coal Measures	Jw	Fine labile sandstone, siltstone, mudstone, coal calcareous in part. Plant fossils
	LOWER JURASSIC / UPPER TRIASSIC	Bundamba Group	R-Jb	Sandstone, lesser siltstone, mudstone, conglomerate. Section only
		Marburg Sandstone	Jlm	Feldspathic to feldspathic sublabile sandstone, pebbly in part; lesser siltstone, mudstone. Basal pebbly arkose in west
		Ripley Road Sandstone	Jlr	Feldspathic to quartzose sandstone with massive cross-beds
		Raceview Formation and Aberdare Conglomerate	Rr	Feldspathic to quartzose sandstone and siltstone with massive conglomerate near base (section only)
	MIDDLE TO UPPER TRIASSIC	Ipswich Coal Measures	Ri	Shale, siltstone, sandstone, conglomerate, coal (section only)
			Rv	Basalt, andesite, trachyte (section only)
			Rb	Conglomerate, basic lava and tuff, quartzose sandstone, carbonaceous shale
	LOWER TRIASSIC	Ruby Creek Granite	Rlr	Granite
		Herries Adamellite	Rlh	Adamellite
		Stanthorpe Adamellite	Rls	Adamellite
		Undercliffe Falls Adamellite	Rlu	Adamellite
		Bungulla Adamellite	Rlb	Adamellite
PALAEOZOIC	UPPER PERMIAN OR TRIASSIC		Pua	Adamellite, granite, diorite, granodiorite
		Maryland Granite	Pum	Granite
		Greymare Granodiorite	Pug	Granodiorite
			Pub	Diorite
			Pur	Spherulitic rhyolite, quartz-feldspar porphyry
	UPPER PERMIAN	Gilgurry Mudstone	Pul	Mudstone; minor feldspathic sandstone
	LOWER TO UPPER PERMIAN	Condamine Beds	Puc	Mudstone, poorly sorted sandstone, conglomerate; minor tuff
			Pw	Rhyolite, rhyodacite, tuff
		Drake Volcanics	Pv	Agglomerate, crystal and crystal lithic tuff; minor flows and interbedded sediments
	LOWER PERMIAN	Dundee Adamellite Porphyrite	Pld	Adamellite porphyrite
		Rhyolite Range Beds	Plh	Spherulitic rhyolite, dacite, andesite, agglomerate, tuff; minor conglomerate, sandstone and mudstone at base
		Eight Mile Creek Beds	Ple	Conglomerate, sandstone, mudstone; minor agglomerate and tuff at top
		Razorback Creek Mudstone	Pla	Mudstone
		Eurydesma and Wallaby Beds	Plr	Conglomerate, sandstone, mudstone, pebbly mudstone, minor limestone
			P	Conglomerate, sandstone, mudstone, pebbly sandstone and mudstone, minor limestone and tuff
		Paddys Flat Formation	Plp	Sandstone, mudstone, conglomerate; minor volcanics and limestone
	UPPER CARBONIFEROUS	Mount Barney Beds	Cub	Lithic and feldspathic sandstone, conglomerate, mudstone; minor acid volcanics
		Emu Creek Formation	Cue	Lithic sandstone and mudstone; minor conglomerate
	UPPER DEVONIAN ? TO UPPER ? CARBONIFEROUS	Texas Beds	Clt	Lithic sandstone and mudstone, intraformational conglomerate, slate, chert, jasper, andesite, limestone
	SILURIAN ? TO LOWER DEVONIAN	Silverwood Group: Rosenthal Creek Formation	Dlo	Sandstone and mudstone; chert, intraformational conglomerate, limestone
		Silverwood Group: Connolly Volcanics	Dlc	Coarse andesitic pyroclastics and flows; minor lithic sandstone; limestone lenses near top
		Silverwood Group: Risdon Stud Formation	Dlr	Silicified fine andesitic tuff; silicified siltstone and mudstone
	LOWER PALAEOZOIC		Pz	Undivided Devonian, Carboniferous and Permian strata. Section only

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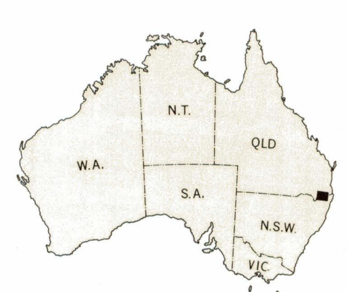
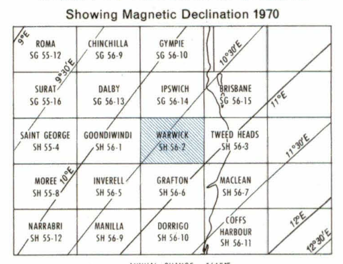


INDEX TO ADJOINING SHEETS

Showing Magnetic Declination 1970



Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

GREY NUMBERED LINES ARE 20,000 METRE INTERVALS OF THE AUSTRALIAN MAP GRID, ZONE 56
GREY TICKS WITH ITALIC NUMBERS INDICATE THE 20,000 YARD GRID, ZONE 8 (AUSTRALIA SERIES)
TRANSVERSE MERCATOR PROJECTION

Sections

Cainozoic sediments omitted

Scale: $\frac{V}{H} = 2$

Palaeozoic geology 1968-69 by F. Olgers, P. G. Flood, W. J. Perry, J. M. Dickins (BMR); A. C. Offenburg, J. Cramsie (GSNSW)
Mesozoic and Tertiary geology mainly 1968 by N. F. Exon, A. Medvecky (BMR); R. F. Reiser, D. J. Casey, A. D. Robertson (GSQ)
C. T. McElroy, R. L. Brunker (GSNSW); N. C. Stevens, P. J. Stephenson (UQ)
Palaeozoic geology compiled 1968-69 by F. Olgers, P. G. Flood (BMR) A. C. Offenburg (GSNSW) A. D. Robertson (GSQ)
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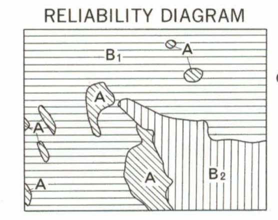
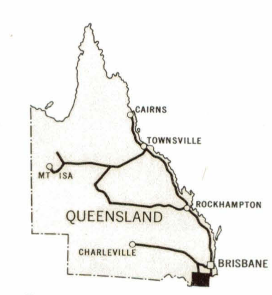
R. L. Brunker (GSNSW)

Cartography by Geological Branch, B M R
Drawn by Contract Drafting and Engineering Services Pty. Ltd. Hobart
Printed by Mercury—Walch Pty Ltd., Hobart, Australia

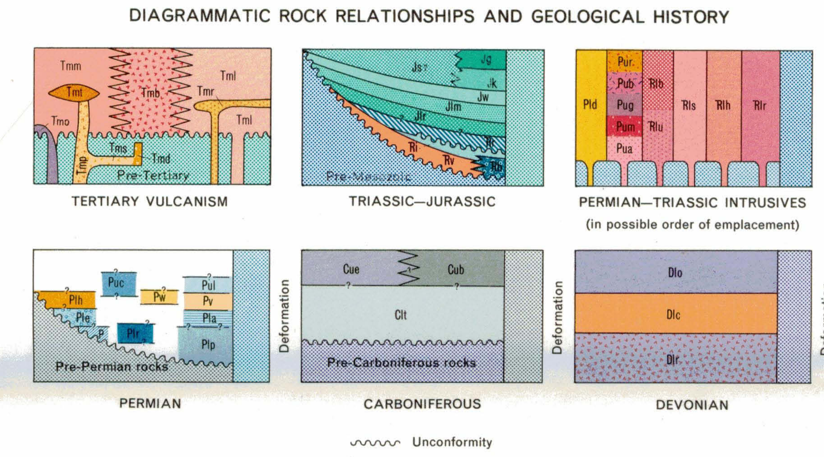
RELIABILITY DIAGRAM

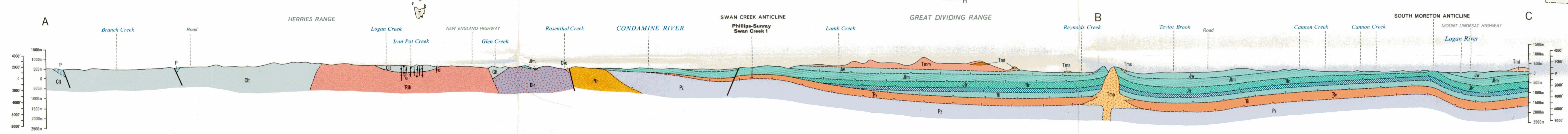


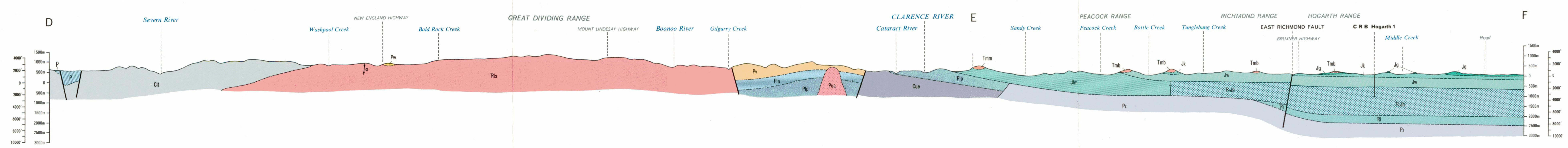
Geology A Detailed mapping
B1 Detailed reconnaissance: numerous traverses and air-photo interpretation
B2 General reconnaissance: compilation of previous work and air-photo interpretation



DIAGRAMMATIC ROCK RELATIONSHIPS AND GEOLOGICAL HISTORY







FIRST EDITION 1972

WARWICK

SHEET SH 56-2

Copies of this map may be obtained from the Bureau of Mineral Resources, Geology and Geophysics, Canberra, A.C.T., the Geological Survey of Queensland, Brisbane, or the Geological Survey of N.S.W., Department of Mines, Sydney