COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT No. 104

Geology of the Mackay 1:250,000 Sheet Area Queensland

BY

A. R. JENSEN and C. M. GREGORY (B.M.R.), and
V. R. FORBES (G.S.Q.)

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SUMMARY

The Mackay Sheet area, a third of which is covered by sea, is on the coast of Queensland about 500 miles north-north-west of Brisbane. The area lies on the north-eastern edge of the Bowen Basin, near a postulated northern extension of the Yarrol Basin. Both basins received thick geosynclinal deposits during the Palaeozoic; the Yarrol Basin from the Middle Devonian to the Lower Permian, and the Bowen Basin from the Lower Permian to the Triassic.

Devonian-Carboniferous units in the area comprise the Campwyn Beds and the Connors Volcanics. The two units are thought to be at least partly coeval. The Connors Volcanics, intruded by components of the Urannah Complex, apparently formed a topographic ridge, the Connors Arch, which had considerable influence on Lower Permian sedimentation.

The Lower Bowen Volcanics and the Carmila Beds are the oldest Permian deposits; the Lower Bowen Volcanics lie mainly on the west side of the Connors Arch and the Carmila Beds on the east. The two units were in part deposited simultaneously, because they lie side by side across the Connors Arch in places.

The Lower Bowen Volcanics west of the Connors Arch are overlain by the Tiverton Formation, the basal unit of the Back Creek Group (formerly known as the Middle Bowen Beds in this area). The Tiverton Formation was succeeded by the Gebbie Formation at a time of expansion and shallowing of the Lower Permian sea when coal measures were formed at Collinsville. The Calen Coal Measures east of the Connors Arch, which rest unconformably on the Carmila Beds, may have been deposited at the same time.

The youngest unit in the Back Creek Group, the Blenheim Formation, was deposited during and after widespread marine transgression. It is overlain by the Upper Bowen Coal Measures which were deposited after the withdrawal of the sea. The Palaeozoic sequence is intruded by the Urannah Complex and by small probably Cretaceous granitic intrusions, and is unconformably overlain by unfolded Tertiary acid and intermediate volcanics, basalt, and freshwater sediments.

The area has not been an important producer of minerals, but a little copper, silver, and gold have come from numerous small workings, mainly in or near the Urannah Complex. At present some mining is being done at Mount Britton for gold. None of the sedimentary sequences on the mainland is likely to contain commercial quantities of hydrocarbons, but traces of crude bituminous material on coastal outcrops could indicate submarine seeps.

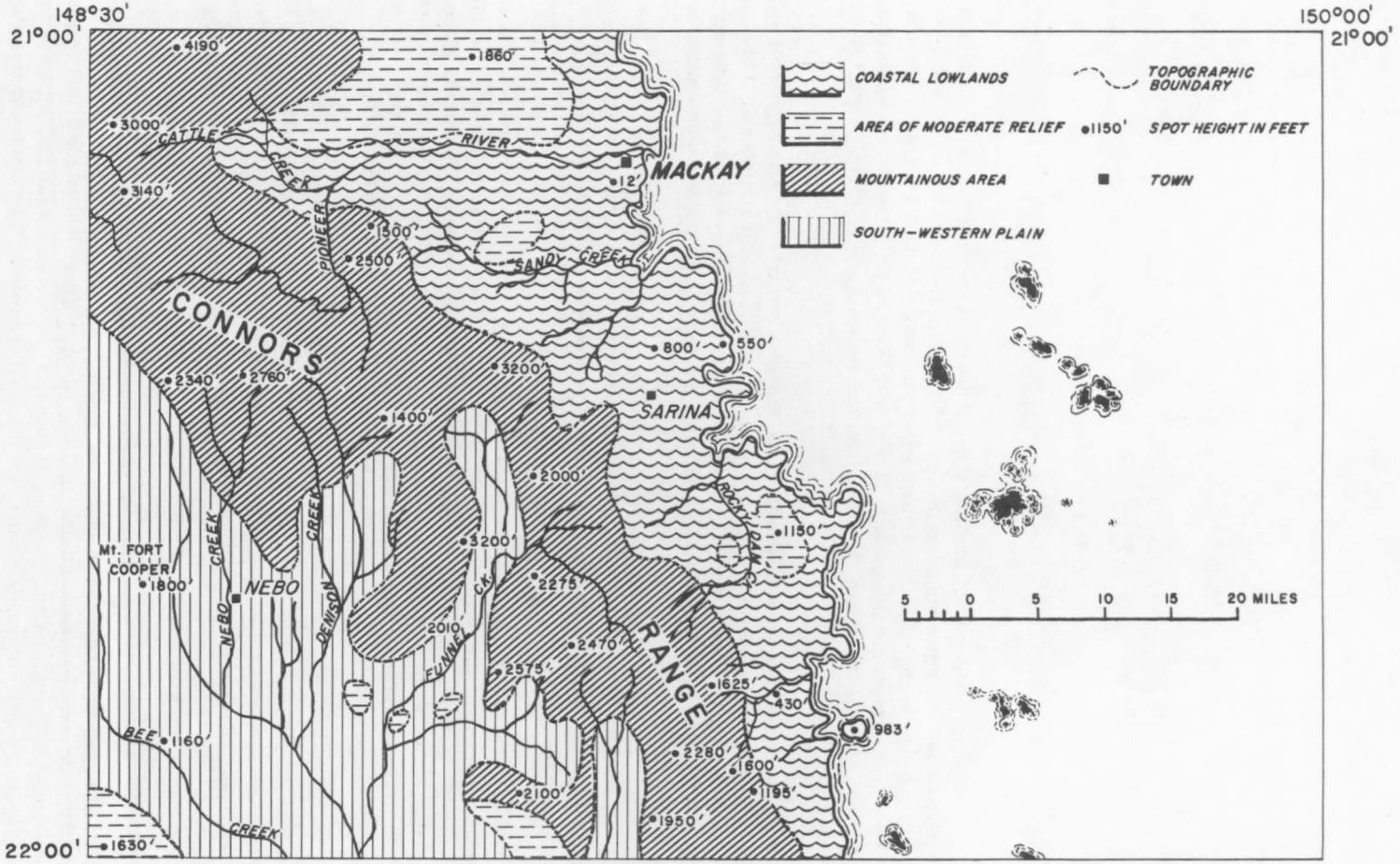

Fig. 1 - Topographic divisions, Mackay 1:250,000 Sheet area.

INTRODUCTION

In 1960 the Bureau of Mineral Resources and the Geological Survey of Queensland commenced a joint programme of regional geological mapping in the Bowen Basin. The western third of the Mackay 1:250,000 Sheet area was mapped in 1961, and a report subsequently written (Jensen, Gregory, & Forbes, 1962). The rest was mapped during 1962 and 1964.

The Mackay area is bounded by latitudes 21° and 22° south, and longitudes 148°30' and 150°00' east. Mackay, the largest town in the area (population about 17,250), has an artificial deepwater harbour and a modern aerodrome; it is linked by rail and road with Brisbane. Smaller towns in the area include: Sarina, Koumala, and Carmila, south of Mackay; Nebo, south-west of Mackay; and Walkeston, Mirani, and Finch Hatton, west of Mackay in the valley of the Pioneer River. The Mackay district produces about a quarter of Queensland's sugar from canefields on the coast and in the Pioneer Valley. Crushing mills are located at many centres on the coast. Methylated spirit and ethyl alcohol are produced as a by-product in the production of sugar at Sarina. Beef cattle are raised mainly west of the Connors Range, and dairying and general farming are important east of the range: timber is gathered on the range. Tourism is an important source of income to the district: the Connors Range provides spectacular mountain scenery with tropical rain-forest vegetation, and Mackay is a port for shipping serving various island resorts of the Great Barrier Reef.

A network of roads provides good access, except in the rugged parts of the Connors Range. A sealed road joins Mackay with Proserpine and Rockhampton. Roads near Mackay are sealed. Most of the other roads are graded but unsealed, and these are often impassable during very wet weather. Even the sealed road running south from Mackay through Sarina and passing Wandoo Homestead is cut occasionally by flooded streams, especially Funnel and Prospect Creeks. The coastal railway from Brisbane passes through Mackay, and a subsidiary line runs west from Mackay to Netherdale, at the foot of the coastal range.

Published maps of the area include a 1:250,000 scale planimetric map prepared by the Division of National Mapping, one inch to one mile maps published by the Royal Australian Survey Corps, and cadastral maps at one inch to two miles scale and one inch to four miles scale published by the Queensland Department of Lands. Air-photographic coverage of the mainland and some of the islands at a scale of 1:85,000 is available, and a photo-mosaic at 1:250,000 scale has been made by the Division of National Mapping. The planimetric base used in the production of the geological map was prepared by the Division of National Mapping.

PHYSIOGRAPHY

The mainland, which occupies about two-thirds of the Sheet area, ranges up to 4000 feet above sea level. Four topographic divisions are recognized (Figs 1 and 2): coastal lowlands; areas of moderate relief; mountainous areas, including the Connors Range; and the south-western lowlands.

The coastal lowlands consist mainly of fertile alluvial plains which support intensive sugar-cane farming. They also include hills up to 500 feet above sea level, as well as mangrove swamps, tidal flats, and sand dunes. Drainage in the coastal lowlands is eastwards to the sea; gradients are low and many of the creeks are tidal. The lowlands are underlain by Devonian-Carboniferous and Lower Permian formations.

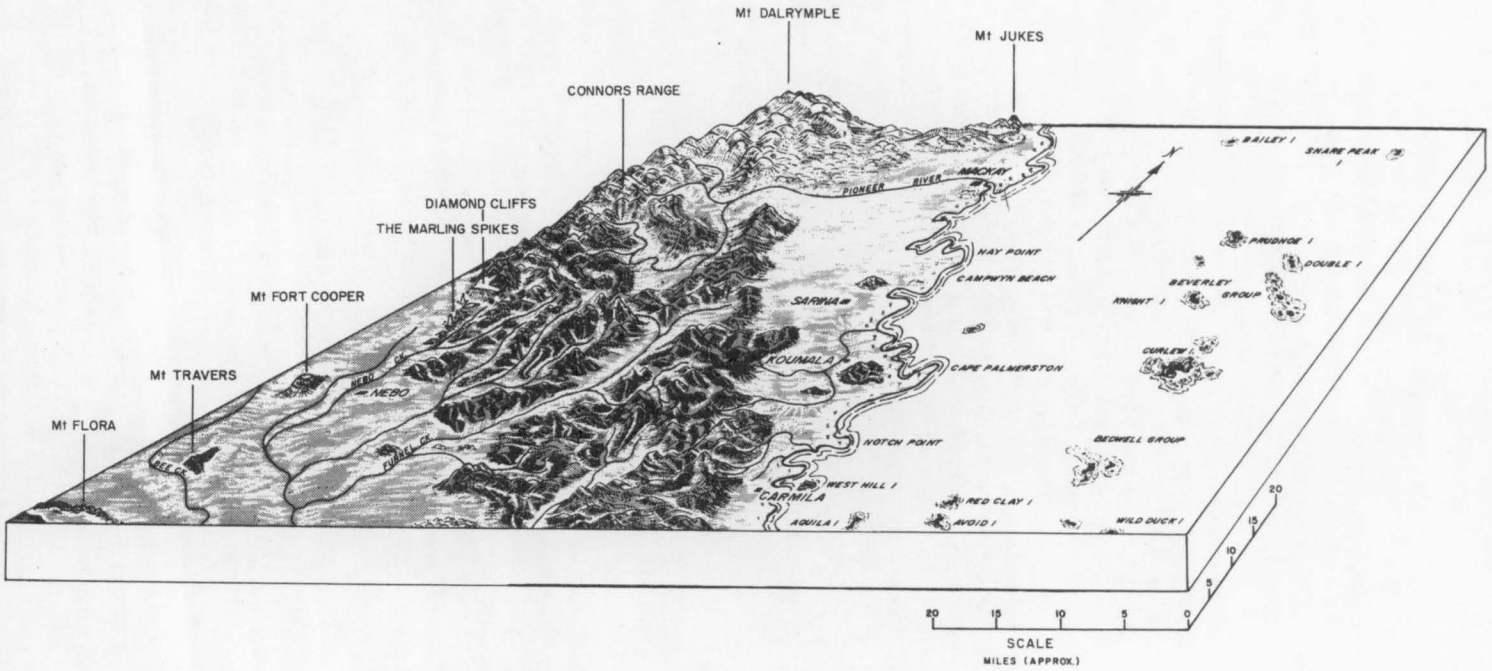

Fig. 2 - Topography, Mackay 1:250,000 Sheet area.

Areas of moderate relief lie east of the Connors Range, and at the southern end of the Connors Range. These areas are intermediate between the lowlands and the mountainous areas. Hills are steep but they are generally less than 2000 feet above sea level. In the south-west, metamorphosed sediments surrounding the Bundarra Granodiorite form hills which are included in this division.

The Connors Range, the main watershed, separates the headwaters of east-flowing coastal streams from the Broken River, which flows west, and the Funnel and Bee Creeks system, flowing south. It has peaks up to 4000 feet above sea level, and the average altitude is about 2000 feet. The range is formed mainly of plutonic rocks of the Urannah Complex, but includes some Tertiary and older volcanics.

The south-western lowlands contain small rounded hills and strike ridges which seldom exceed 200 feet, as well as extensive alluvial plains in the south. Mount Fort Cooper, a diorite plug, rises 1000 feet above the level of the lowlands.

The topography of the islands varies considerably. Some, such as Aquila Island, are low and flat; others, such as West Hill Island, have steep sides rising up to 1000 feet above sea level. The sea is rarely deeper than 30 fathoms.

The area has a hot wet summer and relatively mild dry winter. Along the coast the mean maximum temperature ranges from 85°-90°F in midsummer to 70°-75°F in midwinter; temperatures rarely reach 100°F. Inland from the coastal ranges, the temperature range is greater. The mean maximum temperature inland in midsummer is 90°-94°F, and in midwinter 72°F (Bureau of Meteorology, 1960). The annual rainfall is about 60-70 inches in the coastal areas, decreasing westwards to 30-50 inches in the ranges, and about 25-30 inches in the Nebo district. Two thirds to three quarters of the annual rainfall falls during the summer.

PREVIOUS INVESTIGATIONS

Geological

Most previous geological reports deal with the geology of small mineral deposits; some of these are mentioned in the section on Economic Geology. All known references are listed in the Bibliography.

Only a few reports deal with the regional geology of areas either east or west of the Connors Range. Jack (1887) made a number of isolated observations over a wide area east of the range, but did not nominate any regional geological units. Maitland (1889a), however, introduced such names as 'desert sandstone' and 'carbonifero-permian sedimentary rocks' for geological units of regional extent. West of the range in the Bowen River coalfield, Jack & Etheridge (1892) recognized and described Upper, Middle, and Lower Bowen Formations. Variations on these terms have since been applied to the Permian sequence throughout the Bowen Basin.

Perhaps the most significant contribution to the knowledge of geology of the area was the work of J.H. Reid between 1924 and 1930. He published an account of the geology of the Bowen River coalfield (Reid, 1924-25) and traced units into the south-west part of the Mackay Sheet area (1925). Later he recorded Lower Bowen Volcanics east of the Connors

Range, and correlated the overlying coal measures with the Collinsville Coal Measures (Reid, 1929). There were no regional geological reports for the next 25 years, until Isbell, (1954, 1955) surveyed Nebo-Collinsville coalfield and the northern part of the Bowen Basin.

A field party of the Bureau of Mineral Resources and Geological Survey of Queensland mapped the eastern third of the Sheet area in 1961 (Jensen, Gregory, & Forbes, 1962), and the rest of the mainland was mapped in 1962 (Jensen, Gregory, & Forbes, 1963). The French Institute of Petroleum prepared a photo-geological map in 1961. Some alterations were made to the 1962 preliminary edition of the geological map after further field work in 1964.

W.C. White and G.A. Brown of Ampol Exploration (Qld) Ltd reported on the geology of various islands (White & Brown, 1963), and the geology of the islands on the accompanying map is based mainly on their observations.

Geophysical

Gravity, aeromagnetic, and seismic surveys have been conducted in parts of the Mackay Sheet area. Reconnaissance gravity surveys cover areas off-shore (Marshall & Narain, 1954), coastal (Goodspeed & Williams, 1958), and inland (Mines Administration Pty Ltd, 1959). An aeromagnetic survey of the western part of the mainland was made by the Bureau of Mineral Resources in 1962, and a total magnetic intensity map of the western part has subsequently been issued (map F55/B1-6, BMR, 1964). During the same year, as part of an aeromagnetic survey of the Great Barrier Reef, Australian Oil and Gas Pty Ltd ran two lines across the Sheet area (Hartman, 1962). The off-shore area was covered by an aeromagnetic survey for Ampol Exploration Pty Ltd (Aero Service Ltd, 1963). A marine seismic survey for Ampol Exploration extended south from the Proserpine Sheet area into the Mackay area (Western Geophysical Company of America, 1964).

Exploratory Oil Wells

Three scout bores were drilled in 1955 for the Mackay Oil Prospecting Syndicate - two at Half Tide, 10 miles north-north-east of Sarina, and the third at Hay Point, 12 miles north-north-east of Sarina. The holes were abandoned dry at depths less than 150 feet. (See page 44).

STRATIGRAPHY

The rock units present in the Mackay Sheet area are listed and briefly described in Table 1.

DEVONIAN - CARBONIFEROUS

Campwyn Beds

Summary

The Campwyn Beds crop out in a north-westerly coastal belt extending from latitude 21°45'S to 21°15'S, and recurring north of the Sheet area. The unit is composed mainly of volcanic flow rocks and pyroclastics, interbedded with siltstone, sandstone, conglomerate and limestone. Intrusions are common and low-grade metamorphic rocks are

developed locally. Marine fossils collected in the unit are Upper Devonian to Lower Carboniferous. The unit is folded into a broad south-plunging anticline, which is faulted against Permian units in the west. The unit is estimated to be about 24,000 feet thick in this area.

Definition

'Campwyn Beds' is a new name for a sequence of Devonian-Carboniferous volcanics and sediments which crops out in a north-westerly coastal belt extending from Notch Point in the south to beyond the limits of the Sheet area. Rocks suspected to be Campwyn Beds occur on Avoid Island, West Hill Island, and Temple Island. The unit is named after Campwyn Beach, near Sarina Beach (longitude 149°19'E, latitude 21°22'S). Outcrop at Campwyn Beach is of green volcanic breccia, which is a common rock-type in the unit. No sections have been measured, and no type area has been defined. Very good exposures can be found on every coastal headland within the area of outcrop, but probably the greatest number of easily accessible outcrops are to be found between Hay Point and Sarina Beach, especially in the vicinity of Campwyn Beach. Outcrops away from the coast are poor.

The unit forms low rounded hills, with generally thick vegetation. It is not well bedded, but in places trend-lines on air-photographs can be recognized.

Lithology

Rock types include, in order of abundance, agglomerate, tuff, breccia and flow rocks, siltstone, sandstone, conglomerate, and limestone. Intrusives are common and low-grade metamorphic rocks are developed locally. Epidotization is widespread (especially in the andesitic rocks) and dykes, quartz veins, and calcite veins are common.

Andesitic agglomerate, lapilli tuff, and tuff are very common, and are represented in almost every exposure. They are generally dark green and purple and the shoreline outcrops commonly exhibit honeycomb weathering. Coarse agglomerates are common, and fragments up to 8 inches in diameter have been noted. Tuffs are frequently indurated and some are metamorphosed. Andesitic volcanics at Slade Point, and others as far south as Sarina Beach, show effects of metamorphism to varying degrees. Knight (1939) described siliceous metamorphosed tuffs from the Grasstree Mine area. Contact metamorphic effects are the most obvious, but the local development of schistose lithic tuff in the Alligator Creek area suggests that metamorphic effects may not be due solely to the numerous intrusions.

The tuffs are generally hard and massive with no recognizable bedding, but a few tuff beds are fine, ashy, and well bedded. Pebbly and sandy tuff occurs, but is not common.

Andesite and basalt are common flow rocks and rhyolite is not uncommon. Pyrite is common, in the rhyolite and rhyolitic breccia, and also in andesitic and rhyolitic tuff.

Siltstone is probably the most abundant sedimentary rock, and the best single outcrop is at Half Tide. Here a very large flat wave-cut platform exposes about 300 feet of section comprising approximately 140 feet of basic volcanics, overlain by 70 feet of acid and intermediate tuff and breccia and by 90 feet of siltstone and lithic sandstone. The siltstone is well bedded, with regularly alternating harder and softer beds. The harder beds are 2 to 6 inches thick and generally calcareous. The softer beds are generally porous, ironstained, and up to 2 feet thick, and generally contain tiny pyrite crystals. Massive poorly bedded siltstone, fine lithic sandstone, and rare pebble conglomerate are also exposed.

TABLE 1

SUMMARY OF STRATIGRAPHIC UNITS

Age	Rock Unit & Symbol	Thickness (feet)	Lithology	Fossils	Stratigraphic relationships	Economic geology
Quaternary	Coastal dune sand Qd	less than 30	Quartz-rich sand, minor lithic sand			Heavy minerals in beach sands : magnetite, ilmenite, zircon, gold
	Superficial deposits of alluvium Qa	80 maximum	Sand, silt, mud, clay, gravel			Clay
	Soil Qs	superficial	Soil, minor alluvium			
Tertiary	Laterite	50 maximum	Laterite, pisolitic ironstone, siliceous and kaolinitic pallid zone		Developed on volcanics of the Flat Isles (Red Clay and Aquila)	
	Tv	700 maximum	Acid and intermediate flows and pyroclastics, minor siltstone, sandstone		Lies unconformably on Permian rocks, and lies above Tertiary sediments and basalt	
	Ta	5-265	Mudstone, siltstone, shale, sandstone, conglomerate	Possible fossil leaves reported (Ball 1927)	Unconformably overlies Urannah Complex; underlies Tv at Plevna	Oil shale at Plevna
	Tb	50-200	Olivine basalt, minor porphyritic rhyolite		Unconformably overlies Permian rocks	
	Styx Coal Measures Kls	unknown	Micaceous quartzose sandstone		Found only on Wild Duck Island, overlying weathered rhyolite	
Upper Permian	Upper Bowen Coal Measures Pub	6000 minimum	Siltstone, lithic sandstone, conglomerate, carbonaceous shale	Unidentified fossil wood	Conformably overlies Blenheim Formation	Coal in nearby areas
	Blenheim Formation Pue	5200	Blue siltstone, pebbly lithic sandstone, minor coquinite, quartzose sandstone	Fauna IV) Marine macrofossils: brachiopods, gastropods, pelecypods, bryozoa, corals	Conformably overlies Gebbie Formation	Copper, silver, gold at Mount Flora and Mount Orange - metamorphosed sediments in contact aureole around Bundarra Granodiorite
	Gebbie Formation Plb	1400	Feldspathic sandstone, minor siltstone	Fauna III) Faunas II, III and IV: nomenclature of J.M. Dickins in Malone et al., 1962	Conformably overlies Tiverton Formation	
	Tiverton Formation Plp	1800	Ferruginous mudstone, lithic sandstone, calcareous siltstone, coquinite	Fauna II)	Possibly disconformable on Lower Bowen Volcanics	

Lower Permian	Calen Coal Measures Ple	1000	Quartzose sandstone, siltstone, claystone, minor coal		Disconformably overlies ?Lower Bowen Volcanics and unconformably overlies Carmila Beds	Coal, Proserpine 1:250,000 Sheet
	Carmila Beds Pla	7000	Conglomerate, lithic greywacke, lithic and crystal tuff, acid volcanics, shale	Permian plant fossils including Noeggerathiopsis hislopi (Upper Carb. - Lower Permian)	Rests disconformably on Urannah Complex, Campwyn Beds, and Connors Volcanics	Minor coal, graphite
	Lower Bowen Volvanics Plv	Not measured; of the order of 20,000	Mainly intermediate flows and pyroclastics with minor acid and basic volcanics. Shale, lithic greywacke, conglomerate		Intruded by the Urannah Complex in places. Elsewhere unconformable on Urannah Complex and Connors Volcanics	Gold
Upper Devonian to Lower Carboniferous	Campwyn Beds D/Cc	24,000 minimum	Volcanic flows and pyroclastics, siltstone, sandstone, conglomerate, limestone	Alveolites sp., Thamnopora sp., Phillipsastrea sp., Schuchertella sp., Avonia kennedyensis, Athyris sp., Camarotoechia sp., Aviculopecten sp., Baylea sp., Chonetes sp., Straparollus cf australis, Bellerophon sp., Pugnoides sp., (Upper Devonian fossils on Proserpine 1:250,000 Sheet area, Jensen, 1963)		Copper gold
	Connors Volcanics D/Co	unknown	Andesite, andesitic agglomerate		Intruded by Urannah Complex. Possibly equivalent to Campwyn Beds	

In contrast to the generally unaltered sediments at Half Tide, hardened siltstone is exposed at Eimeo in the north, and near Yarrawonga homestead in the south. The outcrop north-east of Yarrawonga is a hard well-bedded calcareous rock with fine bands of alternating dark siltstone and lighter fine sandstone; some specimens show at least forty bands per inch. Very small-scale current-bedding, but no graded bedding, was noted. The sediments exposed at Eimeo include well-bedded hard non-fissile carbonaceous slates with carbonized plant fragments. Gold in the Alligator Creek district is reported to occur in quartz veins in spotted slate.

Arenaceous sediments are not abundant, but tuffaceous sandstone, lithic sandstone, and some quartz sandstone have been noted. Well-bedded light green and brown lithic and tuffaceous sandstone is common at Cape Palmerston, where beds generally less than 1 foot thick are interbedded with andesitic agglomerate and tuff, rhyolitic flows, and banded chert. Sediments cropping out about 3 miles south of Allom Point include fine non-calcareous quartz sandstone and hard quartz-lithic sandstone. The sandstone is in general well and thinly bedded. It varies from porous, unaltered, and friable in the Allom Point area to hard metamorphosed sandstone and quartzite in the Grasstree area. Light grey crystalline quartzite also crops out near Slade Point.

Conglomerate is not common in the Campwyn Beds. Beds of pebble conglomerate up to 4 feet thick are interbedded with tuff, agglomerate, breccia, and sandstone in the area immediately south-west of Sarina Beach. Hard indurated conglomerate also occurs near Grasstree Mine. Conglomerate (probably with a tuffaceous matrix) is interbedded with andesitic breccia, rhyolitic flows, and bedded tuff at Shoal Point and at other localities north and west of Mackay. Some of the outcrops in this area are very hard and metamorphosed.

Limestone, impure limestone, and calcareous siltstone have been noted, but they represent only a small part of the unit. Most limestone seen is fossiliferous and slightly foetid. Marine fossils were collected from a 4-inch richly fossiliferous band within fine very hard light grey limestone at Allom Point. Another marine fossil collection was made from a 3-foot bed of weathered fine grey limestone about 2 miles east of Notch Point. Limestone and calcareous siltstone occur about 2 miles south-east of Kelvin homestead, but no fossils were seen.

Age

Of the three fossil collections, two contain a Lower Carboniferous fauna, and the third Devonian. Upper Devonian fossils were also collected from the Campwyn Beds in the Proserpine Sheet area (Jensen, 1963), and the age of the unit is therefore Upper Devonian to Lower Carboniferous.

The Lower Carboniferous fauna, identified by R.G. McKellar of the Geological Survey of Queensland, is listed and discussed in Appendix 2. The Devonian fauna, identified by Prof. D. Hill of the University of Queensland, includes:

Alveolites sp.
Thamnopora sp.
Phillipsastrea ? sp.

This collection is from an andesite agglomerate at Campwyn Beach (M798), from which Whitehouse (1939) described fossil corals.

Upper Devonian marine fossils are recorded from the Campwyn Beds on the Proserpine 1:250,000 Sheet area (Jensen, 1963).

Structure

The Campwyn Beds are separated from younger units to the west by a major fault. The block is folded into a relatively simple anticline plunging to the south, whose axis trends north to north-east between Allom Point and Glendower Point. No other major faults have been recognized, but small faults are numerous, and displace in many places dykes cutting the Campwyn Beds. Jointing is generally well developed and joints are commonly filled with quartz veins.

Possible Campwyn Beds crop out west of the fault near Koumala, but the structural relationship between these outcrops and the Campwyn Beds east of the fault is not known. As the Carmila Beds and the Lower Bowen Volcanics dip away from the Campwyn Beds in the Koumala area, the Campwyn Beds may either be the core of an anticline or have been faulted into this position.

Thickness

No sections have been measured in the Campwyn Beds, and neither the top nor the bottom of the unit has been identified. They crop out for some 9 miles in a line south-west from Hay Point; assuming no reversals of dip and no faulting (neither has been seen) and an average dip of 30°, the thickness would be about 24,000 feet.

Connors Volcanics

The name 'Connors Volcanics' was first used by Malone, Jensen, Gregory & Forbes (1965). It is derived from Connors Range on the St Lawrence Sheet area, and the type section is along the Croydon homestead/Killarney homestead road (Lat. 22°28'S, Long. 149°10'E, to Lat. 22°25'S, Long. 149°16'E).

In the Mackay Sheet area, the unit has been recognized east and west of the Urannah Complex in the south. Where seen, it consists of massive green andesite flows interbedded with andesitic pyroclastics. It is characterized by massive volcanic rocks and general absence of sedimentary rocks.

The Connors Volcanics unconformably underlie the Carmila Beds, and farther south they are intruded by Lower Carboniferous granite (Malone et al. 1965) They are considered to be equivalent to the volcanic part of the Campwyn Beds.

The thickness of the unit and its exact age are unknown. It is thought to be Devonian-Carboniferous as it is unconformably overlain by Permian rocks and because the volcanics are similar to those of the Campwyn Beds.

PERMIAN

Stratigraphic Nomenclature of the Bowen Basin Succession

The history and status of the stratigraphic nomenclature of the Bowen Basin Permian succession is discussed by Malone, Corbett, & Jensen (1964). They used the established informal nomenclature; Upper Bowen Coal Measures, Middle Bowen Beds, and

Lower Bowen Volcanics, because a revision of nomenclature had to await completion of the regional mapping programme. Since the programme is still not complete, the terms Upper Bowen Coal Measures and Lower Bowen Volcanics will be used here; but the name Middle Bowen Beds is replaced by Back Creek Group, which is a formal published name for the same rock units.

The name Back Greek Group was published by Derrington, Glover, & Morgan (1959), who applied it to sediments between the Camboon Andesite and Theodore Group in the Banana-Cracow area. The Camboon Andesite appears to be equivalent to the Lower Bowen Volcanics, and the base of the Theodore Group is equivalent to the base of the Upper Bowen Coal Measures. Thus the limits of the Back Creek Group in the type area are the same as the limits of the Middle Bowen Beds in the Mackay area.

In the Mackay area the Back Creek Group consists, in order of decreasing age, of the Tiverton, Gebbie, and Blenheim Formations.

Lower Bowen Volcanics

Summary

The Lower Bowen Volcanics crop out on either side of the Urannah Complex. They give rise to a flat to moderately rugged landscape. The unit consists of volcanics, which predominate, and sediments. The volcanics include both flows and pyroclastics, mainly of intermediate composition, but basic and acid types are present. Interbedded sediments include shale, lithic greywacke, tuffaceous sandstone, and conglomerate. West of the Urannah Complex the unit dips to the south-west, but little is known of the structure east of the complex. The unit disconformably overlies the Campwyn Beds, and is unconformably overlain by the Calen Coal Measures.

Definition and terminology

The term 'Lower Bowen' has been used since 1892, when Jack and Etheridge introduced it as the lowest division of the Bowen Group, in the Bowen River coalfield (Jack & Etheridge, 1892). Reid (1924-25 and 1929a), in his description of the Collinsville area, divided the Lower Bowen Volcanics into three units, the Mount Devlin Volcanics, the Mount Devlin Coal Measures, and the Mount Toussaint Volcanics, but this subdivision was not accepted by Malone et al. (1965), who suggested that the Mount Devlin and Mount Toussaint Volcanics are equivalent.

The unit crops out on either side of the Connors Range, which is formed by the Urannah Complex. We shall call the area south-west of the complex the Nebo area, and that north of the complex the Kungurri area. The Nebo area extends from the headwaters of Moonlight Creek, in the north, to Murray Creek, south of Undercliff homestead, in the southern part of the area. The Kungurri area extends from the northern boundary of the Sheet, near Silent Grove Creek, to the Pioneer River in the south.

The topography is varied. In the Nebo area the volcanics at the top of the sequence produce relatively flat plains, but the lower part of the sequence is marked by moderately high rounded hills, especially near the Urannah Complex, and west of Tertiary volcanics near Homevale. These contrasted types of topography are not seen in the Kungurri area, where, for

the most part, the country is hilly, and almost mountainous where the unit is close to the Urannah Complex.

A great variety of rock types, of both volcanic and sedimentary origin, is included in the Lower Bowen Volcanics in the type area at Collinsville, and in the Mackay area. In most places in the Mackay Sheet area, volcanics predominate and sediments are almost lacking. Mapping was not at a scale which allowed subdivision of the unit into various lithological members, and the following description of lithology, under the headings of Volcanic rocks and Sedimentary rocks, aims at providing a regional picture of the lithology and its variations.

Volcanic rocks

Within the unit lava types range from basic to acid: basalt, andesite, trachyte, dacite, and rhyolite. Andesite, the most abundant rock, ranges in texture from fine to coarse and from massive to markedly porphyritic. Phenocrysts are of plagioclase and commonly hornblende, and rarely of potash feldspar, quartz, and biotite. The most common colour is green, produced by chloritization, but white to buff plagioclase-rich varieties do occur. Some of the lavas have small xenoliths of shale up to half an inch in length. Pyrite is a common accessory mineral, and secondary calcite replaces feldspar. Andesite dykes intruding the sequence may be related genetically to the Lower Bowen Volcanics or to the Urannah Complex.

Rhyolite, toscanite, and dacite are distributed throughout, although they are more common in some places than in others. Leucocratic, and commonly porphyritic, rhyolite is the second most abundant flow rock. Toscanite and dacite are generally darker than the rhyolite, and contain euhedral phenocrysts of potash feldspar, quartz, and rare hornblende. Some of the flows are strongly porphyritic and flow textures are developed in many rhyolite and in some dacite flows. Dykes of dacite intruding the Lower Bowen Volcanics are thought to be comparable in age and genesis to one another.

Trachyandesite and trachyte are relatively uncommon. They range in colour from green to grey and purple, but in places they are creamy white. Textures range from coarse to fine, massive to porphyritic. Flow textures are common in the trachyte. Phenocrysts are of plagioclase, potash feldspar, and hornblende, and rarely quartz and biotite.

Basic lavas, although the rarest rock type, occur throughout the sequence. Both vesicular and massive lavas have been observed.

Coarse pale green agglomerate is one of the most common rock types throughout the unit. Beds range from a few to tens of feet thick, containing ejectamenta up to 2 feet in diameter. The composition is generally andesitic. Both lithic and crystal tuff are also common in the sequence. The crystal tuff is generally red or green, and contains broken crystals of quartz and feldspar; the lithic tuff is generally green. Fine massive tuff of a green or brown colour is also common and its composition ranges from andesitic to dacitic. Epidotization, in rare cases, has converted up to 50 percent of the rock to epidote, producing a pale green rock with a saccharoidal texture.

Secondary alteration and weathering has affected most of the volcanics in the unit and produced chlorite, epidote, hydrated iron minerals, and calcite. The hydrated iron minerals are responsible for the red coloration of many of the rocks, the persistent green coloration is attributable to epidote and chlorite.

Sedimentary rocks

The most common sedimentary rocks in the Lower Bowen Volcanics are shale, lithic greywacke, tuffaceous sandstone, and conglomerate. In the Nebo area, thin beds of shale, sandstone, and conglomerate are interbedded with andesitic and acid volcanics. The shale is dark grey and fissile; it is finely laminated and is probably tuffaceous. Sandstone is rare, and where observed it is composed of lithic fragments of volcanic origin. The conglomerate is composed of both angular and rounded constituents, and in places it grades into a volcanic breccia. Small slump structures are present in the shale, and no cross-stratification has been observed in the Nebo area.

In the Kungurri district, dark grey carbonaceous shale with plant fragments is interbedded with massive white rhyolite and green andesite.

Relationships

The two areas of outcrop of the Lower Bowen Volcanics are separated by the Urannah Complex. The unit in the Nebo area dips to the south-west at about 30°, forming part of the east limb of the Bowen Syncline. Reliable dips are difficult to find in this unit because of the abundance and massive nature of the volcanic members. A dip to the south-west is evident in the Homevale area, but near Hamilton Park the dip is to the south. Inconsistent dips farther south, near New Yard homestead, and the fact that the Back Creek Group crops out to the south of the volcanics, may indicate that a fault separates the two units in that locality.

The Lower Bowen Volcanics and the Carmila Beds are almost certainly coeval. They are not, however, coextensive: the Lower Bowen Volcanics lie mainly west, and the Carmila Beds entirely east, of the Urannah Complex. On the other hand, possible interfingering of the two units is revealed in outcrops in the Undercliff area, where rocks characteristic of the Carmila Beds are interbedded with Lower Bowen Volcanics.

The Urannah Complex appears to intrude the volcanics, but in most places the contact is obscured. The straight contact between the Lower Bowen Volcanics and the complex west of Kungurri is taken to indicate a fault, and the swing to the south of the Pioneer River at Gargett may be another indication.

The Lower Bowen Volcanics probably unconformably overlie the Campwyn Beds, but a contact has not been observed. Their age probably ranges from Upper Carboniferous to Lower Permian, but no fossils have been found in this area. The thickness of the unit is unknown.

Carmila Beds

Summary

The Carmila Beds, an Upper Carboniferous to Lower Permian freshwater sequence 7000 feet thick, crop out in the eastern part of the mainland. They consist of conglomerate, lithic sandstone, siltstone, lithic and crystal tuff, acid flow rocks, and shale. In the southern area of outcrop the unit is folded into a broad south-plunging syncline, the axis of which trends north-north-west. In this area it lies unconformably on the Urannah Complex. The unit, in part coeval with the Lower Bowen Volcanics, contains fossil plants

which range from Upper Carboniferous to Lower Permian. Farther south in the St Lawrence Sheet area, it contains Lower Permian marine fossils near the top.

Definition

Carmila Beds is a new name here proposed for a sequence of Permian mainly freshwater sediments and volcanics cropping out east of the Urannah Complex in two areas, one north and the other south of Koumala. No sections have been measured, and no type area has been defined. Good exposures can be found in most creeks within the area of outcrop, but most of the common rock types in the unit are exposed in gravel pits and creeks within a short distance of Carmila.

Southern area

In the southern area the Carmila Beds form easily recognizable strike ridges and cuestas. The ridges are highest in the west, and disappear under the coastal alluvium to the east. Rock types, in order of abundance, include conglomerate, lithic sandstone, siltstone, lithic and crystal tuff, acid flow rocks, and shale. In general the succession consists of acid volcanics at the base of the unit, followed by conglomerate and sandstone with some volcanics, and overlain by sandstone, siltstone, and shale, with some acid flows and fine tuff.

Conglomerate is very abundant in the north of the area of outcrop, and is well exposed in the upper parts of Basin Creek and Marion Creek, and along Funnel Range. Mount Funnel is capped by 80 feet of conglomerate and coarse sandstone; a 30-foot bed of cobble conglomerate with interbedded tuff, sandstone, and siltstone is exposed on Mount Cutlack; a bed of boulder conglomerate at least 30 feet thick overlain by rhyolite flows caps Mount Christian. However, the largest and most accessible outcrop of conglomerate is in the bed of Rocky Dam Creek about three quarters of a mile east of Mount Christian siding. Here a thick, uniform bed of hard boulder conglomerate overlain by coarse lithic tuff and dipping gently to the east forms the wall of a natural rocky dam. The conglomerate has regular bedding, and no obvious torrential structures. Phenoclasts are generally 4 to 6 inches in diameter, but rare 4-foot boulders are present. The conglomerate in the unit, in general, is hard, and a tough greenish probably tuffaceous matrix is not uncommon; coarse lithic sandstone also serves as matrix, which in some places is sparse. Phenoclasts are mainly acid volcanic rocks, principally porphyritic and fluidal rhyolite. Except for occasional boulders of plutonic rock, the phenoclasts are similar to volcanics in the Carmila Beds; the scarcity of phenoclasts of basic volcanics is consistent with the absence of basic types from the volcanic sequence.

The beds of conglomerate are generally thick and uniform, and appear to persist unchanged over extensive areas, especially in the upper reaches of Basin Creek and Marion Creek. Cross-bedding and lensing of beds are rarely seen, and only occasionally are sandy beds and lenses included. In general, the conglomerate beds are only moderately permeable, and the matrix and relative absence of joints makes them less attractive as aquifers than would normally be expected for unmetamorphosed conglomerate.

Conglomerate forms the base of the sedimentary sequence in the Carmila Beds, overlying acid volcanics. Thick gently dipping beds of conglomerate are common in the north but are covered by coastal alluvium to the south; at Flaggy Rock only the lowermost flows and tuffs are exposed, and sediments in the sequence do not crop out.

Lithic sandstone and tuffaceous sandstone are the most common arenaceous sediments. Feldspathic sandstone and quartz lithic sandstone are present in the sequence, but quartz sandstone is rare. The sandstones are generally not well sorted, and contain some pebbly bands; these are commonly yellow or brown and rarely olive green or khaki. Lithic sandstone appears to be harder than the more quartzose varieties. In places it appears silicified and a few specimens contain a calcareous cement. Most sandstones are of low permeability. Coarse sandstone is generally massive and poorly sorted; medium to fine-grained sandstone is better sorted, thin-bedded, and commonly interbedded with siltstone and shale. Most beds of sandstone are uniform and structureless, and few internal bedding structures were noted. Some of the well-bedded medium-grained quartz lithic sandstone shows ripple marking and contains thin lenses and seams of siltstone.

Coarser sandstone is interbedded with, or lies above, the lower conglomeratic section; the finer varieties are generally higher in the sequence, interbedded with siltstone, which is the dominant rock at the top of the unit. Best exposures occur in creeks and gullies along the road between Ilbilbie and Notch Point.

Siltstone and shale are well exposed in road and rail cuttings and creeks between Ilbilbie and West Hill. Probably the best single outcrop is in a railway cutting immediately north of the Gillinbin Creek bridge, where 60 feet of interbedded tuff, tuffaceous and lithic sandstone, siltstone, carbonaceous shale, and a thin seam of soft black carbonaceous pug is exposed. The siltstone is generally well bedded, uniform in appearance and grainsize within each bed, but not well laminated. Sandy lenses within beds are uncommon. Shale is less abundant and is generally very fissile, carbonaceous, and dark grey or purplish. Shale beds sometimes exhibit slight pinch and swell.

Plant remains are common; the best collections have come from light grey thin-bedded hard siliceous siltstone. The carbonaceous shale is usually very fissile and so rich in carbonized plant remains that it crumbles on splitting. Khaki and dark grey siltstone with poor fissility and uniform appearance is common, but it usually crumbles on exposure to angular fragments too small to contain useful plant remains. The less common dark micaceous siltstone and light grey shale do not crumble so readily, but have only fragmentary plant remains.

Siltstone and subordinate shale, interbedded with fine tuff and sandstone, form the upper part of the Carmila Beds exposed in the Ilbilbie/West Hill area. There are local reports of coal in the vicinity of Koota, but none was seen.

Rhyolite and dacite are the most abundant flow rocks in the area. Trachyte has been noted in the field, but no andesitic or basaltic rocks have been seen.

Several thick rhyolitic flows crop out strongly in the area. Bull's Head Bluff and other well developed cuestas at the heads of Basin Creek and Gillinbin Creek represent the outcrop of thick rhyolitic flows and tuffs near the base of the Carmila Beds in this area. These are overlain by interbedded conglomerate, coarse sandstone, and other acid volcanics. Another rhyolite flow up to 50 feet thick overlies conglomerate capping Mount Christian. Most flows, however, are 10 feet or less in thickness.

The rhyolite and dacite are generally light grey or green, in places porphyritic or, less commonly, fluidal. Thin flows of porphyritic rhyolite-dacite with phenocrysts of

biotite in a fine light grey groundmass are not uncommon, and trachyte flows and flow breccias have been identified near the base of the Carmila beds in the Flaggy Rock area.

Lithic tuff, rhyolitic tuff, and rhyolitic and dacitic crystal tuff are the common pyroclastics in the Carmila Beds. Acid volcanic breccias and lapilli tuffs are less common, and agglomerates and basic pyroclastics are very rare.

The pyroclastics form cuestas, especially in the vicinity of Flaggy Rock. The Bluff, south-west of Flaggy Rock, is capped by 300 feet of coarse-grained light green bedded tuff of intermediate composition. The lithic tuff is generally well bedded and light green, grey, or brown. The coarse-grained variety is tough, and volcanic fragments containing quartz, feldspar, and mica are not uncommon. The finer-grained lithic tuff is generally weathered, porous, and darker. Acid crystal tuff, which is frequently hard and siliceous, contains grains of feldspar and clear quartz in a reddish purple or light green fine-grained matrix.

Intrusives into the Carmila Beds in the southern area are rare. A weathered basic dyke 4 feet wide cuts shale and siltstone south of Ilbilbie. Another outcrop exposes quartz-veined hornblende diorite in a creek about 3 miles south of West Hill. The Carmila Beds are not epidotized and quartz veins are extremely rare - one narrow vein cutting conglomerate was noted in upper Marion Creek. Many of the conglomerates near the base of the unit are very hard, but are not known to be intruded.

Northern area

In the northern area, the unit forms rugged country, and some flat areas. Strike ridges and cuestas are not common.

Sediments, including siltstone, coal, sandstone, and conglomerate, constitute most of the section at the Range Hotel, in the Eton area. Well exposed sediments in Black Waterhole Creek are indurated at the contact with the Urannah Complex. The siltstone is grey, yellow, or purple; in places it is micaceous, carbonaceous, or graphitic, and commonly contains plant fragments. It may be tuffaceous in part. The sandstone ranges in colour from white to grey-brown and green and the proportion of lithic fragments varies considerably. It is generally well bedded, laminated, and poorly cross-bedded.. Tuffaceous sandstone crops out in places, particularly at the top of the range, on the Eton/Nebo road. The conglomerate is invariably hard and its constituents, which range from pebble to boulder size, are well rounded; many of them are of plutonic origin. Thin seams of coal were reported by Dunstan (1901). Coal has been converted to graphite by intrusives in the Homebush area.

Dumbleton Rocks, on the Pioneer River 7 miles west of Mackay, is a large outcrop of Carmila Beds. Abour 500 feet of section is exposed, consisting of interbedded conglomerate, tuffaceous sandstone, black siliceous shale, and volcanics. The basal part of this section is a massive pebble to boulder conglomerate. Some of the tuffaceous sandstone is cross-stratified. Diorite dykes are common. Outcrops near Homebush and in the Mount Jukes area are of rocks similar to those at Dumbleton Rocks.

Structure

In the southern area the dominant structure in the Carmila Beds is a relatively simple syncline plunging to the south, whose axis trends north-north-west and passes about

2 miles east of West Hill. Most of the eastern limb has been faulted out or covered by alluvium. Dips in the western limb are consistent in direction, and become steeper towards the south. However, none exceeds 30°, and few exceed 20° Small tighter folds are superimposed on the centre of the syncline, as can be seen from closely spaced opposing dips as high as 45° along the Ilbilbie/Notch Point road. In the northern area, the regional structure is a north-plunging syncline, truncated on the western limb by a fault; but locally the pattern is much more complex. Most faults affecting the unit appear to trend either north-north-west or north-east.

The Carmila Beds lie unconformably on the Connors Volcanics. Near Oaky Creek, about 5 miles west of Carmila, interbedded rhyolite and conglomerate of the Carmila Beds, which dip at about 15° east, are underlain by basic tuff of the Connors Volcanics, dipping 50° south-east.

The contact between the Carmila Beds and the underlying Campwyn Beds is faulted wherever it has been seen; in view of the age difference between them an unfaulted contact would probably prove to be unconformable.

The Carmila Beds apparently unconformably overlie part of the Urannah Complex near Borstal Mountain west of Ilbilbie. The exposed contact shows acid tuff of the Carmila Beds overlying weathered granite. There are no indications of intrusion into the overlying tuff, but minor faulting observed in the area may give a false impression.

An angular unconformity separates the Calen Coal Measures. The regional dip of the Carmila Beds in the Pioneer River is about 20° to the west, whereas the regional dip of the Coal Measures just to the north of the river is northwards at about 10°.

Age

No marine fossils have been discovered in the Carmila Beds in the Mackay area, but fossil plants are common. These include species of Glossopteris as well as Noeggerathiopsis hislopi, Phyllotheca australis, Samaropsis dawsoni, Vertebraria indica, and Nummulospermum bowenensis. The assemblage is Upper Carboniferous to Lower Permian (See Appendix 3).

Marine fossils of Fauna I (Dickins, Malone, & Jensen, 1964) are contained near the top of the Carmila Beds at several localities in the St Lawrence 1:250,000 Sheet area. These indicate a Lower Permian age and confirm correlation of the Carmila Beds with the Lower Bowen Volcanics, which contain the same fauna.

Thickness

No sections have been measured in the Carmila Beds, but in the southern area they are at least 7000 feet thick.

Environment of deposition

The Carmila Beds appear to be a continental deposit formed east of the present position of the Urannah Complex in an area partly separated from the Bowen Basin by a ridge, formed of uplifted Connors Volcanics and Urannah Complex. The predominance of acid volcanic phenoclasts in conglomerates indicates provenance from volcanic terrain for much of the material. Flows become fewer, and fine sediments and tuffs appear towards the top of the Beds; so vulcanism diminished and the shedding area flattened, as time went on.

Calen Coal Measures

Summary

The Calen Coal Measures which crop out over a small area in the north are a sequence of sandstone, siltstone, claystone, and minor coal at least 1000 feet thick. They are folded into a broad syncline, and are severely faulted. The unit unconformably overlies the Lower Bowen Volcanics and the Carmila Beds. In the type area it contains Permian plants.

Definition

The term 'Calen Coal Measures' was first used by Hill (in Hill & Denmead, 1960), for a unit described, but not formally named, by Reid (1929b). Reid described about 1000 feet of coal measures cropping out west of Calen, in the Proserpine 1:250,000 Sheet area; and the unit can be traced southwards into the Mackay Sheet, north of the Pioneer River. Near Mount Toby it forms high hills with steep sides; farther to the north and east the topography is more subdued, consisting of low strike ridges in relatively flat terrain.

Lithology

The Calen Coal Measures comprise sandstone, siltstone, claystone, and coal. The sandstone is coarse, quartzose, brown to white, and thick-bedded. Large-scale cross-stratification makes the measurement of dips difficult; and small-scale slumps have been observed. Although the beds are well sorted, bands mainly of quartz and quartzite pebbles are common. Thin beds of siltstone in the unit grade laterally into soft brown claystone. Local residents report thin beds of coal near Mount Toby. Road cuttings 5 miles west of Yakapari, on the Bruce Highway, show excellent exposures of the thinner sandstone and siltstone beds.

Structure

The structure of the unit is possibly synclinal with a plunge to the north. Beds in the western outcrops dip gently north-east off the Lower Bowen Volcanics at about 20°. In the southern outcrops, just north of the Pioneer River, the regional dip is to the north, but this is interbedded by faulting and minor folding. Sills and dykes intrude the deformed rocks in the central part of the area of outcrop, as can be seen in some Bruce Highway road cuttings. Intrusion has evidently caused some folding, but as some of the dykes and sills are themselves faulted it has to be assumed that at least some of the faults are caused by regional stresses.

Larger faults affecting the Coal Measures trend north-westerly, but their hade and direction of movement are unknown; similar faults on the Proserpine Sheet, and at Sarina, have large vertical displacements.

The Calen Coal Measures unconformably overlie the Carmila Beds, the Coal Measures dipping regionally to the north and the Carmila Beds to the west in the Dumbleton Rocks area.

Age

At Calen the unit contains Glossopteris and Vertebraria (Reid, 1929b), of Permian age. Underlying beds yield Upper Carboniferous to Lower Permian plant fossils such as

Noeggerathiopsis hislopi (Jensen, 1963). Local reports of marine fossils near Mount Toby were investigated, but no fossils were found. However, it is possible that the unit is in part marine, and that Reid (1929b) correctly correlated it with the Lower Permian Middle Bowen Beds (Gebbie Formation, in modern terminology). Probably most of the Coal Measures are exposed at Mount Toby, which is 1000 feet high; and as dips are low, and neither top nor bottom is exposed, the total thickness is probably between 1000 and 2000 feet.

Tiverton Formation

The name Tiverton Formation was applied by Malone et al. (1965) to a sequence whose type area is near Blenheim homestead on the Mount Coolon Sheet. In the Mackay Sheet area the unit is eroded to relatively flat country with low ridges. The most prominent ridge, at Homevale station, is a well known fossil locality. At Homevale, the outcropping sediments are brown ferruginous mudstone, lithic sandstone, and coquinite. The same rocks crop out in a creek bed about 1 mile north of Mount Landsborough. Bluish grey micaceous siltstone is interbedded with calcareous lithic sandstone in two small areas of outcrop south of New Yard homestead, and ferruginous fossiliferous rubble is common nearby.

The formation is better exposed in Hazlewood Creek south of Eungella homestead in Mount Coolon Sheet area, about 8 miles north-west of Homevale station. A stratigraphic section of the basal part of the unit in this area is shown in Figure 3. Figure 4 shows a generalized section of the entire unit in this area.

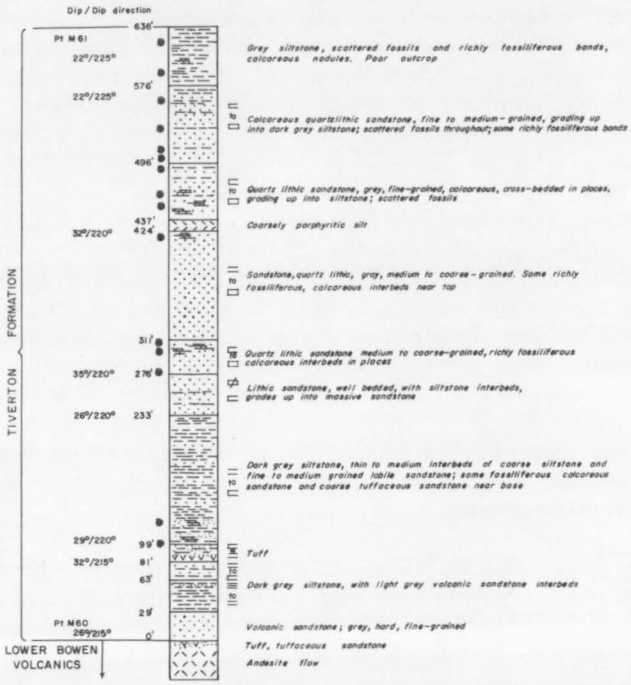

Fig. 3 - Measured section through the bottom part of the Tiverton Formation. Base pt M60; top pt M61. Mackay 1:85,000 photos, Run 3/5060. Section measured along upper reaches of Hazlewood Creek in Mount Coolon Sheet area, using Abney Level.

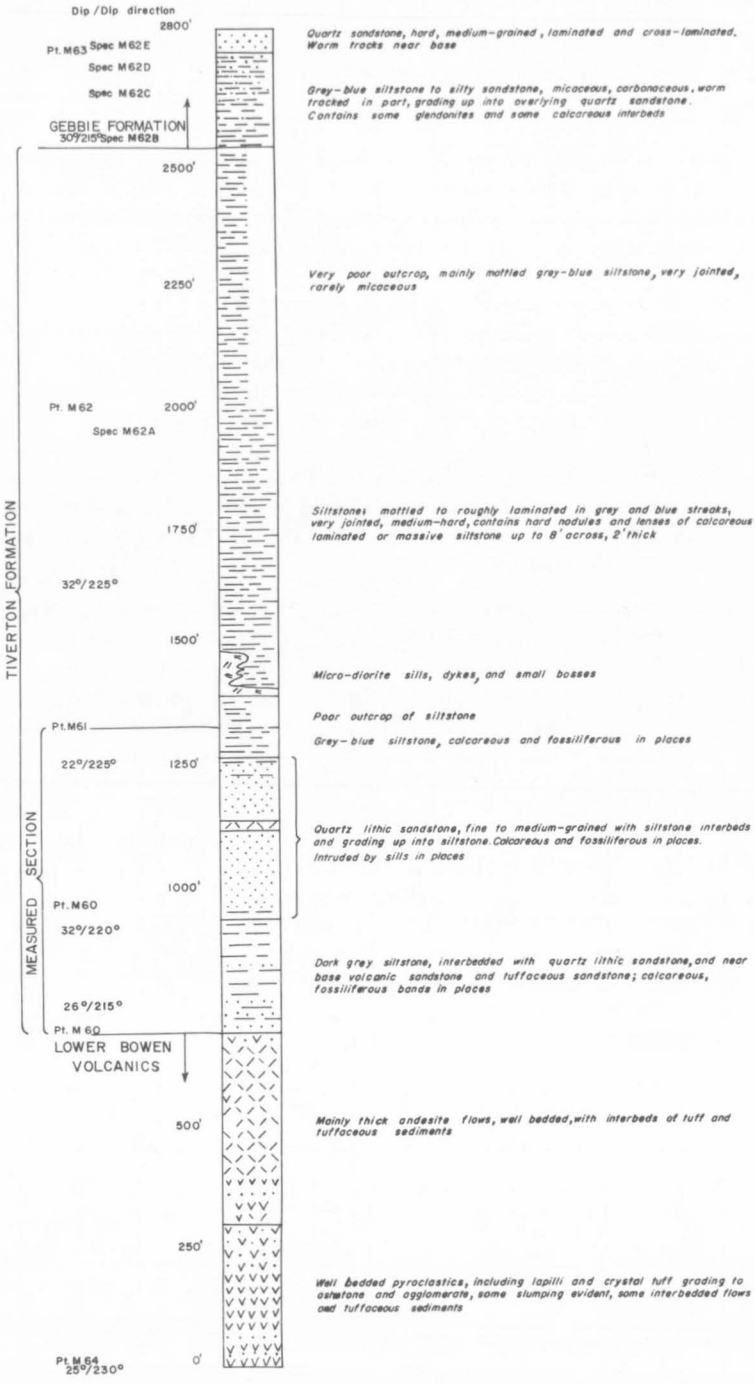

Fig. 4 - Generalized section, measured in part, through top of Lower Bowen Volcanics, Tiverton Formation, and base of Gebbie Formation in Hazlewood Creek area. Thicknesses estimated from photos using measured dips. Base pt M64; top pt M63. Mackay 1:85,000 photos, Run 3/5060. Mount Coolon Sheet area.

The Tiverton Formation in the Mackay area dips regionally to the west. Exceptions to this are the south dip at Homevale and the north dip in the New Yard area. The reasons for these local discordant dips are not known.

In the vicinity of Mount Landsborough the formation is approximately 1800 feet thick. The thickness of the unit in the Hazlewood Creek section, as measured by E.J. Malone (see Fig. 4) is 1850 feet. The unit thins markedly to the north from Hazlewood Creek, and near Blenheim homestead in the Mount Coolon Sheet area is only 750 feet thick.

Marine fossils collected from the unit belong to Fauna II of Dickins (Dickins et al., 1964), which is considered to be Lower Permian. Campbell (1953, 1959, 1960, 1961, and 1965) has described spiriferoids and terebratuloids from the Homevale beds.

Gebbie Formation (Malone et al., 1965)

The type section of the Gebbie Formation is in Gebbie Creek on the Bowen 1:250,000 Sheet area, where the unit is 1450 feet thick. The Wall Sandstone Member (Reid, 1924-25) is included in the lower part of the formation, its lower boundary being about 200 feet above the base of the formation.

Near Homevale station, the Gebbie Formation forms low strike ridges which die out southwards into flat plains with few outcrops north of Mount Landsborough. The basal part of the formation is exposed in a ridge on the western side of Oaky Creek about 1 1/2 miles north of Carrinyah homestead. Interbedded grey siltstone and thin-bedded fine-grained buff silty quartzose sandstone make up the lowest part. This passes up into buff thicker-bedded medium-grained quartz sandstone, some of which is calcareous and fossiliferous (M413F, the lower gastropod-pelecypod fauna of Campbell & Tweedale, 1960, p.200) and makes up the top of the ridge. In stratigraphical position and lithology this sandstone resembles the Wall Sandstone Member to the north. To the west of the ridge the middle part of the formation does not crop out, but the top part is shown in a second ridge. The lowest exposure is mainly thin-bedded coarse siltstone and fine sandstone with some white to yellowish medium-grained quartzose sandstone with fossils (M417F). This passes up into thicker-bedded fossiliferous sandstone with a few scattered mainly quartz pebbles which makes up the top of the ridge (M416F, the upper gastropod-pelecypod fauna of Campbell & Tweedale, 1960, p.201). Campbell & Tweedale apparently misunderstood Reid (1925) in saying that he equated the sandstones of this second ridge with the Wall Sandstone of the Collinsville area.

The Gebbie Formation dips regionally to the west and is conformably overlain by the Blenheim Formation, the boundary being marked by a pebbly sandstone (Fig. 5). In the area just north of Mount Landsborough the formation is 1400 feet thick.

The unit contains marine fossils belonging to Faunas IIIa and IIIc of Dickins et al. (1964). Fossils found in the unit in this area indicate a Lower Permian age.

West of Homevale no sharp boundary is apparent between the Gebbie and Blenheim Formations. The better sorted predominantly quartz sandstone with few pebbles and some marine fossils (M416F) is, however, referred to the Gebbie Formation, and the more poorly sorted sandy beds with interbedded siltstone, which have a great variety of pebbles and cobbles and which in places are calcareous and richly fossiliferous (M417F), are referred to the Blenheim Formation. Possibly the boundary could be placed slightly lower down, below M416F, which is already rather pebbly, although M416F appears to have a Fauna III rather than a Fauna IV.

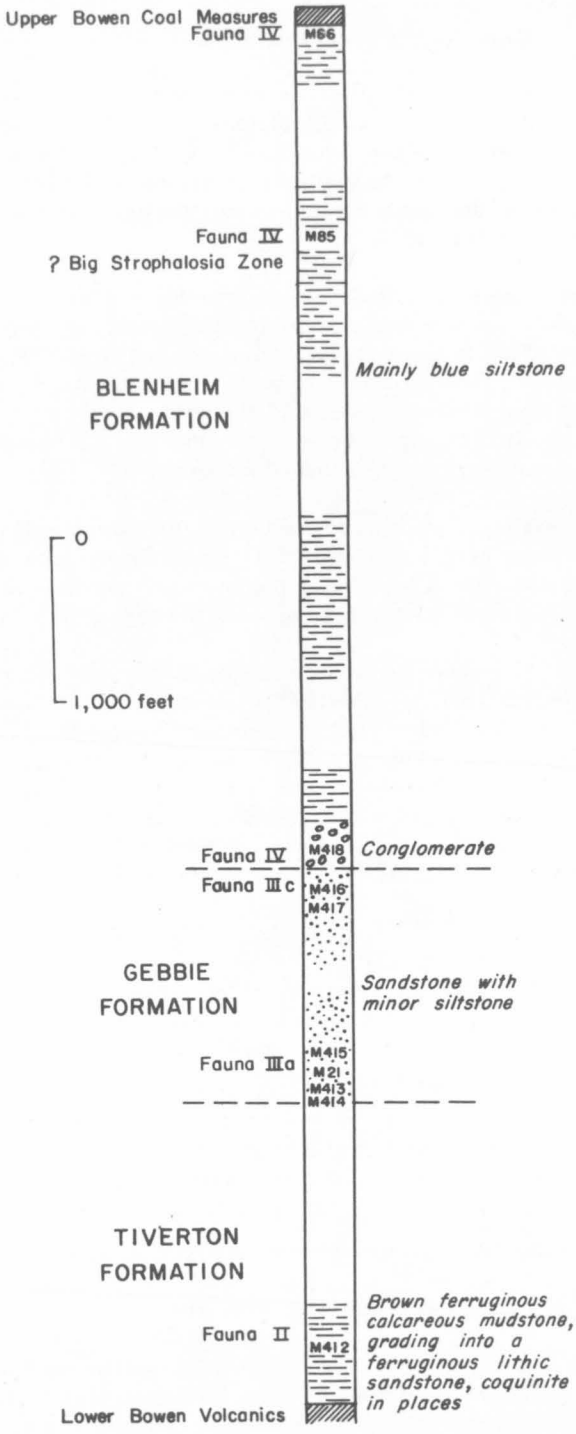

Fig. 5 - Stratigraphical position of fossils collected at Mount Landsborough and Homevale.

Blenheim Formation (Malone et al., 1965)

The Blenheim Formation crops out from the Homevale area to Mount Landsborough, and also in the Mount Flora area. From Homevale to Mount Landsborough it forms long low rounded strike ridges which die out southwards. Around Mount Flora the unit produces relatively flat country, but thermally metamorphosed sediments in the basal part form a line of steep hills, and sandstone lenses near the top of the unit form steep-sided cuestas. Outcrop in all areas is poor.

In the Homevale/Mount Landsborough area the unit consists mainly of light to dark bluish grey micaceous siltstone with scattered pebbles; pebbly sandstone, in places very fossiliferous, crops out at the base. A richly fossiliferous bed about 1300 feet below the top of the formation, and containing Strophalosia cf. clarkei and Strophalosia cf. ovalis, is regarded as the Big Strophalosia Zone (Dickins in Malone et al., 1965). A higher fossiliferous horizon weathering red and concretionary resembles in appearance and stratigraphical position the 'Streptorhynchus pelicanensis Bed' of the Collinsville area.

No macrofossils, apart from crinoid stems, have been found in the Back Creek Group in the Mount Flora area. The sediments are metamorphosed and sheared by the Bundarra Granodiorite, and outcrop is poor and discontinuous. Outcrops in two creeks north of the intrusion have yielded some information regarding the sequence.

The lowest bed has been metamorphosed by the intrusion to andalusite hornfels. The following 2500 feet consists mainly of sheared blue siltstone, and fine sandstone, friable in places. This is overlain by an indurated thick-bedded quartz sandstone, and then by 3000 feet of poorly outcropping blue and white siltstone, purple siltstone, and brown micaceous sandstone. Overlying these beds is a distinctive sequence of about 800 feet of purple siltstone which weathers to a light green colour, and contains crinoid stems. This is overlain by a pebble conglomerate, 2500 feet below the top of the unit. A bed of cross-bedded quartz sandstone crops out 1500 feet below the top, forming large cuestas; this is overlain by interbedded blue and white siltstone to the top of the unit.

The formation dips regionally to the west in the Homevale area, conformably beneath the Upper Bowen Coal Measures. It is folded into small folds plunging steeply to the north, in the Mount Landsborough area, and domed by the Bundarra Granodiorite in the Mount Flora area. Dips away from the intrusion range from 30° to 60°.

The Blenheim Formation is 5200 feet thick in the Mount Landsborough area, and 2310 feet thick in the type area. Calculations based on rather inconsistent dips in the Mount Flora area indicate approximately 8000 feet of section. This sequence is correlated with the Blenheim Formation, but further work may establish that the Tiverton and Gebbie Formations are also represented.

Marine fossils found in the unit are regarded as Upper Permian (Fauna IV).

Upper Bowen Coal Measures

The Upper Bowen Coal Measures conformably overlie the Back Creek Group. They crop out in three small areas in the south-west: Homevale, Mount Travers, and Mount Flora. The Coal Measures are a continuation of those cropping out on the Mount Coolon and Bowen Sheet areas, forming part of the eastern limb of the 'Bowen Syncline'.

In the Homevale area, the Coal Measures, like the Back Creek Group, give rise to long, low rounded strike ridges. Trees are sparse, except in a patch south of The Peak where dense brigalow scrub grows. A distinctive air-photo pattern, produced by trees growing along bedding trends, shows the structure of the unit, even though outcrop is poor. Hills in the Mount Travers area are low, rounded, and without orientation or lineation. Again, bedding trends are emphasized by the vegetation. The Mount Flora area is flat, and outcrop is extremely poor.

The unit consists of siltstone, lithic sandstone, and conglomerate. The presence of volcanic lithic fragments in the sandstone and conglomerate, and an abundance of fossil wood and leaves, distinguish the Upper Bowen Coal Measures from the Back Creek Group.

The base of the unit was seen in three places: near Harrybrandt homestead; 3 miles east-south-east of Harrybrandt homestead; and near The Peak. Near Harrybrandt the change from Back Creek Group is transitional: quartz-rich pebble conglomerate grades into conglomeratic lithic sandstone with bands of white micaceous quartz siltstone. East of Harrybrandt the change is sharp, from thin-bedded blue micaceous siltstone to cross-bedded lithic sandstone, with abundant fossil wood, interbedded with thin beds of brown (?sideritic) carbonate rock. The same rock types are present at the boundary between the two units near The Peak, except for the thin carbonate beds.

In the Mount Travers area the unit consists of thinly bedded claystone and siltstone with fossil plant debris, sandstone, and conglomerate. The sandstone contains varying proportions of feldspar and quartz, and a high proportion of volcanic fragments; it is commonly festoon-bedded. Volcanic pebble conglomerate is common.

The formation dips regionally at about 30° to the south-west, but in places it is folded into small tight folds which trend north-north-west. Minor faulting affects the beds. The unit is domed by the Bundarra Granodiorite. Its contact with the Back Creek Group is conformable and it is unconformably overlain by Tertiary basalt.

The top of the sequence does not crop out and hence thickness cannot be determined. In the adjacent Mount Coolon Sheet area, it is 6000 feet thick.

The abundance of plant debris, the absence of marine fossils, and the presence of moderately large scale festoon bedding, are taken to indicate a continental environment. Contemporaneous vulcanism is indicated by devitrified glass and volcanic rock fragments.

No identifiable plant remains were found. Elsewhere in the Bowen Basin the Upper Bowen Coal Measures are regarded as Upper Permian.

TERTIARY

Basalt

Tertiary olivine basalt crops out mainly in the west and south-west; there is also a small outcrop north of Mirani. The basalt, which is variously vesicular, amygdaloidal, porphyritic, and non-porphyritic, is unconformable on the Permian Bowen Basin sequence. It is less than 200 feet thick, and similar to Tertiary basalt in the Mount Coolon Sheet area.

About 40 square miles of black soil plains, west of Nebo, are the weathered product of the underlying Tertiary basalt flows.

Basalt also crops out south-east of Waitara, north of Plevna, and at the base of Mount Britton and Diamond Cliffs. South-east of Waitara it forms low rubble-covered rises and small hills. North of Plevna, in the Eungella district, it caps hills and is found as boulders in deep soil profiles exposed in road cuttings. North of Mirani it crops out in the flood plain of the Pioneer River. Outcrop is poor and the basalt is covered by red soil and alluvium.

Some of the basalt west of Nebo is vesicular or amygdaloidal, some is even-grained, and some porphyritic. It consists of olivine, titanaugite, and labradorite. The biggest amygdules are a foot across, but the average size is 1 to 2 inches. The basalts north of Plevna and Mirani are lithologically similar to the olivine basalt west of Nebo; constituent minerals are olivine, titanaugite, and labradorite, with phenocrysts of bytownite rounded by resorption. Basalt beneath Mount Britton and Diamond Cliffs is interbedded with basaltic tuff and conglomerate. The conglomerate includes boulders of basalt with chalcedonic anygdules, similar to the basalt west of Nebo.

The thickness of basalt in the Nebo area is less than 200 feet. Reid (1925) estimated it to be 100 feet, that is, the height of Mount Fort Cooper above the level of the plain. However, Mount Fort Cooper is now thought to be a volcanic plug, because (i) it is an isolated hill of basalt very much higher than the surrounding country, (ii) it has the shape of a truncated cone except for the flat top, (iii) basic plugs are known in the Clermont Sheet area south-west of Nebo (Veevers, Randal, Mollan, &Paten, 1965), (iv) air-photographs show it to be surrounded, at its base, by a slightly raised bench which could mark part of the old crater rim, (iv) exceedingly coarse-grained olivine diorite crops out on top of the hill. Townsend (1964) reports that the olivine diorite is composed mainly of sodic andesine and subhedral crystals of titanaugite, with interstitial patches of glassy selvage - evidence of rapid cooling.

The basalt unconformably overlies the Back Creek Group west of Homevale, Back Creek Group and Upper Bowen Coal Measures west of Nebo, Lower Bowen Volcanics south-east of Waitara and at Mount Britton, and Urannah Complex north of Plevna. At Mount Landsborough, south-east of Waitara, Diamond Cliffs, and Mount Britton it is overlain by acid volcanics.

The Tertiary basalt of the Mount Coolon area (Malone et al., 1964) continues eastwards into the Homevale area. Amygdaloidal basalt west of Nebo is overlain by a more massive rock typical of that of the Mount Coolon area.

Acid and intermediate volcanic rocks

Volcanic rocks of possible Tertiary age crop out in a number of places. They have three types of topographic expression: plateaux bounded by vertical cliffs, high mountainous country, and small rounded or conical hills. They include flows and pyroclastics of acid and intermediate composition which unconformably overlie rocks folded by the Triassic orogeny. They are about 700 feet thick west of Homevale, but elsewhere the thickness, where known, is less.

Acid and intermediate volcanics crop out in a discontinuous line from Plevna in the north-west to Murray Creek in the south. They also crop out at The Leap, near Koumala, at Glendower Peninsula, West Hill Island, and Mount Hector.

North of Homevale, the rocks form a high plateau with vertical sides (Diamond Cliffs) about 500 feet high. The plateau surface is rough and broken. Small remnants of the once larger plateau area now stand isolated from the main plateau. The same type of topography has been produced north of Burrenbring, but the plateau is more dissected. The volcanic terrain is mountainous at Mount Britton and at Pine Mountain north of Waitara homestead; west of Koumala and Pine Mountain, it is not only high and mountainous but also covered by thick scrub, making access difficult. Small hills of volcanics occur in several areas: north of Mount Landsborough, in the Murray Creek valley, and at West Hill Island, Mount Hector, and Glendower Peninsula. The Peak, the Marling Spikes, Mount Hector, and West Hill Island are conical hills.

The volcanics are acid and intermediate flows and pyroclastics. Rock types, in order of abundance, are: rhyolite (flows and pyroclastics), trachyte, trachytic tuff, and ignimbrite. Brown or white rhyolite, the most common rock in the sequence, displays various textures: fine-grained and non-porphyritic, porphyritic, and flow laminated. The porphyritic rhyolite has quartz and potash feldspar phenocrysts up to 1/4 inch in diameter. Pyrite cubes and pyritohedra, up to an inch in diameter, are common in the Boothill Creek area. Flow laminae in the rhyolite are commonly contorted, plicated, or undulose.

Rhyolitic breccia and agglomerate are commonly interbedded with flow rocks. They crop out over most of the area, but are most extensive in the Marling Spikes, Mount Britton, and Mount Landsborough areas. Jack (1887) reported that a nearly horizontal deposit of volcanic ash, containing rare large pyroclastic fragments, capped hills east of Homevale Station. Maitland (1889a) described outcrop in about the same area, about a mile to the south of Mount Britton township,* as made up of lava and flows autobrecciated by movement of successive flows over the rapidly cooling mass. In fact, both ash and autobrecciated lava are present.

Rhyolitic agglomerate, brecciated rhyolite, and poorly bedded rhyolitic tuff crop out near Diamond Cliffs. The rugged Diamond Cliffs proved inaccessible for close study, but from a distance blocks up to 2 feet across could be seen. Boulders, presumably from the cliff, were of rhyolitic agglomerate; they contained fragments of fluidal rhyolite and glassy black pitchstone, which ranged from very small to 2 feet across.

The Marling Spikes are a group of spectacular peaks generally regarded as volcanic plugs. They were not studied in detail, but the peaks examined were of fine-grained flow-banded rhyolite or trachyte. The Marling Spikes as well as the acid dykes of Mount Britton and Diamond Cliffs were probably feeders for the acid flows in this area.

Mount Hector and The Peak are regarded as acid volcanic plugs - Mount Hector is a small hill on the coast north of Sarina, about 2 miles south-east of Dudgeon Point. It is approximately circular in plan, and has the characteristic shape of an eroded volcanic plug. In places the outcropping rock is fragmental and bedded, and contains fragments of light grey fine-grained rhyolite. Elsewhere, light grey apparently intrusive rhyolite is exposed. The rocks are weathered and leached, and are commonly stained by limonite and hematite to form attractive intricate patterns with bands developed parallel to the joints. The Peak, an isolated conical hill about 600 feet high, is composed of a core of flow-banded porphyritic rhyolite, surrounded by a low ring of rhyolitic breccia.

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* Mount Britton, an old gold mining town, has since disappeared. It was about 1 1/2 miles north of the Marling Spikes.

Mount Britton, east of Carrinyah homestead and south of the Marling Spikes, is capped by rhyolite or trachyte which may be an outlier of the sheet that covered the Marling Spikes area. At Mount Landsborough, farther south, a thick sheet of brecciated rhyolite overlying vesicular basalt is capped by a thin bed of siltstone.

Rhyolite flows and tuff, possibly also of Tertiary age, overlie the Campwyn Beds in the Glendower Point area. Most of the rock is weathered, but the fresh rock is light grey and porphyritic, with large well-rounded grains of quartz and white feldspar in a very fine grey groundmass. The quartz grains are up to 5 mm in diameter and the feldspar generally smaller. On weathering the quartz is left in relief on the surface. The tuffaceous rocks are generally clayey, weathered, and mottled red and white; a few veins of pure white magnesite up to 4 inches thick were noted.

The trachytic volcanics are generally flow-laminated, porphyritic, or even-grained. Phenocrysts in the porphyritic trachyte are potash feldspar, and less commonly quartz, hornblende, or plagioclase. Iron oxide, generally titaniferous, is a common accessory mineral. More mafic minerals are altered to penninite. Quartz is generally absent from the groundmass.

Tertiary soda trachyte flows and sills are common in the area around Yakapari and The Leap, north-west of Mackay. As Reid (1931) points out, near Yakapari the trachyte has intruded Permian sediments as immense sills. The Leap consists of thick flows of columnar trachyte capping extremely altered sedimentary rocks, which are intruded by thick trachyte sills. Some dykes of olive green glassy perlitic porphyritic pitchstone were noted. The pitchstone contains phenocrysts of quartz and alkali feldspar with needles of sodic amphibole.

West Hill Island, a conical island 980 feet high and about 1 1/2 miles in diameter lying half a mile off shore, is a sodic microgranite plug. It is in strong contrast to the nearby flat coastal plain, which is interrupted only by one rocky headland south-west of the island.

Ignimbrite crops out at Pine Mountain, 11 miles east-south-east of Nebo. It is composed of large flattened lapilli of pumice, minor andesite rock fragments and corroded phenocrysts of quartz and feldspar, in a welded mass of glass shards, volcanic ash, and glass. Much of the glass has devitrified, and pumice fragments have altered to a mass of spherulites. Pine Mountain, 900 feet above the level of the plain, is covered in dense scrub, making approach difficult, and although few cliffs have developed very steep slopes are common, especially near the top. The mountain is a pile of basaltic and andesitic rocks, capped by about seven hundred feet of ignimbrite.

The Tertiary Volcanics unconformably overlie the Campwyn Beds at Glendower Point and intrude them at Mount Hector. They unconformably overlie Lower Bowen Volcanics west of Koumala, at Pine Mountain north of Waitara homestead, north of Burrenbring, and west of Homevale homestead; the Urannah Complex at Plevna and near Tierawoomba; Calen Coal Measures at The Leap; and Upper Bowen Coal Measures and Back Creek Group near The Peak. At Mount Landsborough, acid volcanics overlie Tertiary basalt.

The thickest sequence of Tertiary acid and intermediate volcanics is west of Homevale, where about 700 feet of section crop out. Near Glendower Point they are 180 feet thick. Elsewhere the thickness is unknown.

These acid to intermediate volcanics are probably Tertiary. At Cape Hillsborough north of the Mackay Sheet area, similar volcanics overlie fossiliferous Tertiary sediments. In the west, the acid volcanics overlie basalt of probable Tertiary age. Radiogenic ages on samples of basalt, and acid and intermediate volcanics from the Clermont and Springsure sheet areas all lie within the Tertiary. The basalt and acid to intermediate volcanics of the Mackay Sheet area are similar to those in the Clermont and Springsure areas and are probably of the same age.

Sedimentary rocks

Summary

Sedimentary rocks of possible Tertiary age crop out at Plevna, Rocky Dam Creek, Alligator Creek, Lake Epsom, Boothill Creek, Mount Landsborough, and in coastal creeks. None of the outcrops are extensive. Rocks include mudstone, siltstone, shale, sandstone, and conglomerate. The thickest sequence is at Plevna, where at least 265 feet has been indicated by drilling for oil shale. In all cases the sediments are flat-lying; they overlie folded Palaeozoic units and in some cases are interbedded with Tertiary volcanics.

Plevna

Probably the thickest sequence of Tertiary (?) sediments occurs at Plevna, southeast of Eungella. The sequence, which is known from bores and shafts put down to test an oil shale member, consist essentially of shale at the base, overlain by a thin section (less than 40 feet) of clay and tuff. Rock types logged (Reid, 1942) include carbonaceous shale, tuffaceous shale, oil shale, siltstone, mudstone, fine sandstone, and tuff. Lavas, generally acid, have flowed over the sediments, leaving only a very small area exposed (approximately 60 acres, according to Reid, 1942). Hence the Plevna Tertiary sediments could not be shown on the map; they have been included within the Tertiary Volcanics.

These sediments are younger than the Triassic orogeny which folded the Bowen Basin succession, and the overlying volcanics are believed to be Tertiary (Malone et al., 1964). Moreover, Ball (1927) reported what he thought were Tertiary fossil leaves.

An exploration bore bottomed at 265 feet still within the Tertiary sedimentary sequence.

Rocky Dam Creek basin

Other consolidated Cainozoic sediments in the area crop out as thin and discontinuous sequences which are probably younger than those at Plevna. Several outcrops within the basin of Rocky Dam Creek expose horizontal, easily broken, lacustrine sediments. The best outcrop is in Waterfall Creek, a tributary of Rocky Dam Creek, 8 miles east of Koumala. Here 25 feet of coarse unsorted light brown or white sandstone, pebbly sandstone, and some conglomerate is exposed. Bedding is horizontal and slightly undulating, with beds 2 to 4 feet thick. Another outcrop in Bull Creek, also a tributary of Rocky Dam Creek, 2 miles south of Mount Christian siding, exposes 10 feet of coarse clayey sandstone and poorly sorted cobble conglomerate. The sandstone is slightly calcareous and has numerous open spaces lined with hard light grey clay.

Light brown soft unaltered Cainozoic siltstone overlies granite of the Urannah Complex at an outcrop 7 miles south of Koumala, near another small tributary of Rocky Dam

Creek. The siltstone is very porous and has a high clay content, but sandy bands and rare rounded pebbles occur. The exposure is at least 4 feet thick, but the siltstone is probably not extensive.

Alligator Creek basin

Thin Cainozoic sediments crop out in various places in the Alligator Creek basin and probably underlie much of the soil and alluvium in this area. The best outcrop, in a tributary of Alligator Creek 5 miles west of Sarina, exposes about 6 feet of poorly sorted pebbly sandstone and breccia. The breccia consists of coarse very angular boulders, chiefly of greenish siltstone, in a coarse sandy matrix with limonitic cement. Another outcrop at 'The Rocks' near the mouth of Alligator Creek exposes 4 feet of porous easily broken coarse quartz sandstone.

Lake Epsom

Isbell (1955) mentions 'coarse unbedded sandstones and gravels that are sometimes lateritised', which crop out along the Eton-Nebo road, near Lake Epsom. These sediments, which were first noticed by Maitland (1889b), are semi-friable and generally contain abundant quartz and mica. It is possible that Lape Epsom is a shallow remnant of a much larger Tertiary or Recent lake. Although they occur discontinuously over a moderately large area, these beds are very thin, and igneous basement of Urannah Complex is exposed in many places, even close to Lake Epsom.

Boothill Creek and Mount Landsborough

Poorly bedded semi-friable coarse quartz sandstone in the Boothill Creek area is interbedded with Tertiary acid volcanics. A thin bed of siltstone, whose outcrop is too small to show on the map, lies on top of the acid flows and agglomerate at Mount Landsborough.

Other deposits

Many of the coastal creeks in the area are partly blocked by beds of horizontal shelly pebble conglomerate or calcareous sandstone. Probably the best example is at Carmila Creek, where a 2-foot bed of well-consolidated sandy pebble conglomerate with shell fragments almost blocks the mouth, just above high water mark. These may be stranded 'beach-rock' deposits.

QUATERNARY

Alluvium covers five main areas: in the Bee and Funnel Creek flood plain, in the Cattle Creek valley, in the Pioneer River valley, in the upper Funnel Creek valley, and in coastal areas.

The alluvium of the Bee and Funnel Creek flood plain, in the south-west part of the Sheet area, is known from water bores to be at least 80 feet thick in places.

Alluvium of the Pioneer River valley has been studied in connexion with water supplies for Mackay. Abbiss (1959) described the stratigraphic section in the alluvium in a depression known as The Lagoons, near Mackay. It consists of clay loam top soil, grading to

silt, fine sand, coarse sand with silt and clay, and a few bands of clean sand and water-worn pebbles. Depth to bedrock varies from 70 feet to 100 feet.

The coastline is characterized by numerous rocky headlands, extensive swamps in the sheltered portions, and some sandy beaches. Numerous small areas of vegetated coastal sand dunes, designated as Qd on the map, have not been studied in any detail. The areas of sand accumulation are usually long, narrow, and parallel to the coast; few extend more than half a mile inland. They are commonly backed by swamps. The dunes are generally less than 30 feet high and tend to form ridges with a south-east trend, parallel to the prevailing wind. This is well illustrated in the extensive areas of dune sand north of Mackay. The sand around Mackay is white, well sorted, and rich in quartz, but some of the sands near West Hill Island and Carmila Beach are darker and appear to contain more lithic fragments and other minerals.

INTRUSIVE ROCKS

Urannah Complex (Malone et al., 1965)

The Urannah Complex is a diorite-granite-granodiorite mass with minor basic and intermediate intrusives, and abundant acid and intermediate dykes. It occupies a strip of country about 20 miles wide, extending from the north-west corner to the southern boundary; it also extends on to the Mount Coolon, Bowen, Proserpine, and St Lawrence Sheet areas. It is the product of several intrusive epochs, starting in the Carboniferous and ending some time in the Cretaceous.

Although it occupies a large part of the area mapped, the complex was not examined in detail.

The main area of outcrop on the Mackay Sheet area extends from the north-east corner, where it is about 20 miles wide, to the southern edge, where it is much narrower. Stocks cropping out on either side of the main area of outcrop contain the same type of intrusive rocks, and are included in the unit. The complex crops out from Bowen in the north to St Lawrence in the south, a distance of over 150 miles.

Topography produced by the complex generally consists of high and rugged mountains, with steep ravines. Mount Dalrymple, at the headwaters of Finch Hatton Creek, is just under 4100 feet above sea level, and Finch Hatton, 8 miles to the south, is only 300 feet above sea level. The sides of Cattle Creek Valley rise steeply to 1500 feet above the creek. Massey Gorge, just off the north-west corner of the Sheet area, is reported to have an almost sheer drop of 1000 feet. Topography is more subdued, however, south of Cattle Creek, in the vicinity of Mount Spencer, and in the Funnel Creek Valley, near Wandoo homestead. The rugged terrain makes access difficult; but a forestry road runs from Pinnacle homestead to Endeavour Creek, giving access to good exposures in the nearby creeks. Outcrop of the complex near the Bruce Highway and on the road from Strathdee homestead to the Range Hotel is poor.

The complex was not studied in detail: the rocks examined are almost identical with those described in some detail by Malone et al., (1965).

The most abundant plutonic rocks in the complex are diorite and granite. Diorite is most common in the north-west, and granite in the south-east. Other coarse-grained plutonics include pegmatite, gabbro, granodiorite, and hornblende. Dyke rocks consist of basalt, andesite, microdiorite, and aplite.

Diorite ranges from fine to very coarse, and from massive to foliated. The mineral assemblage is normal, with plagioclase, hornblende, minor quartz, and accessory iron oxide. Xenoliths are common in places.

Granite varies from massive to foliated, the latter type being more abundant west of Netherdale. Grainsize is generally even, but in the porphyritic rocks the phenocrysts are up to three times the size of the main mass of crystals. Phenocrysts are of potash feldspar, usually quite rounded. Pegmatite dykes consist of coarse crystals of potash feldspar and quartz, up to 2 inches long, with minor smaller crystals of biotite and muscovite.

The fabric of the granodiorite, like that of the granite, varies from massive to foliated and even to gneissic in places. However, the foliated type was seen only outside the Sheet area. Granodiorite commonly contains xenoliths of fine-grained melanocratic amphibolite. Pegmatitic dykes are commonly associated with it.

Subround stocks of gabbro and hornblendite intrude the complex, occupying areas of low relief up to a square mile in area. The gabbro grades into hornblendite, containing large phenocrysts of green-brown hornblende enclosing anhedral crystals of labradorite (An 60). No inclusions were seen in these poorly exposed basic intrusions.

Basalt and dolerite dykes occur throughout the complex and appear to be of at least two different ages. All the primary minerals in the dykes are at least partly altered to calcite, epidote, chlorite, saussurite, and hydrated iron minerals; some are extensively epidotized. The fabric of these intrusions varies from intergranular to porphyritic. The dykes range in size from an inch to 20 feet wide, and bifurcations are common.

Most of the dykes in the complex are formed of microdiorite and andesite. In outcrop they are dark to light green, depending on the degree of epidotization and chloritization. The dykes vary greatly in width as do the basaltic dykes; in texture they range from fine-grained to medium-grained, and in places are porphyritic. Chilled margins against the diorite and the granite are usual. There are at least two ages of intrusion of microdiorite. Most dykes run north-west. Subround masses of microdiorite, probably related to the dykes, intrude the complex.

Amphibolite generally occurs as xenoliths in diorite and granodiorite, but it was also noted as a separate mass or roof pendant, near a coarse-grained intrusive of hornblendite. As xenoliths, the amphibolite consists of a medium-grained equigranular mass of green hornblende, plagioclase, and quartz. The xenoliths range from 1 inch up to 20 yards in length. They are generally elongate and narrow, and show a random distribution with concentrations in certain areas.

The Urannah Complex intrudes the Lower Bowen Volcanics and the Connors Volcanics. On the eastern margin it is commonly faulted against the Lower Bowen Volcanics; the fault can be seen in Black Waterhole Creek, near the Range Hotel. Tertiary basalt, acid and intermediate volcanics, and sediments overlie the complex unconformably in many places.

In the St Lawrence Sheet area, a granite of the complex intrudes Connors Volcanics near Burwood homestead. This intrusion has a radiogenic age of 318 m.y. (A.W. Webb, pers.comm.) Plutonic rocks of this age, intruding the Connors Volcanics, probably formed the Connors Arch on which the Lower Bowen Volcanics and the Carmila Beds were

unconformably deposited. Farther north, in the Pinnacle Range, west of Mackay, granodiorite has been dated at 270 m.y. (See Table 2). On the other hand, biotite-hornblende-granodiorite from a point 2 miles west of Netherdale, and on the Pioneer Lineament (see p.) is 128 m.y. old (Webb & McDougall, 1964). Thus there have been at least three separate ages of intrusion - Middle Carboniferous, about the Carboniferous-Permian boundary, and Lower Cretaceous. There is also evidence of minor Upper Permian intrusion (Webb & McDougall, 1964).

TABLE 2

Isotopic age of samples from Mackay area

Sample	Lat.	Long.	Age (m.y.)	
			Biotite	Hornblende
* GA 1186	21°31'S	148°11'E		256 (min.)
* GA 1136	21°13'S	148°42'E	279, 274	
* GA 1137	21°14'S	148°41'E	272	267
* GA 1138	21°17'S	148°39'E	271	
+ GA 792	21°07'S	148°30'E	128	127
* GA 5291	21°41'S	149°18'E		289

* Tentative age, A.W. Webb, pers.comm.

\+ Webb & McDougall, 1964.

Bundarra Granodiorite

The Bundarra Granodiorite crops out over an area of about 80 square miles in the Mackay, Mount Coolon, Clermont, and St Lawrence Sheet areas. The name was first used by Malone et al., (1964) in place of the old name 'Mount Flora granite'; Mount Flora itself is composed of metamorphosed sediments. The granodiorite crops out poorly to form an area of low relief, surrounded by a ring of hills of metamorphosed Back Creek Group. The only outcrops found in the Mackay Sheet area consisted of small patches of andalusite hornfels and, near the base of Mount Flora, grey gneissic granodiorite. From previous work (Malone et al., 1964) the intrusive is known to range from leucocratic granodiorite to an alkali granite. Biotite is the main ferromagnesian mineral, but in places hornblende is abundant and the rock approaches a syenite. The margins of the intrusive have been mined on a small scale for copper and gold, and intensively prospected; most of the mineralization is within the metamorphosed sediments, but a few veins continue into the igneous rock. Ball (1910a) described the geology and mineralization.

The intrusive domed the Back Creek Group and the Upper Bowen Coal Measures, and the strike of the beds on the northern flank is consistently north-east. However, the dip does not decrease regularly away from the intrusive; so the beds were, perhaps, gently folded before the intrusion. The granodiorite was probably intruded during the Mesozoic Hunter-Bowen orogeny.

The granodiorite near Mount Travers

A small elongate stock intrudes the Upper Bowen Coal Measures near Mount Travers in the south-west. It forms two parallel ridges, one longer than the other, with a

maximum height of 150 feet above the plain. By contrast, the Bundarra Granodiorite forms an area of low relief.

At Mount Travers the intrusive is a grey microgranodiorite with altered sodic plagioclase, accessory muscovite, and secondary calcite. Southwards it grades into a fine-grained grey-brown acid porphyry, with phenocrysts of plagioclase and hornblende. The weathered surface of this rock is banded, and contains small cavities some of which are filled with quartz.

Near Mount Travers the Upper Bowen Coal Measures are folded tightly on axes striking north-north-west. Although the intrusive is aligned in this direction, it cuts the bedding of the sediments. It was therefore intruded after the folding of the coal measures. Both the intrusive and the sediments are affected by a fault, west of Mount Travers.

The intrusive may be an exposed dyke from the Bundarra Granodiorite which crops out 4 miles to the south. However, the Bundarra intrusive was emplaced into beds which were gently folded.

Intrusions into the Campwyn Beds

There are numerous intrusives into the Campwyn Beds, especially in the north. Mount Chelona, 4 miles north of Sarina, and rising over 500 feet above the surrounding country, is composed of tor-forming homogeneous medium-grained pink granite. At Mount Basset, near Mackay, quarrying has exposed a heterogeneous mass of microgranodiorite-diorite intruded by dark fine-grained dykes. North and west of Mackay small metamorphosed remnants of rocks of the Campwyn Beds intruded by large irregular masses and dykes of microdiorite are common. Reid (1931) described Flat Top Island, south-east of Mackay, as consisting entirely of granite and diorite, with intrusive porphyry dykes and masses. Irregular diorite intrusives are common in the Grasstree area, and have been noted at Half Tide and on Freshwater Peninsula. Medium-grained granodiorite crops out 3 miles south of Allom Point, but plutonic intrusives are less common in this area. Andesitic or basaltic dykes can be found in almost every outcrop, but are more numerous in the north. Dykes in the Slade Point/Mount Basset area, which are generally andesitic, trend north-south and dip steeply to the west. Most are 2 to 6 feet wide, but dykes more than 20 feet wide are present. Andesitic dykes occur at Dudgeon Point and Hay Point, and a rhyolite (?) dyke 40 feet wide trending north-east cuts siltstone and volcanics at Half Tide. The fine-grained basic dykes in the Grasstree/Campwyn Beach area appear to have a general north-east trend, and are less than 10 feet wide. Knight (1939) described dyke rocks in the Grasstree mine area as 'hornblende porphyrite' and 'felsite'. Both basic and rhyolite dykes occur on Freshwater Peninsula. Most of the dykes strike north-north-east, and in places dykes of porphyritic rhyolite appear to cut the basic dykes. Dykes are less numerous in the south, but have been noted at Armstrong Beach, and at Notch Point near Walter Reid homestead.

Miscellaneous intrusives

Mount Jukes (1850 feet above sea level) is a spectacular topographic feature, surrounded by a narrow valley which in turn is ringed by a low circular ridge. The intrusive was reported to be 'an eruptive centre .... a ring complex intrusive' (Hill & Denmead, 1960 p.369). It is composed of a high core of granophyre with dolerite and rhyolite dykes. There is no outcrop in the valley, but trachyte and gabbro boulders have been found in small creeks. The surrounding ridge is composed of metamorphosed Permian rocks, and in part by the granite of Mount Blackwood.

Mount Blackwood is essentially a coarse grandior intrusive, with steep sides and covered with dense vegetation. The intrusions of Mount Blackwood and Mount Jukes are post-Permian, as they intrude the Carmila Beds.

Intrusive rocks forming the off-shore islands are reported to range in composition from granite to granodiorite and syenite; they intrude possible Tertiary volcanics (White & Brown, 1963).

STRUCTURE

The inferred structure of the area is shown in Figure 6. The Connors Arch separates the south-west-dipping Bowen Basin sequence from a more structurally complicated block to the east. It is composed mainly of the Urannah Complex, with Connors Volcanics in the south. Much of the eastern boundary of the arch is faulted.

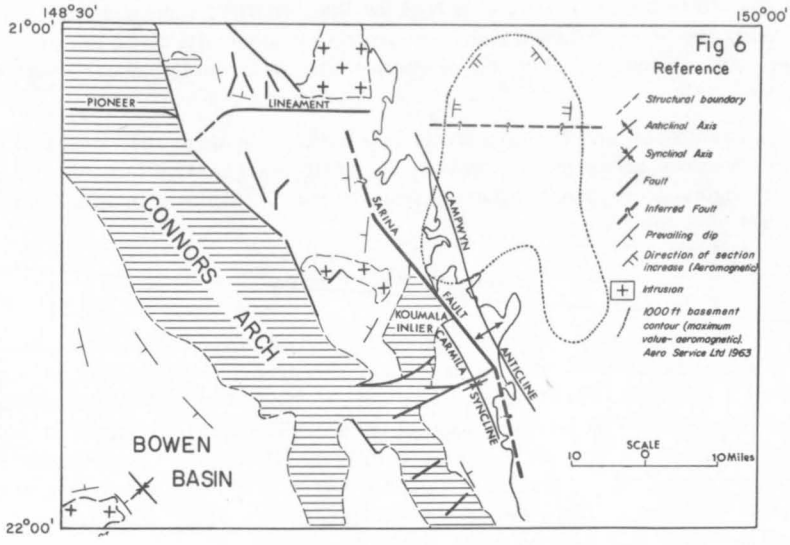

Fig. 6 - Inferred structure, Mackay 1:250,000 Sheet area.

West of the Connors Arch the Permian sequence dips regionally to the south-west at about 40°, forming part of the east limb of the Nebo Synclinorium (Malone, 1964). Small areas of tight folding, similar to the folding of the Folded Zone (Malone, 1964), are found about 4 miles north-west of Mount Landsborough and near Mount Travers. The regional south-west trend is interrupted in the south-east by a dome around the Bundarra Granodiorite.

The area east of the Connors Arch may be considered in six parts: (1) The Carmila Syncline, (2) the Koumala Inlier, (3) the area between the Pioneer Lineament and the Koumala Inlier, (4) the area east of the Sarina fault, (5) a postulated off-shore depression, (6) the area north of the Pioneer Lineament.

The Carmila Syncline plunges south-east away from the Koumala Inlier. The western limb of the syncline dips at 10° to 20°, and most of the eastern limb is truncated by the Sarina Fault. Apparently, a complementary syncline plunges north-west from the north-

west edge of the inlier. East of the Sarina Fault the Devonian-Carboniferous sequence is folded into the south-plunging Campwyn Anticline.

An off-shore basin has been delineated by an aeromagnetic survey (Aero Service Ltd, 1963) and the 1000 foot (maximum) depth-to-basement contour is shown on Figure 6. The maximum depth to basement is thought to be 3900 feet. The shape of the contours suggests a south-plunging syncline, possibly complementary to the Campwyn Anticline. Similar graben-like depressions were mapped to the north.

North of the Pioneer Lineament, the Calen Coal Measures, dipping gently to the north, are faulted against south-west-dipping Carmila Beds.

Faulting is common in all Palaeozoic units. The most common fault direction is north-north-west; another system strikes approximately north-east. These two directions are common farther north (Jensen, 1963), where the north-east-trending faults have a marked transcurrent component, and the north-west-trending faults are characterized by vertical movements. Cattle Creek and the lower part of the Pioneer River form a distinctive line which we have called the Pioneer Lineament. Cretaceous intrusives lie along this line, which may be a large fault. It appears to cut the offshore basin, as shown by the aeromagnetic results (Aero Service, 1963).

Cretaceous and Tertiary strata have not been shown on the structural sketch map (Fig. 6). Cretaceous rocks crop out only on the north coast of Wild Duck Island, where they dip south at angles decreasing southwards from 70° to 10° (White & Brown, 1963). Tertiary rocks have not been folded.

GEOLOGICAL HISTORY

Vulcanism was widespread when the Upper Devonian/Lower Carboniferous sea covered all or part of the area. Most of the deposits formed during this time were of volcanic origin, but in a few places epiclastic deposits were formed. Uplift about the Middle Carboniferous probably resulted in the withdrawal of the sea. The uplift was probably accompanied by intrusion of granites into the Connors Volcanics. During the Upper Carboniferous and early Permian a pile of freshwater sediments and pyroclastics was deposited east of the Connors Arch and volcanic flows were poured out west of the Arch. Granites were emplaced in the Eungella area during the lowermost Permian.

During the Lower Permian the sea entered the Bowen Basin west of the Connors Arch and marine sediments were deposited. The sea shallowed considerably during the deposition of the Gebbie Formation, and at the same time a paludal environment in places led to the formation of coal in the northern part of the Bowen Basin, and also east of the Connors Arch at Calen. A return to deeper water conditions, when sediments of the Blenheim Formation were deposited, was followed by the final withdrawal of the sea from the Bowen Basin. The upper part of the Upper Permian was a period of widespread fluvial, lacustrine, and paludal deposition represented by the Upper Bowen Coal Measures.

The Palaeozoic sequence was folded and faulted by compressional forces in the Upper Triassic. Faulting and intrusion took place again in the Cretaceous, with the formation of graben-like structures east of the present coastline.

The Tertiary was marked by volcanic activity, firstly basaltic and then acidic. In some places freshwater lakes received their sedimentary deposits, and there may have been considerable sediment shed from the Connors Range eastwards to the sea.

ECONOMIC GEOLOGY

The area has not been an important producer of minerals, but a little copper, silver and gold have been won from numerous small workings in four main fields: Mount Britton, Mount Spencer (Pinevale), Mount Flora, and Grasstree. Deposits of coal, graphite, oil shale, heavy mineral sand, molybdenite, and wolfram have been tested but have not been exploited. The occurrence of a complex uranium/rare earth mineral has been reported. Brick clay has been mined.

Recent mining operations have been confined to Mount Britton (gold), Mount Orange (copper), and Glenella (clay). Enterprise Exploration Pty Ltd have carried out an intensive geochemical prospecting campaign in the Mount Flora area, and small-scale prospecting is in progress around Pinevale, Grasstree, and Bolingbroke. Ampol Exploration (Qld) Pty Ltd hold Authority to Prospect for Petroleum 93P, embracing most of the land east of the coast range, and extending out to sea. It appears unlikely that commercial accumulations of hydrocarbons will be found on the mainland.

Surface water is relatively abundant throughout the area, and underground water has not been extensively exploited except in the Lower Pioneer Valley.

Table 3 is a summary of recorded production for mines in the Mackay Sheet area.

Copper

Copper ores are associated with many of the various intrusive rocks. The copper mineralization occurs close to the contact of the intrusive rocks with the bedded rocks, principally in the Mount Flora/Mount Orange area and the Pinevale area. Areas of minor mineralization include Netherdale, Freshwater Point, and Sarina Beach.

Mount Flora and Mount Orange. The Mount Flora and Mount Orange fields lie about 20 miles south-west of Nebo. In this area, the Bundarra Granodiorite intrudes sediments of the Back Creek Group. Contact metamorphic effects are considerable, and copper mineralization was associated with the intrusion. Malachite, azurite, chrysocolla, chalcocite, and chalcopyrite occur in joints at right angles to the contact. The richest orebodies were found in the metasediments, but a few extend into the granodiorite. Numerous porphyry dykes are associated with the granodiorite, and in several cases the introduction of the copper ore was believed to be directly connected with these dykes, both in the granodiorite and in the metasediments (Ball, 1910a).

Copper ore was first discovered in the late 1870's, and a smelter was erected in 1879. Copper matte was produced spasmodically until 1912, when the smelter blew up. A new smelter was erected in 1913, worked in 1914, and shut down in 1915. Production since 1918 has been small and spasmodic. During 1957, the old workings at Mount Orange were reopened, and the deepest shaft is accessible to 30 feet. The production between 1900 and 1918 was recorded as 1624 tons of ore yielding 260 tons of copper, 8384 oz of silver, and 20 oz of gold, valued at £26,000. Latest production recorded is 15 tons of copper ore in 1960.

Enterprise Exploration Pty Ltd carried out a geochemical survey of the Bundarra Granodiorite in 1962.

TABLE 3

RECORDED MINE PRODUCTION, MACKAY SHEET AREA

Producer	Chief Production	Ore (tons)	Gold (oz)	Silver (oz)	Copper (tons)	Wolfram (lb)	Clay (tons)	Recorded Value (£)
Mount Britton	1881-1890	1110	14,760* (mostly alluvial)	23				55,000 approx.
Pinevale	1940-1957	2433	24	8759	248			43,500
Mount Flora and Mount Orange	1900-1918	1755	22	9244	290			27,600
Grasstree	1892-1901 1936-1940	9000 10,595	2000 4560	284				24,900
Ben Mhor	1916	680	42		71			7740
Mackay District (Chiefly alluvial)	1926-1961	232	843	27				5430
Bong Bong (Lone Wolf)	1942-1952	100	14	2457	12			2400
Sunnyside	1932-1958	181	264	11				2260
Blue Mountain	1944-1947	148	4	439	15			1700
Mirani	1951-1953						2000	1200
Netherdale	1907; 1912	143		135	14			730
Mount Mosquito	1935; 1952	126	14					450
Glenella	1961						2100	210
Golden Valley	1940	22	13					120
Alligator Creek	1893	50	27					90
Bolingbroke	1942; 1952					360 (63-69%)		90
Tally Ho	1908	26	10					40
Freshwater Point	1940	4						20
Total	1881-1961	26,600	2 ,500	21,379	650	360	4100	173,500

Owing to the incompleteness of some records, the metal content quoted may not correspond to the quoted tonnage of ore mined, or to the content of other metals.

* Figure from Brooks J.H. (1964)

A copper prospect near Mount Travers, north of Mount Flora, was described by Ball (1910a); the copper occurs as malachite, in joints in Upper Bowen sediments. The mineralization was probably introduced with the microdiorite at Mount Travers. No production is recorded.

Pinevale area. Pinevale copper mine is situated on Pinevale Creek, a tributary of the Pioneer River, 10 miles south of Mirani. Pinevale lies within the Urannah Complex, close to the contact with Lower Bowen Volcanics. Granitic and dioritic rocks occupy the whole of the area in the vicinity of the mine. They are cut by vertical basic dykes, and these in turn by quartz veins, which appear to occupy north-east-trending joints. The orebody is reported to occupy a vertical tension joint within a curved fault-zone some 140 feet wide. The lode consists of quartz veins of variable width, and contains mainly chalcopyrite and bornite, with traces of galena and sphalerite and occasionally hematite. Gold and silver are also present.

Copper was first discovered on Pinevale Creek before 1890, but there was little production until 1942, except for 43 tons of copper produced in 1907-8. During the period 1942-1953, the mine was developed almost to its present state and produced over 1600 tons of ore yielding 184 tons of copper. Since 1953, production has been negligible, except for 565 tons of ore produced during 1956-57. The mine consists of three levels, and three winzes, one of which is used as a shaft, one is filled in, and the other is closed off. Much work has been done in recent years on overhauling the plant, retimbering, development work, testing, and prospecting, but the mine was closed in 1959, and little work of any kind has been done since then.

Bong Bong lies about 2 miles north-west of Pinevale on the same side of the Pioneer River. Mineralized veins in granitic rocks were worked here around 1900 to yield lead, copper, silver, and traces of manganese. Spasmodic work between 1942 and 1952 yielded small quantities of gold, silver, and copper. A little prospecting and development work has been done in recent years, and at present (1961) a shaft and a drive are being constructed in the hope of extracting copper ore.

Copper deposits very similar in occurrence to those at Pinevale have been mined at Mount Ben Mhor, in well-jointed syenitic rock. The Twin Mine was the chief producer. The nearby Blue Mountain copper mine was worked during the early years of World War II for galena, sphalerite, chalcopyrite, and minor bornite.

Several small copper prospects have been worked in the Netherdale district. Chalcopyrite and some malachite occur in fissures and quartz veins in gabbro, biotite granite, and other intrusives of the Urannah Complex. Mines worked include Royal Victory, Silver King, and King Copper. Production has been small, but actual grade and tonnages are not recorded, except for 134 tons of 10 percent copper ore from the King Copper mine in 1912, and 135 oz of silver from the Silver King on Cattle Creek, in 1907.

A copper-silver prospect about 6 miles north-west of Tierawoomba homestead was mentioned by Jack (1887) and was recently re-inspected by Brooks (1964b).

Malachite, limonite, pyrite, arsenopyrite, and possibly tetrahedrite occur in a quartz lode averaging 4 feet in width. The lode occurs within granodiorite which is intruded by rhyolitic and andesitic dykes. Some irregular veins of cupriferous material occur in kaolinized granodiorite. Brooks (1964b) quotes one sample from 5 feet to 8 feet in a recently

sunk shaft which assayed 16.2 percent copper, 50.7 oz per ton of silver and 10.2 dwt per ton of gold. However, other samples from the same shaft (total depth 22 feet) gave much lower assays.

A 15-ton parcel of ore is reported to have been sent away during earlier attempts at development, but no production is officially recorded. Small-scale prospecting is continuing in the area.

Copper ores are sometimes associated with intrusives into volcanics of the Campwyn Beds. An old shaft on Freshwater Peninsula was reopened in 1940 to produce 4 tons of copper ore, consisting of malachite and azurite in andesitic tuff. Assays showed 13-19 percent copper, 2 oz silver, and a little gold. Samples submitted from Sarina Beach in 1940 assayed 4.5 percent copper.

Lead

The Tally Ho deposit, 5 miles south of Pinevale, consists of pipe-like quartz-sulphide lodes in brecciated granite. The sulphides, in order of abundance, include sphalerite, galena (probably argentiferous), tetrahedrite, and a small amount of pyrite and chalcopyrite. Some gold is present. The deposit was discovered in 1908, and Cameron reported a 62-foot shaft in 1915. However, total recorded production is only about 26 tons of ore, mostly hand-picked. An assay of Tally Ho ore, quoted by Cameron (1915), gave 4.2 percent lead, 8.0 percent zinc, 12.4 oz silver, and a trace of gold. The complex ore is reported to be amenable to flotation treatment, but apparently the owners could not overcome the twin difficulties of transport and treatment, and there has been little work done since 1915. Cameron (1915) noted that ore at greater depth may be richer in lead and zinc sulphide, and thus Tally Ho may repay deeper prospecting.

Gold

Gold has been found at Mount Britton, Sunnyside and Eton, Kungurri, Grasstree, Alligator Creek, Golden Valley, and Mount Mosquito.

The occurrences appear to be confined to the Lower Bowen Volcanics and the Campwyn Beds, and associated with intrusives into these units. Most of the gold occurs in quartz veins and lenses cutting volcanics, but some quartz veins cutting intrusives of the Urannah Complex carry low gold values. However, in the Grasstree area, the gold is generally not associated with quartz veins, while the occurrences at Mount Mosquito suggests an alluvial deposit.

The Mount Britton area has been the chief producer of gold in the area, and some gold is still being mined. The present Mount Britton mine lies about 4 miles north of Homevale homestead, north-west of Nebo. The gold occurs in quartz veins and lenses in a generally andesitic country rock of the Lower Bowen Volcanics, not far from its contact with the Urannah Complex. However, most of the gold was obtained from a 3-mile stretch in the bed and banks of Oakey Creek near the mine. A feature of the field was the scarcity of fine gold, and the sporadic distribution of large nuggets (up to 69 oz).

Payable gold was first reported from Mount Britton in March 1881, and in a few weeks about 300 men were on the field. Early in May a large number of nuggets were found, causing a gold rush to the area; by June, 1500 men were on the field, and by the end of the year

4808 oz of gold had been won. Various reefs were subsequently opened up, notably the Little Wanderer and Lady Mary, but were abandoned after intensive and costly prospecting. In the ten years 1881-1890, records show production of 14,000 oz of gold valued at £48,700. By 1893, only a few alluvial miners remained. Since 1890, production from the field has been small and spasmodic. A floater containing 15 oz of gold was discovered in 1931. Brooks (1964) reports renewed interest in the field.

A three-head stamp battery, erected in 1933 at Sunnyside, 8 miles north-west of Sarina, crushed gold ores for prospectors working small gold leaders in the Carmila Beds in the area. Many leases were worked, but the chief producer was the Merry Widow. Sporadic gold with quartz and pyrite occurs in gossanous vugs in silicified conglomerate at Lucky Hit Lease, 4 miles south-west of Eton. Samples from the Follow On Lease in the same area showed traces of arsenic. Exaggerated reports of a find near Black Waterhole Creek, south of Eton, caused a rush to the area in 1896, but recorded production from all prospects in this area is negligible.

Reid (1936) described a gold prospect near Kungurri, close to the contact between silicified sediments of the Lower Bowen Volcanics and quartz diorite of the Urannah Complex. Veins of quartz carrying galena cross the contact. No production is recorded and the best gold assay was 25 dwt per ton.

The most important gold occurrences in the Campwyn Beds are found in the Grasstree area. The Grasstree Mine, formerly known as The Zelma, is situated on the coast, 1 1/2 miles north of Sarina Inlet. The geology of the mine area is complex. The workings are in kaolinized intruded metamorphosed volcanics and sediments of the Campwyn Beds. Rocks include andesitic tuff and breccia, andesitic and rhyolitic flows, andesitic agglomerate with scattered poorly preserved corals, and indurated conglomerate, intruded by masses of diorite, and associated dykes. The more important gold occurrences appear to be confined to metamorphosed tuff, and most evidence indicates that the gold is older than the diorite (Reid 1939); one small vein of quartz and chalcopyrite in diorite had low gold values. Reid (1939) mentions 'felsites' which are older than the diorite, and suggests the gold may have been hydrothermally associated with these. Brecciated zones were also important loci of ore deposition. The richest ore in the mine was a siliceous kaolin breccia with sparsely disseminated pyrite.

The Zelma Mine was opened in 1886 and a 20-head battery was completed by the end of 1891. From 1892 to 1901, records indicate crushings of over 9000 tons of ore, which yielded over 2000 oz of gold. Jack (1893) recorded small trial crushings which yielded 2 to 9 dwt per ton. The field was practically idle from 1897 till 1935, when the Grasstree Gold Mining Syndicate began operation. In the period 1936-1940, over 10,000 tons of ore yielded 4560 oz gold and 284 oz silver. Since 1940, activity has been limited to prospecting and testing. Two gold-mining leases were granted in 1961.

Gold was discovered east of the mouth of Alligator Creek in 1886. There was a five-stamp battery at the site, and two shafts, 25 feet and 30 feet deep, but the only crushing recorded is of 50 tons of ore yielded 27 oz of gold in 1893. The gold occurs in iron stained quartz veins up to 3 inches thick in spotted slate of the Campwyn Beds. High gold values were reported, but the ore petered out quickly. Since then there has been spasmodic prospecting in the area, and later assays of quartz reefs gave values of 10 to 15 dwt per ton.

A number of small deposits in the Golden Valley area, 1 1/2 miles south of Grasstree, were tested around 1940. These deposits, like those at Grasstree, occur within the Campwyn Beds. East (1946) mentioned intrusives cut by 'hornblende porphyrite dykes' which both he and Jensen (1947) thought could be related to the intrusives at Grasstree. The only production recorded is 12.5 oz of gold in 1940.

Since 1933, prospecting around Mount Mosquito, east of Ilbilbie, has revealed what Reid (1935) thought was probably a bedded deposit, of unusual type, containing very fine gold in folded and hardened sandstone and mudstone. Numerous shallow shafts and trenches were dug, but only small production is recorded. Prospecting also revealed traces of copper mineralization in fine hard lithic sandstone of the Campwyn Beds on Green Hill, 2 miles to the north.

Wolfram

A wolfram occurrence on Bolingbroke Station, 21 miles south-west of Sarina, was described by Shepherd (1952). Magnetite veins have also been reported in this area. The wolfram occurs as small disseminated crystals in numerous white quartz veins in granite of the Urannah Complex. The quartz veins range in thickness up to 4 feet, but are usually lenticular and less than 50 feet in length. Numerous shallow shafts and trenches were sunk in the early 1950's, but recorded production is small. The wolfram crystals are so small and so sparsely disseminated through the quartz that laborious hand-picking is necessary. This area may repay further prospecting.

Molybdenite

Reid (1941) reported the occurrence of molybdenite on Knight Island, 33 miles east of Sarina. The island consists entirely of granite, with a zone of heavily quartz-veined greisen. Molybdenite occurs both in the greisen and in quartz veins cutting it. Reid considered the occurrence unattractive for commercial development beyond small-scale gouging operations.

Uranium

Brooks (1961) reported on a uranium prospect south of Pinnacle homestead on Teemburra Creek, a tributary of the Pioneer River. He described the occurrence of a niobate-titanate-rare earth-uranium oxide mineral in an orthoclase-quartz segregation, in granite within the Urannah Complex. Andesitic dykes are common in the area, but rhyolitic and some small splitic dykes also occur. The uranium mineral occurs as small rounded brown semi-translucent vitreous grains, closely associated with black chloritic material, and in places, with fine-grained pyrite. The prospect is not considered to be of economic significance, but similar deposits may occur in the area around the margins of the granite.

Beach sand heavy minerals

The beach sands were investigated by Dowsett Engineering (Aust.) Pty Ltd in 1955, and by Tweed Rutile and Minerals Ltd, 1956. Dowsett reported no evidence of appreciable heavy mineral concentration except in the Shoal Point/Bucasia area 10 miles north of Mackay.

Connah (1961) examined the Shoal Point area, and reported 'indicated reserves' of 10,000 tons of heavy mineral containing magnetite 52 percent, ilmenite 40 percent, zircon 7 percent, rutile trace, and others 1 percent. However, Connah observed that the beach sands alone do not appear to be sufficient to support a local industry.

An auriferous sand claim was worked at Grasstree in 1936 for a yield of 8 oz gold from 800 tons of sand.

Coal

Minor coal bands have been found in the Calen Beds, the Carmila Beds, and the Upper Bowen Coal Measures. Carbonaceous and graphitic shales are common in the Lower Bowen Volcanics, but no coal seams are known.

Coal has been mined from the Calen Coal Measures at Calen in the Proserpine Sheet area and was reported by Ball (1910d) from Mount Toby and Mount McGregor in the Mackay Sheet area. However, none of the occurrences in the Mackay Sheet area has been exploited as the seams are generally thin, folded, faulted and intruded.

There are local reports of coal in the Carmila Beds between Ilbilbie and West Hill. Carbonaceous shale occurs in this area, but no coal was seen, though beyond the sheet boundaries, at Oakey Creek, thin coal seams do occur in the Carmila Beds. The only other coal seams reported are exposed in Black Waterhole Creek, near the Range Hotel. These were first reported by Dunstan (1901), but no seams thicker than 3 feet have been found, and the coal has not been exploited.

Minor coal has been observed at several localities within the Upper Bowen Coal Measures in the south-west. Cameron (1905) mapped the lower beds of the coal measures, and reported several coal occurrences between Mount Britton and Oxford Downs; none has been exploited.

Oil Shale

Oil shale was first reported by Ball in 1927 from Plevna, on Hazlewood Creek 11 miles south of Netherdale. The Plevna oil shale is in an outlier of Tertiary sediments and tuff, lying on the irregular surface of Urannah Complex and Lower Bowen Volcanic rocks. The oil shale is overlain by about 40 feet of clay and tuff. The Tertiary sequence is exposed only in a narrow central part of about 60 acres, surrounded by hills of younger volcanic rocks, beneath which the sediments may extend in several directions. Reid (1942) stated that the bed of oil shale is probably less than 1 mile across, but because of overlying younger volcanics its extent is unknown.

The shale has not been exploited but seven bores and a shaft were put down during 1939-40, and three bores in 1958, in an attempt to determine reserves. One of these bores bottomed at 265 feet, in what are thought to be Tertiary sediments. The oil shale is uniformly fissile, greenish grey in colour, with an indicated crude oil yield of slightly over 20 gallons per ton.

Graphite

Deposits of graphite near Homebush (Por. 776 and 777, Par. Eton) were examined by Maitland and reported by Ball (1906). Ball noted that the graphite is associated with shale

and quartzite and intrusive igneous rocks. An 80-foot prospecting tunnel revealed a seam of graphite with maximum width of 4 feet and average width of 18 inches.

Several other small occurrences of graphite containing 15 to 70 percent graphitic carbon are known in the Carmila Beds in this area, and at the time of his examination, Maitland (1889a) considered the deposits to be worth further attention.

Clay

Bricks were made from Mirani clay as early as 1907, and a brickworks built on the site later used clay from Mirani and Pindi-Pindi (in the Proserpine Sheet area). However, production has been spasmodic, and the latest recorded production from the Mirani pit was in 1953.

The North Queensland Potteries Pty Ltd commenced operations at Glenella, 4 miles north-east of Mackay, in 1961, and produced over 2000 tons of clay, chiefly from alluvial clays at Glenella. This company also obtains clay from Palmara, Kuttabul, Hampden (fire clay), and the old Mirani pit.

Quarries

Mount Bassett quarry, near Mackay, is the largest in the area; it supplies stone (microdiorite) to the Mackay Harbour Board and the Mackay City Council. Rock for the harbour wall and breakwater is taken as it is blasted down. Gravel for road metal and concrete aggregate is delivered from the crushing plant.

A number of smaller quarries supply road dressing from a great variety of rocks. Reid (1931) examined and described in detail some 15 potential sites within 20 miles of Mackay, for a quarry to supply stone to the Harbour Board. Mount Bassett was the site eventually chosen.

Petroleum

Traces of bituminous material have been reported from several points along the coast, and during the 1962 field season patches of bituminous material were observed at almost every coastal outcrop north of Cape Palmerston. Mott (1958) reported subround pellets, 1/4 inch to 2 inches in diameter, at high water mark on the southern side of Deadman's Island, an extension of Cape Palmerston. Mott noted that the material seems only to occur in a section of the coast between Repulse Bay and Broad Sound. He suggested that the material is probably furnace oil, concentrated by the prevailing currents, which are towards the coast in this area and not parallel to it as is the case along most of the Queensland coast. Bituminous material from Half Tide near Grasstree has been submitted for analysis to the Bureau of Mineral Resources Petroleum Technology Section, and the results are given in Appendix 1. The presence of asphaltenes and resins indicates that the material is unrefined.

Three scout bores were drilled in 1955-56 by the Mackay Oil Prospecting Syndicate (MOPS Nos 1, 2 and 3). Two of the bores, numbered 1 and 2, were on the coastline 10 miles north-north-east of Sarina in portion 1, 296, parish of Hector, county of Carlisle, near Grasstree, in Campwyn Beds. They both encountered silicified sandstone and tuff; No. 1 was abandoned at a depth of 55 feet, and No. 2 at 150 feet. Bore No. 3 was drilled at Hay

Point, 12 miles north-north-east of Sarina, also in Campwyn Beds, and the same lithology was encountered. It was abandoned at 150 feet. None of the holes encountered oil or gas.

In October 1962, several inches of a grey-brown oily liquid was reported by a local resident to be on top of fresh water in a well at Walkerston. The depth to water from the surface was 28 feet. A sample of the liquid collected by the local resident was submitted to the BMR Petroleum Technology Section for analysis, and the result of the analysis is given in Appendix 1. Traces of asphaltenes and resins were noted.

It is unlikely that petroleum will be found on the mainland in the Mackay area in economic quantities. Palaeozoic units either lack reservoir rocks or suitable structure, or they are intruded. The Back Creek Group contains possible source rocks in the Tiverton and Blenheim Formations; and the Gebbie Formation has some porous beds. The structure of the unit in this area, however, does not appear to be encouraging.

Although Tertiary oil shale has been found at Plevna, Tertiary sediments on the mainland are unlikely to be an economic source of petroleum. The sequence is thin, discontinuous, and lacking in permeability. The widespread occurrence of bituminous material on the coast possibly indicates submarine seeps, and it is possible that small Cretaceous-Tertiary marine basins lie between the edge of the Barrier Reef and the present coastline. On the other hand the bituminous material may have come from passing ships.

Water

Lower Pioneer Valley and City of Mackay. The average annual rainfall in this area is 60 to 65 inches; the rainfall is seasonal with a pronounced wet season from December to April. Most streams are permanent and surface water is plentiful. However, the increasing demand for water by sugar mills and for city water supply and irrigation has led to increased interest in the conservation of surface water, and in the search for good supplies of underground water.

The Pioneer Valley below Mirani is an extensive area of alluvial flats with a few hills, crossed by surface drainage channels running roughly parallel to the Pioneer River. Calvert (1959) observed that near Mirani are found the remains of an old anabranch which consists of swamps in the upper reaches, but later forms a channel known as Sandy Creek, near Eton. He also noted a second anabranch near Walkerston, which becomes Baker's Creek, and a third south of the river below Dumbleton Rocks which is referred to as 'The Lagoons'.

Underground water may be obtained from the alluvial sediments at practically any point in the lower valley and flood plain, the quantity depending mainly on the permeability of the aquifer. Water of good quality is struck at depths from 5 feet to 60 feet (in some places more). The underground water supplies in the area east of Walkerston, between Baker's Creek and the Pioneer River, have been extensively developed for irrigation and domestic purposes. The present Mackay supply is drawn from bores in the Lagoons area, on the south-west boundary of the city.

The City of Mackay has depended on this source for its water supply since 1896. From 1921 onwards, a gradual lowering of the water levels at the pumps at the end of each dry season was noted, until at the end of the 1953 drought, the level at the city's waterworks fell, and salinity increased slightly. Since 1953 the Council, with the advice and assistance of the Irrigation and Water Supply Commission, has carried out an almost continuous investigation of the underground water supply.

The area between the Pioneer River and Bakers Creek has been the site of several systematic investigations, the most recent and extensive of which was by the Irrigation and Water Supply Commission during 1947-51. In this survey, 19 lines of bores were put down along and across the valley, and a total of 4500 feet drilled, using auger and percussion plant. Where good waterbeds were obtained, observation pipes were inserted, and many readings of standing water level were taken. In 1947, the Pioneer Basin was constituted a declared area under the Water Acts, and systematic records of water levels in observation bores throughout the area have been kept since then. A direct result of this investigation was the sinking, development, and equipping of three Council bores in Alexander Street, with a combined capacity of 100,000 g.p.h.

The depression known as The Lagoons at one time formed part of the Pioneer River, and could now be described as an anabranch which has become silted by deposition from river flooding and surface runoff. Bores on the line of the Lagoons depressions in general show the greatest thickness of coarse sediments in the Pioneer Basin. Depth to bedrock varies from 70 feet to 100 feet from the surface.

Abbiss (1959) considered that during periods of high rainfall and good recharge, the supply available for pumping from underground sources would meet the demands of the city for at least 20 years. However, because of the danger of silt infiltration, and to prevent restriction upon usage during drought years, the city water supply is augmented by taking surface water from the Pioneer River at Dumbleton Rocks. The demand for water for mill and irrigation supplies in the Marian area led to the construction of the Marian Weir, commenced in 1950.

Dalrymple Heights - Eungella - Crediton Areas. Dalrymple Heights, Eungella, and Crediton lie respectively north, west, and south of Netherdale, on a plateau at the head of the Pioneer Valley, about 50 miles west of Mackay. Most of the area is closely settled, and devoted to dairying. Rainfall averages vary from 90 inches to 136 inches per year, but because of fast runoff, and the comparatively long dry season, the local interest in water conservation schemes is high.

The majority of rocks in the area are highly weathered, and soil depth is considerable. Throughout the area the water-table is fairly high, appearing as springs near the heads of gullies, but because of the abundance of igneous rocks, there seems little likelihood of obtaining sufficient supplies of underground water for irrigation. In the Urannah Complex, water is held only in the joints and fractures, and consequently the springs give only small flows, and the yield from bores would be similarly low. The basalt allows water to percolate through it more rapidly, but as it is mainly at a higher elevation, bores into it would have poor local storage, and consequently a lower yield. Baird (1962) suggested that the contact between the basalt and the granite appears to offer the best change of higher yield. He also suggested that earth dams for surface storage on the Urannah Complex may in many cases offer a better economic return than bores that may give only a limited supply.

Apart from a few shallow wells little attempt has been made to tap underground water in the area. Thus no figures are available as a guide to estimating flows that could be expected. In isolated instances, wells into patches of alluvium along some of the creeks may give flows sufficient for stock water or small-scale irrigation.

Baird (1962) includes analyses of water samples from springs and wells in the area. All were declared suitable for watering stock, but one was considered unsuitable for

domestic purposes, because of its hardness and high chloride content. Most samples were acidic, with pH generally between 6 and 6.5, and thus untreated water could be corrosive to metals.

As a result of a proposal for the development of the upper Broken River for hydroelectric power generation, Wyatt (1958) reported on the geology of the area, and his map shows two possible dam sites, of which one is in the Sheet area, south-west of Netherdale This scheme has been shelved, at least for the present, because of insufficient rainfall data.

Eton - Sarina - Koumala - Carmila district, east of the coast ranges. Average annual rainfall in this area is generally between 55 and 70 inches. Surface water is relatively abundant, and streams are generally permanent, so that few bores have been put down. Moreover, records are largely incomplete, so that it is hard to obtain a useful picture of the occurrence of groundwater from them.

The area is occupied by rocks of the Urannah Complex, Connors Volcanics, Campwyn Beds, and Carmila Beds, none of which appear to contain extensive aquifers. Bores into the Urannah Complex are rare. Water is sometimes obtained where the bore intersects a major joint, but otherwise chances of obtaining good supplies are poor. Quality too, is unpredictable, but water is generally more or less acid and corrosive.

Neither the Connors Volcanics nor the Campwyn Beds have potential as underground water producers, and bores into them are rare. Bores near Koumala put down for town water supply penetrated tuff and yielded water at the rate of 24,000 g.p.h. and 30,000 g.p.h. from bores 71 feet and 75 feet deep. This water was hard and considered unsuitable for cordial-making. The abundance of andesitic volcanics and the occurrence of calcite veins in both the Connors Volcanics and the Campwyn Beds suggest that underground water is likely to be hard, and rich in lime.

Few bore records are available for bores into the Carmila Beds, but the rocks are generally impermeable. A bore near Eton, 68 feet deep in 'slate', is reported to yield 8000 g.p.h. It is possible that underground water (possibly subartesian) may be available from sandstones at the top of the Carmila Beds, which are covered by alluvium, in the area east of the railway line, between Ilbilbie and Carmila.

Sarina water supply is obtained from a dam on Middle Creek, a tributary of Plane Creek, 8 miles south-west of the town. Domestic water supplies for some of the small coastal settlements (e.g. Grasstree & Slade Point) are supplemented by water obtained from shallow spears and wells into dunes close to the beach, which apparently tap a thin layer of fresh water floating on the salt sea water. The supply remains fresh providing the well is not deepened, and pumping rate is not excessive.

Nebo district, south and west of the coast ranges. Average rainfall in this area is about 30 inches per year. Most creeks flow seasonally, but generally have large permanent waterholes, and water can usually be obtained from spears in the sandy beds of many of the larger streams.

Permanent water is usually obtained at shallow depth in the alluvium close to the creeks, and most of the bores in the area are in alluvium south and west of Nebo, along Cooper Creek and Moonlight Creek. Bores in the Nebo area range from 50 feet to 350 feet in depth. One bore 4 miles south of Nebo passed through 115 feet of alluvium. The town supply bore produces good water from a depth of 61 feet.

In contrast to the generally good underground water around Nebo, all twelve bores along Moonlight Creek and Cooper Creek produced permanent water described as hard or very hard. These bores are all around 70 feet deep, and produced at a rate of about 700 g.p.h.

In general, the Urannah Complex and Lower Bowen Volcanics have little potential as underground water producers. Both the Back Creek Group and the Upper Bowen Coal Measures contain aquifers for subartesian water. Farther west, in the Mount Coolon Sheet area, good underground water production is commonly obtained near coal seams in the Upper Bowen Coal Measures.

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APPENDIX 1

ANALYSIS OF BITUMEN AND OIL SAMPLES FROM THE MACKAY AREA

by

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Three samples submitted on the 6th November 1962 have been tested. Characterization of these samples is based on paper chromatography techniques. Distillation characteristics could be obtained only in the case of the oily phase of the water well samples.

Results of quantitative tests and observations are given in the following table.

Results and observations on bitumen and oil samples from the Mackay area

Sample description	Composition			Distillation			Observations
	water	hydro-carbons	solids	70-110	C° 110-280	280-360	
Bitumen from Finlayson Point, Proserpine Sheet area.	1%	3.7%	95.2%	---	not	---	Viscous, black, odourless
Reported oily phase in water from well of Mr Taylor, Fadden St., Walkerston. Mackay Sheet area	98.5%	1%	0.5%	12%	8%	21%	Non-viscous green oil. Distillation residue - slightly viscous liquid, strong naphthenic odour.
Bitumen from Half Tide, near Sarina Beach Mackay Sheet area.	6.8%	74%	20%	---	not tested	---	Waxy, black, odourless

Each sample contained asphaltenes and resins, but oil from the water well sample contained only traces of these compounds. Practically no polycyclic hydrocarbons were noticed in the oil from the water well sample, but they were more evident in the bitumen sample from Half Tide.

The sample from Finlayson Point appears to be derived from a crude base different from that of the other two samples.

APPENDIX 2

CARBONIFEROUS MARINE FOSSILS FROM THE MACKAY SHEET AREA

by

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Collection M608F, map reference 225.287, Mackay Sheet.

Schuchertella sp.
Avonia kennedyensis Maxwell
Athyris sp.
Camarotoechia sp.
Aviculopecten sp.
Indet. ? pteriid pelecypod
Baylea sp.
Straparollus cf. australis Maxwell

Lower to middle Tournaisian.

Collection M639F, map reference 201.345, Mackay Sheet, near Dudgeon Point.

Chonetes sp.
Pugnoides sp.
Indet. spiriferid fragment
Athyris sp.
Bellerophon sp.
Straparollus sp.
Indet. gastropod fragments.

Lower Tournaisian.

Remarks: Specimens of Avonia kennedyensis in collection M608F compare quite closely with those described and figured by Maxwell (1954) from middle Tournaisian or slightly older sediments (Chonetes Zone) near Mt Morgan. The species has been recognized from numerous localities in the Yarrol and Star Basins, and stratigraphically is the most useful species in the collection. Schuchertella sp. is marked by its very small shell and particularly flat brachial valve.

Fossils in collection M639F are few and very poorly preserved. The only specimen of stratigraphic value is the brachial valve of a small rhynchonelloid brachiopod, Pugnoides sp. The species has been recognized only from earliest Tournaisian strata near Wheelbarrow Dam on the Ben Lomond 1-mile sheet, Star Basin (McKellar, 1963), and in the Cania area, Yarrol Basin.

References: MAXWELL, W.G.H., 1954 : Upper Palaeozoic formations in the Mt. Morgan district - faunas. Univ. Qld Dep. Geol. Pap., 4(5).

McKELLAR, R.G., 1963 : Palaeontological report on collections B.L. 14b-25 submitted by District Geologist, Charters Towers, from the Ben Lomond 1-mile sheet area. Unpub.rep.geol.Surv.Qld.

APPENDIX 3

FOSSIL PLANTS FROM THE CARMILA BEDS

The following determinations were made by Mary E. White (1963a, b).

(i) Fossil localities in the southern area

Locality 506 — 5 miles north-east of Ilbilbie. B.M.R. registered number F 22269

Indeterminate plant fragments

Locality M654 — 3 miles south-south-east of Ilbilbie. Specimens F 22267

Glossopteris communis Feist.

Phyllotheca australis Bgt., stems and sheaths

Glossopteris indica Sch.

Nummulospermum bowenensis Walk.

Locality M675 — ½ mile west of Ilbilbie. Specimens F 22270

Noeggerathiopsis hislopi (Bunb.)

Equisetalean stems

Nummulospermum bowenensis Walk.

Glossopteris venation fragment

Locality M604 — 1 mile north-west of West Hill.

Equisetalean fragments

Seeds (? Samaropsis)

? Glossopteris type venation fragments

(ii) Localities in the northern area

Locality M572 — 4 miles south-west of Sarina. Specimens F 22266

Glossopteris indica Sch.

Small Samaropsis seeds

Equisetalean stems

Equisetalean leaf sheaths, probably Phyllotheca australis Bgt.

Locality M754 — 10 miles south-west of Mackay.

Glossopteris ampla Dana

Glossopteris indica Sch.

Noeggerathiopsis hislopi (Bunb)?

Samaropsis dawsoni Shirley

Equisetalean stems

Locality M140 10 miles west-south-west of Mackay. Specimen F 22268

Equisetalean stems

Locality M423 3 miles north of Range Hotel. Specimens F 22034-5-6-7.

Samaropsis dawsoni

Noeggerathiopsis hislopi (Bunb.)

Vertebraria indica Royle

Locality M765 Dumbleton Rocks. Specimen F22273

Small equisetalean stems

Indeterminate plant fragments

Locality M446 2½ miles east-north-east of Range Hotel. Specimen F 22038

Glossopteris indica Sch.

Equisetalean stems

Locality M751 6 miles west of Sarina. Specimen F 22271

Equisetalean stems.

AUSTRALIA 1:250,000

MACKAY
QUEENSLAND

1:250,000 GEOLOGICAL SERIES SHEET SF55-8

PRELIMINARY EDITION, 1962

SUBJECT TO AMENDMENT

Reference

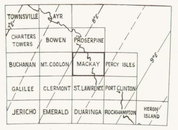
CAINOZOIC		Qd	Coastal dune sand
		Cza	Soil, sand, alluvium, coastal sediments, flood plain despoasits. Mangrove swamp.
		Cz	Undifferentiated unconsolidated sediment
	TERTIARY	Ta	Semi-friable sandstone
		Tv	Rhyolite, trachyte, andesite, rhyolitic agglomerate and breccia, minor basalt, ignimbrite.
		Tb	Mainly basalt flows, some minor porphyritic rhyolite
		Ti	Undifferentiated intrusive rocks
MESOZOIC		Mi	Undifferentiated basic and intermediate intrusive rocks
		Mg	Acid intrusive rocks
	Bundarra Granodiorite	Mgb	Leuco-granodiorite
	CARBONIFEROUS TO MESOZOIC — Urannah Complex	C-Mr	Granite-diorite-granodiorite complex with abundant acid, intermediate, and basic dykes.
PALAEOZOIC	PERMIAN — Upper Bowen Coal Measures	Pub	Lithic sandstone, siltstone, carbonaceous shale, coal, conglomerate bands
	Middle Bowen Beds	Plm	Quartz sandstone, lithic sandstone, blue micaceous fossiliferous siltstone
		Ple	Lithic sandstone, quartz sandstone, chert, carbonaceous shale, siltstone, coal, rhyolite.
	Carmila Beds	Pla	Conglomerate, siltstone, carbonaceous shale, lithic sandstone, rhyolite, dacite, tuff.
	Lower Bowen Volcanics	Plv	Andesitic flows, agglomerate and tuff, minor rhyolite and dacite, tuff, siltstone, feldspathic sandstone.
	UPPER DEVONIAN TO LOWER CARBONIFEROUS — Campwyn Beds	D-Cc	Andesite and rhyolite flows and pyroclastics, siltstone, fossiliferous limestone (includes minor intermediate and basic intrusives).

- Geological boundary
- Fault
- Where location of boundaries and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries are dotted, faults are shown by short dashes.
- Strike and dip of strata
- Prevailing dip of strata
- Vertical strata
- Overturned strata
- Strike and dip of foliation
- Bedding trend lines
- Joint pattern
- Dykes:- an = andesite, rh = rhyolite
- ⊕ M412 Macrofossil locality
- ◊ M781 Plant fossil locality
- Fossil wood
- Mine
- Prodject
- Ag Silver
- Au Gold
- Cu Copper
- Cy Clay
- G Graphite
- M Molybdenite
- Oil Oilshale
- Pb Lead
- Rm Road metal
- U Uranium, Nb Niobium, Ti Titanium, Rare earths
- W Wolfram
- Z Zirconium, Beach sands
- Zn Zinc
- Windpump
- Homestead
- Airfield
- Road
- Vehicle track
- Cliff
- Metamorphic aureole

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Geological Survey of Queensland. Slotted template control supplied by the Division of National Mapping, Department of National Development, 1962. Spot heights taken from Lands Department Queensland Four Mile Series. Transverse Mercator Projection.

INDEX TO ADJOINING SHEETS

Showing Magnetic Declination



(ANNUAL CHANGE 3' E)

Scale 1 : 250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

GEOLOGICAL RELIABILITY DIAGRAM

B – *Detailed reconnaissance - numerous traverses*

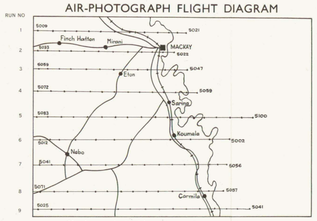
C – *Air-photo interpretation - few traverses*

Geology by: A.R. Jensen, C.M. Gregory (B.M.R.) and V.R. Forbes (G.S.Q.), 1961, 1962

Compiled by: A.R. Jensen, C.M. Gregory (B.M.R.) and V.R. Forbes (G.S.Q.), 1962

Drawn by P.J. Brown

AIR-PHOTOGRAPH FLIGHT DIAGRAM



Air photography by Adastra Airways Pty Ltd complete vertical coverage at 1 : 85,000 scale.

Sections

SCALE: V/H = 4

MACKAY SF55-8