copy 3

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

COMPLIMENTARY

Report No. 64

GEOLOGY OF THE MOUNT COOLON 1:250,000 SHEET AREA

BY

E. J. MALONE, D. W. P. CORBETT, and A. R. JENSEN

Issued under the Authority of Senator the Hon. Sir William Spooner,
Minister for National Development
1964

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Report No. 64

GEOLOGY OF THE MOUNT COOLON 1:250,000 SHEET AREA

BY

E. J. MALONE, D. W. P. CORBETT, and A. R. JENSEN

Issued under the Authority of Senator the Hon. Sir William Spooner,
Minister for National Development
1964

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

Minister: SENATOR THE HON. SIR WILLIAM SPOONER, K.C.M.G., M.M.

Secretary: SIR HAROLD RAGGATT, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Director: J. M. RAYNER

This Bulletin was prepared in the Geological Branch

Chief Geologist: N. H. FISHER

CONTENTS

APPENDICES

TABLES

PLATES

FIGURES

SUMMARY

In 1960, the Bureau of Mineral Resources, in association with the Geological Survey of Queensland, initiated a programme of regional mapping of the Bowen Basin, Queensland, whose primary aim was to assist the search for oil in the basin. Two parties were in the field during 1960. This progress report covers the work of one of these parties which mapped most of the Mount Coolon 1:250,000 area. A preliminary edition of the Mount Coolon Sheet, in the 1:250,000 Geological Series, is issued with the report; further mapping in adjacent areas is required to resolve some outstanding problems.

The oldest rocks in the Mount Coolon area are the Anakie Metamorphics: these crop out in the Anakie High, in the west of the area, and were not mapped in any detail.

A great thickness of sediments, the Drummond Group, was deposited in the Drummond Basin west of the Anakie High, mainly during Lower Carboniferous time. Some of these beds crop out in the south-west of the Mount Coolon area, dipping west off the Anakie High. The marine sediments of the Mount Wyatt Beds, the acid volcanics and minor sediments of the 'Undifferentiated Volcanics', and the Carboniferous Bulgonunna Volcanics crop out east of the Anakie High. The Bulgonunna Volcanics constitute a massive block which forms the western basement of the Bowen Basin.

Deposition in the Bowen Basin began in late Carboniferous or early Permian time with the deposition of the Lower Bowen Volcanics, a very great thickness of mainly andesitic volcanics and interbedded sediments, and possibly contemporaneous intrusives. The unit contains rare plant fossils almost throughout, and marine fossils near the top. A disconformity and a possible angular unconformity separate the Lower Bowen Volcanics from the overlying marine Middle Bowen Beds. The marine beds contain three stratigraphically discrete fossil faunas, ranging in age from Artinskian to late Lower Permian. All three faunas are found in the north-east of the Mount Coolon area, where the unit consists of a deep-water quartz greywacke/siltstone assemblage, from 4500 feet to 8000 feet or more thick. Only the youngest fauna occurs in a quartz sandstone on the western side of the basin, where about 2000 feet of this shelf-type deposit unconformably overlie the Bulgonunna Volcanics; it represents a late-stage transgression of the Middle Bowen sea on to the Bulgonunna Volcanics.

The Upper Bowen Coal Measures conformably overlie the Middle Bowen Beds. They were deposited in a shallow restricted basin becoming swampy at times, permitting coal seams to develop. The unit consists of about 10,000 feet of lithic sandstone and calcareous lithic sandstone, siltstone, conglomerate, carbonaceous shale, and coal; it contains an abundant fossil flora. The unit is probably Upper Permian in age, but may extend into the Lower Triassic.

The Carborough Sandstone, 1500 feet of current-bedded quartz sandstone, is structurally conformable but possibly disconformable on the Upper Bowen Coal Measures. It grades upwards into the micaceous lithic sandstone and micaceous siltstone of the Teviot Formation. This formation contains Triassic plants.

Tertiary sediments and basalts which unconformably cover the older rocks in many areas are remnants, some quite large, of very extensive Tertiary deposits. Cainozoic alluvial deposits and soils cover much of the area. Laterite profiles are developed on the Tertiary rocks and on some of the older units.

Igneous rocks of several ages intruded the Anakie Metamorphics, the Drummond Group, and the Bulgonunna Volcanics. A suite of intrusives, ranging from granodiorite to gabbro, intruded the Bowen Basin succession. They are possibly late Triassic or post-Triassic.

The relationship of the Urannah Complex to the adjacent Lower Bowen Volcanics is not known.

The Bowen Basin developed about the beginning of Permian time, received sediments, with only one known interruption, into the Triassic, and was folded and intruded in late Triassic or post-Triassic time. A shelf area, apparently free of major intrusives, and an intruded, folded zone are recognized within the basin.

Oil source beds may be present in the thick quartz greywacke, siltstone assemblage of the Middle Bowen Beds; potential reservoir beds exist in the quartz sandstone of the Middle Bowen Beds in the western shelf area. Prospecting for oil may best be confined to the eastern edge of the western shelf of the basin.

INTRODUCTION

This report and the geological map of the Mount Coolon 1:250,000 Sheet area are almost entirely based on field work undertaken between 9th June and 14th October 1960, as part of the first stage of a programme of regional geological mapping in the Bowen Basin undertaken jointly by the Bureau of Mineral Resources and the Geological Survey of Queensland to assist the search for oil in Queensland. The members of the party were E.J. Malone, D.W.P. Corbett, and A.R. Jensen, of the Bureau of Mineral Resources, and P.E. Bock (from 9th June to 9th September) and L.G. Cutler (from 9th September to 14th October) of the Geological Survey of Queensland. G. Tweedale of the Geological Survey of Queensland led the party on a reconnaissance of the northern part of the Bowen Basin from 31st May to 5th June 1960.

The Mount Coolon Sheet area lies near the northern end of the Bowen basin. Mackay on the Queensland coast is the nearest large town and is 45 miles east of the area, which is bounded by the 21st and 22nd south parallels, and by east meridians 147° and 148° 30'.

The Clermont/ Mackay highway crosses the south-east corner of the area. Elsewhere, a network of graded roads and vehicle tracks link Mount Coolon township in the north-west, and the numerous homesteads, with Collinsville to the north, Nebo to the east, Clermont to the south, and the Clermont/Charters Towers highway to the west. These roads provide good access to most of the area, except for the very rugged and thickly timbered ranges in the north-east corner of the Sheet.

The annual rainfall ranges from 20 inches in the west to 30 inches in the east, and is considerably higher in the Eungella Range. Most of the rain falls in the summer, from November to March, but some rain may be expected during the winter months. Frosts are common during the winter.

The pastoral industry is the only industry of most of the area, which contains 42 homesteads. Fences are numerous, but most are in poor repair and offer no bar to progress. Where the fences are in good repair, station tracks and gates are usually available. Some dairy and mixed farming is done on the Eungella Range, on small blocks of good land cleared of the rain forest. The timber industry is flourishing on the Eungella Range; a number of saw mills, some quite large, lie along the road through the Range, which, at Eungella, lies just within the eastern edge of the Mount Coolon area. The timber is cut in the rain forest, partly within the Mount Coolon area, and the timber-cutters' tracks give some access to this most inhospitable country.

The Mount Coolon area is covered by RAAF air photographs, taken in 1947, at a scale of 1:50,000 and of very poor quality. It is also covered by recent Adastra photography at a scale of 1:26,000. Photo-scale slotted-template compilations of the area, with principal points only, were produced by the Division of National Mapping, using the RAAF photographs. Geology, drainage, topography, and cultural detail were transferred to the photo-scale compilations and these were reduced to 1:250,000 scale to produce the map accompanying this report (Plate I).

Previous investigations

Several authors have referred to the units cropping out in the Mount Coolon area, but not many have actually worked in the area. Gibb Maitland in 1889 was probably the first to work there. Ball, in 1909, visited the south-east corner of the area in the course of mapping the Mount Flora Gold and Mineral Field. Morton visited the area in 1935 to map the Mount Coolon Gold Field and made notes on the geology of the district.

Reid has contributed most to the geology of the area. During the years 1924 to 1929, he mapped large parts of the area in reconnaissance detail. He mapped the Bee Creek/ Lake Elphinstone area in 1946, to assess the coal resources. From 1948 to 1950 he was geological consultant in a diamond-drilling programme to test the coal reserves, the results of which are recorded in the Powell Duffryn Technical Services report (1949) on the coal industry of Queensland. A further 7 holes were drilled and one test shaft sunk in 1951 and these are reported by Shepherd.

Isbell (1955) mapped a large part of the northern Bowen Basin, including part of the Mount Coolon area, in reconnaissance detail. He reviewed the existing literature on the area and contributed some original work.

Laing (1959) mapped the area, again only in reconnaissance detail; in his unpublished report, he suggested some subdivision of the Upper Bowen Coal Measures and some new formation names.

PHYSIOGRAPHY

Seven types of topography are recognised in the Mount Coolon area. These are the Eungella and Broken River Ranges, highlands, lowlands, plains, an inclined plateau, a tableland and several mesas, and a group comprising the Carborough, Kerlong, and Burton Ranges and the Redcliffe Tableland. The distribution of these is shown on Figure 1. The three main drainage systems in the area, the Suttor River, the Isaacs River, and the Bowen River, are also shown on Figure 1.

Eungella and Broken River Ranges

The Eungella and Broken River Ranges include the highest hills in the area. Near Eungella they rise to about 3000 feet above sea level. The area is extremely rugged with local relief of the order of 1500 feet. Valleys are generally narrow, v-shaped and steep-sided. Some of the bigger streams, such as the Broken River, are more mature; they do not fully occupy the bottoms of their valleys, but the valley sides are still steep. Some of the drainage is linear and apparently controlled by faults. Razorback ridges are common.

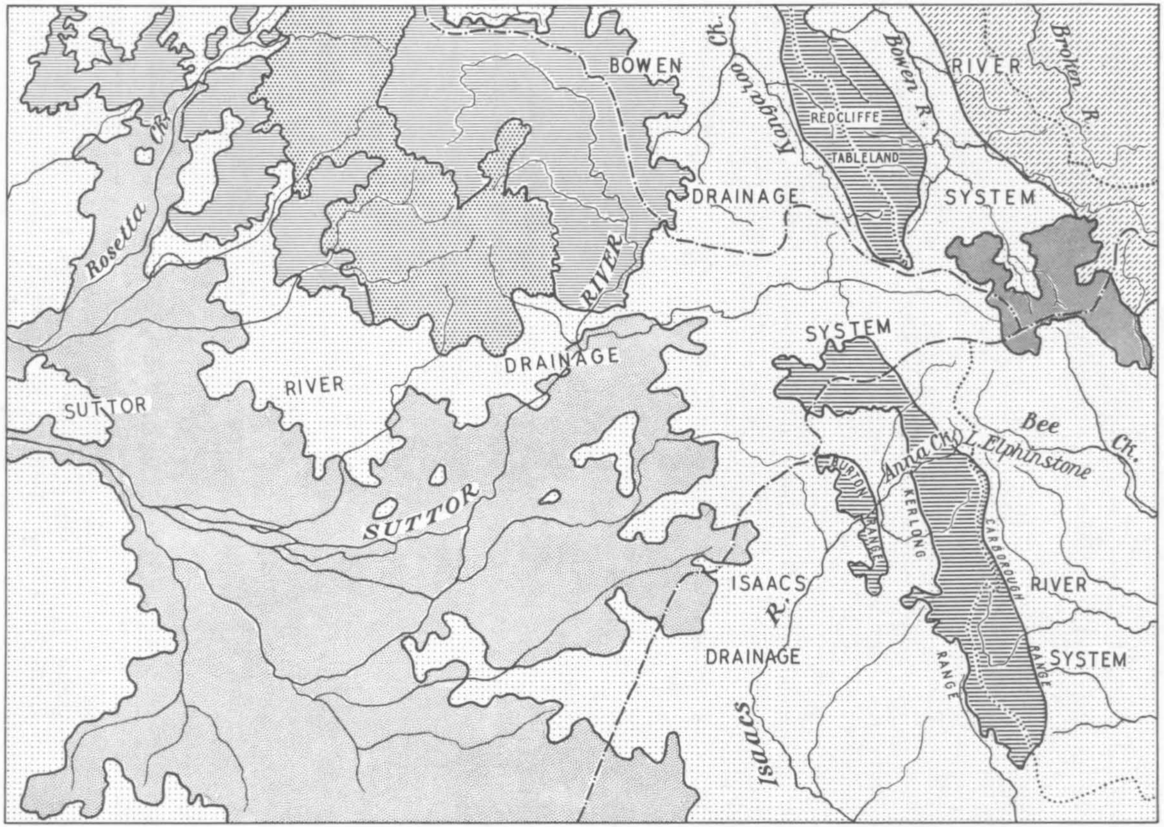
This very youthful topography reflects moderately rapid erosion of a recently uplifted terrain composed mainly of resistant igneous and volcanic rocks. The rapid rate of erosion is due to the high rainfall on these ranges, which separate the high-rainfall coastal strip from the 20 to 30-inch rainfall area farther west.

Highlands

The highlands are an area of moderately rugged topography, north of the Suttor River. The elevation of the area is probably nowhere greater than 2000 feet above sea level; local relief is about 500 feet to 800 feet. The topography is not as youthful as that found in the Eungella and Broken River Ranges; it consists mainly of small, undulating plateaux, with rounded or hummocky surfaces, bounded by steep slopes, and separated by deeply incised

Figure 1.

PHYSIOGRAPHIC SKETCH MAP
OF MT COOLON 1:250 000 SHEET AREA



Reference

- Eungella and Broken River Ranges.
- Highlands.
- Lowlands.
- Plains.
- Inclined plateau.
- Tableland and mesas.
- Carborough, Kerlong and Burton Ranges and Redcliffe Tableland.
- *Boundaries between physio-graphic units.*
- *Major divides between drainage systems.*
- *Minor divides within drainage systems.*

Scale

8 4 0 8 16

MILES

Bureau of Mineral Resources, Geology & Geophysics. May 1961.

F55/7/1 G.M

streams. Some isolated hills rise above the general level. The topography is the result of a long period of erosion of an extremely resistant acid-volcanic terrain and shows a mixture of mature and youthful features. Many of the larger streams have ceased deepening their courses and, in that respect, are mature; few of them have widened their valleys to any extent. All the minor tributaries are quite youthful and many of them are obviously controlled by joints and structures within the volcanics.

Plains

The plains are widespread in the western half of the Mount Coolon area. They are extremely mature and are drained and, at times, flooded by a braided drainage system, incised to a depth of 10 to 30 feet. The plains are quite level; a few mounds of laterite or gravel-covered rises are the only features possessing noticeable relief. The drainage indicates that the plains, as a whole, slope gently from east to west.

Lowlands

The lowlands cover most of the area and include topographic forms transitional between the highlands and the plains. Inplaces, there is considerable local relief, particularly in the metamorphosed rocks about igneous intrusions. The topography is also fairly youthful in the north-west of the area, where the rocks have only recently been exposed to erosion by reason of the shrinking of the mesas which protected them.

Generally, however, the topography of the lowlands is mature. It consists of rounded, separate hills and ridges rising above soil-covered plains. Local relief is about 200 feet. The streams draining the lowlands are not braided; most have cut through the soil cover to the underlying rocks, at least for some of their length. Some small areas of alluvium are included in the lowlands, particularly in the eastern part of the Sheet around Bee Creek.

Inclined Plateau

An inclined plateau occurs near the eastern edge of the sheet. Its northern margin is a steep, very dissected face up to 400 feet high. Southwards, and westwards, it slopes down to the level of the lowlands. The surface of the plateau is mainly flat with some conical hills.

Tableland and Mesas

A tableland and several mesas in the north-west of the area were probably connected at one time, though it is doubtful if they ever completely covered the highlands which separate them. The mesas are fairly flat on top, although some are bevelled near the edges. They are being eroded mainly by scarp retreat. The mesas rise 200 feet to 300 feet above the adjacent lowlands.

The tableland is much more dissected. It is being cut up into a number of mesas by the headwaters of the Suttor River. The Suttor River has cut down to the level of the lowlands where it drains off the tableland at its southern margin. Elsewhere, the rivers are not as deeply incised; the tableland surface consists of flat-topped to rounded hills and rises, separated by shallow, broad, sandy stream beds. The eastern margin of the tableland is marked by a series of scarps rising to about 200 feet above the lowlands. The southern and western margins are lower, and in places are indefinite.

Carborough, Kerlong, and Burton Ranges and Redcliffe Tableland

The Carborough and Kerlong Ranges are essentially complementary cuestas. They are the topographic expression of an elongate syncline composed of resistant sandstone. The ranges slope towards each other at low angles and are bounded on their outer margins by steep, rugged slopes rising, in places, to more than 600 feet above the lowlands. The names Carborough and Kerlong Ranges are applied to the steep outer margins, on the eastern and western sides respectively. The ranges are continuous around the southern and northern ends of the structure. The space between them is occupied by low rolling hills and sandy plains at the same elevation as the adjacent lowlands. Where the ranges join, and especially at their northern end, they form a concave or sloping tableland.

The Burton Range is a very dissected, rugged fault block, rising about 400 feet above the lowlands. Its topography is similar to that of the tableland at the northern end of the Carborough and Kerlong Ranges.

The Redcliffe Tableland is somewhat dissected. It is similar to the Carborough and Kerlong Ranges but lacks a central depression. It is bounded by steep, rugged slopes rising to about 600 feet above the lowlands.

The Carborough, Kerlong, and Burton Ranges and the Redcliffe Tableland are all composed of resistant sandstone and are similar in topography. Their outer margins consist of very steep, almost sheer cliffs rising above gentler scree slopes. Joints and faults control much of the drainage, and erosion proceeds by the undermining and collapse of blocks bounded by joint surfaces. Valleys of the smaller streams are very steep-sided and are choked with very large blocks of sandstone. Larger streams, such as the Isaacs River and Anna Creek, have cut somewhat wider, sandy beds through the Carborough and Burton Ranges, but are in places dammed by them. The headwaters of Anna Creek, in particular, are dammed by the Carborough Range, forming the almost permanent Lake Elphinstone.

Drainage

The Suttor River drainage system is the most important of the three in the area. It drains more than half the area, but commonly flows for only about 8 months of the year. Rivers, such as the Suttor River and Rosetta Creek, have clearly defined courses in the lowlands but become braided and indefinite in the plains.

The Isaacs River system drains the south-east corner of the Mount Coolon area. A minor divide separating the two parts of this system is shown on Figure 1: the two parts are the Isaacs River and tributaries, which drain first south and then south-east, and Cooper, Bee, Walker, and Carborough Creeks, which flow east to south-east, and drain the area east of the Kerlong Range. These streams flow into the Connors River, which later joins the Isaacs River. The divide between the two parts of the system is rather vague in the headwaters region. It is located in gently rolling, mainly soil-covered lowlands and is not a feature of any great relief.

None of the streams in this drainage system is permanent. Cooper Creek flows longer than the others. It rises in the southern end of the Eungella Ranges, an area of higher rainfall and greater run-off than most parts of the Sheet area.

The Bowen River system drains the north-east corner of the Sheet area. Two minor divides are shown on the sketch-map. These separate the Kangaroo Creek drainage, west of the Redcliffe Tableland, the Bowen River drainage, east of the Redcliffe Tableland, and the Broken River drainage, in the Broken River/Eungella Ranges.

The Broken and Bowen Rivers flow for most of the year: they drain the area of highest rainfall in the Mount Coolon area. Kangaroo Creek, on the other hand, is non-permanent and is typical of most of the drainage in the area.

STRATIGRAPHY

The Mount Coolon area includes parts of the Anakie Metamorphics, the Drummond Group, the Mount Wyatt Beds, Undifferentiated Volcanics, the Bulgonunna Volcanics, and the Permian—Triassic succession of the Bowen Basin. A complex of igneous rocks crops out in the rugged north-east of the Sheet-area but the age and relationships of these rocks are not known. Tertiary sediments and basalt flows cover much of the area and Cainozoic alluvial deposits are widespread. The rock units present in the Mount Coolon area are listed and briefly described in Table 1.

ANAKIE METAMORPHICS

The Anakie Metamorphics crop out in the long, narrow Anakie High, which extends across the western edge of the Mount Coolon area. The rock types represented are siltstone, quartz greywacke, quartz sandstone, and quartz pebble conglomerate. They probably belong to more than one rock unit. These rocks have been metamorphosed to a low grade, but many show obvious schistosity, lineation, close jointing, and other results of dynamic metamorphism. The age of the Anakie Metamorphics is not known. They are here referred to as Lower Palaeozoic.

Nomenclature

The name Anakie was first applied to these rocks by Jensen (1921), who called them the Anakie Series. In the type area near Anakie, the rocks were described as granite, porphyry, schist, and slate. Subsequently, the name Anakie High was applied to the 200-mile-long narrow structure, extending from Anakie to north-west of Mount Coolon, in which the rocks are found. They were referred to as the Anakie Metamorphics in the Geological Map of Queensland (Geological Survey of Queensland, 1953) and as the Anakie Complex in the Geology of Queensland (Hill & Denmead, 1960). The name Anakie Metamorphics is preferred because the rocks are low-grade metamorphics, readily distinguished from the igneous intrusives. They probably include several units.

Distribution

The Anakie Metamorphics crop out in the western part of the area. Here, the Anakie High is fairly narrow, 20 miles wide near the southern boundary and about 30 miles wide near the north-west corner. South of the Mount Coolon/Yacamunda Road, the topography is fairly mature. The metamorphics generally form low hills with little relief above the surrounding plains. In places, they crop out in gullies and re-entrants around the margins of low tablelands formed by a dissected laterite profile developed on the metamorphics. Elsewhere, they may be covered by ferruginous gravel and quartz rubble. In general, outcrop of the metamorphics in this south-west area is poor. Outcrop limits were determined mainly by photo-interpretation.

In the north-west, where the topography is less mature, the Anakie Metamorphics crop out in hilly country. Resistant, lateritized, flat-lying Tertiary sediments unconformably overlying the metamorphics form mesas with a relief of 200 to 300 feet. The metamorphics commonly crop out in the lower flanks of the mesas, though a few are composed entirely of Tertiary sediments. In this area, the Anakie Metamorphics are well exposed. The Ukalunda/ Scartwater Road runs across the north-west corner of the Sheet, through an area of good outcrop. Elsewhere access is very poor and a youthful drainage system makes cross-country travel difficult and slow.

Lithology

There appear to be two rock units in the Anakie Metamorphics in the Mount Coolon area. These are a siltstone/quartz greywacke assemblage, and a quartz sandstone/ conglomerate assemblage. The first is more widespread. The coarser sediments were seen only near Rosetta Creek between Yacamunda and Bungobine Homesteads, and outside the area, west of Yacamunda Homestead.

Siltstone/quartz greywacke assemblage: The rock types within this unit include lineated siltstone, somewhat spotted in places; closely jointed, fine greywacke; schistose siltstone, laminated in places; phyllite; sheared feldspathic sandstone; and rare mica schist. In some places, the cleavage was seen to parallel the bedding. The siltstone shows weak lineation or weakly to strongly developed schistosity; close jointing is most commonly developed in the coarser sediments.

The sediments have been weakly metamorphosed. Strongly schistose laminated siltstone appears in hand specimen to be highly metamorphosed; however, thin-section examination reveals the rock to consist of laminae composed almost entirely of quartz grains, separated by micaceous laminae. The mica is mainly flaky sericite, replacing the original argillaceous material. In places, the sericite flakes are draped around quartz grains or blebs of iron oxide to form small augen structures. The sericite flakes are oriented parallel to the laminations, giving the rock its schistose appearance. The quartz grains show strain extinction, and some signs of re-orientation and solution. A small amount of possibly authigenic feldspar is present in the matrix; small blebs of iron oxide are numerous throughout the rock. This rock was subjected to mild deformation after the development of the schistosity, during which the schistose laminae were folded into small folds whose axes strike at about 100^{o}, nearly at right angles to the north-south strike of the schistosity. Some other siltstone specimens, examined in thin section, consist mainly of quartz grains in an argillaceous matrix, with some sericite flakes. The rocks are deeply weathered and iron-stained. Iron-staining is very noticeable in the Anakie Metamorphics in outcrop.

A specimen of fine quartz greywacke examined consists of sub-angular quartz grains in a calcitic and chloritic matrix with small amounts of plagioclase. The rock contains some bands rich in sericite. Opaque iron oxide is common, particularly in the sericite-rich bands.

Quartz sandstone/conglomerate assemblage: This unit consists of quartz sandstone grading in places into fine quartz conglomerate. Close jointing is common and the rocks are silicified in places. In thin section, they contain rounded to sub-angular quartz grains, which may be cracked and broken and commonly show strain extinction and solution effects. The matrix usually consists of finer quartz grains, feldspar, sericite, and iron oxide. The sericite may be aligned to produce a faint lineation. In one specimen the quartz grains are flattened and aligned, giving the rock a distinctly lineated appearance.

A specimen of partly silicified quartz sandstone grading into fine conglomerate was found to contain large patches of quartz with a mosaic texture, indicating that parts of the rock had been converted to quartzite. This rock contains a very small amount of chlorite and sericite in the matrix. A specimen of Anakie Metamorphics collected near Mount Coolon was found to be a crushed, sericitized quartzite, containing quartz-goethite-sericite veinlets. This rock was collected near the contact between the Anakie Metamorphics and the overlying undifferentiated Devonian/Carboniferous Volcanics, in an area of igneous intrusion and mineralization. The quartz-goethite-sericite veinlets apparently produced the sericitization, and are most probably related to the intrusion. The quartz sandstone and conglomerate are more widespread west of the Mount Coolon area, where they are abundantly veined, by quartz, and silicified. The quartz veining and silicification may be due to reorganisation of quartz present in the sediments. In some places the quartz veins have been brecciated and resilicified.

The effects of metamorphism on these rocks are revealed mainly by the nature of the quartz grains, which are cracked, broken, and strained, and in places re-oriented. In general, the grade of metamorphism of the Anakie Metamorphics in the Mount Coolon area is low. The rocks are best described by their sedimentary names, modified to indicate the effects of moderate, mainly dynamic, metamorphism. Some higher-grade metamorphism is shown by the rocks adjacent to igneous intrusions.

Scattered outcrops and boulders of algal limestone protrude from soil cover within the area of outcrop of the Anakie Metamorphics, a few miles west of the Mount Coolon area. The soil cover obscures the relationships of the limestone to the metamorphics. The limestone is unmetamorphosed; it may be unconformably younger than the metamorphics. The age of the algae cannot be determined. No other fossils were found within the area of outcrop of the Anakie Metamorphics.

Structure

The Anakie Metamorphics constitute the Anakie High, a long, narrow inlier overlain unconformably by Upper Devonian and younger rocks. Within the Mount Coolon area, the High is overlain by the Devonian-Carboniferous Drummond Beds dipping off it to the south-west, and by the Mount Wyatt Beds and the undifferentiated Devonian-Carboniferous Volcanics, dipping off it to the east. The actual unconformities between the Anakie Metamorphics and the overlying Drummond Beds, Mount Wyatt Beds, and Devonian-Carboniferous Volcanics were not seen. However, there is sufficient evidence to confirm their existence: the regional structure of the units, and the presence of schistosity, phyllitic cleavage, lineation, and secondary crenulation in the Anakie Metamorphics, and their absence from the younger units. Not much is known of the structure within the Anakie High. Schistosity and bedding were generally found to be parallel where both were visible. Strike of schistosity and bedding were generally north, ranging to 30^{o} east of north, and dips ranged from 50^{o} to vertical.

Age

The age of the Anakie Metamorphics is not known. Farther south, rocks of the Anakie High are unconformably overlain by lower Middle Devonian rocks. During 1961, the

TABLE 1. - ROCK UNITS OF THE MT. COOLON 1:250,000 SHEET AREA.

AGE	ROCK UNIT AND LETTER SYMBOL	THICK-NESS (feet)	LITHOLOGY	DISTRIBUTION	TOPOGRAPHY	PALAEONTOLOGY AND AGE	STRATIGRAPHIC RELATIONSHIP	DEPOSITIONAL ENVIRONMENT
	Czs	up to 200	Soil, sand, alluvium, laterite, lateritic soils and gravels.	Widespread particularly in mature western part.	Plains, low gravel and sand-covered rises	Deposition of these units commenced in the Tertiary and still continues.		
	Czr	up to 100	River channel and flood plain deposits	Long plain extending south-east from Blenheim H.S.	Now being eroded into rounded hills and deep narrow gullies, hilltops are at a uniform elevation			
	Suttor Formation (Ts)	Variable, about 200 200 locally up to 400	Medium to coarse grained cross-bedded quartz sandstone, lenses of fine and pebble conglomerate, and pebble conglomerate, sandy claystone, silicified claystone, river channel conglomerate.	Widespread in north-western, central and southern parts of sheet but more deeply eroded in south.	Forms tablelands commonly with steep scarp edges, or low sandy and rubble-covered rises.	Contains rare dicotyledonous leaves.	Appears to overlie main mass of basalt but in part may be interbedded with basalt flows	Deposited in extensive shallow lakes. Unconformably overlies Mesozoic and older rocks.
	(Tb)	up to 600	Basalt flows and plugs, rare trachyte flows, plugs and dykes	Remnants throughout eastern part of area.	Caps mesas and tablelands in places; elsewhere, forms black-soil plains.			
	Exevale Formation (Te)	abt 400	Medium to very fine grained friable quartz sandstone with scattered pebbles and some thin conglomerate bands; silicified quartz sandstone; white friable siltstone, clayey in part.	Around Exevale Homestead, and on Redcliffe Tableland	Forms rolling country, or flanks of basalt-capped mesas.		Overlain by basalt, unconformably overlies Permian	Deposited in lakes formed in depressions in Permian rocks
TRIASSIC	Teviot Formation (Rt)	abt 500	Micaceous lithic sandstone, calcareous in places, micaceous siltstone.	On the Redcliffe Tableland and between the Carborough and Kerlong Ranges	Erodes fairly readily into rounded hills with scattered boulders	Contains Triassic plants: Dicroidium feistmanteli (Johns) Gothan, Dicroidium odontopteroides (Morr.) Gothan	Conformably overlies the Carborough Sandstone. At the base of the Teviot Fm. there is a narrow transition zone.	Possibly last stage of deposition in the Bowen Basin. Shallow water environment.
	Carborough Sandstone (Rc)	up to 1500	Cross-bedded, medium to coarse quartz sandstone, feldspathic in places, some fine and pebble quartz conglomerate	Redcliffe Tableland, Carborough, Kerlong, and Burton Ranges	Rugged topography. Forms steep sided tablelands or cuestas with gentle dip slopes and steep scarps.		Appears to be conformable on the Upper Bowen Coal Measures	Shallow water possibly deltaic.
PERMIAN	Upper Bowen Coal Measures (Pbu)	10,500	Cross and festoon bedded, well sorted and bedded lithic sandstone, calcareous in places, siltstone, carbonaceous shale, some coal seams, abundant conglomerate in places.	Throughout eastern half of Sheet except north-east corner.	Generally forms rolling plains and low hills, with some higher hills and strike ridges, which are not very steep.	Abundant fossil plants including:- Glossopteris indica Sch. G. browniana Brong. G. angustifolia Brong G. conspicua Fm. Phyllotheca australis Brong. Nummulospermum bowenense Walk. Sphenopteris lobifolia Morr. Cladophlebis roylei Arker. Samaropsis sp.	Conformably overlies the Middle Bowen beds.	Shallow water, probably freshwater at times.
	Middle Bowen Beds. (Pbm)	Variable 4500 to 8000 at least	STOCKTON-HILLALONG AREA Quartz greywacke, grey-blue greywacke, grading into micaceous siltstone, siltstone, quartz sandstone, calcareous quartz greywacke and siltstone lenses, richly fossiliferous in places, minor limestone.	Long narrow zone trending north-west across the north-east corner of the Sheet.	Mainly rounded to moderately steep hills, very rugged in places.	Abundant marine fossils belonging to three distinct faunas:- martiniopsids Strophalosia Glyptoleda Anidanthus Eurydesma pectenids	Overlies Lower Bowen Volcanics with a disconformity, probably representing only a short time break, and in places some evidence of angular unconformity.	Marine; no shallow-water structures. Eastern limit of Bowen Basin was much further east.
		Probably 8000	ANNANDALE AREA Metasediments include knotted schist, slate, graphitic schist, hornfels. Sediments as above.	South-east corner of Sheet.	Rugged near the intrusion, rounded hills grading into plains elsewhere.		Intruded and domed by Bundarra Intrusion.	Marine; no shallow water structures.
		abt. 2000	WESTERN EDGE OF BOWEN BASIN Current-bedded, quartz sandstone, fine and pebble quartz conglomerate.	Discontinuous outcrops extending south across middle of Sheet including Collinsville Coal Measures (Pc) in Parrot Creek area.	Mature topography, most outcrop in gullies, low sandy rises.		Overlies the Bulgonunna Volcanics with a marked angular unconformity.	Deposited on shallow shelf near western margin of Bowen Basin.
	Lower Bowen Volcanics (Pbl)	At least 10,000 may be 20,000	Andesite flows, sills, crystal and lithic tuffs, beds and slump masses of agglomerate, black siltstone, thinly interbedded black siltstone and tuff showing graded bedding from coarse tuff to volcanic ash. Medium to coarse grained intermediate intrusives, probably intrusive equivalents of the andesite flows.	North-east corner of Sheet.	Very rugged topography, steep hills, short ridges and narrow valleys.	Rare plant remains including Glossopteris. Marine fossils in tuff near top of the unit include Eurydesma, Deltopecten, martiniopsids. Unit may extend down into the Carboniferous.	The volcanics plunge west from Urannah Complex. Relationship with igneous rocks not known, possibly intrusive.	Definitely marine in part. Some sedimentary structures suggest deep water and moderate distance from source.
CARBONIFEROUS	Bulgonunna Volcanics (Cbv)	Not known possibly 15,000	Flow banded rhyolite, porphyritic rhyolite, quartz-feldspar porphyry, acid tuff and agglomerate. Intrusive acid to intermediate stocks and bosses, and other intrusive rocks, probably equivalents of the extrusives.	Extends from north to south across Sheet between Bowen Basin sediments and Anakie Metamorphics.	Rugged topography in north of area. Farther south, forms isolated hills and ridges of moderate relief.		Unconformably overlie Anakie Metamorphics. Relationship to Lower Bowen Volcanics not known. Overlain with marked unconformity by Middle Bowen Beds.	Very thick pile of volcanics with minor sediments.
DEVONIAN - CARBONIFEROUS	Drummond Group (D/Cd)	Not well developed in area; about 20,000 farther west	Feldspathic quartz sandstone, buff siltstone and claystone, rhyolite flows, rhyolitic agglomerate, quartz greywacke, siltstone.	South-west corner of Sheet	Produces hills and ridges of moderate relief in an area of generally very mature topography.	Fish remains. Plants including Protolepidodendron lineare Walk., found at base of unit west of Sheet, suggest unit commenced in Upper Devonian.	Unconformably overlies Anakie Metamorphics. Not seen in contact with Mount Wyatt Beds but the two units are probably time equivalents in part at least.	Basin bounded to east by the Anakie High. Freshwater or marine or an alternation of both.
	Undifferentiated Volcanics (D/Cv)	Not known	Siliceous tuff and ash, tuffaceous conglomerate and sandstone, porphyritic rhyolitic lavas, andesitic lavas.	Extends north from Mt Coolon township in thin strip between Anakie Metamorphics and Bulgonunna Volcanics.	Generally subdued topography with some steep hills.		Appears to be conformable on Mount Wyatt Beds.	Possibly terrestrial vulcanism.
UPPER DEVONIAN	Mount Wyatt Beds (Dus)	Not known	Tuffaceous lithic sandstone, siltstone, and conglomerate; some tuffs and flows or sills.	Two outcrops in area: at Rosetta Creek crossing; and at northern edge of Sheet, beside Mt Coolon /Ukalunda Rd.	Subdued topography	Contains Upper Devonian Cyrtospirifer cf. reidi farther north. Also plants including Protolepidodendron yalwalense Walk., Psilophytites sp., Stigmaria ficoides Brong.	Possibly unconformable on Anakie Metamorphics.	Shallow to moderately deep, at least partly marine deposition.
	Anakie Metamorphics (Pzla)		Mica schist, phyllite, schistose siltstone, lineated siltstone, lineated and closely jointed sandstone, quartz greywacke; quartz sandstone and quartz pebble conglomerate, in places silicified and quartz veined.	Crops out in the Anakie High, which trends north from the southern boundary to beyond the north-west corner of the Sheet area.	Fairly youthful topography in north-west, becoming mature further south. Anakie High acts as a watershed throughout most of its length.	Algae present, but not determinable.	Oldest rocks in the area.	Several rock units involved. Environment of deposition not known.

Anakie Metamorphics were traced north from the north-west of the Sheet area, with no apparent break, into rocks containing Middle Devonian fossils.

The Metamorphics are referred to as 'Lower Palaeozoic' in this Report.

MOUNT WYATT BEDS

This unit is not named in the map reference (Plate 1). It is the tuffaceous lithic sandstone, sandstone, conglomerate, and siltstone dated as Devonian with the symbol Dus in the reference.

The unit named Mount Wyatt Beds was recognised in the Bowen Sheet area during the 1961 field season. It crops out in the Mount Coolon area at two localities: beside the Mount Coolon/Ukalunda road at the northern margin of the Sheet, and at the Rosetta Creek crossing on the same road.

In the Sheet area, the unit includes fine-grained to coarse-grained, thin to medium-bedded, khaki-brown, poorly sorted, hard tuffaceous lithic sandstone, containing fragments of devitrified volcanic glass. This rock is interbedded with sandstone, siltstone, thin conglomerate lenses, acid tuffs and thin flows, and a dark basic tuff containing inclusions of secondary minerals.

In the Bowen Sheet area the unit contains abundant marine fossils, mainly of one species very closely allied to _Cyrtospirifer_ cf. _reidi_, Maxwell. This form indicates a high Upper Devonian (Famennian) horizon. Plant-bearing sediments are associated with the marine fossiliferous sediments in the type area. Only plant fossils have been found in the unit in the Mount Coolon area. A large collection (MC81F) was obtained at the Rosetta Creek locality and is described in Appendix 2. It includes _Protolepidodendron yalwalense_ Walk, _Psilophytites_ sp., and _Stigmaria ficoides_ Brong.

The formation in the Rosetta Creek area is gently folded. Dips range from 5^{o} to 15^{o}. At the northern margin of the Sheet, the unit dips at about 40^{o} to 50^{o} away from the Anakie Metamorphics, and at one point, is faulted against them. The beds are dragged up against the fault and dip at about 80^{o}.

The unfaulted contact between the Mount Wyatt Beds and the Anakie Metamorphics was not seen in outcrop but is considered to be unconformable.

The thickness of the formation is not known but is probably not very great. At least part of the unit was deposited in marine conditions, and possibly marine conditions prevailed throughout.

The age of the unit is Upper Devonian.

UNDIFFERENTIATED VOLCANICS

Volcanics previously included in the Bulgonunna Volcanics were separated from that unit during the 1961 field season because their structures seem to be related to the orogeny which folded the Mount Wyatt Beds. The Bulgonunna Volcanics are younger than that orogeny. The Undifferentiated Volcanics crop out from the vicinity of Mount Coolon to the northern margin of the Sheet area and as isolated masses near the southern margin of the Sheet area. They occupy a belt of fairly low country, partly overlain by Tertiary sediments, to the west of the high, rugged country occupied by the Bulgonunna Volcanics.

Lithology

The unit consists of porphyritic lavas, acid tuffs, volcanic conglomerate, and tuffaceous sandstone. The conglomerate consists of cobbles and boulders up to 4 feet long of flow-banded rhyolite, fine tuff, and other volcanic rocks, in a white tuffaceous sandstone matrix. Other sediments include well bedded, white, medium-grained feldspathic tuffaceous sandstone overlying interbedded coarse crystal tuff and porphyritic rhyolite flows.

Porphyritic lavas crop out over large areas. They contain a very high proportion of phenocrysts to the fine-grained matrix. One specimen is described as a porphyritic glassy lava with embayed, corroded phenocrysts of quartz and feldspar, in the albite-oligoclase range, set in a flow-banded groundmass of partly devitrified glass. The rock is a porphyritic sodic pitchstone. Another specimen was described as a hybrid andesite lava, containing fragmental, corroded, and altered xenocrysts of quartz and plagioclase. Porphyritic rhyolite crops out in a number of places either in very large outcrops showing contorted flow banding or in thin regularly banded flows interbedded with tuffs.

Very fine-grained, dense, to very coarse-grained siliceous tuffs are common in the unit. They consist of shards, splinters, and angular fragments of partly devitrified glass, quartz grains, oligoclase and other feldspars as grains and aggregates, biotite flakes, and fragments of felsitic lavas set in a very fine-grained matrix of siliceous ash and cryptocrystalline silica. Despite the fragmental nature of most of these, many show some signs of flow banding in the matrix. Some also show vague bedding.

Lapilli tuff occurs in a few places. It consists of lapilli, up to 4 cm. long by 1 cm. across, of very fine devitrified siliceous lava, set in a siliceous tuff matrix. Some of the lapilli partly merge into the siliceous matrix of the tuff. These rocks show some evidence of flowing prior to final consolidation.

Andesite lavas are found in the unit in the vicinity of Mount Coolon. They are typically fine-grained and contain scattered plagioclase laths.

Structures and relationship

Strikes and dips were measured in the unit in several places and many strike ridges and bedding trends are visible on the air photos. These indicate that the unit is moderately folded with fold axes trending north-east. This is compatible with the folding of the underlying Mount Wyatt Beds and the two units may be conformable.

Farther north, the Bulgonunna Volcanics are unconformable on plant-bearing Lower Carboniferous sediments of the Drummond Group. They are probably unconformable on the Undifferentiated Volcanics also. Certainly, they do not possess the north-east structural trend shown by the Undifferentiated Volcanics.

In the Mount Coolon area, this unit is intruded by quartz diorite stocks and bosses, with some silicification and mineralization along shears. In this area, there is some evidence that it is faulted against the Anakie Metamorphics.

Age

It is not certain that all the rocks included in this unit are of the same age. In the north of the area, the volcanics appear to be conformable on the Upper Devonian Mount Wyatt Beds. They may range from the Devonian to Lower Carboniferous in age.

The Undifferentiated Volcanics represent possibly terrestrial vulcanism and minor sedimentation; they are of unknown thickness.

DRUMMOND GROUP

Nomenclature

The Drummond Beds were named by Jack in 1892. Since then, Jensen, Reid, Hill, and others have worked on them, mostly west and south of the Mount Coolon area. The name Drummond Group was introduced in the Geological Map of Queensland (Geological Survey of Queensland, 1953).

Distribution

The Drummond Group crops out only in the south-west of the Mount Coolon area, and is not well exposed. For the most part, outcrops form scattered hills and strike ridges. In places they are covered by parts of a laterite profile or by ferruginous soil and gravel. Some rhyolite flows, interbedded with the sediments, crop out as strike ridges and form the most prominent topographic features in the area.

Lithology

The rock types include feldspathic quartz sandstone grading into quartz sandstone. This is a well sorted, rarely well bedded, fine-grained rock, silicified in places. In places, it contains lenses of fine conglomerate. The conglomerate contains mainly quartz pebbles and some fragments of a green, volcanic rock. Siltstone and claystone are present but are poorly exposed. Buff to brown siltstone crops out in one place, overlying rhyolitic agglomerate. The siltstone is a tough, fine-grained, moderately indurated, closely jointed rock containing fossil fish scales and teeth. The fish remains are not determinable. Rhyolite flows crop out as strike ridges near the southern edge of the area. They are surrounded by lateritic rubble but are apparently interbedded with the sediments. Similar volcanics overlie the Anakie Metamorphics, south of the Mount Coolon area. These volcanics appear to lens out northwards. The Drummond Group in the Mount Coolon area appears to consist of a mixture of quartz sandstone and siltstone and acid volcanic detritus and flows.

Structure

The Drummond Group unconformably overlies the Anakie Metamorphics; its structure is fairly simple in this area. The strike of the beds and of the unconformity is parallel to the Anakie High and trends about north-north-west. Dips are generally about 45° to the south-west, though there is some minor folding of the beds. The structure of the unit is much more complex in the Drummond Basin proper, west of the Mount Coolon area.

Environment

Fossil fish and plant remains are found at a number of places within the unit. Apparently, the Drummond Group was deposited in a paralic environment which was possibly estuarine at times.

Thickness

It was not possible to measure the thickness of the Drummond Group in the Mount Coolon area. The unit was estimated to be up to 20,000 feet thick (Veevers et al., 1964) on the basis of sections measured in the Clermont Sheet area.

Age

Deposition of the Drummond Group may have begun in the Devonian; most of the unit is Carboniferous. Plant fossils were collected near the base of the unit, 10 miles west of the Mount Coolon area, near the St Ann's crossing of the Suttor River. These plants (see specimen MC886F, Appendix 2) were identified as Protolepidodendron lineare Walk. and are probably Upper Devonian. Abundant lepidodendroid material has been collected in the Drummond Group, indicating that deposition continued into the Carboniferous.

BULGONUNNA VOLCANICS

Bulgonunna Volcanics is a new name proposed for the dominantly acid volcanic complex lying to the east of the Anakie High. The unit is well exposed north of the Mount Coolon/Eaglefield Homestead road and forms scattered outcrops south of Eaglefield Homestead.

The unit consists of rhyolite flows, porphyritic rhyolite, rhyolitic tuffs and agglomerates, andesite, and minor acid intrusions.

The Bulgonunna Volcanics unconformably overlie the Anakie Metamorphics. The Volcanics form the basement to the western side of the Bowen Basin, and are unconformably overlain by the Middle Bowen Beds.

The unit comprises a very great thickness of volcanics deposited under terrestrial conditions. Their age is Carboniferous, probably Upper Carboniferous.

Nomenclature and distribution

Bulgonunna Volcanics is a new name proposed in this report. The type area is along Bulgonunna Creek, from the Mount Coolon/Collinsville road crossing, at Lat. 21°19'S, Long. 147°27'E, to the vicinity of Bulgonunna Peak. The unit extends north into the Bowen

Sheet; to the north-east its area of outcrop is limited by the Tertiary Suttor Formation which unconformably overlies it.

In the northern area, the Bulgonunna Volanics produce high, undulating plateaux with steep slopes. Valleys are deeply incised, and are generally youthful. Bulgonunna Peak and other isolated hills rise above the general level of the volcanics. The unit is well exposed; the soil developed on the volcanics is generally thin and supports only light vegetation.

Lithology

The Bulgonunna Volcanics are mainly an acid volcanic sequence. The most common rock type is a porphyritic rhyolite containing quartz and feldspar phenocrysts in a dark, flow-banded, fine-grained, glassy or felsitic groundmass. The quartz phenocrysts are corroded, embayed and cracked, and are commonly highly altered. The feldspar phenocrysts are plagioclase, usually in the albite-oligoclase range. Anorthoclase occurs in some rocks. Aggregates of chlorite, zoisite-epidote, sphene, leucoxene, and opaque minerals and some interstitial calcite are found in the groundmass of many specimens. Mixing of lavas is evident in one specimen examined.

The porphyritic rhyolites fall into two groups: some have a scattering of phenocrysts in a dark, fine, weakly flow-banded groundmass; others have a very high proportion of phenocrysts to matrix and are of doubtful origin. They form massive, structureless blocks and are possibly ignimbrites.

Rhyolite lavas constitute a large proportion of the unit. They possess well developed, generally contorted flow banding, obvious in the hand specimen. Phenocrysts are common and are usually wrapped around by the flow banding. These rocks differ from the phenocryst-poor porphyritic rhyolites in possessing very obvious flow banding.

The Bulgonunna Volcanics are intruded by small acid intrusions, similar in composition to some of the volcanics and in places grading into them. Their limits are difficult to map and they are included in the Bulgonunna Volcanics. They may be intrusive equivalents of the extrusives.

Structure

The Bulgonunna Volcanics are essentially a massive, structureless block. The most common rock type, rhyolite, is completely massive. The rhyolite lavas are flow-banded, but the banding is generally contorted and the lavas are effectively massive. Some folding was seen in interbedded rhyolite flows, tuffs, and agglomerates cropping out in the headwaters of Parrot Creek. One flank of a small fold dips at 80^{o}, the other at 25^{o}; these dips indicate moderately tight, possibly asymmetrical, folding. The folding is quite local and is unimportant when compared to the structureless nature of the bulk of the unit.

In places, the Bulgonunna Volcanics are cut by close-spaced groups of joints. The joints form no recognizable pattern but are characteristic of the unit; some of them are isolated, others cut one another. Separate groups of joints bear no relation to one another. A relatively unjointed central boss or plug was seen in some groups. These joints may be due to cauldron subsidence or may be connected with intrusion into the volcanic pile. This jointing was visible on the aerial photographs and was useful in identifying the Bulgonunna Volcanics.

The Bulgonunna Volcanics were not seen in contact with the Anakie Metamorphics in this area. Farthur north, they unconformably overlie the Anakie Metamorphics and the Drummond Group.

The Collinsville Coal Measures, a unit in the Middle Bowen Beds, unconformably overlie the Bulgonunna Volcanics. The contact is well exposed in the headwaters of Parrot Creek and dips east at about 5^{o}. The volcanics form the basement to the western side of the Bowen basin. They were transgressively overlain by the upper part of the Middle Bowen Beds.

Environment

No evidence of the environment of deposition of the Bulgonunna Volcanics was seen; they may be terrestrial.

Thickness

The thickness of the Bulgonunna Volcanics is not known.

Age

The Bulgonnuna Volcanics are unconformably overlain by Lower Permian sediments of the Bowen Basin sequence; farther north they unconformably overlie plant-bearing Lower Carboniferous sediments of the Drummond Group. They are therefore Carboniferous, possibly Upper Carboniferous.

PERMIAN

Summary of stratigraphic nomenclature of the Bowen Basin succession

Etheridge, in 1872, applied the name Bowen Group to the entire Bowen Basin succession in the Collinsville area. Jack (1879) introduced the subdivisions Lower Bowen, Middle Bowen, and Upper Bowen, but placed a sequence of andesitic lavas and tuffs between the Middle Bowen and the Lower Bowen divisions. Subsequently, a number of authors sub-divided, modified, and altered Jack's classification.

In 1929, however, Reid reverted to Jack's system, though placing the andesitic lavas and tuffs in the Lower Bowen and sub-dividing some of the units. Reid's classification was as follows:

Upper Bowen Series.
Middle Bowen Marine Series
Collinsville Coal Measures

	(Devlin Volcanic Series
Lower Bowen Series	(Devlin Coal Measures
	(Toussaint Volcanic Series.

This has been used as the basis for all later work in the northern part of the Bowen Basin. The subdivisions apply only in the Collinsville area, north of the Mount Coolon area.

The Geological Map of Queensland (Geological Survey of Queensland, 1953) summarized the then current usage as follows:

Upper Bowen Coal Measures
Middle Bowen Group
Lower Bowen Volcanics.

Since then, many geologists have worked in the southern part of the basin. The geological story emerging as a result is much too complicated to be easily related to the above classification. However, in broad terms this classification is suitable for describing the geology of the Mount Coolon area, which lies in the northern part of the Bowen basin. For the purpose of this report, the above classification is altered in one respect: the Middle Bowen Group will be referred to by the informal name Middle Bowen Beds. This unit is richly fossiliferous and biostratigraphic correlation with other units throughout the basin should be possible. The stratigraphy will be revised when the present programme of regional mapping of the Bowen Basin is complete. Untill then, the informal 'Middle Bowen Beds' is preferred.

The Upper Bowen Coal Measures and the Lower Bowen Volcanics contain few fossils, or only plant fossils which are not useful for correlation; these units are best described by lithological terms. The names should be applied, however, only where continuity with the unit in the type area can be established.

LOWER BOWEN VOLCANICS

Summary

The Lower Bowen Volcanics consist of intermediate to basic flows, tuffs, and agglomerates, with interbedded sediments and minor acid flows. Some sills and small intrusive bosses are included. The unit is a thick wedge of volcanics cropping out on the eastern side of the Bowen Basin and lensing out towards the south-west. It is not present on the western side of the basin in the Mount Coolon area. The Lower Bowen Volcanics are underlain by the igneous rocks of the Urannah Complex; the nature of this contact is not established; it may be intrusive. The Middle Bowen Beds overlie the volcanics with a definite disconformity and a probable angular unconformity.

The Lower Bowen Volcanics were deposited in a partly marine environment. They contain rare plants throughout and marine fossils at one locality near the top of the unit.

Nomenclature and distribution

Reid (1928b) applied the name Lower Bowen to equivalent volcanics cropping out near Collinsville. He subdivided the unit into three parts, but these are not recognised in the Mount Coolon area.

The Lower Bowen Volcanics crop out in a belt cutting across the north-east corner of the Mount Coolon area. Their area of outcrop is extremely rugged and partly lies within the Broken River and Eungella Ranges. The topography mainly consists of steep hills and long ridges separated by deeply incised valleys. Some valleys are occupied by dissected level plains, from which in places round-topped, steep-sided hills rise. An example of this is the very large valley extending south from near Blenheim Homestead. The vegetation is thick and the youthful drainage makes access difficult. Outcrop is fairly good and the unit is partiicularly well exposed in the larger streams. Good exposures were examined in Lizzie and Hazelwood Creeks. Plate 2 shows over 800 feet of section measured in Lizzie Creek.

Lithology

The Lower Bowen Volcanics include a wide variety of rock types. Flows make up about one-third of the unit; they are mainly andesite, though some specimens examined were slightly more basic and were on the borderline between andesite and basalt. Most of the flows are medium-grained to coarse-grained, rarely fine-grained, and range in thickness from a few feet to a few hundred feet thick. The thicker flows, or more probably groups of flows, crop out as prominent strike ridges and lens out along strike. Acid flows were noted near the contact of the Lower Bowen Volcanics and the Urannah Complex, but are rare elsewhere in the unit.

Pyroclastics constitute about half the unit. They include tuff, ranging from coarse tuff to volcanic ash, lapilli tuff, crystal tuff, and agglomerate. They are mainly andesitic in composition. The tuff is usually a brown or creamy to white rock, showing graded bedding from coarse-grained or medium-grained to volcanic ash. It commonly occurs in beds about 1 inch thick, interbedded with black siltstone which also contains some volcanic detritus. The volcanic ash is hardened in many places, producing a chert-like rock.

Medium to thick-bedded or massive green tuff crops out in many places, commonly containing fragments and slabs of hard black thin-bedded siltstone and round boulders of limestone to 9 inches across. This tuff is similar to the matrix of the agglomerate.

Lapilli and crystal tuffs crop out in beds and lenses to 15 feet thick, though more commonly about 2 feet thick. In places they contain fragments and slabs of black siltstone and thinly interbedded siltstone and tuff. They are usually coarse-grained, containing crystals and bombs up to small pebble size, and are dark green, green-blue, or green.

Agglomerate crops out in lenticular slump masses, up to 50 feet thick in places, or in partly slumped beds about 2 feet thick. The bigger slump masses contain slabs and fragments, up to 5 feet across, of the thinly interbedded black siltstone and tuff. The agglomerate has a very coarse-grained green to green-blue matrix.

Black siltstone is the most abundant sediment in the unit, and in places it also contains some volcanic detritus. It crops out as thin beds interbedded with the volcanics or in a thin to medium-bedded sequence, up to 300 feet thick. The thicker beds are very closely jointed and, in places, contain hard round nodules to 9 inches across. Micaceous calcareous greywacke, feldspathic greywacke, and grey-green mudstone are other sediments which occur in a few places within the unit.

Several igneous bodies intrude the Lower Bowen Volcanics and are included in the unit. Most of them are intermediate to basic in composition, including diorite, gabbro, and micro-gabbro. They are in every respect similar to the coarser-grained andesite flows and usually can only be recognised as intrusives where they transgress the structures. The intrusives are sills or laccoliths and crop out in elongate rounded hills which more or less conform to the structure. They may be intrusive equivalents of the extrusives, intruded into the volcanic pile but not reaching the surface. Some intrusive bodies seem to bulge out beneath thick andesite flows.

An apparently very thick pile of green tuffs, fine agglomerates, and diorite intrusions crops out near the base of the unit north of the Mount Barker Granodiorite, and overlies the Urannah Complex. This pile of volcanics is practically structureless, and is rather poorly exposed where accessible. It was not mapped in detail.

Structure

The relationship between the Lower Bowen Volcanics and the Urannah Complex is probably intrusive. Some pendants of metamorphosed rocks included in the Complex look like metamorphosed Lower Bowen Volcanics. The rocks of the Complex cropping out near the Volcanics are a finer-grained phase of the main mass, possibly representing a marginal phase.

The Lower Bowen Volcanics are overlain by the Middle Bowen Beds with a definite disconformity and a probable angular unconformity. The evidence for the angular unconformity is mainly regional, as the trends in both units are nearly parallel near the contact. Variation in thickness of the Middle Bowen Beds along strike suggests that they were deposited on eroded, possibly mildly folded, Lower Bowen Volcanics. However, most of the structures in the volcanics reflect the main orogeny which folded the entire Bowen Basin succession.

The regional dip of the Lower Bowen Volcanics is to the south-west at about 40°. It forms part of the eastern limb of the Bowen synclinorium. This limb is outlined by the outcrop of the Middle Bowen Beds, and the Lower Bowen Volcanics largely conform to this structure but are affected by more secondary folding than affects the Middle Bowen Beds. The volcanics are folded into a large anticlinal structure west of the Mount Barker Granodiorite. This structure plunges south and appears to die out, as it is not reflected in the overlying Middle Bowen Beds.

The Lower Bowen Volcanics are overturned near Blenheim, as are the overlying Middle Bowen Beds. This overturning results from a push from the north-east which may be connected with the intrusion of the Urannah Complex. Some thrust-faults affect the volcanics near the northern margin of the sheet, just north of the zone of overturning. The thrusting may be due to the same forces which produced the overturning.

Environment

The sequence exposed and measured in Lizzie Creek (Plate 2) contains thin tuff beds which, even down to a fraction of an inch thick, show well developed graded bedding. The coarse sediments in the same sequence were mainly slump masses or showed signs of slumping. This suggests that they were deposited a considerable distance from source and possibly in deep water. Plant fossils are found in siltstone in this sequence and rare plants occur almost throughout the unit. Marine fossils were found in a tuff near the top of the unit; thus the environment was marine near the end of deposition of the Lower Bowen Volcanics. Much of the vulcanism may have been terrestrial with some of the volcanic detritus eroded and redeposited in a marine environment some distance from source.

Thickness

The thickness of the Lower Bowen Volcanics is not known; it is estimated to be of the order of ten to twenty thousand feet.

Age

One fossil collection, MC479, was made near the top of the Lower Bowen Volcanics, north-west of the Turrawalla/Eungella road crossing at Lizzie Creek. The fossils are contained in andesitic tuff overlain by andesite flows. J.M. Dickins has identified fourteen species in this collection (Appendix 1). Most of these species are present in the fossil assemblage at the base of the overlying Middle Bowen Beds. However, a few species are not found in the younger collections; these suggest that this assemblage may be correlated with the Dalwood Group (Lower Marine) of New South Wales. The differences between this collection and the fossil assemblage at the base of the Middle Bowen Beds are slight. However, a disconformity, probably only of short duration, may separate the Lower Bowen Volcanics from the Middle Bowen Beds.

MIDDLE BOWEN BEDS

Summary

The informal name Middle Bowen Beds refers to the fossiliferous marine sequence overlying the Bulgonunna Volcanics and the Lower Bowen Volcanics and conformably overlain by the Upper Bowen Coal Measures. Fossils collected to date belong to three distinct faunas; they include approximate equivalents of those found in the Cattle Creek and Ingelara Formations, and possibly of those found in the Mantuan Formation, of the Springsure area.

Two lithological assemblages are recognised in the unit. A siltstone/quartz greywacke/greywacke assemblage, from 4500 to 8000 feet thick, crops out in the north-east of the area and around the Bundarra Granodiorite in the south-east. A current-bedded quartz sandstone/conglomerate assemblage, about 2500 feet thick, crops out in a narrow, meridional zone in the centre of the Sheet area.

The quartz sandstone assemblage was deposited in a shallow-water environment, on the western shelf of the Bowen Basin. There, the unit unconformably overlies the Bulgonunna Volcanics, dipping east off them at angles of up to 5^{o}.

The siltstone/quartz greywacke assemblage shows no sign of shallow-water deposition. Its structure is much more complex; in the north-east of the area, it crops out in one limb of a major syncline. The limb generally dips south-west at about 35^{o}; it is overturned for a strike length of 6 miles, dipping north-east at about 70^{o}. Farther along strike, the unit is involved in a number of minor folds but the regional dip remains about 30^{o} south-west. In the south-east of the Mount Coolon area, the unit crops out in a dome about the Bundarra Granodiorite. Dips are about 70^{o} near the intrusive and decrease to 20^{o} to 30^{o} near the contact with the overlying Upper Bowen Coal Measures.

General

The Middle Bowen Beds crop out in three areas in the Mount Coolon Sheet area. These are: the Stockton-Hillalong area (Plate 3), a north-westerly belt cutting across the north-east corner of the area; the Bundarra area, a roughly circular area surrounding the Bundarra Granodiorite in the south-east corner of the Sheet; and the western shelf area, a discontinuous area of outcrop trending from north to south down the centre of the Mount Coolon Sheet. The rocks cropping out in these areas will be dealt with separately.

The Stockton-Hillalong Area

Distribution

In the Stockton-Hillalong area, the Middle Bowen Beds are best exposed in the narrow belt extending north-west from near the Lizzie Creek Road to the northern boundary of the Sheet. South-east along strike from the Turrawalla/Eungella road, the unit crops out in rugged, thickly timbered country and, in places, is overlain by Tertiary sediments and basalt flows.

Topographically, the unit usually forms strike ridges. Some, such as the Wall Sandstone ridge north of Blenheim Homestead, are very persistent and, in places, rise to a height of 500 feet above the plains. Others are quite low. The strike of the bedding is clearly displayed on the air photographs, both by the ridges and by trends which persist in areas of quite low relief. In places, the Middle Bowen Beds are hardened by intrusives and form areas of higher than average relief. These may be roughly circular, surrounding a valley in which the intrusive crops out, or may be irregular hills with no sign of the intrusive rock. In a few places, the trends of the Middle Bowen Beds end abruptly at low soil-covered areas. These areas are apparently depressions in the Middle Bowen Beds and the intrusives, infilled with Cainozoic sediments.

Lithology

The Middle Bowen Beds cropping out in the Stockton-Hillalong area consist of siltstone and quartz greywacke - the two most abundant rock types - greywacke, quartz sandstone, some thin conglomerate beds, and minor limestone. The quartz greywacke is calcareous in many thin beds and contains closely spaced calcareous nodules in zones to 3 feet thick. The siltstone and greywacke are calcareous in places. Fossils are found throughout the unit, but are most numerous in the calcareous layers. Sections measured in this area are illustrated in Plate 3.

Quartz greywacke is the dominant rock near the base. It is generally a grey-green semi-friable fine-grained rock. The bedding consists of rough laminations with streaks of silty and carbonaceous lithologies, which are possibly the result of marine scavenger action. Beds of medium-grained to coarse-grained quartz greywacke occur throughout the unit. They are medium to thick-bedded, are moderately hard, and, in places, are superficially silicified.

Siltstone is an important rock type throughout the unit, and particularly near the top. It may be grey, grey-blue, black, brown, or white. It is very commonly micaceous and is generally coarse-grained, grading into arenite. The siltstone is thinly laminated to thick-bedded, with close jointing developed in the thick beds.

Greywacke is less abundant than quartz greywacke or siltstone and is most common about the middle of the section. It is a dark grey-blue, micaceous, thick-bedded, medium-hard, fine-grained to very coarse-grained rock and usually contains soft red flecks and blebs of iron oxide. In places, it grades into greywacke-siltstone; in others, it is extremely coarse and poorly sorted, containing scattered pebbles, cobbles, and rare boulders up to 12 inches across. It is calcareous and fossiliferous in places.

Quartz sandstone crops out as long prominent strike ridges. It is a white to brown (in places grey-green), well sorted, medium-grained, medium to thick-bedded rock constituting about 10 percent of the total section. Some cross-bedding and some minor cross-lamination were observed. In a few places, it is poorly sorted, ranging from fine-grained to coarse-grained and containing scattered pebbles.

A few thin beds of conglomerate occur, but are not very prominent. Mostly conglomerate-size fragments are scattered through the coarser arenites.

The Middle Bowen Beds in the Stockton-Hillalong area contain many calcareous beds and lenses. These are usually calcareous quartz greywacke and, less commonly, calcareous siltstone and greywacke containing blebs and patches of calcite, either as original cement or replacing the matrix. The calcareous quartz greywacke beds are generally fine-grained to medium-grained, hard when fresh, and brown, ferruginous, and friable when weathered. They are commonly richly fossiliferous.

Some thin beds of impure limestone were also noted. These are fine-grained dense grey rocks containing a considerable quantity of clastic material. Limestone was observed near Mount Cona. It contains a sparse fauna of solitary corals and brachiopods.

Measured sections and thicknesses

Five sections were measured in the Middle Bowen Beds in the Stockton-Hillalong area; these represent about half the total thickness of the unit. The sections are figured on Plate 3.

The thickness of the unit was computed along six section lines, the locations of which are shown on Plate 3. Observations of bedding strike and the bedding trends visible on the air photographs were used to plot these section lines as near as possible at right angles to the strike; section line A was bent, each part being nearly at right angles to the strike throughout its length. The top and bottom of the unit were plotted on the air photographs and the plan thickness of the unit was measured off the air photographs along the section line. This was converted to actual thickness, using the large number of dip readings measured along the section line. The thickness along section line A was computed in two parts.

The computed thicknesses are:

Section Line A	8000 feet
" " B	6400 feet
" " C	5250 feet
" " D	4500 feet
" " E	4650 feet
" " F	5500 feet

Measured sections coincide with section lines A, C, D and E. The computed thickness over the interval of the measured section agreed quite closely with the measured thickness, indicating that the computed thicknesses are probably reasonably accurate. At all events, the errors in the computed thicknesses would be less than the variation in thickness which they show. The computed thicknesses reveal a significant thinning of the unit along a strike length of about 15 miles.

The most probable explanation of this thinning is that the Middle Bowen Beds were deposited on an uneven basement of Lower Bowen Volcanics. The surface of the volcanics was arched upwards, the crest of the arch corresponding to the zone of thinning. This arch may have been due to gentle folding or to erosion prior to the deposition of the Middle Bowen Beds. It is at its highest about section line D. The complete Middle Bowen sequence was deposited over this arch, but was thinner on top than on the flanks. Several quartz sandstone beds, which are prominent in the section north and south of the zone of thinning, lens out as they approach it.

The Lower Bowen Volcanics are not thrust over the Middle Bowen Beds in the zone of thinning since the fossils collected indicate that the basal part of the Middle Bowen Beds is present throughout the zone. Five large fossil collections were made, located as follows:

MC485F: About 1000 feet above base. Section line A
MC657F: In basal 500 feet of section. Between section lines C and D
MC1065, MC141F: In basal 500 feet of section. Between section lines D and E
MC421F: In basal 500 feet of section. Section line F.

These collections contain essentially the same fossil assemblage, and belong to the same stage. Therefore, transgressive overlap of the Middle Bowen Beds on to the Lower Bowen Volcanics was not responsible for the thinning.

There is no loss of section from the top part of the Middle Bowen Beds throughout the zone of thinning. The Upper Bowen Coal Measures conformably overlie them and the trends in both units and the contact between them are parallel.

The thinning may be due to the middle part of the Middle Bowen Beds being absent. The fossil record is not continuous enough to prove or disprove this. However, it seems more likely that the complete section is present throughout the area.

Structure

The Middle Bowen Beds in this area crop out in one limb of a major fold structure. The beds dip to the south-west, generally at angles of 30^{o} to 50^{o}; they become steeper towards Blenheim Homestead. Near Blenheim Homestead, the beds are overturned and dip north-east at about 75^{o}. South of Hazelwood Creek, they are involved in some minor folding, but the regional dip is still south-west.

If the thinning of the Middle Bowen Beds is due to deposition on an uneven basement of Lower Bowen Volcanics, the relationship between the two units is at least disconformable; it is possibly an angular unconformity. Significant differences between the fossil collection from the top of the Lower Bowen Volcanics and the collections from the base of the Middle Bowen Beds also indicate a disconformity, though probably only of short duration. Possibly, the thinning of the Middle Bowen Beds is due to differences in the amount of subsidence contemporaneous with deposition.

Environment

The Middle Bowen Beds cropping out in the Stockton-Hillalong area were laid down in a marine, moderately deep-water environment. Marine fossils are found throughout the unit. The depth of water is indicated by the lack of shallow-water structures. Poor sorting of some of the sediments and the high proportion of labile fragments indicate either rapid burial or deposition below the depth of reworking. The basin probably shallowed somewhat towards the end of deposition of the Middle Bowen Beds and became a freshwater basin. The transition from a marine to a restricted, mainly freshwater environment was effected without any obvious break in sedimentation, and was apparently quite rapid. Marine fossils below and plant fossils above are found quite close to the contact between the Middle Bowen Beds and the Upper Bowen Coal Measures.

Thickness

The thickness of the Middle Bowen Beds in this area ranges from 8000 feet to 4500 feet. The unit may thicken south-east along strike from section line A, but it was not possible to measure or even estimate thicknesses in that area.

The Bundarra Area

The Middle Bowen Beds crop out in the south-east of the Mount Coolon Sheet area, in a dome about the Bundarra Granodiorite. Metasediments crop out as high, rugged hills in the contact metamorphic aureole around the margin of the intrusive. Farther from the intrusive, the Middle Bowen Beds crop out in lower, rather dissected country, with very thick vegetation. An impure sandstone, near the top of the unit, forms prominent hills. Cainozoic sediments overlie them in places, but the Middle Bowen Beds are exposed in the creeks and the Cainozoic deposits are not differentiated on the map.

Lithology

The metamorphosed Middle Bowen Beds around the Bundarra Granodiorite include quartz-sericite schist, graphitic schist, and knotted schist, all originally carbonaceous. The grade of thermal metamorphism was not very high, though some new minerals were formed, for example the 'knots' in the knotted schist, which are possibly andalusite. The intrusion has dragged up the sediments, producing the schistosity.

Beyond the metamorphic aureole, the rock types resemble those found in the Stockton-Hillalong area. They include roughly bedded, thick to thin-bedded, medium-grained to fine-grained, grey-white micaceous quartz greywacke, hardened in places; micaceous blue-grey greywacke; fossiliferous calcareous quartz greywacke; pinkish-blue micaceous fine greywacke grading into greywacke-siltstone, containing crinoid stems and other fossils; and thinly interbedded fine-grained to coarse-grained micaceous greywacke, blue-white micaceous siltstone, and chert. Thick-bedded, superficially silicified micaceous quartz greywacke crops out near the top of the unit, forming prominent strike ridges.

Structure

The Middle Bowen Beds in this area crop out in a dome about the Bundarra Granodiorite. The injection of the granodiorite has produced the schistosity of the sediments, and gneissic layering in the granodiorite near the contact. The contact between the sediments and the intrusive is smoothly curved for most of its length, becoming crumpled near the southern margin of the Sheet. The bedding trends in the Middle Bowen Beds and the overlying Upper Bowen Coal Measures roughly parallel this contact.

Dips of the schistosity range from 70° to vertical in the contact aureole. At one place near the contact, bedding and schistosity were parallel to gneissic banding in the adjacent intrusive; all three dipped at about 45° away from the intrusion. Intersections in old mine shafts in the area suggest that the sediment-granodiorite contact dips at about 45° (Ball, 1910).

Some minor folding and some faulting, possibly with associated drag-folding, affect the beds. Their regional dip is away from the Bundarra Granodiorite, at angles of 40° to 70°. The contact between the Middle Bowen Beds and the Upper Bowen Coal Measures was not seen in this area. However, the trends in both units visible in the air photographs are parallel and the contact is probably conformable.

Environment

The environment of deposition of these sediments was marine, and probably deep water. No shallow-water structures were observed.

Thickness

The thickness of the Middle Bowen Beds in the Bundarra area is not known. It is probably considerable, of the order of 5000 feet to 10,000 feet. Probably, the base of the unit is not exposed in this area.

Palaeontology and Age

Not many fossils were found in the Middle Bowen Beds of the Bundarra area, and most of those had been recrystallized by metamorphism. The fossils include bryozoa, crinoid stems, and fragments of brachiopods and pelecypods. None of this material is suitable for accurate determination, but it indicates a Permian age for the sediments. Fossils were found in these beds a few miles to the south in the Clermont area. These are correlated with the uppermost stage of the Middle Bowen Beds in the Stockton-Hillalong area.

Not much is known about the Middle Bowen Beds in the Bundarra area. Only one traverse, of three days duration, was made into the area; the short time spent in the area, under conditions of fairly difficut access and thick cover, was not sufficient for accurate mapping.

Western Shelf Area

Discontinuous outcrops of Middle Bowen Beds mark the western edge of the Bowen basin. The best outcrop is in the valley of the headwaters of Parrot Creek, near the northern boundary of the Mount Coolon Sheet. Elsewhere, outcrop is found in gullies around the edges of low rises covered with ferruginous gravel, a remnant of a laterite profile developed on the Middle Bowen Beds.

Lithology

The Middle Bowen Beds in the western Sheet area consist mainly of quartz sandstone, siltstone, and minor conglomerate. In Parrot Creek at the northern margin of the Sheet, they consist of medium to thick-bedded, white, micaceous, cross-bedded quartz sandstone interbedded with 6-inch to 1-foot beds of quartz pebble conglomerate. In places, the quartz sandstone is flaggy and is interbedded with thinly bedded micaceous, grey, very fine-grained sandstone and siltstone and thin beds of pebble conglomerate. The quartz sandstone contains worm tracks in places, but no other fossils were found. The quartz sandstone is case-hardened in the creek; elsewhere it is medium hard to slightly friable, with little matrix or cement. The Parrot Creek sequence belongs in the Collinsville Coal Measures, a unit of the Middle Bowen Beds. It is conformably overlain to the east by sandstone, calcareous quartz greywacke, and siltstone of the Middle Bowen Beds.

Farther south, outcrop is very poor. Rock types seen include medium-grained to coarse-grained quartz sandstone, commonly grading into fine quartz conglomerate; fossiliferous, calcareous quartz greywacke, brown, friable, and ferruginous in outcrop; micaceous quartz greywacke, grading into fine conglomerate and interbedded with reddish-brown ferruginous, micaceous siltstone. The coarser arenites commonly contain scattered subangular pebbles of quartz and chert. The quartz sandstone is a superficially iron-stained, well sorted, grey-white, medium-bedded or massive to poorly bedded rock, cross-bedded in places.

Structure

The Middle Bowen Beds in the western shelf area overlie the Bulgonunna Volcanics with a strong angular unconformity. The unconformity is exposed in the headwaters of Parrot Creek. There, beds of agglomerate and flow-banded rhyolite are folded, dipping at angles of up to 80^o. The unconformity cuts across these structures and dips east at angles of less than 5^o. Six-inch to 1-foot thick patches of pebble and cobble conglomerate mark the unconformity in places; the pebbles are fragments of the Bulgonunna Volcanics. The conglomerate is overlain by the assemblage described above.

Farther south, bedding in the Middle Bowen Beds is rather obscure. In the few places where bedding was observed, it is sub-horizontal to east-dipping, at angles of 5^o or less.

No contacts were observed between the Middle Bowen Beds and the overlying Upper Bowen Coal Measures, but the two are probably conformable.

Environment

The sequence was laid down on a marine, shallow-water shelf. Well sorted current-bedded quartz sandstone is the characteristic lithology, indicating that shallow-water conditions prevailed. Fossils are moderately common, though a worthwhile collection was made at only one locality, in the upper part of the unit, west of Dabin Homestead. Elsewhere, only casts of pectinids and fragments of fossils were found. The large collection is equivalent to the assemblage contained in the upper part of the Middle Bowen Beds in the Stockton-Hillalong area. This suggests a marine transgression over the western shelf area about the middle of the time of deposition of the Middle Bowen Beds. The transgression overlapped a moderately irregular surface of Bulgonunna Volcanics which sloped east at a gentle angle or was downwarped to permit the transgression. The surface of unconformity on the Bulgonunna Volcanics is irregular in detail, though the irregularities appear to have a low relief. The surface is not as dissected as the pre-Tertiary surface of the Bulgonunna Volcanics farther west. The smoothness of the surface of unconformity may be due to shoreline erosion by a slowly advancing sea. This surface of unconformity is very irregular in the Clermont area.

Thickness

The thickness of the unit in the western shelf area is not known. Outcrop is poor, and dip and strike information is usually too vague to permit estimation of the thickness. In the Parrot Creek area, there is an estimated minimum thickness of 1500 feet of Middle Bowen Beds; the total thickness may be considerably greater. This shelf assemblage of the Middle Bowen Beds extends south in to the Clermont Sheet area, where it is more than 2000 feet thick (Veevers et al., 1964).

Palaeontology and Age of the Middle Bowen Beds

Three stratigraphically discrete faunas are recognised in the Middle Bowen Beds. All three are closely related to those in the Maitland Group (Upper Marine) of New South Wales, although the lowest has some relationship with the faunas in the Dalwood Group (Lower Marine). Complete lists of the species determined in these faunas by J.M. Dickins are given in Appendix 1.

The oldest fauna is represented by the following fossil collections: MC484F, MC485F, MC878F, MC1414F, MC421F, MC1065F, and MC657F. At least 24 species are present in these collection. This fauna is probably Artinskian. It is closely related to that found in the Cattle Creek Shale of the Springsure area and the two are probably about the same age. In the Mount Coolon Sheet area, this fauna is found only in the basal 1000 feet of the Middle Bowen Beds in the Stockton-Hillalong area. The same fauna is found at Homevale, east of the Mount Coolon area.

The middle fauna is represented by only two collections, MC669F and MC420F, from about 1500 feet above the base of the Middle Bowen Beds in the northern part of the Stockton-Hillalong area. At least ten species are present in this fauna, including species of Glyptoleda. This assemblage is probably slightly older than the Ingelara Shale of the Springsure area.

The youngest fauna in the Middle Bowen Beds of the Mount Coolon area is represented by the following collections: MC423Fa, MC423Fb, MC802IF, MC803F, MC311F, MC292Fa, MC293F, MC553F, MC575F, MC957F. All except MC311F came from the upper 2000 to 2500 feet of the Beds in the Stockton-Hillalong area. MC311F came from the Middle Bowen Beds cropping out in the western shelf area; consequently, these beds are correlated with the upper part of the unit in the Stockton-Hillalong area.

This upper fauna may be correlated with the fauna of the Middle Bowen Beds of the Clermont area, which includes Strophalosia clarkei, and the fauna of the Middle Bowen Beds overlying the Collinsville Coal Measures, including the Big Strophalosia Zone. It appears to be about the same age as the upper part of the Maitland Group (Upper Marine) of New South Wales. It is not older than the Ingelara Shale of the Springsure area; indeed the entire fauna could be younger than the Ingelara Shale.

Most of the fossil collections referred to above were collected in the Stockton-Hillalong area. The positions of these are shown on Plate 3, relative to the computed thicknesses of the Middle Bowen Beds.

UPPER BOWEN COAL MEASURES

Summary

The Upper Bowen Coal Measures consist of 10,500 feet of apparently freshwater sediments, conformably overlying the marine Middle Bowen Beds and overlain by the Carborough Sandstone. Throughout the unit is found an abundant and varied fossil flora.

The unit crops out in the eastern half of the Sheet area, bounded by outcrops of the Middle Bowen Beds to the west and north-east. It is intruded by a possibly differentiated suite of intrusive rocks ranging from gabbro to granodiorite and by numerous sills and dykes of dolerite and microdiorite.

Measured sections are shown in Plate 4. Rock types include lithic sandstone, calcareous in places, siltstone, silicified siltstone, carbonaceous shale, conglomerate, and minor coal. The lithic sandstone is the dominant rock type in outcrop. It generally forms very large, festoon-bedded lenses interspersed in thin-bedded siltstone and finer arenites. Carbonaceous shale and coal are widespread, but generally constitute only a small fraction of the section. Substantial coal deposits suitable for open-cutting are known in only two areas: north-east of Lake Elphinstone and the Kemmis Creek area.

The Upper Bowen Coal Measures are folded into a number of anticlines, synclines, domes and basins, and some monoclines. Intrusives crop out in the core of some of the domes. In the western part of their area of outcrop, they dip east at low angles or are folded into complex low-amplitude domes and basins.

The unit is thought to be Upper Permian.

Nomenclature

The Upper Bowen Coal Measures is a rock unit name introduced by Jack in 1879 and reviewed by Reid in 1929. No type area has been defined as yet, nor have type sections been measured. With further work, it should be possible to define lesser units of formation or member rank within the Upper Bowen Coal Measures.

Distribution

The Upper Bowen Coal Measures are poorly exposed in much of the eastern part of the Sheet area. The unit forms gently undulating country with considerable soil cover and crops out mainly in creek sections. Some long, low, rounded or benched strike ridges are produced where the unit is moderately steeply dipping, as in the areas east of the Carborough Range and south-east of the Redcliffe Tableland. Good outcrop and the most rugged topography are produced where the unit has been contact-metamorphosed. In places, patterns in the vegetation are visible on the air photographs. These reflect the bedding; apparently some types of vegetation follow certain beds.

The unit is very poorly exposed west of the Kerlong Range. It is overlain in many places by Tertiary sediments and deep alluvial cover and is only rarely exposed in the creeks, most of which have not cut down through the alluvium to the underlying rocks.

Lithology

The Upper Bowen Coal Measures consist of conglomerate, sandstone, siltstone, and shale, though it is difficult to estimate the relative proportions of each. In the measured sections (Plate 4) the proportions of the main lithologies are:

Siltstone and Shale	10 percent
Arenites	15 "
Conglomerates	5 "
Intrusives	10 "
Coal	0.2 "
No outcrop	60 "

So, in outcrop, the proportion of lutite to arenite to rudite is approximately 2:3:1. The total amount of lutite is probably much higher as it would constitute a larger proportion of the non-outcropping section.

In the northern part of the Mount Coolon Sheet area, east of the Redcliffe Tableland, conglomerate occurs about 4000 feet above the base of the Upper Bowen Coal Measures. It consists of four or five beds or lenses from twenty to one hundred and forty feet thick. The conglomerate fragments range in size from 1/10th inch to six inches; the rock itself is fairly hard and compact; fractures commonly run through the grains rather than around them. The matrix is of brown arenaceous and argillaceous material, mainly quartz, mica, and chlorite, with some calcite cement. The fragments, many of which are rounded, consist mainly of volcanic detritus. Volcanic glass is common and, like the tuffaceous material present, shows signs of attrition. Some conglomerate has shale partings, in which are abundant plant remains.

Elsewhere in the Upper Bowen Coal Measures conglomerates do occur as fairly persistent beds; one conglomerate bed east of Lake Elphinstone is known to have a lateral extent of at least six miles.

There are, broadly, two types of arenite in the Upper Bowen Coal Measures. The first type has a calcite matrix making up to 50 percent of the rock. The second type is a lithic sandstone in which rock fragments and feldspar constitute up to 70 percent of the rock.

The first type contains up to 60 percent quartz and rock fragments. The quartz is generally more abundant than the rock fragments and is extremely angular. It also shows large embayments and could be described as 'volcanic quartz'. The rock fragments are mostly of volcanic origin and consist of small plagioclase laths enclosed in a devitrified glassy matrix or a cryptocrystalline matrix. Considering the rock as a whole, the rock fragments and quartz grains are set in a fine-grained cryptocrystalline matrix composed of calcite. Spherulites, in the calcite, are common. This rock is a limestone or marl into which volcanic detritus has been dropped. It may best be called a calcareous lithic sandstone.

Finer sediments occurring within the Upper Bowen Coal Measures consist of siltstone, calcareous siltstone, silicified siltstone, and possibly phosphatic rocks. The siltstone varies both in colour and grain size: the colours are white, grey, black, grey-blue, brown, or yellow; the grain size varies through all sizes of the siltstone range. Much of the siltstone contains calcareous material, of primary or secondary origin.

Silicification is noted in some siltstone, particularly in very fine current-laminated rocks. The resultant siltstone is a hard, dense, impervious rock which has alternate bands of blue and buff coloured sediment. In some instances very distinct impressions of leaves are preserved.

The carbonaceous shales also vary in colour from brown to grey and black. The lighter brown is probably due to weathering. The shales contain an abundance of plant fossils both as carbonaceous material and as impressions in the argillaceous material.

Banded, possibly phosphatic, sediments were observed in one locality, showing contraction cracks. Nodules had been formed by a 'rolling up' of this sediment.

Coal in the Upper Bowen sediments does not crop out well. However, since 1875 there have been many reports of coal seams in the Mount Coolon Sheet area, and one new exposure of coal was noted during 1960, in Kangaroo Creek about one mile south of Weetalabah Station. Details of this exposure are noted in Section RJl in Plate 4. The coal is thin and contains many shale partings. In some occurrences the coal is reported to be as much as 25 feet thick. Coal reserves suitable for open cutting have been proved by drilling in two areas: 16 million tons in an area north-east of Lake Elphinstone; and 7 million tons in an area west of Kemmis Creek Homestead (Shepherd, 1951).

<u>Structure</u>

The Coal Measures are conformable with the underlying marine beds. The contact is exposed in Blenheim Creek, near the Collinsville road crossing. At this point the top of the Middle Bowen is represented by a bed of quartz sandstone, underlain by blue siltstone showing scavenger action, and a fossiliferous calcilutite. Immediately above the sandstone, and structurally quite conformable with it, is a series of thinly bedded siltstone which contains fossil leaves.

The boundary between the Upper Bowen Coal Measures and the overlying Carborough Sandstone appears to be structurally conformable, but is lithologically very abrupt. It marks a change in the type of sedimentation from the labile sediments of the coal measures to the mature quartz sands of the Carborough Sandstone. The boundary may be disconformable.

The unit is folded into a number of anticlines, synclines, and monoclines, the axes of which trend north-north-west, and some domes. The folding generally dies out fairly rapidly up the section, though fold axes may be traced for some distance. The axis of a syncline west of the Redcliffe Tableland may be traced for a distance of twelve miles; and the axis of the elongate dome south of the Redcliffe Tableland may be traced for almost 20 miles, though the amplitude of the fold decreases rapidly with distance from the centre of the dome. Monoclines were noted in a number of places, particularly west of the Redcliffe Tableland. In one structure in that area the dip increases from 3^{o} east to 50^{o} east then decreases to 25^{o} east.

Intrusives, such as the Gotthardt Granodiorite, crop out in the cores of a few domes. The Gotthardt Granodiorite is more or less concordant with the structure. It was possibly emplaced during the folding of the sediments.

The Upper Bowen Coal Measures, east of the Carborough Range, are folded into complex minor folds, characterized by rapid reversals of plunge. Outcrop is confined to creek sections, and the structure cannot always be disentangled from the array of disconnected strike and dip observations. A somewhat similar situation exists west of Byerwen and Weetalabah homesteads, where, again, outcrops are confined to the creeks: the dips are usually shallow, but the dip directions vary widely. Some shallow-amplitude domes and basins are postulated in this area.

West of the Kerlong and Burton Ranges, the unit is poorly exposed. Folding is minor and the beds appear to dip east at low angles.

The Upper Bowen Coal Measures are faulted in places. The faulting is minor and is not well exposed in these relatively incompetent beds.

Environment

The Upper Bowen Coal Measures were deposited in a rapidly sinking restricted basin. The environment permitted preservation of the abundant plant fossils, and was probably freshwater or at least estuarine. However, the quantity of calcite present, mainly in calcareous lithic sandstone, suggests an influx of sea water from time to time. At times the basin shallowed and became swampy, and coal was laid down.

Thickness

The Upper Bowen Coal Measures are 10,500 feet thick; this figure is based on measured sections and on measurement from the air photographs. Reid (1924) estimated a thickness of 9600 feet.

Palaeobotany and age

Fossil plants were collected from several localities in the unit. The reference numbers of the collections are MC225Fa, MC233Fa, MC233Fb, MC1017Fa, MC236Fa, MC289F, MC608F, MC292Fb, MC755F, MC62F, MC46F, MC535F, MC727F; these are described by Mary E. White in Appendix 2. Species identified include *Glossopteris indica* Sch., *G. browniana* Brong., *G. angustifolia* Brong., *G. conspicua* Fm., *G. spathulato - cordata* Fm., *Phyllotheca australis* Brong., *Nummulospermum bowenense* Walk., *Sphenopteris lobifolia* Morr., *Cladophlebis roylei* Arber, *Samaropsis* sp., and *Vertebraria indica* Royle.

These plants belong to a Permian/Lower Triassic assemblage and are not suitable for more accurate age determination. The Upper Bowen Coal Measures are thought to be Upper Permian and may range into the Triassic.

CARBOROUGH SANDSTONE

Summary

The Carborough Sandstone, of presumably Triassic age, overlies the Upper Bowen Coal Measures with apparent conformity and is conformably overlain by the Teviot

Formation. It consists of about 1500 feet of current-bedded quartz sandstone with minor bands of quartz pebble conglomerate. It crops out in the Carborough, Kerlong, and Burton Ranges and the Redcliffe Tableland. The unit is folded and crops out in a number of synclines and one anticline; generally dips are 15^{o} or less.

Nomenclature

The term Carborough Sandstone was first used by Reid in 1928 to refer to the rocks of the Carborough Range. Later, he applied a different name, the Redcliffe Series, to the same unit cropping out in the Redcliffe Tableland. The name Carborough Sandstone is preferred. The type area of the unit is in the Carborough Range.

Distribution

The Carborough Sandstone crops out in three structures: a fault block, forming the Burton Range; a syncline, the east and west limbs of which form the Carborough and Kerlong Ranges respectively; and a bifurcating syncline and associated anticline, forming the Redcliffe Tableland. The Carborough Sandstone is resistant to erosion. Its areas of outcrop are bounded by steep cliffs and gentler scree slopes rising more than 600 feet above the surface formed on the Upper Bowen Coal Measures. Outcrop is fairly good, though true dips are commonly difficult to measure, owing to the amount of cross-bedding. Many outcrops are actually large blocks out of place.

Lithology

The dominant rock type is quartz sandstone, containing little or no matrix. It may contain up to 15 percent of chert, quartzite and other rock fragments, minor feldspar and mica. The grains are subrounded, medium to coarse, and well sorted, though larger grains or pebbles occur scattered through the rock or in bands. Many of the quartz grains show evidence of solution and movement of silica.

Structure

Folding in the Carborough Sandstone consists of the few structures mentioned above. Generally, the limbs of these folds dip at angles of 15^{o} or less. The Carborough Sandstone was folded with the Upper Bowen Coal Measures, and both units are involved in these structures. The structures are generally tighter at depth in the Coal Measures, and become gentler as they approach the relatively thick, competent Carborough Sandstone. That the Carborough Sandstone reacted to the folding stresses as a competent unit is shown near the northern end of the Redcliffe Tableland. A gabbro intrusion has gently domed the Carborough Sandstone and the Upper Bowen Coal Measures. The stresses in the Carborough Sandstone were relieved by a radiating set of tension cracks.

The Carborough Sandstone is mainly preserved in the troughs of synclines. It crops out in a minor anticline at the southern end of the Redcliffe Tableland, and in this area the tableland is much more dissected than elsewhere.

The boundary between the Carborough Sandstone and the Upper Bowen Coal Measures is structurally conformable. It is marked by an abrupt change in the type of sedimentation, and may be disconformable. The boundary between the Carborough Sandstone and the overlying Teviot Formation is well exposed on the Redcliffe Tableland. The contact is conformable and transitional; the quartz sandstone grades upwards into the lithic sandstone of the Teviot Formation within ten feet of section.

Environment

The abundance of current-bedding and the good sorting and maturity of the sediments suggest a shallow-water environment, with considerable current action. The environment may have been deltaic.

Thickness

A section through part of the Carborough Sandstone was surveyed by tape, compass, and abney level in the Carborough Range, north of Carborough Creek. The thickness, based on a number of dip measurements, totalled 1181 feet. The section began at the lowest outcropping bed but did not reach the top of the unit. The total thickness is estimated to be at least 1500 feet.

Age

No fossils have been found in the Carborough Sandstone. The overlying Teviot Formation contains definite Triassic plants; the underlying Coal Measures contain a Permian-Triassic flora, and are, at the earliest, Upper Permian. The Carborough Sandstone is considered to be Triassic, though it may extend down into the Permian. Locating the Permian-Triassic boundary in the Upper Bowen Coal Measures and Carborough Sandstone sequence is extremely difficult; it is arbitrarily and conveniently placed at the boundary between the two.

TEVIOT FORMATION

Summary

Teviot Formation is a new name proposed for the topmost unit in the Bowen Basin succession. It consists of up to 400 feet of micaceous lithic sandstone, calcareous in places, and micaceous siltstone, conformably overlying the Carborough Sandstone. The unit crops out on the Redcliffe Tableland and between the Carborough and Kerlong Ranges. It contains Triassic plants.

Nomenclature and type area

The name, Teviot Formation, is proposed in this Report. The name is derived from Teviot Creek, which rises in the Formation between the Carborough and Kerlong Ranges in the Burton Downs 1-mile area. The type area is along the track from Ellenfield Homestead to Kemmis Creek Homestead, which crosses the formation for a distance of three miles, about Lat. 21°42'S., Long. 148°16'E., a few miles south of the headwaters of Teviot Creek. No section has been measured in the formation.

Distribution

The Teviot Formation crops out between the Carborough and Kerlong Ranges and on the Redcliffe Tableland. It is not very resistant to erosion and produces a rather subdued topography, consisting of rounded hills and undulating sandy plains. The relief of the hills is about 150 feet in the type area, but is much lower on the Recliffe Tableland.

Lithology

The formation consists of micaceous lithic sandstone and micaceous siltstone: the abundance of mica is the main difference between them and similar lithologies in the Upper Bowen Coal Measures. The sandstone is a medium-grained to fine-grained well sorted rock showing large-scale current-bedding and small slump structures. In places, it is tough and brown or grey, and has a cryptocrystalline calcite cement constituting up to 40 percent of the rock. Elsewhere, it is completely ferruginized, possibly owing to replacement of calcite by iron oxides. In many specimens, the sandstone has no cement and little or no matrix; such rocks are semi-friable, and brown to reddish.

The sandstone is commonly thin to medium-bedded. The grains are angular and consist of quartz (about 50 percent of the total), lithic fragments, feldspar, and mica.

The micaceous siltstone is not well exposed. It is generally a brown, medium-grained to coarse-grained rock and contains a considerable proportion of relatively large mica flakes.

Structure

The Teviot Formation was folded with the Carborough Sandstone and the Upper Bowen Coal Measures, but crops out only in the troughs of two synclines. The attitude of the beds varies from flat-lying to dipping at 12°. The formation conformably overlies the Carborough Sandstone, with a transitional zone from one to the other over about 10 feet of section. On the Redcliffe Tableland, the formation is unconformably overlain by Tertiary sediments and basalt flows.

Environment

The environment of deposition is probably shallow freshwater or estuarine, similar to that of the Upper Bowen Coal Measures.

Thickness

The thickness of the Teviot Formation is not known. About 400 feet is present between the Carborough and Kerlong Ranges, but the top of the formation is not preserved. The thickness present on the Redcliffe Tableland is probably less than 200 feet.

Palaeobotany and age

Plant fossils were collected in the formation at one locality, MC697F, and are described in Appendix 2. They are identified as Dicroidium feistmanteli (Johns) Gothan and Dicroidium odontopteroides (Morr.) Gothan, and indicate a Triassic age.

EXEVALE FORMATION

Summary

Exevale Formation is a new name proposed for presumably Tertiary lake deposits which unconformably overlie Permian and Triassic sediments and intrusives, and are conformably overlain by basalt flows. They crop out around Exevale Homestead and on the Redcliffe Tableland, in the north-east of the Sheet area. The formation consists mainly of quartz sandstone and siltstone.

The name is derived from Exevale Homestead, 62 miles east-north-east of Mount Coolon, on the Nebo-Collinsville Road.

Distribution

The formation crops out in an area of about 60 square miles around Exevale Homestead, in several small outliers north of Exevale, and on the Redcliffe Tableland. The type area lies two miles south of Exevale Homestead, about Lat. 21°19'S., Long. 148°18'E. This is a moderately dissected area of low hills leading up to the steep scarp edge of a basalt-capped plateau. The unit is well exposed in the hills and in gullies and re-entrants into the plateau.

The formation generally forms low rolling country with little or no outcrop. Some outcrop is found in the creeks, but many creeks have cut through to the underlying rocks. The topography of the formation is more rugged on the flanks of basalt-capped mesas and in those areas recently denuded of the basalt cover of which the type area is an example.

Lithology

The Exevale Formation includes quartz sandstone, quartz greywacke, and siltstone These sediments are quartz-rich; they vary mainly in grain-size and the quantity of matrix present. Most are poorly sorted and display poor bedding.

The quartz sandstone is generally a white friable rock consisting of medium to very fine sub-angular quartz grains with very little matrix or cement. In places, a completely silicified quartz sandstone crops out.

The quartz greywacke is a fine-grained to coarse-grained friable to medium-hard rock containing mainly angular to sub-angular quartz grains in an argillaceous quartz siltstone matrix. The colour is variable, and ranges from white to reddish-white or yellow-brown.

The greywacke and, less commonly, the sandstone are poorly sorted in places, containing scattered pebbles. The pebbles are mostly flat with rounded edges, and include quartz, quartzite, hard rock fragments, and some smaller fragments of siltstone. In places, the pebbles are numerous enough to form thin beds of conglomerate, which are rarely thicker than two or three pebbles.

A white argillaceous quartz siltstone is the only other abundant rock type in the formation. Generally, the siltstone is friable and weathers to a fine white dust, particularly on vehicle tracks. In a few places, it is superficially hardened.

The Exevale Formation, where it crops out on the Redcliffe Tableland, is not very thick and consists of a red sandy claystone and some rubble and boulders of silicified quartz sandstone. The claystone is poorly indurated and is most probably a product of lateritization of an argillaceous siltstone. The sandstone may have been silicified by overlying basalt flows, remnants of which still remain, or during lateritization.

Structure and relationships

The Exevale Formation was deposited on an irregular basement of Permian and Triassic sediments and intrusives. Most of the outliers of the formation were deposited in separate depressions in this basement and may not have been continuous with the formation in the type area. The shapes of some of the smaller depressions are still preserved in the present-day topography, outlined by remnants of the Exevale Formation. The formation weathers more readily than the underlying rocks and in places has been almost completely removed. It is generally preserved only where protected by a remnant of the basalt flows which overlie it.

The formation is poorly bedded in general, but lines of coarser grains usually indicate the bedding. Not many dip observations were made because of poor outcrop, but dips are generally shallow. Some dips of about 20^{o} are probably due to cross-bedding.

Environment

The environment of deposition of the unit was probably a freshwater lake.

Thickness

A thickness of 260 feet was measured with a barometer at one place, but this does not represent the whole of the unit. The maximum thickness is probably between 300 and 400 feet.

Age

The Exevale Formation is regarded as Tertiary. No fossils were found in the unit. However, it is younger than the late Jurassic or post-Triassic orogeny which folded the Bowen Basin succession. It is overlain with apparent disconformity by basalt flows of probably Tertiary age. It is in many respects similar to the Tertiary Suttor Formation which overlies the basalts. The Exevale Formation may represent the first part of the Tertiary freshwater sedimentation, interrupted by the basalt outpourings, which continued over a much greater area farther west as the Suttor Formation.

A similar situation exists in the Emerald area. There the Emerald Formation, a unit somewhat similar to the Exevale Formation, is overlain by thick basalt flows; and some of the flows are overlain, in turn, by a 'lateritised rudaceous formation' (Hill & Denmead, 1960, p. 354).

BASALTS

Basalts of probable Tertiary age cover an extensive area in the eastern half of the Mount Coolon area. Outcrops are not continuous, but are thought to be remnants of a widespread basalt sheet. The basalt overlies the Exevale Formation and is overlain by the Suttor Formation, both contacts being apparently disconformable.

Distribution

The basalts crop out in two main areas: one east of the Redcliffe Tableland and the Carborough-Kerlong Ranges, the other west of these features. The eastern area extends south-east from near Exevale Homestead to beyond the eastern margin of the Sheet. The western area lies between the Redcliffe Tableland and the Leichhardt Range, and extends south-south-west, immediately west of the Kerlong Range. Some basalt is also found on the Redcliffe Tableland.

In places, the basalts form steep-sided mesas or plateaux, such as near Exevale Homestead and west of the Redcliffe Tableland. Farther south, they are covered by rich dark soil with scattered basalt float.

In the eastern area, the basalt crops out over an area of about 100 square miles east, west, and south of Exevale Homestead. The thickness of the basalt is variable, reaching a maximum of about 400 feet west of Exevale Homestead. A feature of this area is the presence of conical peaks rising above the general level of the basalt surface. These are basaltic plugs marking the original extrusive vents. Several of these plugs transgress structures in the underlying Middle Bowen Beds, and there is little doubt that they are intrusive. They vary considerably in size, the largest being Mount Cona, about 1 square mile in area. Thick vegetation around the summit of the plugs is a characteristic feature which is very useful in photo-interpretation. Metamorphic effects of these plugs on the surrounding rocks appear to be insignificant.

In the western area, the basalt sheet was more extensive, but has been more dissected. Basaltic plugs are found east of Weetalabah and Byerwen Homesteads, intruding the Upper Bowen Coal Measures, but the basalt flows originally associated with the plugs have been completely removed. Farther south, there are large areas of basalt with isolated plugs; these are mainly covered by a distinctive, rich basalt soil with some basalt float. In places, the basalt is lateritized; it crops out in the lower benches of mesas capped by a laterite profile more than 50 feet thick. The thickness of basalt and laterite cropping out in this area is usually about 100 feet. It was probably originally thinner than the basalt sheet in the Exevale area, and apparently lenses out to the west. No basalt is found as far west as the Suttor River.

Both basaltic plugs and remnants of flow basalt crop out on the Redcliffe Tableland. These basalts are higher than the base of the flows in the Exevale area, though no higher than the top. They are relatively thin, and may have connected the basalt flows west and east of the Tableland at a late stage in the basalt outpourings. Well-developed 'billy' horizons are found beneath the basalt on the Redcliffe Tableland.

Petrography

The basalts are mainly olivine-bearing rocks which vary widely in texture. The most typical is a holocrystalline, equigranular rock consisting of olivine, labradorite, augite, and magnetite. The steeply conical plug immediately north of Mount Roberts is filled by a dense fine-grained basalt with clots of olivine and pyroxene. The clots have the composition of a peridotite. They are possibly differentiates of the basaltic magma at depth, and were incorporated in the lava upon its entry into the extrusive vent. None of these clots was found in the basalt flows but they may be present. Typically, very fine-grained basalt forms most of the plugs, but at Mount Roberts the rock is quite coarse-grained and is a gabbro.

Relationships

In the Exevale area and on the Redcliffe Tableland, the basalt overlies the Exevale Formation and in places is found infilling channels in that formation. West of the Redcliffe

Tableland, the Suttor Formation apparently overlies the basalt. These three units are apparently conformable, but there were obviously periods of erosion between them. West of the Suttor River, the Suttor Formation directly overlies the Bulgonunna Volcanics; the basalt flows did not extend as far west as that.

The basalt is not the result of a single outpouring. It probably represents several phases of extrusion from a large number of vents, during a fairly short period of time. The flows united to form a more or less continuous sheet of basalt.

Thickness

The basalt is about 400 feet thick near Exevale and probably thins to the west.

SUTTOR FORMATION

Summary

Suttor Formation is a new name proposed for a widespread thin flat-lying sequence of freshwater sandstone, argillaceous siltstone, and conglomerate. Rare dicotyledonous leaves indicate a Tertiary age. The formation is best developed in the northern part of the Mount Coolon area, where it unconformably overlies Permian sediments, the Bulgonunna Volcanics, the Undifferentiated Volcanics, and the Anakie Metamorphics, and disconformably overlies probable Tertiary basalt flows.

Dissected, lateritized, poorly outcropping sediments which overlie the Permian succession in the southern part of the Mount Coolon area are included in the Suttor Formation. The formation has been extensively lateritized and most outcrops are capped by part of a laterite profile.

Nomenclature

The formation name is derived from the Suttor River, which flows through the main area of outcrop of the unit in the northern part of the Mount Coolon area. The type area extends along the track from Byerwen Homestead to Cerito Homestead, from the foot of the Leichhardt Range, at Lat. 21°10'S., Long. 147°50'E., to the Suttor River. About the Suttor River, outcrop is poor, owing largely to a cover of sandy soil derived from the Suttor Formation.

Distribution

The Suttor Formation forms an extensive tableland on either side of the Mount Coolon/Collinsville Road. The eastern limit of the tableland is a 100-foot scarp, where the unit overlies Tertiary basalt. Farther east, the unit occupies depressions in the basalt surface. The western limit of the tableland is north-east of Mount Coolon. Beyond that, the unit crops out as mesas overlying the Bulgonunna Volcanics and the Anakie Metamorphics.

Tertiary sediments crop out south of the type area, in the central and south-eastern parts of the Sheet area; these are tentatively correlated with the Suttor Formation. Where a laterite profile caps the unit, its outcrop area is bounded by a steep scarp of about 50 feet relief. Elsewhere, it occupies low sand-covered areas with rare outcrop and many boulders of quartz sandstone. There is some doubt about the relationship of these poorly exposed sediments to some equally poorly exposed basalt flows. South of the Sheet area similar sediments appear to overlie the basalt flows of the Peak Range area.

Lithology

In the type area, the Suttor Formation consists of about 60 feet of quartz sandstone overlain by 45 feet of weathered claystone, in its turn overlain by about 70 to 100 feet of sandstone, clayey sandstone, and sandy claystone.

The sandstone at the base of the formation is mainly a white, or red and ferruginous, friable cross-bedded coarse-grained feldspathic quartz sandstone. In places, it is superficially silicified. The sandstone contains lenses of quartz pebble to cobble conglomerate.

The claystone is actually an argillaceous quartz siltstone. The clay minerals make up less than a third of the rock but give it a fairly distinctive appearance, particularly when weathered. It is usually white or banded and mottled white, red, and yellow. In many places, it contains angular, sand-size grains of clear quartz.

The claystone is overlain by red medium-grained to coarse-grained quartz sandstone, clayey in places, and grading into a sandy claystone.

Not all the section is present everywhere in the area; in many places, the claystone rests directly on the underlying Bulgonunna Volcanics. The angular clear quartz grains in the claystone were probably derived from the volcanics, which contain numerous angular clear quartz phenocrysts. Erosion and alteration of the volcanics may have contributed some of the clay.

A hard white siliceous rock is prominent in the formation about the Mount Coolon/Collinsville Road and on most of the mesas in the north-west of the area. It is a quartz siltstone with a siliceous, clayey matrix and contains angular clear quartz grains. It usually crops out at the top of the formation or is overlain by the ferruginous zone of a laterite profile. This rock was produced by partial silicification, probably in the pallid zone of a laterite profile, of an argillaceous quartz siltstone similar to the claystone described above.

In the north-west of the Sheet area, the Suttor Formation includes some coarse river gravels. These were deposited near the base of river channels incised into the Anakie Metamorphics to a depth of about 75 feet below the normal Tertiary base level. The gravels are gold-bearing. They are about 20 feet thick, and consist of well rounded fragments, ranging up to large cobbles in size, in a sand and clay matrix. The cobbles consist of quartz quartzite, intrusive and volcanic rock fragments, and rare metamorphic rock fragments, and could have been supplied by the Anakie Metamorphics, the Undifferentitiated Volcanics, and the Bulgonunna Volcanics and intrusives. Overlying the gravels, about 60 feet of soft white to brown clay and sandy clay are exposed in a shaft sunk to work the gravel.

Structure and relationships

The Suttor Formation is effectively a flat-lying veneer of sediments deposited on a rather irregular surface, producing in places steep depositional dips. The irregularities of this surface are obvious where the unit overlies the Bulgonunna Volcanics, north-east of

Mount Coolon. There, remnants of Suttor Formation are found against the sides of volcanic hills which were probably islands in the Tertiary lake.

In different places, the formation unconformably overlies the Anakie Metamorphics, the Undifferentiated Volcanics, the Bulgonunna Volcanics, the Middle Bowen Beds, the Upper Bowen Coal Measures, and the Triassic Carborough Sandstone.

The Suttor Formation crops out in the Leichhardt Range overlying the basalt flows. South-east of the range, near the abandoned Newlands Homestead, the relationship between the two is not so clear. Basalt and Tertiary sediments are found at the same elevation on opposite sides of some valleys which are eroded below the base level of Tertiary sedimentation. These sediments are thought to belong to the Suttor Formation, deposited in depressions in the underlying basalt surface. Possibly, the situation may be reversed: the bâsalt may occupy depressions in an older Tertiary sediment surface.

The Suttor Formation directly overlies the Bulgonunna Volcanics a few miles west of the Suttor River, the basalt flows having lensed out to the west.

Thickness

The Suttor Formation is generally about 200 feet thick. In places, it may be up to 400 feet thick, where it has been deposited in a depression in the underlying basement.

Age

One fossil dicotyledonous leaf was found in the formation during the 1960 season, and established the Tertiary age of the formation (Appendix 2).

UNDIFFERENTIATED CAINOZOIC

Cainozoic deposits, apart from the three Tertiary units, are shown on the map to cover about half the Mount Coolon area. Their distribution in fact is considerably greater. In many soil-covered areas, it is possible to map trends of the underlying rocks on the air photographs and actual outcrops in the creeks; these areas are shown on the map as the underlying rock unit. This is particularly true of the Upper Bowen Coal Measures, which are soil-covered in most places. The Cainozoic deposits are delineated where they completely mask the underlying rocks.

Most of these deposits are grouped on the map under the letter symbol Czs. They include soil, sand, alluvium, some laterite and lateritic soils, and gravels. They are most widespread in the mature central, western, and southern parts of the Sheet area. There, they consist mainly of old, possibly late Tertiary, alluvial flood-plain deposits, on which a stable soil profile has developed. They are being slowly dissected by the braided streams of the present-day drainage system, which in turn are building modern alluvial deposits mostly of reworked older material. No attempt was made to separate the younger alluvial deposits from the older.

The process of lateritization may have operated several times in the history of the area; the most widespread profile was developed after the Suttor Formation was laid down. This profile has been largely eroded, but is extensive in the western part of the Sheet, capping outcrops of the Suttor Formation. Some remnants of a laterite profile were included in 'Czs'. They crop out in mature plains and the unit on which they developed cannot be identified.

Lateritic soils and gravels, produced by erosion of the laterite profile, are widespread in the west and south-west of the area.

River-channel and flood-plain deposits, shown on the map as Czr, crop out in a long plain extending south-east from near Blenheim Homestead. These deposits are at least 70 feet thick. They are ill-sorted and contain boulders up to one foot or more across, scattered in a gravel-sand-clay matrix. They are now being dissected into steep gullies and rounded hills, but the original level surface of the flood plain is indicated by the uniform elevation of the hilltops.

Smaller river-channel deposits, not shown on the map, were seen along the courses of the Bowen River, Hazelwood Creek, and some other streams in the north-east of the area. These deposits are almost certainly related to the streams beside which they occur, though the streams have cut down below them to a depth of about 50 feet. The drainage system must, therefore, have been rejuvenated fairly recently; this rejuvenation is evident throughout the Sheet area, but is most noticeable in the north-east.

The coarse alluvial deposits found in the plain south-east of Blenheim Homestead are in marked contrast to the Tertiary Exevale Formation. Both were deposited in depressions in the Middle Bowen Beds or the Lower Bowen Volcanics. These depressions occupy similar positions, now, to the very rugged and high Eungella Ranges; but the Exevale Formation is quite fine-grained and the Cainozoic deposits are extremely coarse. It is suggested that the north-east part of the Mount Coolon area was uplifted since the Exevale Formation was deposited. This uplift reached its maximum in the Eungella Ranges and decreased with distance to the south-west. Such a recent uplift would account for the exemely rugged and useful topography of the ranges.

IGNEOUS INTRUSIVES

Intrusives into the Anakie Metamorphics

Two igneous masses intrude the Anakie Metamorphics in the north-west. Only one body was seen in outcrop and sampled; both were mapped from air photographs. Specimens were collected from a third mass intruding the metamorphics a few miles west of the Sheet area. All the specimens collected were hornblende-biotite granodiorite, and probably the intrusions are related. The age of the intrusions is not known.

Devonian-Carboniferous Intrusives

Several igneous bodies intrude the Undifferentiated Volcanics, the Bulgonunna Volcanics, and the Drummond Group. They probably represent an intrusive epoch during the Carboniferous, before the deposition of the Bowen Basin succession. Some of these intrusives may be contemporaneous with the Bulgonunna Volcanics.

A granite is exposed along the Mount Coolon/Collinsville Road, intruding the Bulgonunna Volcanics, though the relationships are obscured by a blanket of Tertiary sediments. In some places, it is a medium to coarse even-grained granite; in others, it is a fine-grained or porphyritic rock showing some lineation. At one place, intrusive rock appears to grade into the adjacent flow-banded rhyolite.

Of the masses that intrude the Undifferentiated Volcanics near Mount Coolon, a quartz diorite mass has intruded and metamorphosed the Anakie Metamorphics as well as the volcanics. This diorite produced the Mount Coolon gold lode, mineralizing the andesites of the Volcanics along a shear zone. The quartz diorite occurs as scattered tors protruding from soil cover. Other intrusives form single large rounded hills, suggesting that they are bosses.

Several diorite masses crop out near the south-west corner of the Mount Coolon area, intruding the Drummond Group. They are mainly fine-grained to medium-grained rocks, in places containing phenocrysts of feldspar and hornblende. One contains vugs partly infilled by secondary quartz and other minerals. In this area, several small basic masses intrude the Drummond Group. These include a fine-grained dark rock, possibly a diabase, and a coarse dark hornblende gabbro.

Urannah Complex

This complex is not named in the map reference (Plate 1). It is the alkali granite, adamellite, aplite, and gabbro dated as Palaeozoic or Mesozoic with the symbol Pz/Mi in the reference.

The Urannah Complex includes rocks varying through a wide range of texture and composition. Alkali granite and acid granodiorite are the most common rock types in the north-west of the complex. They contain albite or oligoclase as the dominant feldspar; the potash feldspar content is variable but small. The ferromagnesian minerals in the granodiorite are biotite and its alteration products. Some specimens of the alkali granite are very fine-grained and may possess a graphic texture. Some approach aplite in texture and composition. Several specimens collected in this area were adamellites, in which muscovite with subordinate biotite were the ferromagnesian minerals. This rock type is closely related to the more common alkali granite.

Another specimen of adamellite was collected further south in the Complex, about four miles north-east of Eungella Homestead. This is generally similar to the alkali granite and adamellite described above but differs in containing appreciably more ferromagnesian minerals, including biotite, hornblende, and chlorite.

Specimens collected in the eastern part of the Complex, near Eungella township, were found to be gabbro. They consist of plagioclase (about An60), augite, green hornblende, biotite, and traces of interstitial quartz.

The outcrop of this igneous complex is very rugged and inaccessible and only a few traverses were made into it. As a result, the relationship of the gabbro at Eungella to the adamellite and alkali granite to the west and north-west is not known. The extent of the Complex was mapped by photo-interpretation linking the few points where the boundary was observed. Consequently, some rocks other than igneous rocks may be included in the Complex. The boundary of the Complex is generally concordant with the structures in the Lower Bowen Volcanics.

The age of intrusion of these igneous rocks is not known. They probably intrude the Lower Bowen Volcanics, though this is not definitely established.

Mount Barker Granodiorite

The Mount Barker Granodiorite crops out a few miles south-west of the Urannah Complex. It is a biotite-hornblende granodiorite, conspicuously unlike the rocks of the Complex in hand specimen, though less different in thin section. The granodiorite outcrop is two-pronged and trends nearly north-south. It transgresses structures in the Lower Bowen Volcanics and in that respect also is unlike the Complex. It was probably intruded during the Mesozoic, during or at the close of the orogeny which folded the Bowen Basin succession.

Intrusives into the folded zone of the Bowen Basin

A number of igneous bodies intrude the Upper Bowen Coal Measures and the Middle Bowen Beds in the folded zone of the Bowen Basin; they range in lithology from gabbro to granodiorite.

A gabbro intrudes the Upper Bowen Coal Measures near the northern end of the Redcliffe Tableland. It is a leucocratic anorthite gabbro containing, as well as anorthite, essential augite and accessory biotite and hornblende. Associated with the intrusion is a swarm of dolerite and porphyritic plagioclase dolerite dykes. Some of these dykes intrude the Carborough Sandstone, occupying joints produced when the gabbro intrusion gently domed the Carborough Sandstone.

Several bodies of various sizes intrude the Middle Bowen Beds and the Upper Bowen Coal Measures east and south-east of the Redcliffe Tableland. These include hornblende granodiorite, porphyritic micro-granodiorite, leuco-diorite and micro-diorite. Most of these rocks are fine-grained and many are porphyritic. The granodiorites are generally poor in quartz, but their ferromagnesian content seems more closely related to granodiorite than diorite. The ferromagnesian minerals are pale hornblende and pale biotite, though the biotite is usually altered to chlorite and, in places, epidote.

These intrusives range up to 4 or 5 miles across. Many are partly concordant with the folds and may be large sills or laccoliths. An intrusion near the junction of Sandy Creek and the Bowen River appears to consist of a number of large sills and a central boss. Large numbers of smaller sills and dykes, mainly porphyritic micro-diorite and porphyritic dolerite, intrude the Middle Bowen Beds and the Upper Bowen Coal Measures throughout the folded zone of the Bowen Basin. They are particularly numerous east of the Redcliffe Tableland.

Gotthardt Granodiorite

The Gotthardt Granodiorite is probably related to the above group. It is a somewhat larger intrusive, occupying the core of a dome in the Upper Bowen Coal Measures. It is a biotite-hornblende granodiorite, rather poor in quartz. A marginal phase is a porphyritic micro-granodiorite very similar to some of the preceding group of intrusives.

Bundarra Granodiorite

The Bundarra Granodiorite lies partly within the south-east corner of the Mount Coolon area. It is the largest intrusive in this part of the Bowen Basin and occupies the core of a dome reflected through 10,000 to 15,000 feet of the Bowen Basin succession. At the base of this pile is a considerable thickness of Middle Bowen Beds.

The intrusive ranges from leuco-granodiorite to alkali granite in composition. Biotite is the main ferromagnesian mineral, though in places hornblende is very abundant and the rock approaches a syenite.

The Bundarra Granodiorite was intruded at a much greater depth than were those described above. It is surrounded by a considerable metamorphic aureole, as are the Gotthardt Granodiorite, the gabbro near the northern end of the Redcliffe Tableland and a few of the other intrusives. Remarkably little metamorphism is associated with the large sill-like masses cropping out north-west of Exevale Homestead.

The age of intrusion of these bodies is late Triassic or post-Triassic; that is they were intruded during the orogeny which folded the Bowen Basin succession.

Several sills and dykes of porphyritic micro-diorite and dolerite were found intruding the Upper Bowen Coal Measures in the western shelf area of the Bowen basin. No large intrusive bodies were seen in this area.

STRUCTURAL GEOLOGY

Six structural units are recognised in the Mount Coolon area. These are the Anakie High, the Bulgonunna Block, the Drummond Basin, the western shelf of the Bowen Basin, the folded zone of the Bowen Basin, and the Urannah Complex. Their distribution is shown on the structural sketch map, Figure 2.

Anakie High

The Anakie High is a long, narrow structure forming the eastern margin of the Drummond Basin. It probably existed at the time of deposition of the Mount Wyatt Beds, the Undifferentiated Volcanics, and the Drummond Group. Of the few structural observations made on the low-grade Anakie Metamorphics, most were at variance with the trend of the Anakie High. This suggests that the high is not directly related to the folding of the Anakie Metamorphics, but rather was gently superimposed on an already folded unit. It is probably a relic of the positive area between the sinking Drummond Basin to the west and the locus of deposition of the sediments and volcanics to the east. The concordance of the Anakie High and the Drummond Basin structures indicates that both were affected by the same folding. This folding movement accentuated the structurally high position of the Anakie High.

Bulgonunna Block

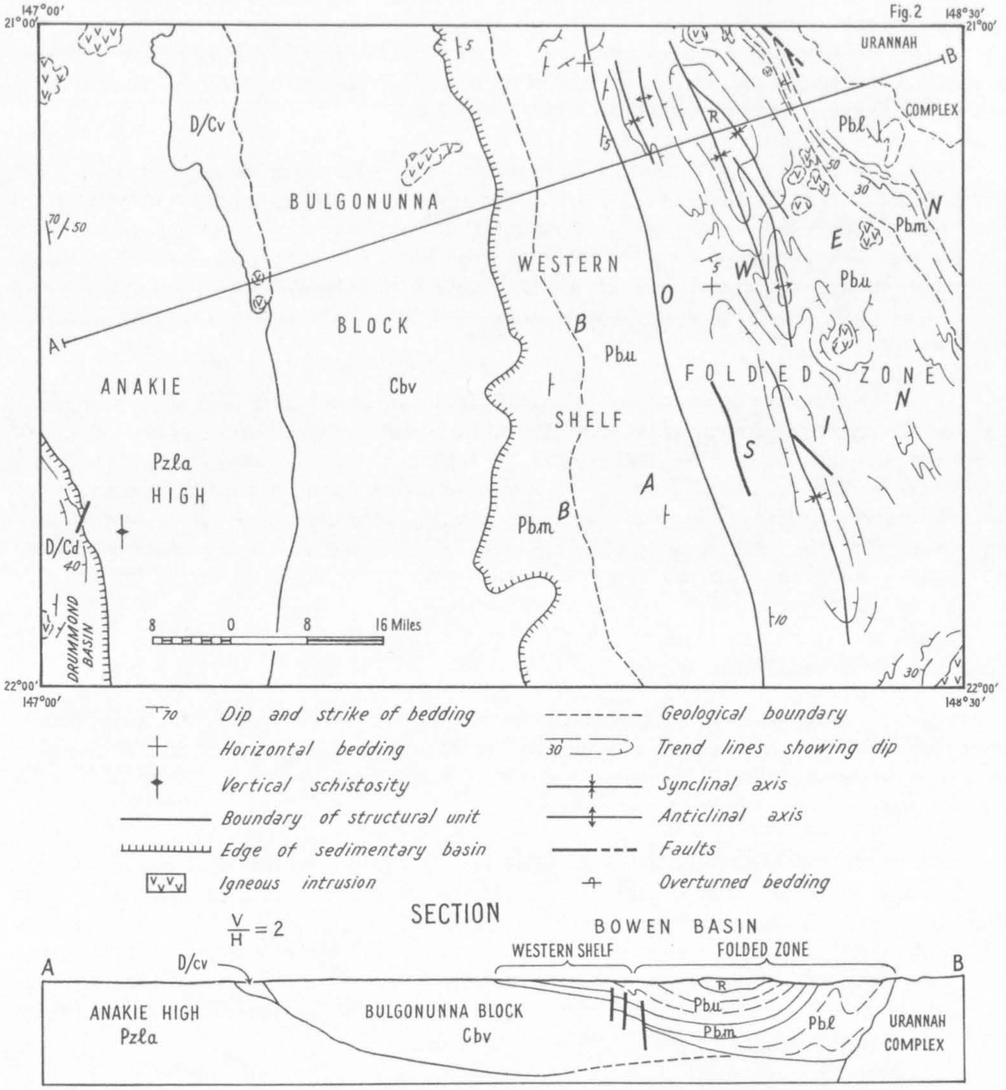
The Bulgonunna Block is a solid block of volcanics welded on to the eastern side of the Anakie High. The volcanics are practically structureless, apart from some sediments near the base of the unit. Mostly they consist of rhyolite lavas with contorted flow banding, massive porphyritic rhyolite bodies, which may be ignimbrites, and complexes of acid intrusive and extrusive rocks. This massive block is the basement of the Bowen Basin, at least on the western side.

Drummond Basin

The Drummond Basin developed west of the Anakie High, and only a small part of it lies within the Mount Coolon area. The structures within the basin trend north-north-west,

STRUCTURAL SKETCH MAP

OF MOUNT COOLON 1 : 250,000 SHEET AREA



Pbu Upper Bowen Coal Measures

Pbm Middle Bowen Beds

Pbl Lower Bowen Volcanics

Cbv Bulgonunna Volcanics

D/Cd Drummond Group

D/Cv Undifferentiated Volcanics

Pzla Anakie Metamorphics

parallel to the Anakie High. The Structures are the result of east-west compression of the basin.

Western shelf of the Bowen Basin

The western shelf of the Bowen Basin is a zone of transgressive overlap of marine Middle Bowen Beds on to a fairly regular surface of Bulgonunna Volcanics. The surface of unconformity slopes eastward at an angle of less than 5^{o}. It is not much steeper now than the slope of the original surface of deposition, indicating that the Bulgonunna Block was virtually unaffected by the folding of the Bowen Basin.

Within the shelf area, the beds generally dip east at angles of 5^{o} or less. Some folding is found near the northern margin of the Sheet; outcrop is poor, but rapid changes of the direction of plunge are obvious and the structures seem to consist of complex shallow domes and basins. The measured slope of the Bulgonunna Block underneath the Bowen Basin must increase greatly to accommodate the great thickness of sediments deposited in the centre of the structure, estimated to be at least 20,000 feet thick in the axial plane of the Redcliffe Syncline.

Faulting is known in the Collinsville area, with a shelf area west of the fault zone and steeply dipping sediments east of it. Possibly, a southern continuation of the same fault zone separates the western shelf area from the folded zone of the Bowen Basin in the Mount Coolon area. The postulated faulting, as shown on Figure 2, affected the Bulgonunna Block near the eastern margin of the shelf area; it was probably active at times during deposition of the sediments. No signs of this faulting were found in outcrop, except for some prominent east-dipping monoclines in the Upper Bowen Coal Measures, situated east of the probable locus of the fault.

Folded zone of the Bowen Basin

The folded zone of the Bowen Basin occupies the eastern part of the Mount Coolon area. It is essentially a synclinorium; the syncline was noted quite early and was responsible for the name Bowen Basin. However, the outcrop of the syncline does not coincide with the limits of the original basin of deposition.

The eastern limb of the synclinorium is outlined by the outcrop of the Middle Bowen Beds in the Stockton-Hillalong area. The limb is extremely persistent and is little affected by minor folding; it is somewhat crumpled south of the Mount Barker Granodiorite. It dips at varying angles, ranging from 30^{o} south-west to vertical, and near Blenheim Homestead is overturned, dipping at about 70^{o} to the east. This overturning is possibly due to the intrusion of the Urannah Complex. The relationship of the Complex to the Lower Bowen Volcanics is not known, but is probably intrusive.

There is some folding east of this limb-at least one anticline is known in the Lower Bowen Volcanics - and fairly intense folding west of it. The latter affects the Upper Bowen Coal Measures, which have been folded into anticlines, synclines, domes, some basins, and a few monoclines. The axes of these folds trend generally north-north-west. The Carborough Sandstone and the Teviot Formation are involved in this folding; they crop out in a number of synclines and at least one anticline. The structures in the Upper Bowen Coal Measures die out quickly, both along and across strike. In particular the structures are seen to die out as they near the contact between the Carborough Sandstone and the Upper Bowen Coal Measures. This is probably due to the more competent nature of the Carborough Sandstone. The tendency of the fold structures to die out up the section is well displayed by the dome and associated folds located south of the Redcliffe Tableland. It seems to be characteristic of the folding of the Upper Bowen Coal Measures and may indicate that folding was partly contemporaneous with deposition.

The cores of several domes are occupied by igneous intrusives, such as the Gotthardt Granodiorite and the Bundarra Granodiorite. The Bundarra dome is the most profound structure in the area; it is the only structure in which Middle Bowen Beds are exposed within the area of outcrop of the Upper Bowen Coal Measures.

A north-north-west trend is prominent throughout these five structural units. Possibly, they represent various stages of a process of continental accretion.

Urannah Complex

The sixth structural unit in the area is the Urannah Complex, which occupies the north-east corner of the Sheet. It is a massive igneous block whose relationship to the Bowen Basin is not known. As mentioned previously, intrusion of these igneous rocks may be responsible for the overturning near Blenheim Homestead. Structures within the unit consist mainly of a system of joints and faults visible on the air photographs. The complex may include some areas of sedimentary or volcanic rocks.

Faulting

Faulting is not common in outcrop, though it may have played an important role in the depositional history of the area. A thrust fault was mapped near the northern margin of the Sheet, north of Blenheim Homestead. Movement on this fault plane has cut off the base of the Middle Bowen Beds, and has thrust Lower Bowen Volcanics over them. This thrusting was probably produced by the same push from the north-east that overturned the eastern limb of the Bowen syncline. A number of other small, apparently unimportant, faults were noted in this area.

The Burton Range is a block of Carborough Sandstone, preserved on the downthrow side of a thrust fault. Other faults were mapped in the Carborough Sandstone. They are mainly normal faults with displacements of 100 feet or less. Similar faults probably cut the Upper Bowen Coal Measures, but are not as well exposed as those in the more competent Carborough Sandstone.

Some faults were mapped around the margin of the Anakie High; one displaces the contact between the Anakie Metamorphics and the Drummond Group in the south-west of the area. The relationship of the Anakie Metamorphics and the Undifferentiated Volcanics suggests that their contact may be faulted near Mount Coolon.

SUMMARY OF GEOLOGICAL HISTORY

The Geological history is summarized in Table 2.

TABLE 2

SUMMARY OF GEOLOGICAL HISTORY

			Rejuvenation of drainage
Widespread lateritization probably continued throughout period	CAINOZOIC	late Tertiary	Widespread depostion of alluvium, soil and sand. Uplift of north-east of area, followed by deposition of river channel and flood-plain deposits.
		Unconformity	
		Tertiary	Deposition of Exevale Formation, basalt flows, and Suttor Formation, with some disconformities.
		Unconformity	
		?Triassic	Intrusion and folding, followed by long period of erosion.
		Mid-Triassic	) Deposition of Carborough Sandstone and) Teviot Formation.
		Lower Triassic	))
Shallowing of Bowen Basin and development of estuarine conditions.		Upper Permian	) Deposition of Upper Bowen Coal) Measures.
(Middle Bowen Beds transgress Bulgonunna Volcanics to west. ((		Top of Lower Permian	)) Deposition of Middle Bowen Beds)
		Disconformity	?Short erosional break
		About base of Permian	Development of Bowen Basin, followed by deposition of Lower Bowen Volcanics.
		Unconformity	
		Carboniferous	Deposition of Bulgonunna Volcanics, with contemporaneous and subsequent intrusion, and some folding.
		Unconformity	
Deposition of Drummond Group west of Anakie High.		Devonian - Carboniferous	Deposition of volcanics east of Anakie High
		Upper Devonian	Deposition of Mount Wyatt Beds.
Development of Anakie High separating Drummond Basin from eastern depositional area.		Middle Devonian and older ?	Deposition and folding of Anakie Metamorphics, with intrusions.

ECONOMIC GEOLOGY

Minerals

The Mount Coolon Sheet area has not been an important mineral producer. The only mine of any size is the Mount Coolon gold mine in the north-west, described by Morton (1935). The gold was won from a single lode system contained in a local development of andesites within the Undifferentiated Volcanics. The lode consisted of siliceous rock, developed adjacent to a shear in the andesites; away from the shear the siliceous lode graded into silicified andesite. It was apparently an end-product of silicification of the andesite. The lode averaged 7 feet in width and could be traced for half a mile. Gold was bound up with pyrite mineralization and was largely confined to the siliceous lode. The source of the silicification and mineralization is thought to be a quartz diorite mass which intrudes the andesites and the Anakie Metamorphics to the west.

The lode was discovered in 1913 and was first worked the following year. Operations ceased in February 1939. The total production of gold was about 197,500 oz. Approximately 60,000 oz. of silver were produced after 1930; silver production before 1930 is not recorded.

In 1937-38, the Aerial, Geological and Geophysical Survey of Northern Australia made a geophysical survey of a small area extending south-east from the Mount Coolon mine (Oakes, Rayner, & Nye, 1941). This survey used mainly the potential ratio method to search for siliceous lodes in the andesite country rock. Ten zones of low electrical conductivity, probably representing siliceous lodes, were recognized in an area covered by alluvium. The three most interesting zones were tested, but the results were disappointing. No further testing was recommended because of these disappointing results, and because the zones of low conductivity were short and any oreshoots within them would be even shorter.

Other mines in the area have produced little. The Mount Barker silver-lead mine, north of the Mount Barker Granodiorite, was first opened in the 1930's when a few small parcels of ore were sent to Chillagoe for treatment. It was reopened in 1947, and in the following two years produced about 4000 oz of silver and 70 tons of lead. A diamond drilling programme was commenced in 1950 to test the lode; the drilling was only partly successful and the operation was abandoned. The mine has been closed since and is falling into disrepair.

The Lady Norman mine is a group of shafts and pits south of Eungella, near the eastern edge of the Sheet area. A few parcels of gold ore were won from them in the 1930's but they have been abandoned since.

Part of the Mount Flora Gold and Mineral Field lies within the south-east corner of the Mount Coolon area. This field produced small quantities of copper, silver, and gold in the early part of this century (Ball, 1910). The mineralization was mainly found in shears or joints in metamorphosed sediments around the Bundarra Granodiorite. The joints are usually at right angles to the granodiorite-sediment contact. They persist into the granodiorite for some distance, but usually are poorly mineralized in the granodiorite.

Water

Many bores have been drilled; most are reported to produce about 1000 gallons an hour or more of sub-artesian water. However, the available records are poor; neither the total number of bores drilled nor the proportion of successful bores to failures is known.

All the bores sunk through the large sheets of basalt are reported to be successful, producing good quantities of water from immediately below the basalt. Some bores drilled in the Upper Bowen Coal Measures are good producers; others are very poor. Good production is commonly obtained from the vicinity of coal seams. Obviously, there are aquifers in the Upper Bowen Coal Measures, but their location would be hard to predict.

The Middle Bowen Beds on the western side of the Bowen Basin may contain good aquifers. They dip under the Upper Bowen Coal Measures and in most places would be too deep to be economic.

The Lower Bowen Volcanics, the Bulgonunna Volcanics, and the Anakie Metamorphics have little potential as underground water producers. Many of the station owners and managers in the area prefer to erect earth dams and tanks to collect surface water rather than sink bores. The rainfall in the area ranges from 20 to 30 inches per year; it falls mainly during the four or five months of the wet season, but some falls during the winter. Thus, the dependence on underground water is not as great as in drier areas farther west. Supplementary water is obtained from spears sunk in the sandy beds of many of the larger watercourses. These spears may be temporarily pumped dry at a fast rate of production, but they usually recover if left for a short time.

Coal

At least 25 separate occurrences of coal are reported, but most are relatively unimportant. The two most promising occurrences are immediately south-east of the abandoned Lake Elphinstone Homestead, and a few miles farther south-east, at the head of Kemmis Creek. The coal seams at these localities were tested by a drilling programme during the years 1948 to 1951. This was begun by the Power and Traction Co. Ltd, represented by Powell Duffryn Technical Services Ltd (1949). They drilled 18 holes in the Lake Elphinstone area and 5 holes in the Kemmis Creek area. A further 7 holes were drilled and a test shaft was sunk in the Kemmis Creek area by the Queensland Department of Mines to complete the project. The results are presented by Shepherd (1951).

In the Lake Elphinstone area, drilling proved 16 million tons of coal under an area of about 900 acres. The overburden ranged from a minimum of 25 feet, to avoid weathered coal, to a maximum of 150 feet. The coal seam averaged 14 feet in thickness.

In the Kemmis Creek area, approximately 7 million tons of coal were proved in a narrow strip of 265 acres, between the 25 feet and 150 feet depth-of-overburden contours. The thickness of the coal seam ranged from 32 feet to 22 feet, with an average of 25 feet. A test shaft was sunk in this area. It intersected 31 feet 9 inches of coal under 42 feet of overburden. The top 5 feet of coal was slightly weathered; it contained 9.9 percent moisture at 105°C as compared to 1.5 percent for the remaining 26 feet 9 inches of coal.

Further prospecting and some drilling has been done south and east of these prospects, and the work has indicated some interesting areas.

Oil

Potential source beds are present in the thick section of marine Middle Bowen Beds cropping out in the north-east of the area. The quartz sandstone of the Middle Bowen

Beds on the western side of the basin may contain potential reservoir beds. Many igneous bodies intrude the sequence and reduce its attractiveness for oil prospecting. However, no large intrusions are known west of the Redcliffe Tableland or the Kerlong Range. This area, particularly the eastern edge of the western shelf, may be worth prospecting. Some geophysical data on the shape of the basement to the Bowen Basin would be required as a first step.

BIBLIOGRAPHY

BALL, L.C., 1910 - Field notes on the Mount Flora Gold and Mineral Field. Publ.geol.Surv.Qld, 228.

BRYAN, W.H., and JONES, O.A., 1946 - The fauna of the Permo-Carboniferous Ingelara beds of Queensland. Pap.Univ.Qld Dep.Geol., 4 (3).

DAINTREE, R., 1872 - The geology of the colony of Queensland. Quart.J.geol.Soc.Lond.,28,271-317.

DAVID, T.W.E., 1930 - Permo-Carboniferous correlation. Rep.Aust.Ass.Adv.Sci., 20, 62-76

DAVID, T.W.E., (ed. W.R. Browne), 1950 - THE GEOLOGY OF THE COMMONWEALTH OF AUSTRALIA. London, Arnold.

ETHERIDGE, R. (Snr), 1872 - Description of the Palaeozoic and Mesozoic fossils of Queensland. Quart. J.geol.Soc.Lond., 28, 317-350.

ETHERIDGE, R. (Jnr), 1880 - Fossils from the Bowen River Coalfields. Proc.Roy.Phys.Soc.Edinb., 5,263-328.

FEISTMANTEL, O., 1890 - Geological and palaeontological relation of coal and plant bearing beds of Palaeozoic and Mesozoic age in Eastern Australia and Tasmania. Mem.geol.Surv.N.S.W., Palaeont. 3.

GEOLOGICAL SURVEY OF QUEENSLAND, 1953 - GEOLOGICAL MAP OF QUEENSLAND. Brisbane, Dept of Mines.

HILL, D., 1943 - A re-interpretation of the Australian Palaeozoic record based on a study of rugose corals. Proc.Roy.Soc.Qld, 54, 53-66.

HILL, D., 1951 - The geology of Queensland. Handbook Aust.Ass.Adv.Sci., Brisbane, 13-24.

HILL, D., 1954 - Contributions to the correlation and faula of the Permian in Australia/New Zealand J.geol.Soc.Aust., 2.

HILL, D., 1957 - Explanatory notes on the Springsure four-mile Sheet. Bur.Min.Resour.Aust.explan.Notes 5.

HILL, D., and DENMEAD, A.K., (eds) 1960 - The geology of Queensland. J.geol.Soc.Aust.,7.

ISBELL, R.F., 1955 - The geology of the northern section of the Bowen Basin. Pap.Univ.Qld Dep.Geol., 4.

JACK, R.L., 1879 - On the Bowen River Coalfield. Publ.geol.Surv.Qld, 4

JACK, R.L., and ETHERIDGE, R. (jun.), 1892 - The geology and palaeontology of Queensland and New Guinea. Ibid., 92.

JENSEN, H.I., 1921a- Geology of the Mount Coolon District. Qld Govt Min.J., 22, 491-495.

JENSEN, H.I., 1921b- The geology and mineral resources of the Carnarvon district. Ibid., 22, 401-407.

JENSEN, H.I., 1923 - Some notes on Permo-Carboniferous and overlying systems in central Queensland. Proc. Linn.Soc. N.S.W., 48, 153-158.

JENSEN, H.I., 1925 Palaeogeography of Queensland. Qld Govt Min. J., 25-26, 379, 422, 459.

JENSEN, H.I., 1926 - Oil possibilities in Queensland. Ibid., 27, 12, 48.

LAING, A.C., 1959 - Reconnaissance geology of the northern section of the Bowen Basin and the Styx Basin. Assoc.Freney Oil Fields, Unpub. Rep. Q/56P/63.

MAITLAND, A.G., 1889 - Geological observations at the head of the Isaacs River. Publ.geol.Surv.Qld, 54.

MORTON, C.C., 1935 - The Mount Coolon Goldfield. Qld Govt Min.J., 36, 196, 232.

OAKES, B.P., RAYNER, J.M., and NYE, P.B., 1941 - Geophysical report on the area south-east of Mount Coolon gold mine. Aer.Surv.N.Aust.,Qld Rep. 36.

POWELL DUFFRYN TECHNICAL SERVICES, 1949 - First reports on the Coal Industry of Queensland. 3 Vols. Qld parl.Pap.A 16-1949.

REID, J.H., 1924 - Geology of the Bowen River Coalfield. Qld Govt Min. J., 25, 399, 447.

REID, J.H., 1925 - Permo-Carboniferous Coal Measures, etc., of the Nebo District. Ibid.,26, 465-474.

REID, J.H., 1928 - The Isaacs River Permo-Carboniferous Coal Basin. Western Portion. Ibid., 29, 192, 236, 282.

REID, J.H., 1930(a)- The Queensland Upper Palaeozoic succession. Publ. geol. Surv. Qld, 278.

REID, J.H., 1931 - Correlations of Queensland. Permo-Carboniferous Basin. Proc.Roy.Soc.Qld, 43, 56-65.

REID, J.H., 1946 - Geological reconnaissance of the Nebo District Coal Areas. Qld Govt Min.J., 47, 10.

REID, J.H. and MORTON, C.C., 1928 - Central Queensland geological section. Ibid., 29, 384, 441.

SHELL (QLD) DEVELOPMENT PTY LTD, 1952 - General report on investigations and operations carried out by Shell in Queensland, 1940-1951. Unpubl. Report.

SHEPHERD, S.R.L., 1951 - Test drilling of Nebo Coalfield. Qld Govt Min.J., 52, 51-61.

VEEVERS, J.J., RANDAL, M.A., MOLLAN, R.G., and PATEN, R.J., 1964 - The geology of the Clermont 1:250,000 Sheet area. Bur.Min.Resour.Aust.Rep. 66.

WALKOM, A.B., 1922 - Palaeozoic floras of Queensland. Part I. Publ.geol. Surv. Qld, 270.

WEBB, E.A., 1956 - Review of exploratory oil wells penetrating Permian sections in Central Queensland, Australia. Bull.Amer. Ass.Petrol.Geol., 40, 10.

WHITEHOUSE, F.W., 1928 - Report on Permo-Carboniferous fossils collected by J.H. Reid and J.R.T. Dunlop in the Isaacs River districts, North of Clermont. Qld Govt Min.J., 29, 285-286.

WHITEHOUSE, F.W., 1930 - The geology of Queensland. Handbook Aust. Ass. Adv. Sci., Brisbane.

WHITEHOUSE, F.W., 1940 - Studies in the late geological history of Queensland. Pap.Univ.Qld Dep.Geol., 2 (1).

APPENDIX 1

PERMIAN MACROFOSSILS FROM HOMEVALE AND FROM THE MOUNT COOLON 1:250,000 SHEET AREA

by

J.M. Dickins

INTRODUCTION

The identifications presented are based mainly on special collections made towards the end of the 1960 field season by J.J. Veevers and the author working with the Mount Coolon Field Party. These collections were made with the intention of obtaining material from localities where fossils were best represented and from localities which had stratigraphic significance. Some material was collected by members of the field party.

The pelecypods and gastropods are identified, where possible, at the specific level. Most brachiopods are identified at the generic level. K.S.W. Campbell of the Australian National University has examined some of the martiniopsids and is working on the dielasmatids. The other fossils are listed without generic or specific identification.

Homevale is not on the Mount Coolon 1:250,000 Sheet, but fossils have been collected there for reference purposes.

FAUNAL SUBDIVISIONS AND CORRELATIONS

Four stratigraphically discrete faunas are found. The lowest fauna (Fauna I) is found at only one locality in the upper part of the Lower Bowen Volcanics. The next fauna (Fauna II) is widespread and occurs at seven localities in the bottom part of the Middle Bowen Beds on the east side of the Bowen Basin overlying the Lower Bowen Volcanics. This fauna is also found in the Beds at Homevale. Fauna III is separated from Fauna II by about 1000 feet of barren sediment. It is represented by collections from two localities, one of which immediately underlies the 'Wall Sandstone'. The fourth and highest fauna (Fauna IV) is represented by nine localities. About 1500 feet of strata, from which no fossils were collected, separates it from Fauna III. Fauna IV extends over about 2000 feet of strata to the top of the Middle Bowen Beds (from MC802FI to MC292Fa & b in Plate 3 of main report).

Fauna I (in top part of Lower Bowen Volcanics).

Of the identifiable species, all except three are found in the overlying fauna: *Pachymyonia* cf. *etheridgei*, *Aviculopecten* sp., and a species of *Notospirifer*. *Aviculopecten* sp. shows a less advanced type of ribbing than found in *A.* sp. nov. from the overlying beds and *P. etheridgei* is found in the Dalwood Group (Lower Marine beds) of New South Wales. Although no definite conclusion is possible, these three species suggest that Fauna I is significantly, although only slightly, older than Fauna II. The affinities of Fauna I seem to be with the Dalwood Group (Lower Marine) of New South Wales.

Fauna II (in lower part of Middle Bowen Beds).

This fauna occurs in many places in the lower parts of the Middle Bowen marine sequence. In one place at least (MC657F) it is associated with coarse, pebbly, sandy sediment.

Few of the species are found in the higher faunas.

It is characterized by Eurydesma, Deltopecten, Taeniothaerus, Anidanthus, and Neospirifer (Grantonia), which do not occur in higher beds. Other forms not found higher include species of Parallelodon, Astartila, Trigonotreta, Terrakea, and Strophalosia.

The fauna resembles that near the base of the marine sequence near Cracow Homestead, the Productinae of which have been described by Hill (1950). The fauna in the Cattle Creek Formation (in outcrop) of the Springsure area is also similar. Eurydesma, Anidanthus, and Taeniothaerus occur in both. Campbell (pers.comm.), based on his study of the martiniopsids, considers that Fauna II is slightly older than that of the Cattle Creek Formation.

The fauna appears to contain species related or identical to forms found in both the Dalwood and Maitland Groups (Lower and Upper Marine) of New South Wales.

Pseudomyalina mingenewensis is found in the Byro Group of the Carnarvon Basin of Western Australia and the discovery of a similar, or the same, species in these beds is confirmatory evidence for the suggestion that the Cattle Creek Formation in outcrop may be of early Artinskian rather than Sakmarian age (Dickins, 1961).

Fauna III (in middle part of Middle Bowen Beds)

This rather small fauna is characterized by Glyptoleda, Platyteichum, Stutchburia cf. costata, a species of Pachymyonia or Myonia, and Ingelarella. The species of Glyptoleda and Platyteichum seem indistinguishable from those that occur in the Ingelara Shale of the Springsure area. Campbell (pers. comm.) considers that the martiniopsids may be intermediate between those of the Cattle Creek and the Ingelara localities.

Stutchburia cf. costata, Pachymyonia or Myonia sp., and Mourlonopsis cf. strezleckiana indicate correlation with the Maitland Group (Upper Marine) of New South Wales.

Prof. B.F. Glenister of the State University, Iowa (in a letter) has identified a single ammonite from MC 420F as Neocrimites cf. fredericksi (Emeliancev). He considers that it is not of early Artinskian age, that 'the probabilities are slightly in favour of a Baigendzhinian age (Upper Artinskian age - J.M.D.) but Guadalupian is almost equally plausible'.

Fauna IV (top part of Middle Bowen Beds)

This fauna has distinctive species of Parallelodon, Myonia, Schizodus, Terrakea, Strophalosia, Neospirifer, Trigonotreta, and Ingelarella. It is distinguished also by 'Solemya' edelfelti, Walnichollsia subcancellata, and a species of an apparently unnamed astartid genus. Detailed stratigraphical subdivision of this fauna is not attempted.

The discovery of a species similar to Glyptoleda reidi of the Ingelara Shale may appear anomalous but it probably indicates that Glyptoleda has a longer range than had previously seemed likely.

Fauna IV is the marine fauna found in the Middle Bowen Beds in the Clermont area, on the west side of the Basin on the Mount Coolon 1:250,000 Sheet (MC311F) in beds overlying the Carboniferous Bulgonunna Volcanics, and in the Collinsville area overlying the Collinsville Coal Measures. For example all the ten identifiable species of pelecypods and gastropods from MC423Fa, except possibly Aviculopecten sp., are found at CL12/1, which immediately overlies the clarkei Bed in the Mount Lebanon area on the Clermont 1:250,000 Sheet (for CL12/1 see Dickins in Veevers, Randal, Mollan, & Paten, 1964).

This fauna is also found in the Flat Top Formation of the Banana area (identifications in Dickins, 1959). It is not older than the Ingelara Shale of the Springsure area and could be entirely younger. The Mantuan Productus Bed is equivalent to some part of the beds with Fauna IV, but its exact relationship is, at present, not clear. Beds with Fauna IV appear to be equivalent to the upper part of the Maitland Group (Upper Marine) of New South Wales.

The pelecypod fauna at MC423Fa, mentioned above, suggests deposition in deeper water than at CL12/1 in the Clermont area. This is discussed in more detail in the report on the fossils of the Clermont area (Dickins, in Veevers et al., 1964).

GENERAL FEATURES OF THE PELECYPOD AND GASTROPOD FAUNAS

The faunas identified lack the diversity found in the Permian of New South Wales. Part, at least, of this could be explained by the absence in marine beds of the equivalents of the lower part of the Dalwood Group (Lower Marine). Faunas equivalent to the Lochinvar and Allandale Formation of the Hunter Valley appear to be absent. This may explain the failure to find Eurydesma cordatum Morris, 1845 and Deltopecten illawarensis (Morris), 1845 or D. mitchelli (Etheridge & Dun), 1906, which are especially characteristic of the Dalwood Group. The more complex Deltopecten forms such as D. squamuliferus (Morris), 1845 and D. multicostatus (Fletcher), 1930 may also be absent - a feature more difficult to explain.

IDENTIFICATIONS

Fauna I

MC479F - 3/4 mile north-west of the Turrawalla/Eungella road crossing of Hazlewood Creek.

Pelecypods

- Astartila cf. gryphoides (de Koninck), 1877 (some specimens are similar to Megadesmus nobilissimus)
- Pachymyonia cf. etheridgei Dun, 1932
- Myonia cf. davidis Dun, 1932
- Chaenomya sp.
- Eurydesma hobartense (Johnston), 1887
- Merismopteria sp.
- Deltopecten cf. limaeformis (two poorly preserved specimens)
- Aviculopecten sp. (large specimen with simple type of ribbing)
- Streblopteria sp. ind.
- Cypricardinia? sp. ind.

Gastropods

- Warthia sp.

Brachiopods
- Terrakea
- Ingelarella
- Notospirifer

Crinoid Ossicles

Fauna II

Homevale - ridge just east of Homestead (details of the beds at Homevale are given by Campbell & Tweedale, 1960).

Pelecypods
- Nuculopsis (Nuculanella) sp.
- Parallelodon sp. ind.
- Astartila cf. gryphoides (de Koninck), 1877
- Myonia cf. davidis Dun, 1932
- Chaenomya sp. ind.
- Pseudomyalina cf. mingenewensis (Etheridge Jnr.), 1907
- Modiolus sp.
- Eurydesma hobartense (Johnston)
- Deltopecten limaeformis (Morris), 1845
- Deltopecten sp. (small biconvex shell with distinct primary and intermediate ribs)
- Aviculopecten sp. nov. (advanced A. subquinquelineatus type)
- Streblopteria cf. englehardti (Etheridge & Dun), 1906 (radiating ribs on right anterior ear and very faint radiating ribs on body, rather opisthocline).
- Stutchburia cf. randsi (Etheridge Jnr), 1892 (radial ribbing only on middle part of shell)
- Cypricardinia? sp.

Eurydesma does not occur in the topmost of the beds of Homevale.

Brachiopods
- (Ingelarella and Notospirifer from this locality are described and discussed by Campbell (1961)).
- Terrakea
- Cancrinella
- Anidanthus
- Strophalosia
- Taeniothaerus
- Lissochonetes
- Neospirifer
- Trigonotreta
- Ingelarella
- Notospirifer
- Pseudosyrinx?
- Rhynchonellids
- Dielasmatids
- An inarticulate brachiopod

Bryozoans
- Fenestellids

Straight Nautiloid

MC 421F - 3 miles east of Nebo-Collinsville road crossing of Bowen River, on Bowen 1:250,000 Sheet area.

Pelecypods
- Aviculopecten sp. nov.

Brachiopods
- Terrakea
- Anidanthus?
- Lissochonetes
- Ingelarella
- Pseudosyrinx?

MC 484F - west bank of Hazelwood Creek, about 1 1/4miles upstream from Turrawalla/ Eungella road.

Brachiopods
- Ingelarella

MC 485F - 1 1/2 miles upstream from Turrawalla/Eungella road crossing of Hazelwood Creek.

Pelecypods
- Parallelodon sp. nov. A
- Astartila cf. gryphoides (de Koninck), 1877
- Myonia cf. davidis Dun, 1932
- Merismopteria sp. ind.
- Eurydesma hobartense (Johnston), 1887
- Deltopecten limaeformis (Morris), 1845
- Aviculopecten sp. nov.
- Streblochondria? sp. (close fine ribbing)
- Stutchburia cf. randsi (Etheridge Jnr), 1892
- Cypricardinia? sp. (cf. C? gregarius (Etheridge Jnr.)
- Cypricardinia? sp. (strong radial ribbing, (1900) perhaps different to C ? sp. above).

Gastropods
- Warthia sp.
- Indet. Mourlonia-like gastropod

Conulariids
- Indet. fragment

Brachiopods
- Terrakea
- Cancrinella
- Anidanthus?
- Strophalosia
- Taeniothaerus
- Neospirifer
- Trigonotreta

Ingelarella
Dielasmatids
Streptorynchus sp. ind.

Bryozoans

Fenestellids

Crinoid Ossicles

Conulariids

Form with vertical ornament

MC 657F - 2 miles west of junction of Blenheim/Eungella road and Blenheim/Lizzie Creek road.

Pelecypods

Parallelodon sp. ind.
Eurydesma hobartense (Johnston), 1887
Deltopecten limaeformis (Morris), 1845
Aviculopecten sp. ind.
Cypricardinia? sp. (may be different from species at Homevale)

Brachiopods

Terrakea
Cancrinella
Strophalosia
Taeniothaerus
Neospirifer
Trigonotreta

Bryozoans

Cylindrical branching forms

Crinoid Ossicles

MC 878F - 5 miles east-south-east of Turrawalla/Eungella road crossing of Hazelwood Creek.

Pelecypods

Aviculopecten sp. nov.

Brachiopods

Taeniothaerus
Trigonotreta

Ingelarella

MC 1065F - in Creek 1 1/2 miles north-north-west of Blenheim Homestead.

Pelecypods

Megadesmus? cf. nobilissimus (de Koninck) 1877 (may be a variant of A. gryphoides).

Brachiopods

Terrakea
Anidanthus
Strophalosia
Taeniothaerus
Lissochonetes
Neospirifer (Grantonia) cf. hobartense (Brown), 1953.
Trigonotreta (close to T. stokesii of Brown, 1953)
Dielasmatids

MC 1414F - in Creek 1 1/2 miles north-north-west of Blenheim Homestead.

Brachiopods

Anidanthus
Strophalosia
Lissochonetes
Trigonotreta
Ingelarella

Fauna III

MC 420F - 2 1/2 miles east of Nebo-Collinsville road crossing of Bowen River, on Bowen 1:250,000 Sheet area.

Ammonites

Neocrimites cf. fredericksi (Emeliancev), 1929 (identified by B.F. Glenister).

Pelecypods

Glyptoleda cf. reidi Fletcher, 1945.
Pachymyonia or Myonia sp. (differs from Homevale type, possibly similar to species occurring higher in sequence.)
Chaenomya sp.
Atomodesma cf. mytiloides Beyrich, 1864.
Pseudomonotis? sp. nov. (small gryphoid, spiny shell)
Stutchburia cf. costata (Morris), 1845 (ribbing over middle and back part of shell)

Gastropods

Warthia sp.

Mourlonia (Mourlonopsis) cf. strzeleckiana (Morris), 1845
Mourlonia (Platyteichum) cf. costatum Campbell, 1953 (small but hardly distinguishable from P. costatum)

Conulariids

Small form without vertical ornament

Brachiopods

Terrakea
Ingelarella

MC 669F - in creek 2 miles north-north-east of Turrawalla Homestead.

Gastropods

Platyteichum? sp. ind.

Brachiopods

Ingelarella

Fauna IV

MC 292Fa - at Collinsville road crossing of Blenheim Creek.

Brachiopods

Ingelarella

MC 293F.- 400 yards down creek from Blenheim Homestead

Brachiopods

Terrakea
Neospirifer
Trigonotreta
Ingelarella
Plekonella?

Bryozoans

Fenestellids and cylindrical branching forms.

MC 311F - alongside Nebo/Mount Coolon road, 11 miles west-south-west of Dabin Homestead.

Pelecypods

Schizodus sp. nov.

Brachiopods

Strophalosia ovalis Maxwell, 1954
Terrakea solida (Etheridge & Dun), 1909.

Bryozoans

Fenestellids

Blastoids or Crinoids

Plates

MC 423Fa - about 2 1/2 miles east of junction of Sandy Creek and Bowen River.

Pelecypods

Parallelodon sp. nov. B (well developed radial ornament)
Myonia cf. carinata (Morris), 1845
'Solemya' edelfelti (Etheridge Jnr), 1892
Aviculopecten sp. (possibly different from A. sp. nov. Appears to lack spines on main ribs and has many intermediate ribs, cf. species from Wandagee Formation, of the Carnarvon Basin, W.A.)
Streblopteria sp. ind.
Stutchburia cf. costata (Morris), 1845.
Stutchburia cf. compressa (Morris), 1845
Schizodus sp. nov.
Astartidae gen. et sp. nov. (has radiating ribs and regularly spaced concentric lamellae)

Gastropods

Mourlonia (Mourlonopsis) cf. strzeleckiana (Morris), 1845
Peruvispira sp.? (whorls sharp at slit-band)
Walnichollsia subcancellata (Morris), 1845

Conulariids

Smooth form without vertical ornament

Brachiopods

Terrakea
Strophalosia
Neospirifer
Cleiothyridina
Ingelarella
Pseudosyrinx
Plekonella?
Dielasmatids

Bryozoans

Fenestellids

Crinoid Ossicles

This locality has pebbles up to 1 1/2" across.

MC 423Fb - as for 423Fa, stratigraphically a few feet above.

Pelecypods

Nuculana sp.
Merismopteria sp.
Aviculopecten sp. ind.
Astartidae gen. et sp. nov.

Gastropods

Mourlonia (Mourlonopsis) cf. strzeleckiana (Morris), 1845

MC 553F - Creek crossing on Elphinstone/Homevale road, 1/4 mile before junction with Nebo/Collinsville road.

Brachiopods

Terrakea
Strophalosia cf. clarkei (Etheridge Snr), 1872

Bryozoans

Cylindrical branching forms

MC 575F - immediately west of foot of Mount Cona in small creek.

Corals

Cladochonus

MC 802 IF - 2 3/4 miles north-north-west of Bleinheim Homestead

Brachiopods

Strophalosia clarkei (Etheridge Snr), 1872
S. cf. brittoni var. gattoni Maxwell, 1954

MC 803F - 2 1/2 miles north-north-west of Blenheim Homestead

Pelecypods

Nuculopsis (Nuculopsis) sp. nov.
Nuculopsis (Nuculanella) sp.

Glyptoleda cf. reidi Fletcher, 1945
Astartidae gen. et sp. nov.

Gastropods

Warthia sp.
Indet. mourloniid

Brachiopods

Terrakea
Strophalosia cf. brittoni var. gattoni Maxwell, 1954.
Ingelarella

Bryozoans

Fenestellids and cylindrical branching forms.

MC 957F - 1 mile north of Mount Cona in small creek.

Brachiopods

Productid spines
Strophalosia sp?
Ingelarella

Bryozoans

Fenestellids and cylindrical branching forms

Crinoids

Stems

REFERENCES

CAMPBELL, K.S.W., 1961 - New species of the Permian Spiriferoids Ingelarella and Notospirifer from Queensland, and their stratigraphic implications. Palaeontographica, 17 (A), 159-192.

CAMPBELL, K.S.W., and TWEEDALE, G.W., 1960 - The Middle Bowen of the Homevale Area, North of Nebo, in The Geology of Queensland. J.geol.Soc. Aust., 7, 199-201.

DICKINS, J.M., 1959 - Permian pelecypods and gastropods from the Bowen Basin, Queensland. Bur. Min. Resour. Aust. Rec. 1959/100 (unpubl.).

DICKINS, J.M., 1961 - Permian pelecypods newly recorded from Eastern Australia. Palaeontology, 4(1), 119-130.

HILL, DOROTHY, 1950 - The Productinae of the Artinskian Cracow Fauna of Queensland. Pap. Univ. Qld Dep. Geol., 3(2).

VEEVERS, J.J., RANDAL, M.A., MOLLAN, R.G., and PATEN, R.J., 1964 - The geology of the Clermont 1:250,000 Sheet area. Bur. Min. Resour. Aust. Rep. 66.

APPENDIX 2

PLANT FOSSILS FROM THE MOUNT COOLON AND THE BUCHANAN 1:250,000 SHEET AREAS

by

Mary E. White

CONTENTS

PLATES

CONTENTS (Cont'd)

SUMMARY

Plant fossil specimens collected in the Bowen Basin in 1960 by field parties in the Mount Coolon area are described and representative specimens are illustrated. Age determinations of fossil horizons are made wherever the plant fossils are diagnostic.

A Devonian Protolepidodendron and Psilophytites flora occurs in the Mount Wyatt Beds and a Devonian to Lower Carboniferous lepidodendroid flora in the Drummond Group. Lower Bowen sediments are poorly represented. Very large collections of Upper Bowen specimens yielded fertile material of Glossopteris angustifolia Bgt. of exceptional evolutionary interest, and excellently preserved material of Phyllotheca australis Bgt. and P. robusta Fm. Triassic plants are identified in the Teviot Formation and a dicotyledonous leaf of probable Tertiary age was collected from the Suttor Formation.

INTRODUCTION

Large numbers of plant fossil specimens were collected in the Bowen Basin in 1960 by field parties in the Mount Coolon and Clermont 1:250,000 Sheet areas. The collections from the Mount Coolon area, and from part of the adjoining Buchanan area, are described here and representative specimens are illustrated; descriptions of the Clermont collections were made in White (1961)*.

MOUNT WYATT BEDS

MC81F

Locality: Mount Harry Marsh 1-mile area, at Rosetta Creek crossing of the Mount Coolon/Ukalunda road.

Collector: E.J. Malone.

A large number of lepidodendroid fossils are associated with branching Psilophytalean axes of the sort referred to the form genus Psilophytites (Plate 1, Figure 1).

The lepidodendroid material is mainly in the form of impressions of decorticated stems and there are some casts of small stems. A large cone- Lepidostrobus - is sufficiently well preserved for some detail of structure to be seen (Plate 1, Figure 2). Tests for spores, carried out by P.R. Evans on the powdery film on the surface of this cone, were negative. This cone is superficially indistinguishable from a cone of Lepidodendron cf. L. aculeatum from undifferentiated volcanics on the Clermont 1:250,000 Sheet (CL 134). There is no previous record of cones with Protolepidodendron.

None of the stem impressions shows features diagnostic of Lepidodendron. The few showing surface features are referable to Protolepidodendron. There is no horizontal ridge separating each leaf base from the one below, and the leaf bases are arranged in vertical lines as well as ascending spirals. Plate 2, Figure 1 shows a surface impression of a medium-sized stem. The pattern of leaf bases with very little relief is different from patterns occurring at any decortication level in a Lepidodendron. An impression of a larger stem, slightly

---

* Reference :

WHITE, MARY E., 1961 - Report on 1960 Plant Fossil Collections from the Bowen Basin, Qld. Bur. Min. Resour. Aust. Rec. 1961/60 (unpubl.).

decorticated, is seen in Plate 2, Figure 2. The arrangement of leaf bases is again in straight vertical lines and an ascending spiral, and is consistent with characteristics of a decorticated Protolepidodendron. A decorticated form of this sort on its own could not be safely distinguished from decorticated Lepidodendron.

Stigmaria ficoides Bgt., presumably in this instance the root system of the Protolepidodendron, occurs in some of the specimens (Plate 1, Figure 2, top right).

A species of Protolepidodendron, P. yalwalense described by Walkom (1928) in Upper Devonian rocks at Yalwal in N.S.W., is very similar to the material under discussion, which is therefore referred to that species.

Age of the specimens:

The association of Protolepidodendron yalwalense Walk. and Psilophytites sp. is believed to indicate a Devonian age (probably Upper Devonian).

DRUMMOND GROUP

MC886F

Locality: Buchanan 1:250,000 area - 20 yards north of the St. Ann's/Yacamunda road 100 yards north-east of the Suttor River crossing, close to the unconformity between Drummond Group and Anakie Metamorphics.

Collector: E.J. Malone.

The impressions in these specimens are of decorticated Lepidodendroid stems and two small Calamite stems. Plate 3, Figure 1 shows a stem which is only slightly decorticated and referable to Protolepidodendron. It is similar to P. lineare Walk. None of the other stem impressions are determinate, and the Stigmaria ficoides present does not determine whether they are Lepidodendron or Protolepidodendron.

The determination of Protolepidodendron lineare Walk. from one determinate specimen is not very reliable in view of the confusingly similar decortication forms in the Lycopodiales, but the specimen shows features not typical of Lepidodendron. The evidence for generic identification is fairly reliable, but the species identification may be in doubt.

Age of the specimens: Devonian.

Reference and Selected Bibliography for MC81F and MC886F.

HIRMER, M., 1927 - HANDBUCH DER PALÄOBOTANIK. Munich and Berlin, R. Oldenbourg.

HOEG, O.A., 1952 - Psilophytites, a new form genus of Devonian plants. Palaeobotanist, 1, 212-214.

SEWARD, A.C. 1910 - FOSSIL PLANTS II. Cambridge, The University Press.

WALKOM, A.B., 1928 - Lepidodendroid remains from Yalwal, N.S.W. Proc. Linn. Soc. N.S.W. 53, 3;310-314.

LOWER BOWEN VOLCANICS

MC1066F.

Locality: Stockton 1-mile area - 2 miles north of Blenheim Homestead.

Collector: A.R. Jensen.

The one specimen from this locality contains an impression of Glossopteris indica Sch., a very common plant in Permian and Lower Triassic horizons.

UPPER BOWEN COAL MEASURES

MC535F

Locality: Hillalong 1-mile area, 1 1/2 miles south of the Springs Homestead. Very fine, white siltstone in Upper Bowen Coal Measures.

Collector: D.W.P. Corbett.

Glossopteris angustifolia Brong., narrow scale leaves of Glossopteris, stems of Phyllotheca sp., a seed of Samaropsis? type and small shells are associated in these specimens. Plate 3, Figure 2 shows Glossopteris angustifolia and scale leaves.

Age of the specimens: All the plant species present occur in Permian and Lower Triassic horizons.

MC225Fa

Locality: Newlands 1-mile area, 4 1/4 miles north-west of Weetalabah Homestead. Upper Bowen Coal Measures.

Collector: A.R. Jensen.

The specimens are weathered and contain indeterminate plant fragments and one portion of lamina of Glossopteris indica type.

Age of specimens: Permian or Lower Triassic

MC46F

Locality: Newlands 1-mile area, 6 miles west-north-west of Weetalabah Homestead. Carbonaceous shale, Upper Bowen Coal Measures.

Collector: E.J. Malone.

A few layered impressions of leaves of Glossopteris indica Sch. are associated with very large numbers of small, branching rootlets illustrated in Plate 4, Figure 1.

Age of Specimens: Permian or Lower Triassic.

MC233Fa and b

Locality: Newlands 1-mile area, 2 3/4 miles north-west of Weetalabah Homestead. Upper Bowen Coal Measures.

Collector: A.R. Jensen.

The following plants are identified:-

Phyllotheca australis Brong. (Plate 4, Figure 2, Plate 5, Figures 1 and 2).

Glossopteris browniana Brong.

Glossopteris indica Sch.

Nummulospermum bowenense Walk.

Sphenopteris lobifolia Morr. (Plate 4, Figure 2)

The material of Phyllotheca australis is illustrated in Plates 4 and 5. In a recent revision of the species, Townrow (1954) concludes that it is a Permian form whose presence in Triassic strata has yet to be proved. He regards records of Triassic occurrences by Walkom and others as inconclusive and based on unsatisfactory material. Walkom (1922) positively identified P. australis in the Lower Bowen Series, but material from the Upper Bowen he referred to Phyllotheca sp. The full range of forms seen in the present material leaves no doubt as to the identity of the plant. The range of the plant in Australia cannot be Permian only, as Townrow believes, as this association occurs also in the Lower Triassic.

Seeds referred to Nummulospermum bowenense occur plentifully in Upper and Lower Bowen rocks. They are probably the seeds of a species of Glossopteris.

Reference for MC233F

TOWNROW, J.A., 1954 - On some species of Phyllotheca. J.Roy.Soc.N.S.W., 9;39-63.

WALKOM, A.B., 1922 - Palaeozoic floras of Queensland. 1. The flora of the Lower and Upper Bowen Series. Publ.geol.Surv.Qld, 270.

MC1017Fa

Locality: Stockton 1-mile area, 4 1/2 miles west-north-west of Blenheim Homestead. Upper Bowen Coal Measures.

Collector: A.R. Jensen.

The following plants are identified :-

Phyllotheca australis Brong.

Glossopteris indica Sch.

Sphenopteris lobifolia?

Cladophlebis roylei Arber

Samaropsis sp. (Plate 6, Figure 1) This seed is large, length 2 cm., maximum width across wings near base 1.5cm.

Age of specimens: Permian or Lower Triassic

MC62F

Locality: Newlands 1-mile area, 2 1/4 miles east-south-east of Eastern Creek Homestead. Ferruginous siltstone in Upper Bowen Coal Measures.

Collector: E.J. Malone

Glossopteris indica Sch. leaves in great numbers, closely layered, are associated with occasional Glossopteris browniana Brong. and a few fronds of the fern Cladophlebis roylei Arber.

Age of specimens: Permian or Lower Triassic.

MC236Fa

Locality: Newlands 1-mile area, 5 miles west-north-west of Weetalabah Homestead. Upper Bowen Coal Measures.

Collector: A.R. Jensen.

Paper-thin layers of very large numbers of leaves of Glossopteris compose these specimens. Most of the leaves are of G. indica Sch. with a few of G. browniana Brong. and G. angustifolia Brong., and a few scale leaves of Glossopteris.

An impression of a seed approximately 1 cm. in diameter, with a divided apex and a round nucule situated at the bottom of the wing, may be a poorly preserved example of Nummulospermum bowenense Walk.

Two impressions of small Equisetalean stems show thickened ridges at the nodes; they are referred to Phyllotheca sp.

Age of Specimens: Permian or Lower Triassic.

MC292Fb

Locality: In Blenheim Creek on the west side of the Nebo/Collinsville road crossing. Upper Bowen Coal Measures.

Collector: A.R. Jensen.

Large numbers of layered impressions of leaves of Glossopteris indica Sch. are poorly preserved. The specimens are deeply weathered and disintegrating.

Age of specimens: Permian or Lower Triassic.

MC755F

Locality: Hillalong 1-mile area, about 7 1/2 miles south of the Springs Homestead. Siltstone in Upper Bowen Coal Measures.

Collector: L.G. Cutler

Glossopteris indica Sch., G. browniana Brong., G. angustifolia, and a partially petrified stem which may be Vertebraria are associated in these specimens.

Age of Specimens: Permian or Lower Triassic.

MC289F.

Locality: Stockton 1-mile area, on the west side of the Nebo/Collinsville road 1 1/2 miles south of the Blenheim Creek Crossing. Upper Bowen Coal Measures.

Collector: A.R. Jensen.

An impression of Vertebraria indica Royle showing overlapping segments in four vertical series is seen in Plate 6, Figure 2. Impressions of this sort originally interpreted as rhizomes of Glossopteridae are now thought to be decortication forms of normal Glossopterid stems. They occur in Permian and Triassic Glossopteris floras.

Age of Specimens: Permian or Lower Triassic.

MC608F.

Locality: Stockton 1-mile area, 1 1/2 miles south-west of Blenheim Homestead. Upper Bowen Coal Measures.

Collector: A.R. Jensen.

The following plants are identified in these weathered specimens:-

Phyllotheca sp.

Cladophlebis roylei Arber

Sphenopteris sp.

Glossopteris indica Sch.

Age of Specimens: Permian or Lower Triassic

MC727F

Locality: Burton Downs 1-mile area, 2 miles south-west of Kemmis Creek Homestead. Siltstone in Upper Bowen Coal Measures.

Collector: P.E. Bock

The following plants are identified in these specimens :-

Glossopteris indica Sch.

Glossopteris browniana Brong.

Glossopteris conspicua Fm.

Glossopteris spathulato-cordata Fm.

Scale leaves of Glossopteris - three types; fertile scale leaves of Glossopteris - Lidgettonia australis sp. nov.

Seeds. Cone of unknown affinity.

Sphenopteris polymorpha Fm.

Phyllotheca australis Brong.

Age of Specimens: Permian or Lower Triassic

FERTILE GLOSSOPTERIS MATERIAL

In the past five years very large numbers of Glossopteris and Gangamopteris leaves and scale leaves have been examined from Bureau field collections but no trace of reproductive structures has been seen.

The present collection from Locality MC727F has yielded undoubtedly fertile material of a type similar to Lidgettonia (Hamshaw Thomas, 1958), together with extra information on the nature of scale leaves, and a probable explanation of a problematical fossil known previously from Glossopteris floras. The fertile material is believed to represent a 'missing link' forerunner of the Angiosperms - a concept of the most extraordinary botanical interest.

A full description follows of the selected specimens from which preliminary description of the fertile Lidgettonia australis sp. nov. has been compiled. It is possible that a second species might be present. Advice is being sought on the generic affinity of the material and it may be necessary to create a new genus.

In Plate 7, Figure 1, Glossopteris angustifolia Brong. is associated with Glossopteris browniana (2) and scale leaves (3 and 4). The scales are of the type referred to Lidgettonia australis but are sterile in this specimen.

In Plate 7, Figure 2, a large cordate scale of Lidgettonia australis type is seen at (1). A scale of this sort (2) has radiating markings at its base indicating the point at which a fructification was attached. A small sterile scale is seen at (4). (3) is the base of a leaf of G. angustifolia.

Plate 8, Figure 1 shows scale leaves of L. australis type (2 and 3) and a pointed scale (4). A branching filament (1) has the same appearance as fragments of filament which occur throughout the material.

In Plate 8, Figure 2, the scale leaf (1) is different from those referred to Lidgettonia australis. It resembles the scale leaf figured with Lidgettonia africana by Thomas (1958). The leaf (2) is a larger example of Glossopteris angustifolia.

Plate 9, Figure 1 illustrates a most interesting specimen; a small triangular scale (of Lidgettonia australis type) is attached to a foliose organ with venation as in Gangamopteris. It is the only example in which a scale is seen attached to an entire foliose organ of this sort. There are several examples of impressions of parts of lower, foliose sections of this type and in some there is venation intermediate in type between Gangamopteris and Glossopteris angustifolia. A full series is present grading into typical small leaves of Glossopteris angustigolia.

One foliose organ is similar to the fertile leaf in L. africana figured in Thomas (1958). The top of the fertile leaf in L. africana shows no differentiation as a scale.

Plate 9, Figure 2 shows part of a lower, foliose organ of the type seen in Plate 9, Figure 1, in attachment to a scale leaf. It has gangamopteroid venation and on the surface are small round spots which are believed to be sporangia. A fossil of this sort could be referred to 'Dictyopteridium sporiferum', a problematical fossil recorded in Glossopteris floras, regarded as a fertile fern frond of unkown affinity. There are other small fragments of tissue in the material which seem to be in a highly fertile state with densely crowded, larger sporangia; these are more strictly 'Dictyopteridium sporiferum'. It has proved impossible to obtain satisfactory photographs of these fragments.

In Plate 10, Figure 1, a scale of Lidgettonia australis type is seen attached to a lower, foliose section which is relatively short and broad, and which is characteristically two-lobed at the bottom. (1). The scale with attached lower part has a 'molar with double root' appearance. It is associated with Glossopteris angustifolia (2) and Glossopteris indica (3).

In Plate 10, Figure 2, a small leaf of Glossopteris angustifolia (1) with somewhat gangamopteroid appearance is associated with fragments of 'Dictyopteridium sporiferum, (2), a scale of Lidgettonia australis type (3) and a detached "cupule" (4). At the base of the leaf, where it narrows to a petiole, there are a number of minute rings, each about 0.5 mm in diameter.

Plate 11, Figure 1 shows a small leaf of Glossopteris angustifolia (1) and a scale leaf of Lidgettonia australis type (2) with fragments of tissue attached, all that remains of the foliose part.

In Plate 11, Figure 2, the scale (1) is different from any so far described and illustrated. It tapers to a neck below, and two filaments are attached at the point of narrowing. Other filaments are present, one (2) is forked. This specimen is not believed to be in any way concerned in the reproduction of Glossopteris angustifolia - Lidgettonia australis. It may be fragmentary evidence of a second reproducing species - possibly the G. indica which is also present. If the scale was attached to a laminal section (or fertile leaf) bearing other pairs of filaments, the close relationship to Lidgettonia africana would be obvious. The forking of filaments would not agree, however. The other filament fragments, one with attached seed (?), are assumed to be related to the scale and forked filament.

The evidence in the present collection allows no more than a record of this specimen. In the event of future collections contributing more material and substantiating this new species of Lidgettonia, the name L. bowenense is suggested.

In Plate 12, Figure 1, three scales of Lidgettonia australis type are present. Scale (1) is attached to an almost complete foliose section with two-lobed base. Scale leaf (2) has, at its base, a small rosette-like body apparently made of narrow, filamentary segments radiating from a central point. In the centre is a dense small rosette apparently of small seeds on the central axis. Similar bodies - 'cupules' - can be seen on scale (1) at the point of junction of scale and foliose section, and on the base of scale (3). There are several fragments of detached cupules (4).

The cupules attached to the scales and fossilized separately do not have the massive open-campanulate disc as in Lidgettonia africana (Thomas, 1958). Each appears to be a whorl (or whorls) of small seeds on a central axis, surrounded by a whorl of bracts. The cupule in each scale is attached at the junction of the scale and the laminal section. It is sessile and solitary.

Plate 12, Figure 2 shows the impression of a cupule at the junction of scale and laminal part.

In Plate 13, Figure 1, the apex of a leaf of Glossopteris angustifolia is seen at (1); the midrib persisting to the apex is a characteristic of the species. At (2) is a fragment of a cupule.

In Plate 13, Figure 2 a pair of small leaves (1) has venation half-way between the gangamopteroid type and the type in young leaves of Glossopteris angustifolia. A smaller pair (2) has entirely gangamopteroid venation. The complete leaf in the second pair has its tip modified in texture, resembling a scale in continuity with the lamina. The smaller pair is evidently related to the larger, and the larger, though more flimsy in appearance, is related to the less modified leaf illustrated in Plate 10, Figure 2.

Selected Bibliography for Fertile Glossopteris Material

HAMSHAW THOMAS, H., 1952 - A Glossopteris with whorled leaves. Palaeobotanist, 1, 435 - 438.

HAMSHAW THOMAS, H., 1958 - Lidgettonia, a new type of fertile Glossopteris. Bull.Brit.Mus.(nat.Hist.) Geol.3,5.

PANT, D.D., 1958 - Structure of some leaves and fructifications of the Glossopteris flora of Tanganyika. Bull.Brit.Mus. (nat.Hist.) Geol., 3,4.

PLUMSTEAD, E.P., 1956 - On Ottokaria, the fructification of Gangamopteris. Trans.geol.Soc.S.Afr., 59,211-236.

PLUMSTEAD, E.P., 1958a- Further fructifications of the Glossopteridae and a provisional classification based on them. Trans. geol.Soc.S.Afr., 61, 51-75.

PLUMSTEAD, E.P., 1958b- The habit of growth of Glossopteridae. Trans.geol. Soc.S.Afr., 61, 81-96.

WALKOM, A.B., 1922 - Palaeozoic floras of Queensland.I. Flora of the Lower and Upper Bowen Series. Publ.geol.Surv.Qld. 270.

WALKOM, A.B., 1928 - Notes on some additions to the Glossopteris flora in N.S.W. Proc.Linn.Soc.N.S.W.,53(5), 555-564.

TEVIOT FORMATION

MC697F

Locality: Stockton 1-mile area, 1 mile east-south-east of Redcliffe Vale Homestead.

Collector: A.R. Jensen.

In these specimens, very large numbers of plant fragments are jumbled together, lying in all planes. Indeterminate wood and stem impressions and casts, sculptured fern stems, possible fragmental small cones, etc. are present.

The only determinate fossils are well preserved pinnules of Dicroidium, mostly D. feistmanteli (Johns) Gothan (Plate 14, Figure 1), and a few of D.odontopteroides (Morris) Gothan (Plate 14, Figure 2).

Pinnules of this sort were originally referred to Thinnfeldia but Townrow (1957) has separated several natural groups.

Dicroidium feistmanteli and D. odontopteroides are regarded as typically Middle Triassic forms. They become increasingly rare upwards into Rhaetic strata and differ in cuticle and other features from Thinnfeldia, which is a younger genus.

Age of specimens: Triassic.

Reference and selected bibliography for MC/697F

TOWNROW, J.A., 1957 - On Dicroidium, probably a pteridospermous leaf, and other leaves now removed from the genus. Trans. geol.Soc.S.Afr.,60,21-56.

WALKOM, A.B., 1925 - Fossil plants from the Narrabeen stage of the Hawkesbury Series. Proc.Linn.Soc.N.S.W., 50,(3), 214-224.

WALKOM, A.B., 1915 - Mesozoic floras of Queensland. Pt.I. Floras of the Ipswich and Walloon Series. Publ.geol.Surv.Qld, 257.

DU TOIT, A.L., 1927 - The fossil flora of the Upper Karroo beds. Ann.S.Afr.Mus.22, 19-420.

JONES, O.A. and DE JERSEY, N.J., 1947 - The flora of the Ipswich coal measures: morphology and floral succession. Pap.Univ.Qld Dep.Geol.,3, 1-88.

SUTTOR FORMATION

MC222Fa

Locality: Newlands 1-mile area, 3 3/4 miles west-south-west of Byerwen Homestead.

Collector: A.R. Jensen.

A fragment of dicotyledonous leaf is illustrated in Plate 15, Figure 1.

Age of specimen: Tertiary or younger.

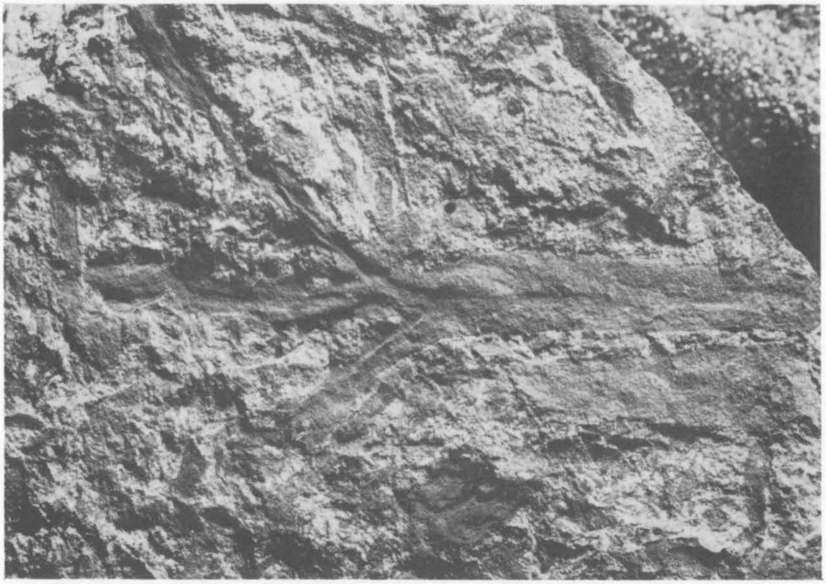


Fig. 1. *Psilophytites* sp.

Fig. 2. *Lepidostrobus*.

Plate 2

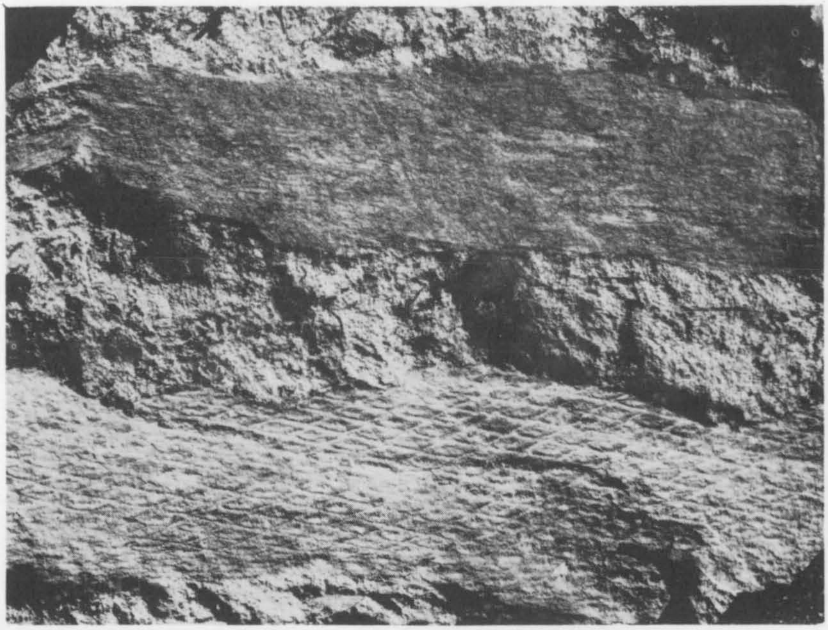


Fig. 1. *Protolepidodendron yalwalense* Walk., surface impression of stem.

Fig. 2. *Protolepidodendron yalwalense* Walk., impression of slightly decorticated stem.

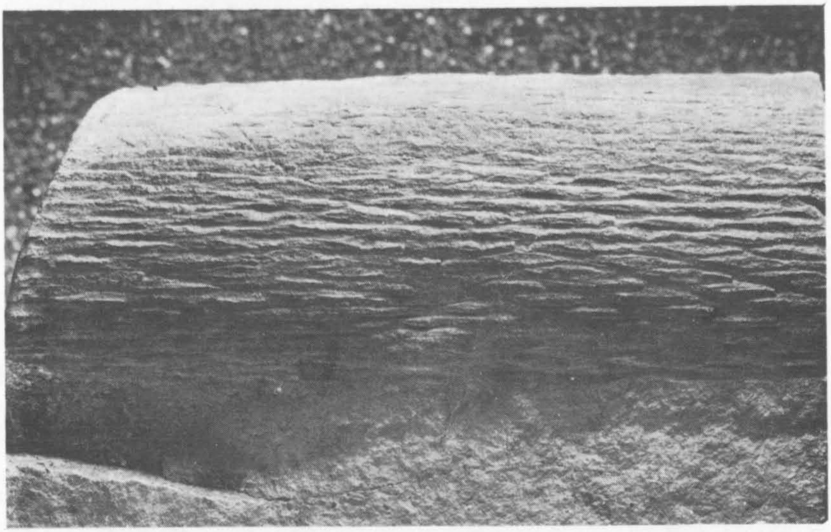


Fig. 1. *Protolepidodendron lineare* Walk., slightly decorticated stem.

Fig. 2. *Glossopteris angustifolia* Brong., with scale leaves.

Plate 4

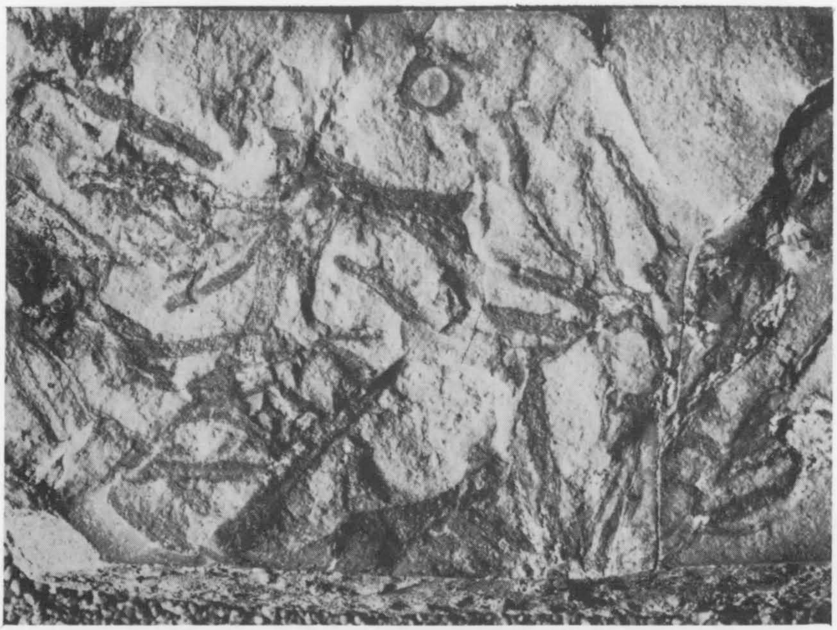
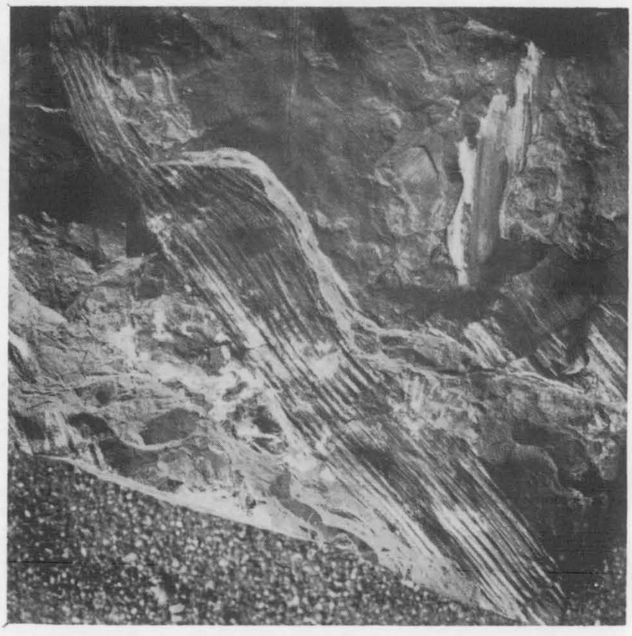


Fig. 1. Densely crowded rootlets, X1.

Fig. 2. *Phyllotheca australis* Brong. stem, and *Sphenopteris lobifolia* Morr., fern frond.



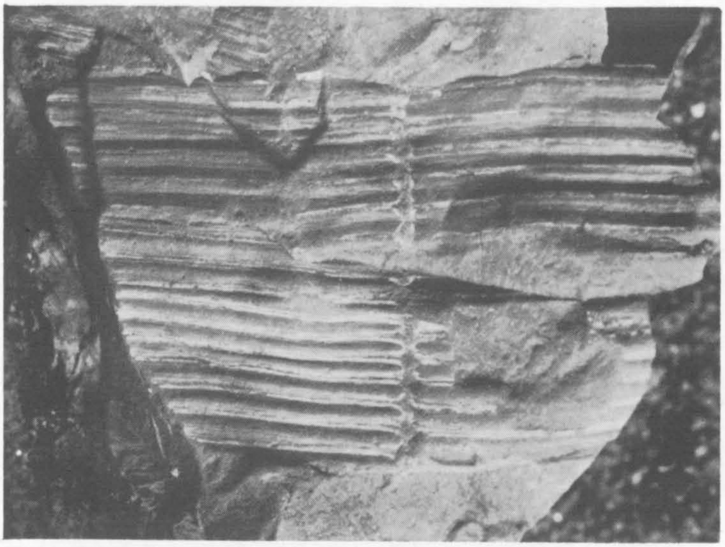


Fig. 1. *Phyllotheca australis* Brong., stem.

Fig. 2. *Phyllotheca australis* Brong., leaf sheath.

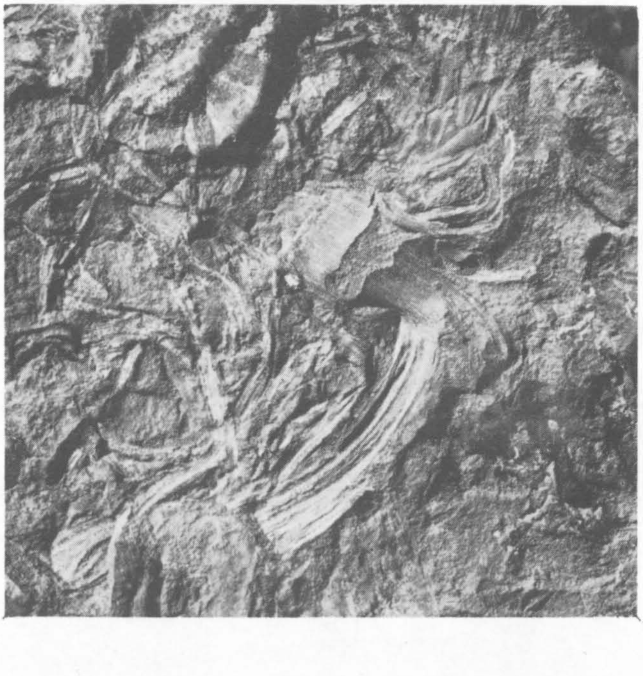
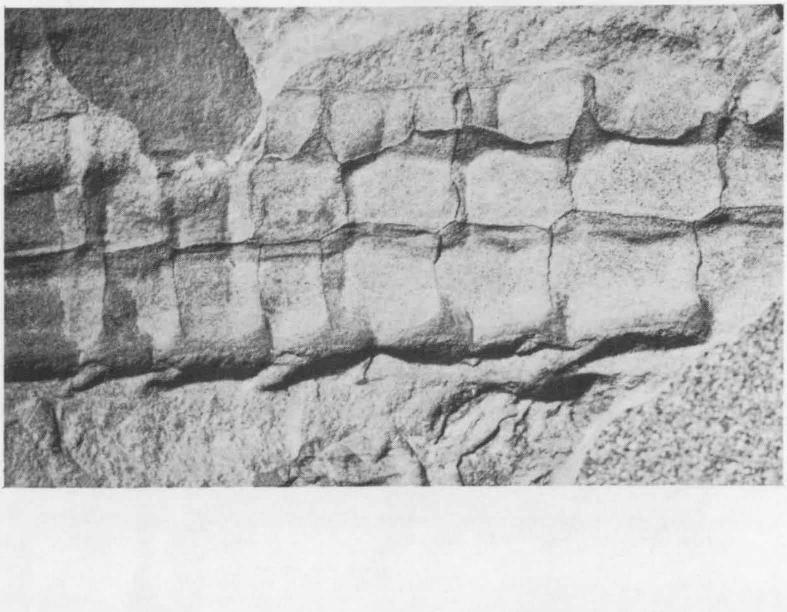


Fig. 1. *Samaropsis* sp.?, large seed, 2 cm. x 1.5 cm.

Fig. 2. *Vertebraria indica* Royle.



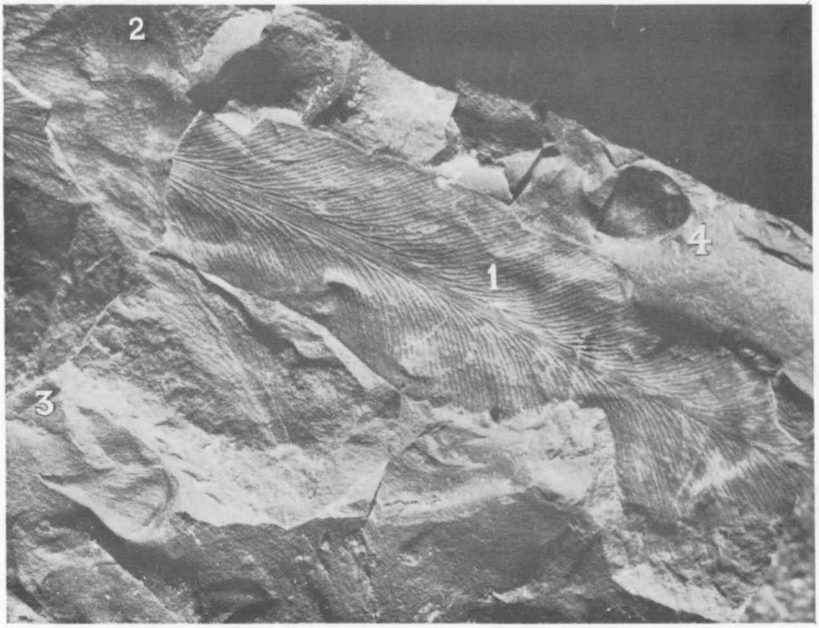
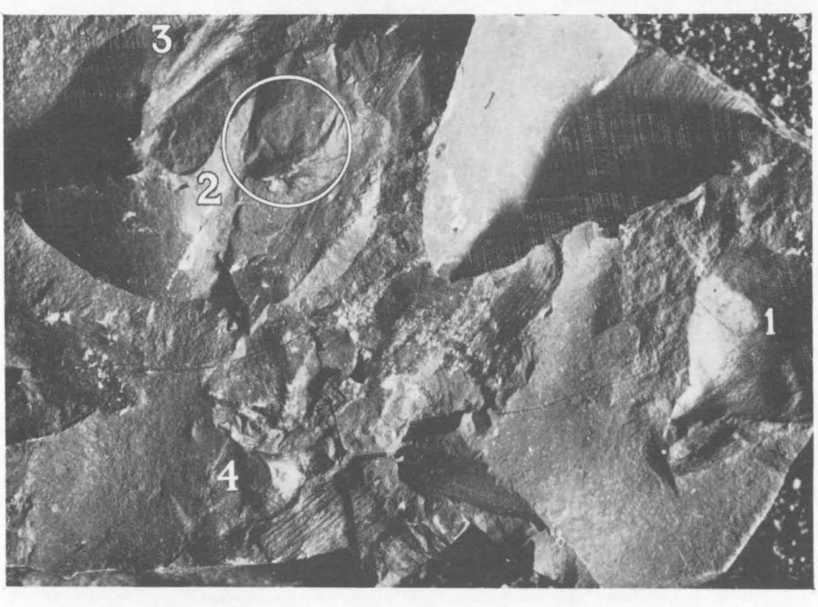


Fig. 1. 1—*Glossopteris angustifolia* Brong.
2—*Glossopteris browniana.*
3, 4—Scale leaves.

Fig. 2. 1—Cordate scale of *Lidgettonia australis.*
2—Scale showing attachment of fructification.
3—Base of leaf of *G. angustifolia.*
4—Sterile scale.



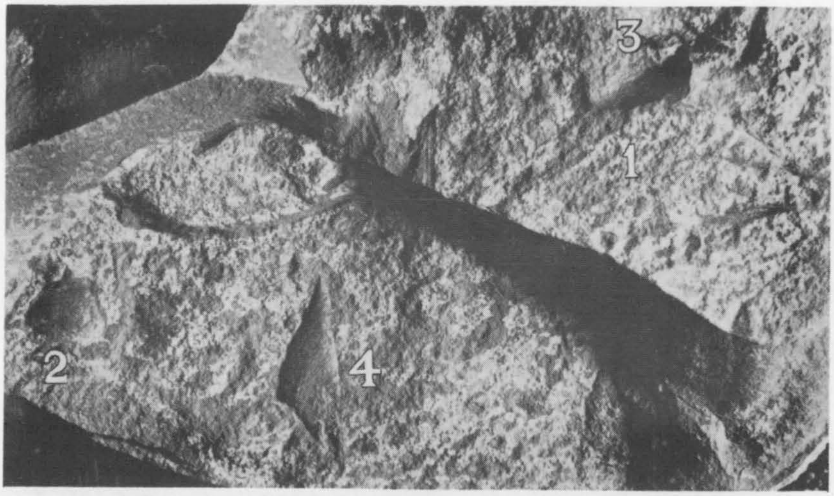


Fig. 1. 1—Branching filament.
2, 3—Scale leaves of *L. australis*.
4—Pointed scale.

Fig. 2. 1—Scale leaf, *Lidgettonia*.
2—Large leaf of *G. angustifolia*.

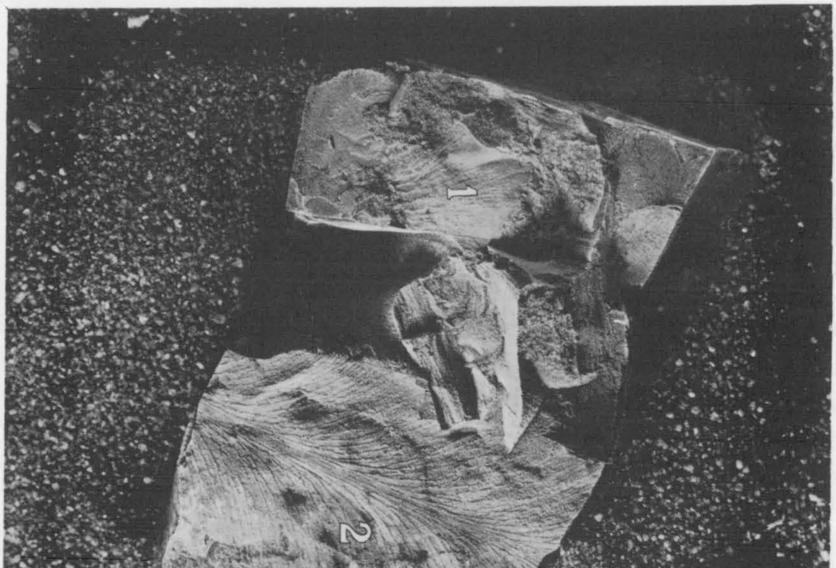
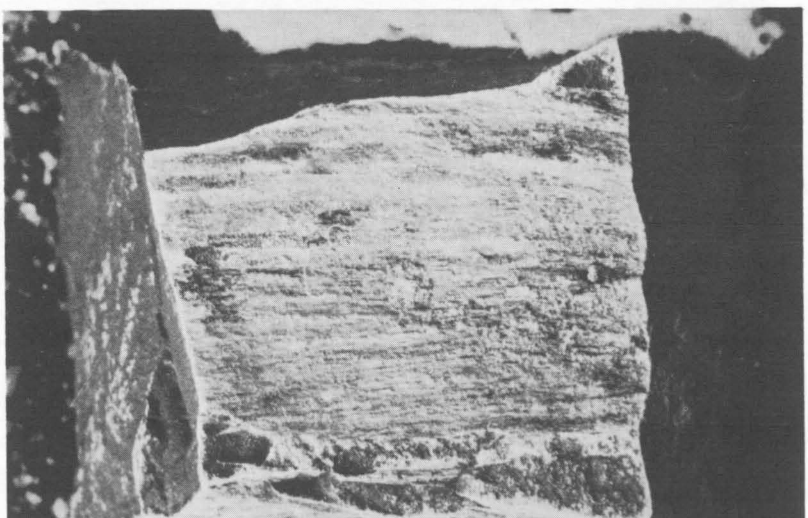


Fig. 1. Triangular scale of *L. australis* type attached to foliose organ with *Gangamopteris* venation.

Fig. 2. Foliose organ with ? sporangia *Dictyopteridium sporiferum*.



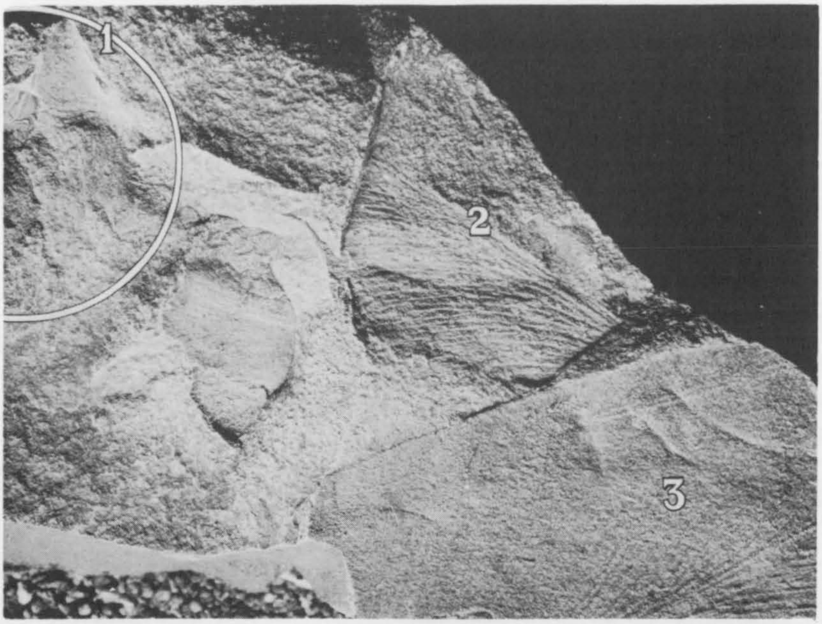
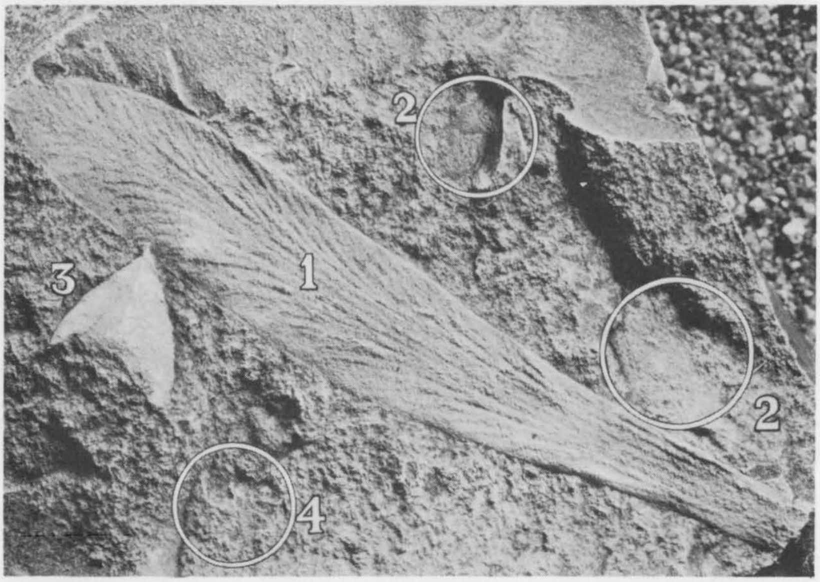


Fig. 1. 1—Scale of *L. australis* type attached to short, broad, two-lobed foliose section, " molar with double root ".
2—*Glossopteris angustifolia*.
3—*G. indica*.

Fig. 2. 1— Gangamopteroid *Glossopteris angustifolia*.
2—" *Dictyopteridium sporiferum* ".
3—Scale of *L. australis* type.
4—Detached cupule.



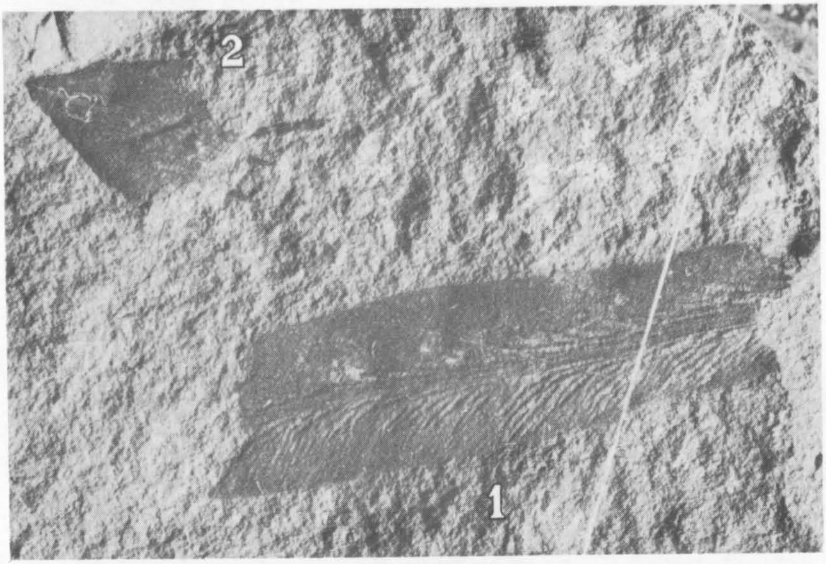


Fig. 1. 1—*G. angustifolia.*
2—Scale leaf of *L. australis* type with fragments of foliose part attached.

Fig. 2. *Lidgettonia* sp.?
1—Scale with filaments.
2—Forked filament.

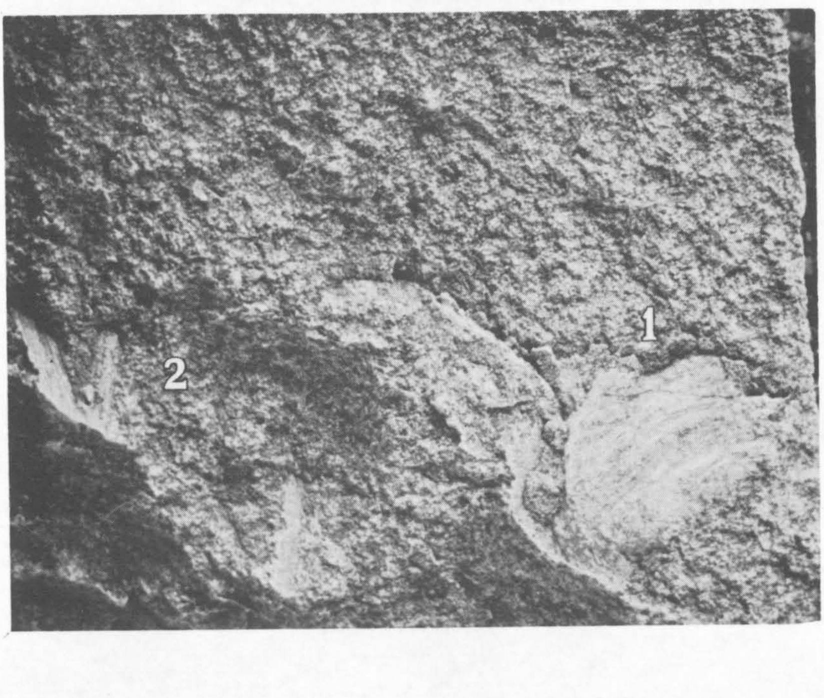


Plate 12

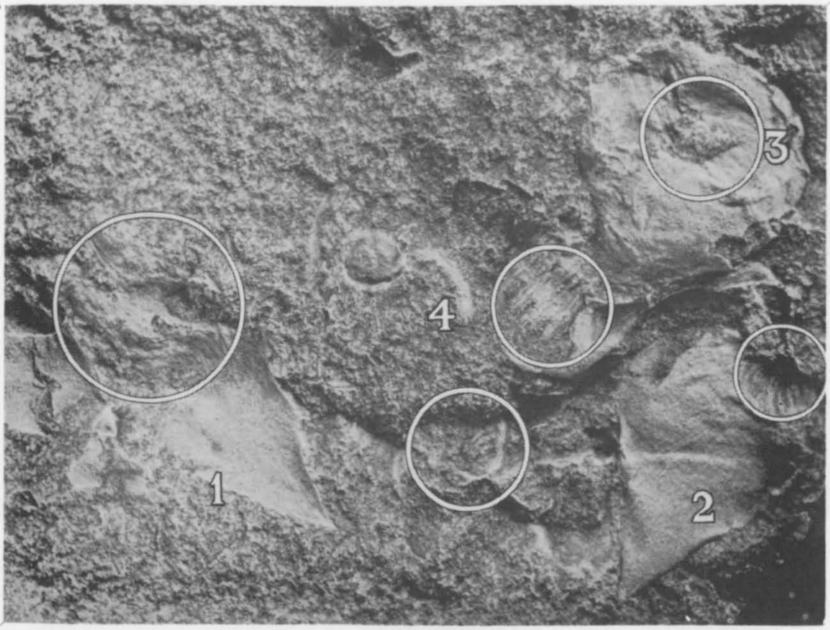
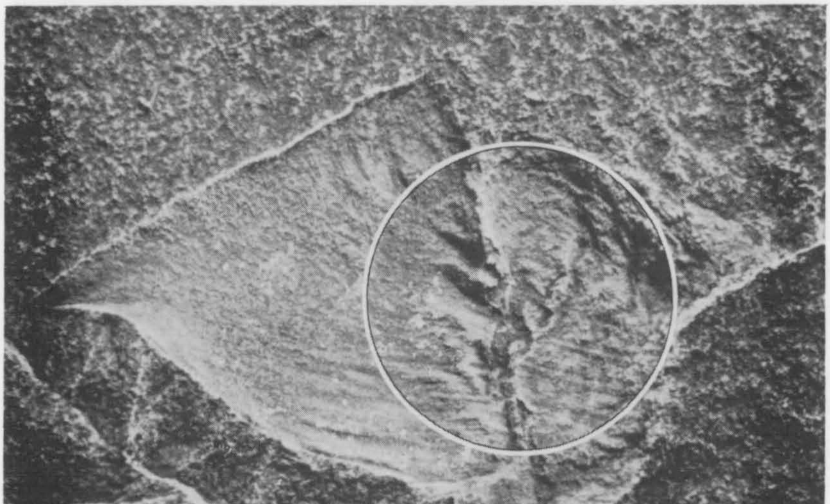


Fig. 1. *Lidgettonia australis*.
1—Scale attached to foliose section with 2-lobed base (ringed).
2—Scale leaf with cupule (ringed).
3—Scale with cupule (ringed).
4—Detached cupules (ringed).

Fig. 2. Cupule (ringed) at junction of scale and laminal part.



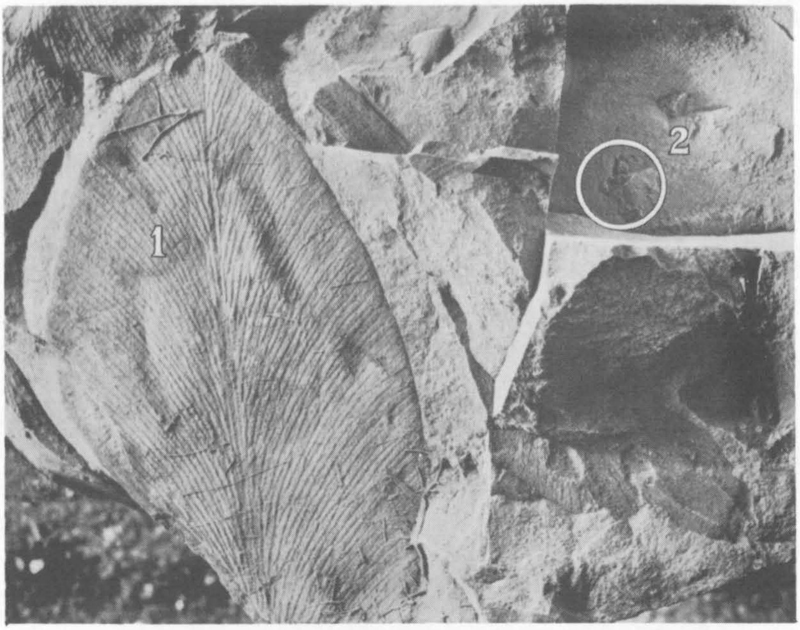


Fig. 1. 1—Apex of leaf of *G. angustifolia*.
2—Fragment of a cupule.

Fig. 2. 1—Leaves with venation between gangamopteroid type and type of young leaves of *Glossopteris angustifolia*.
2—Leaves with gangamopteroid venation, one with scale-like tip.

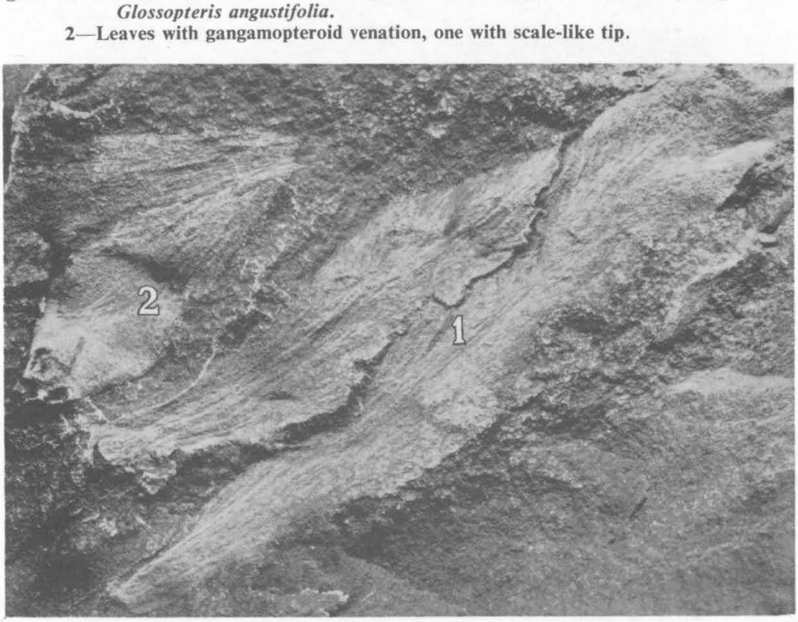


Plate 14

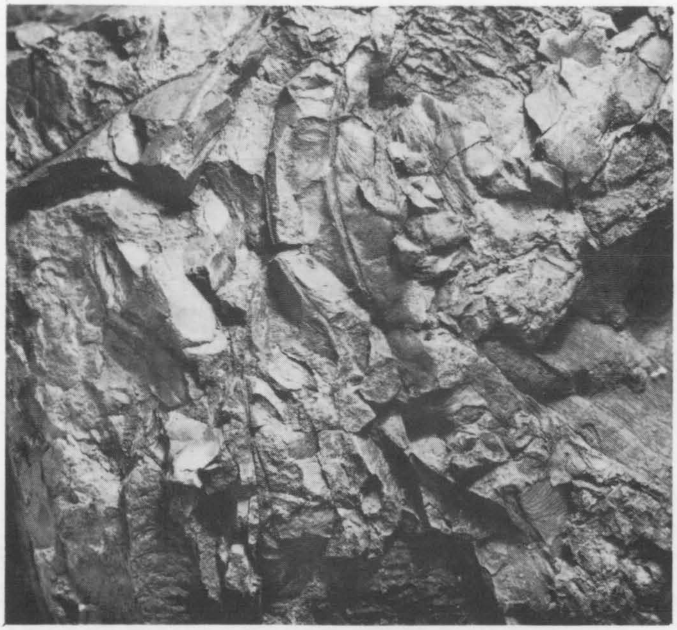
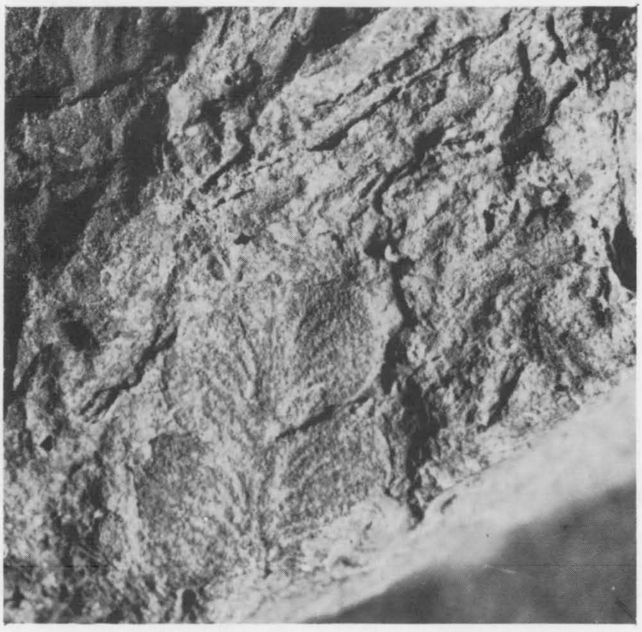


Fig. 1. *Dicroidium feistmanteli* (Johns) Gothan.

Fig. 2. *Dicroidium odontopteroides* (Morr.) Gothan.



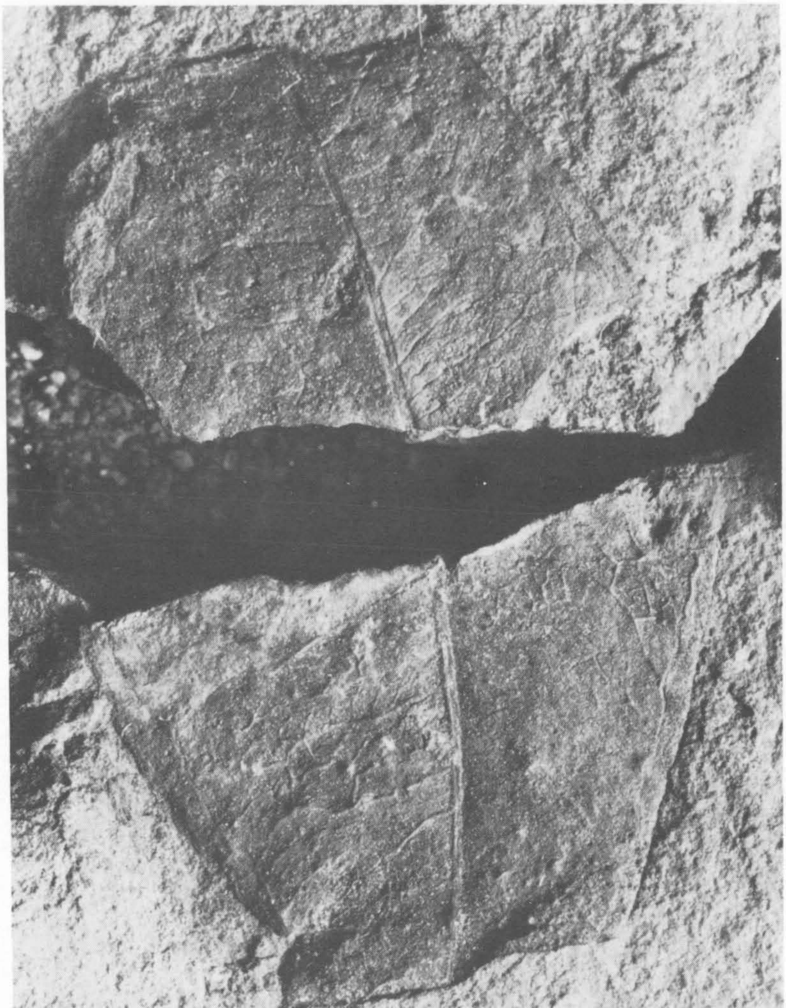


Fig. 1. Dicotyledonous leaf.

MEASURED SECTIONS IN THE UPPER BOWEN COAL MEASURES

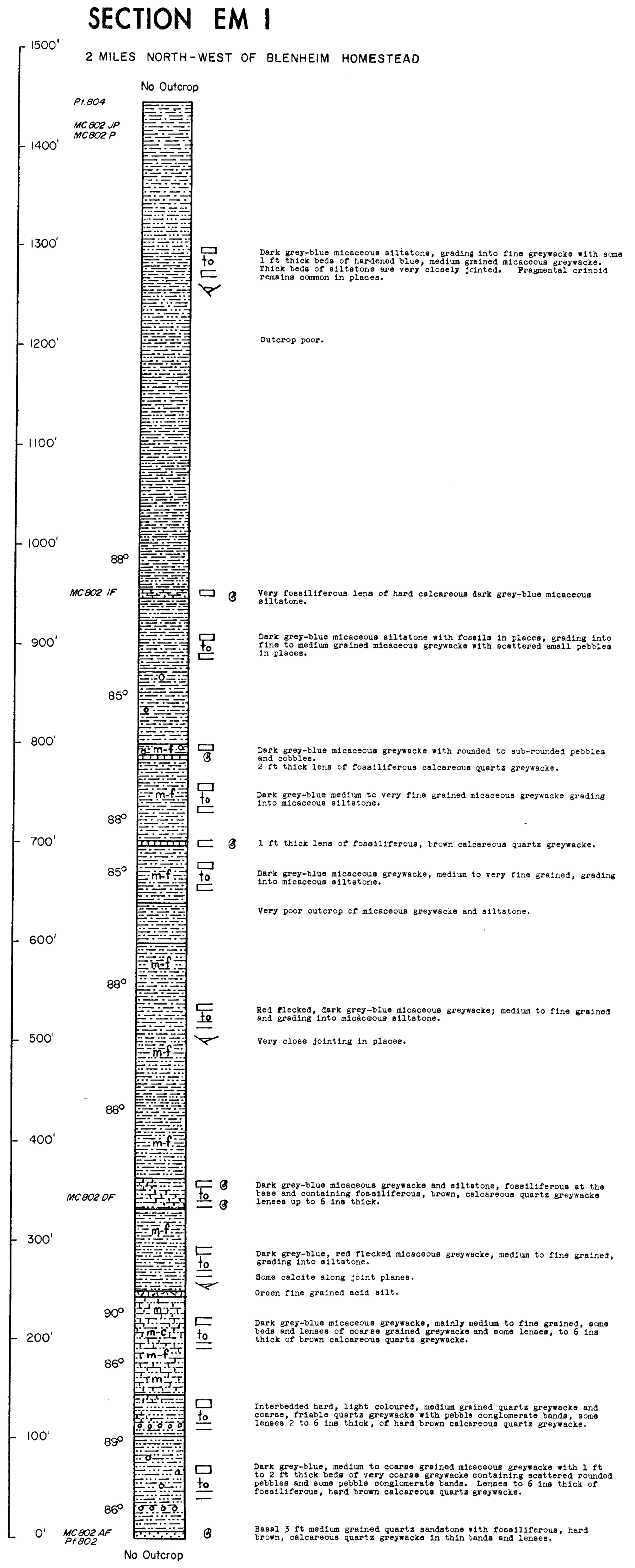
MEASURED SECTIONS IN THE MIDDLE BOWEN BEDS

PLATE 3.

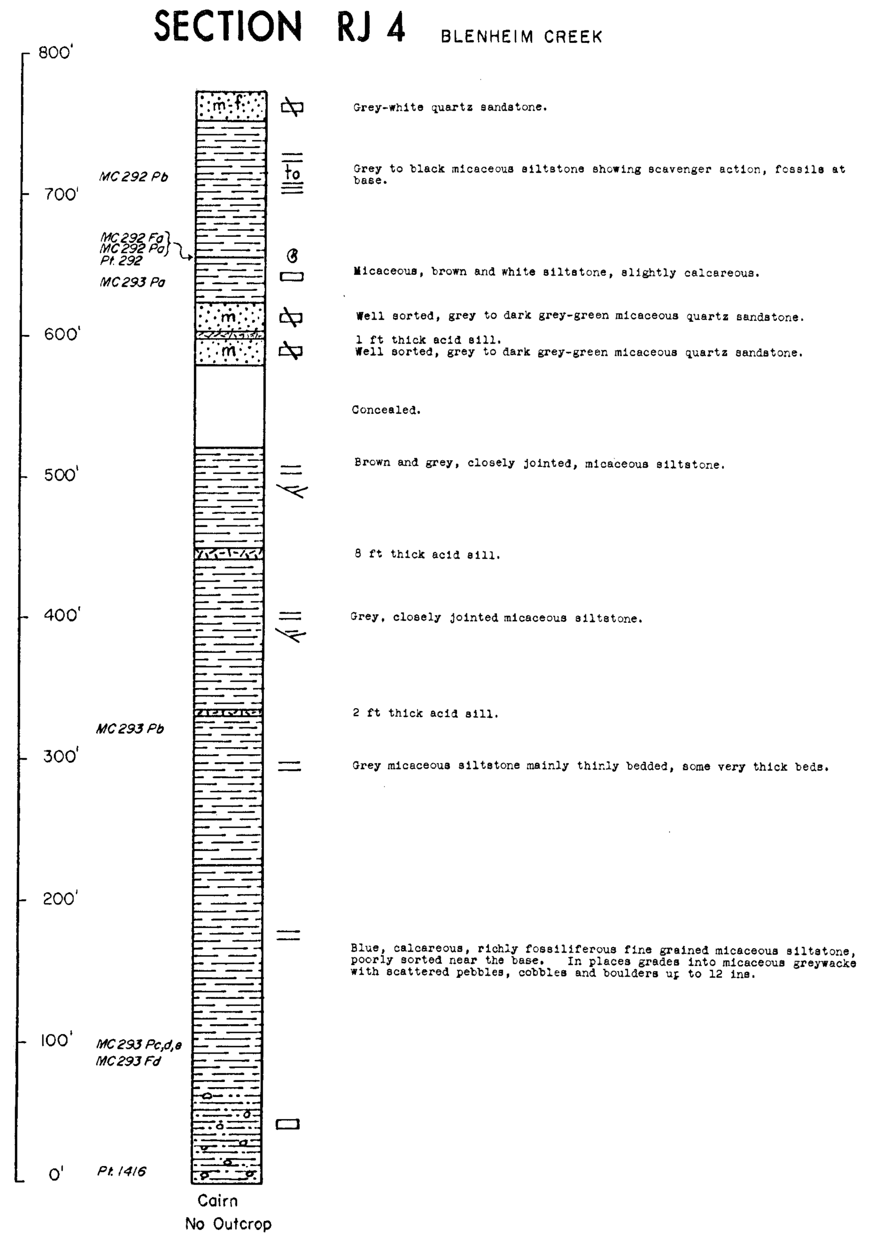
STOCKTON 1-MILE AREA   MT COOLON 1:250000 AREA

SECTION EM 1

2 MILES NORTH-WEST OF BLENHEIM HOMESTEAD

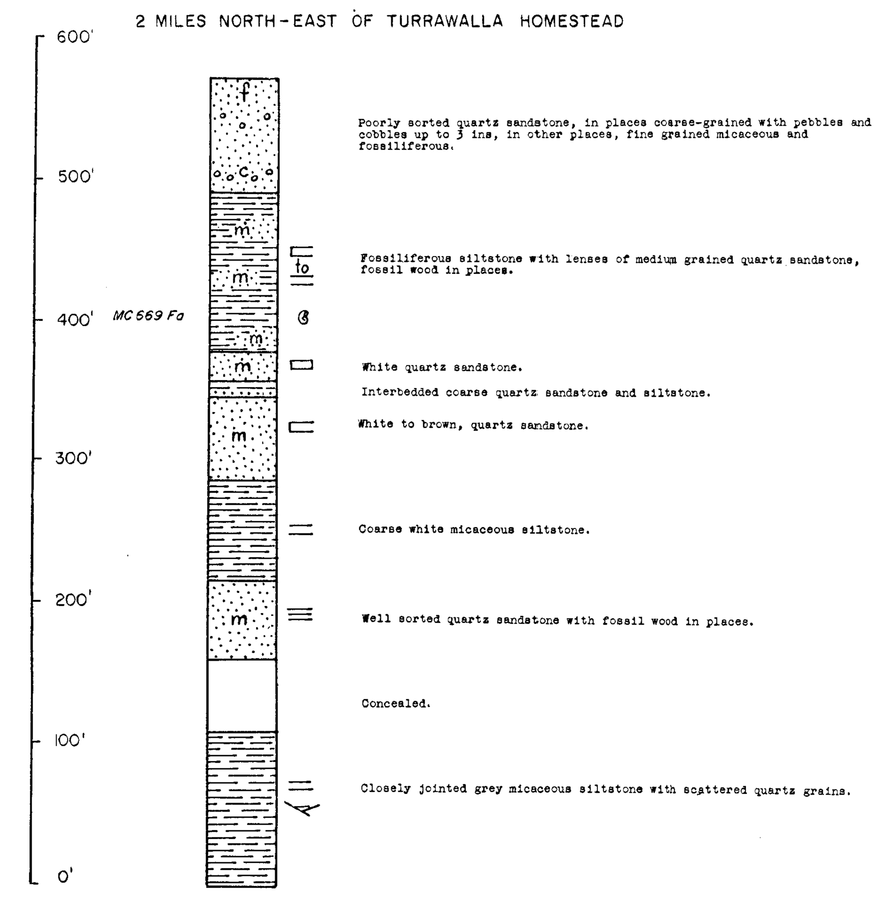


SECTION RJ 4 BLENHEIM CREEK

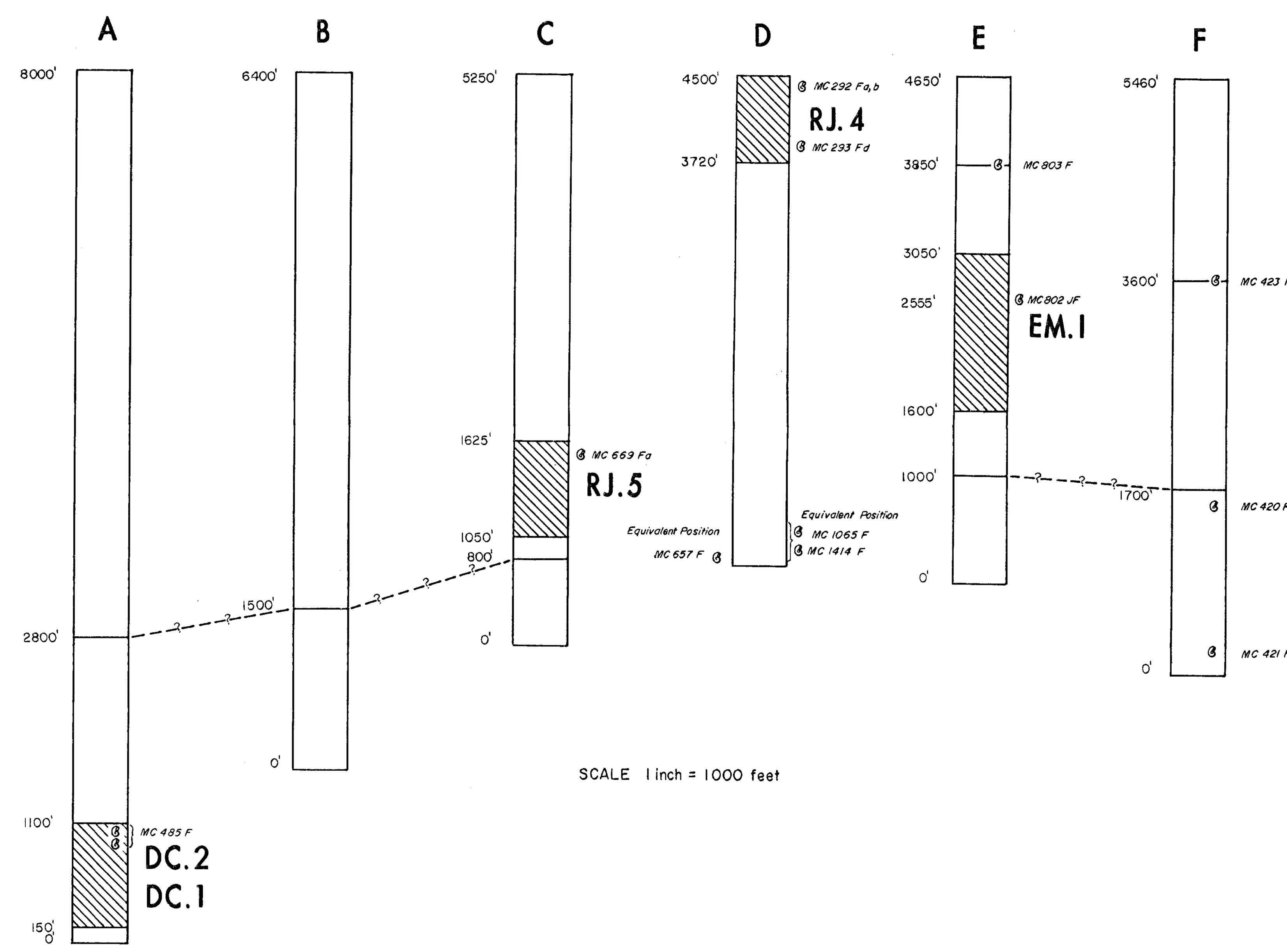


SECTION RJ 5

2 MILES NORTH-EAST OF TURRAWALLA HOMESTEAD

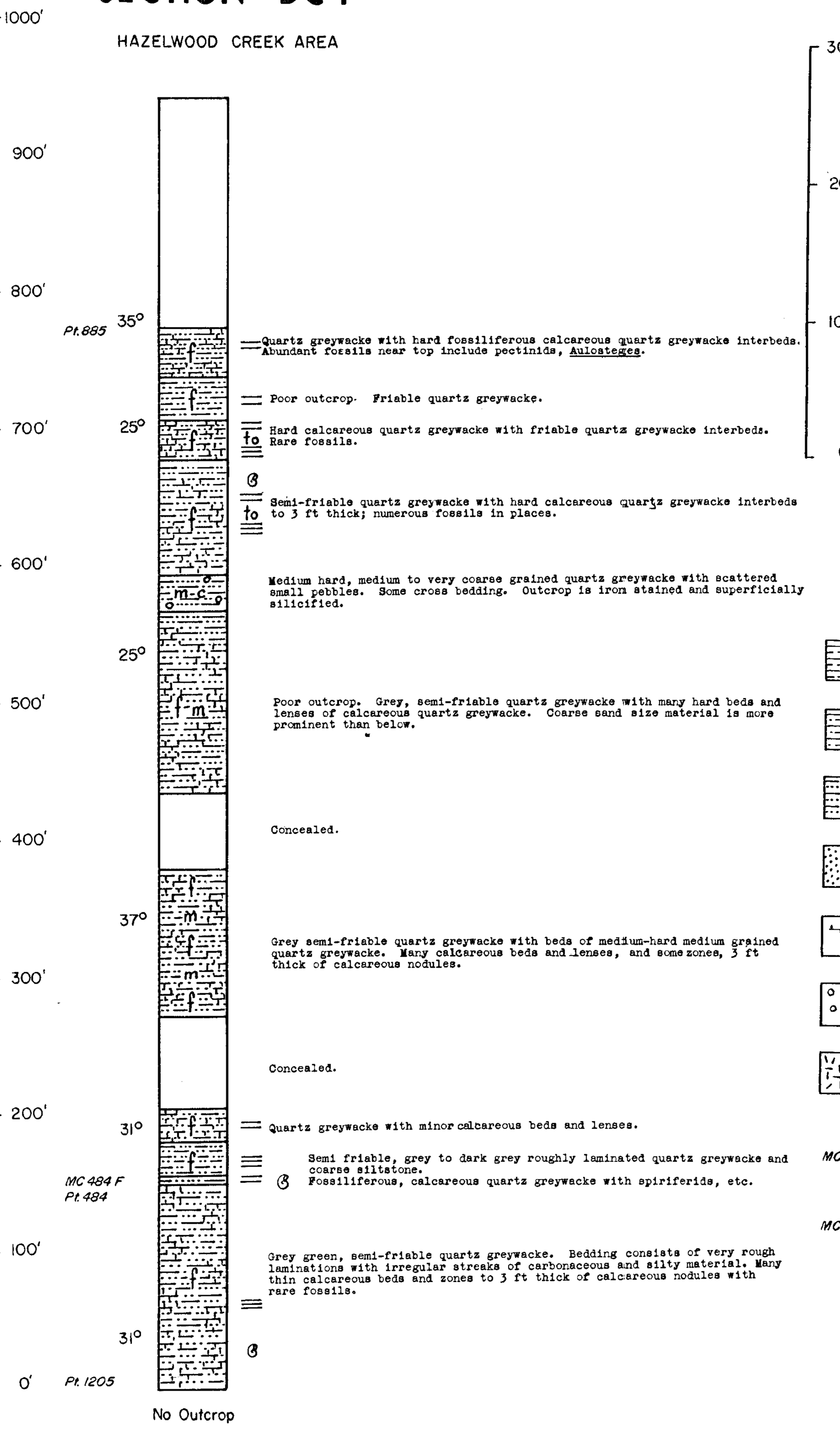


ESTIMATED COMPLETE SECTIONS THROUGH THE MIDDLE BOWEN BEDS SHOWING THE VARIATIONS IN THICKNESS OF THE UNIT ALONG STRIKE THE RELATIONSHIPS OF THE MEASURED SECTIONS, AND THE LOCATIONS OF MAIN FOSSIL COLLECTIONS



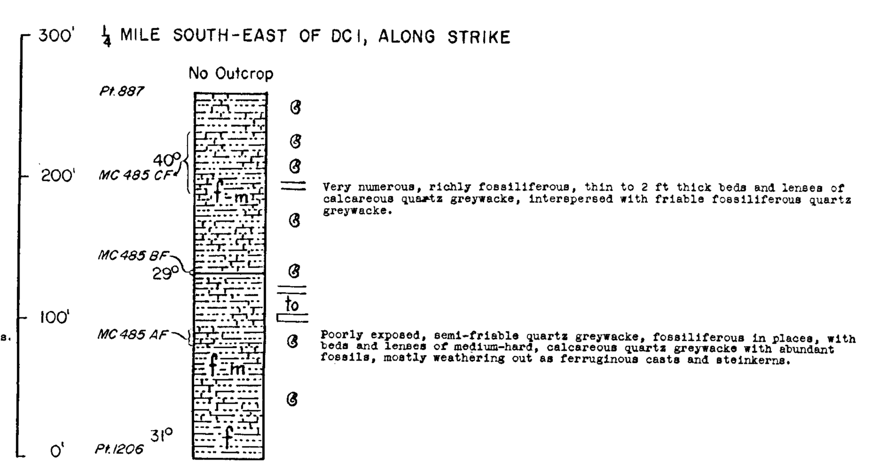
SECTION DC 1

HAZELWOOD CREEK AREA

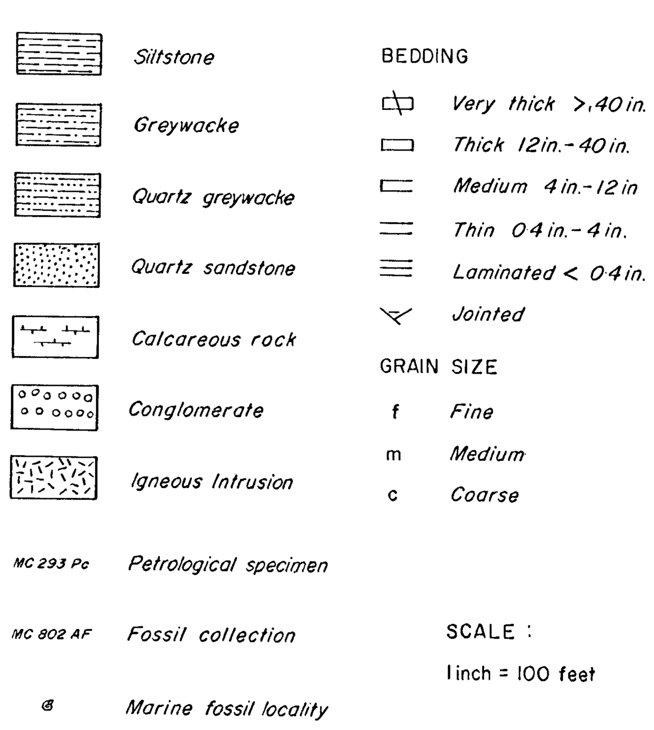


SECTION DC 2

½ MILE SOUTH-EAST OF DC1, ALONG STRIKE

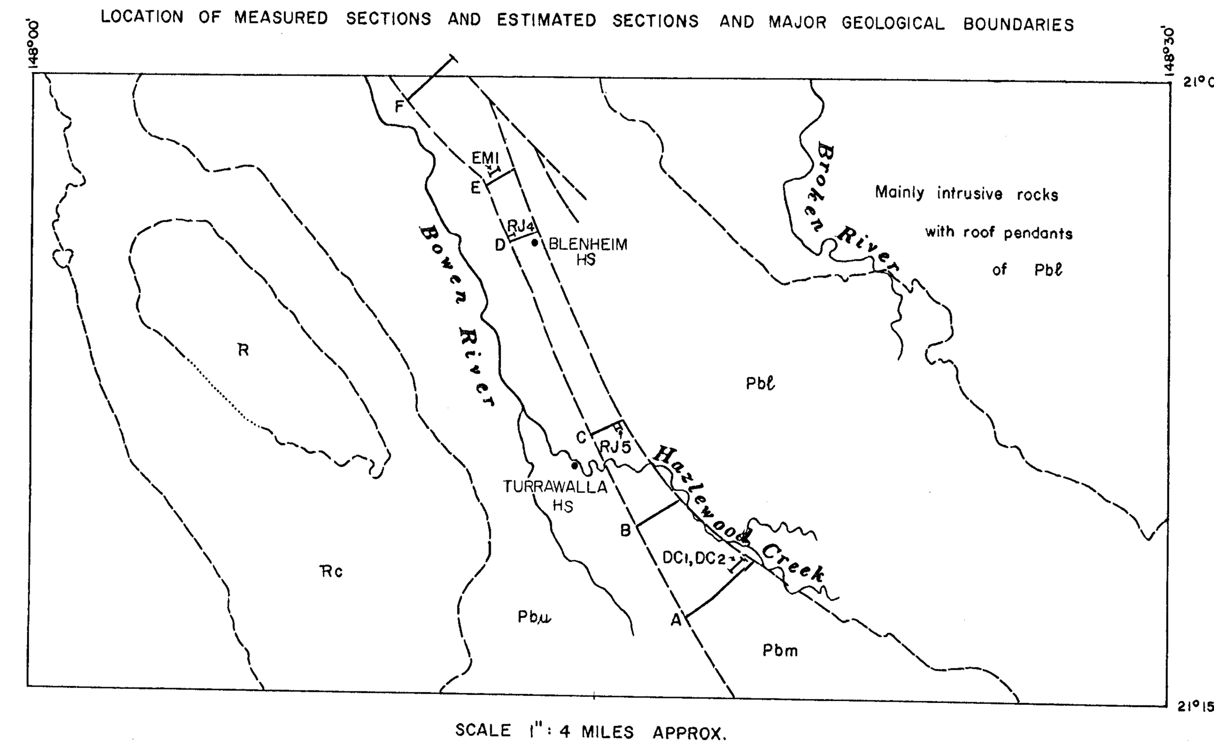


REFERENCE



LOCALITY DIAGRAM
STOCKTON 1-MILE AREA

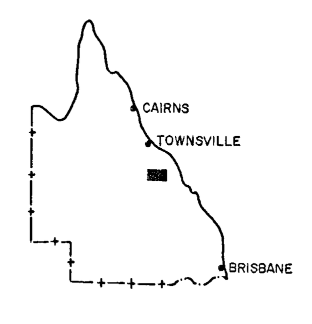
LOCATION OF MEASURED SECTIONS AND ESTIMATED SECTIONS AND MAJOR GEOLOGICAL BOUNDARIES



MT COOLON 1:250000 AREA

1 - mile areas

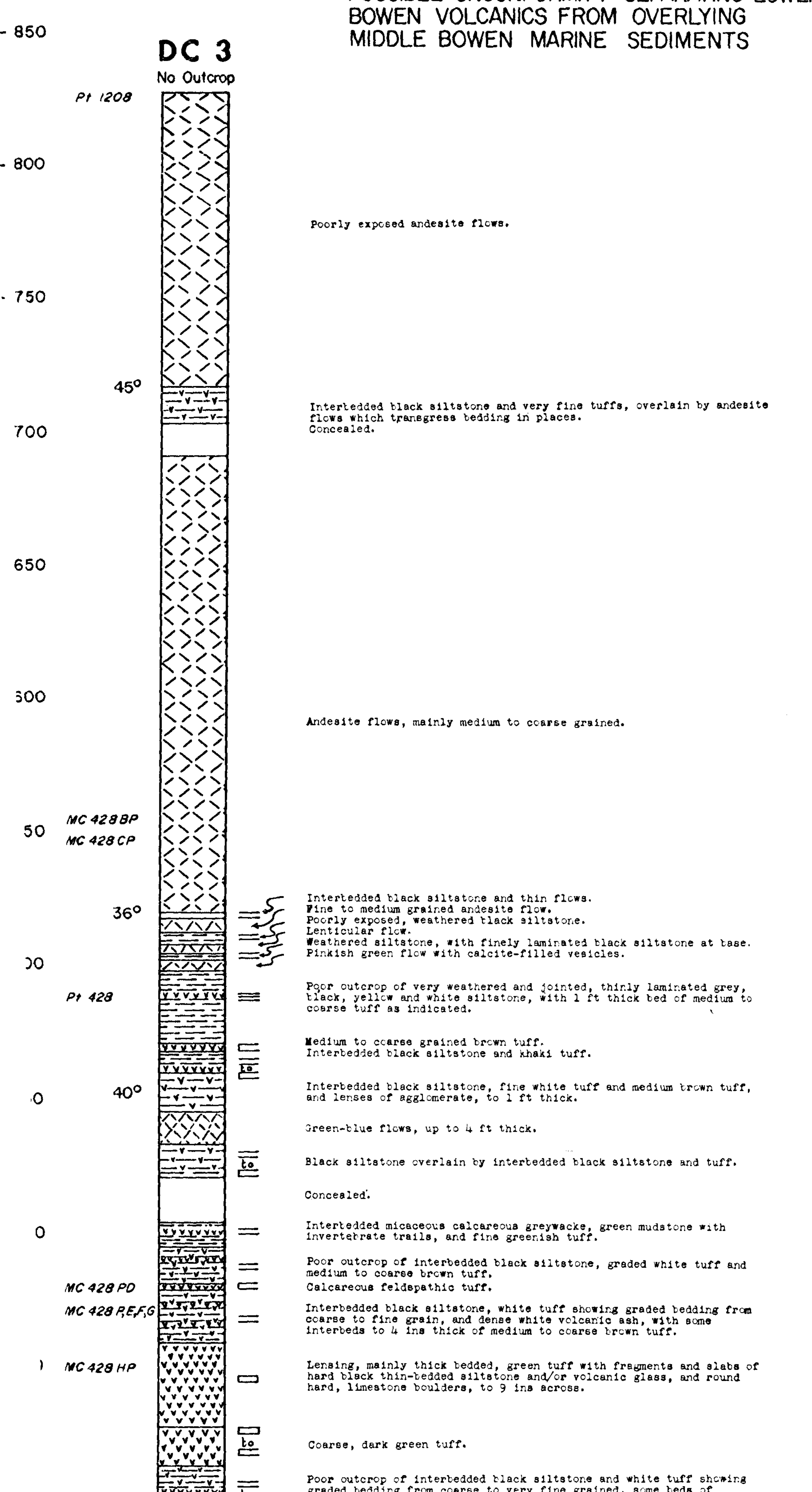
Mt Harry Marsh	Newlands	Stockton
Mt Coolon	Verbena	Hillalong
Logan Creek	Eaglefield	Burton Downs
Lake Suttor	Platypus Creek	Annandale



MEASURED SECTION IN THE LOWER BOWEN VOLCANICS

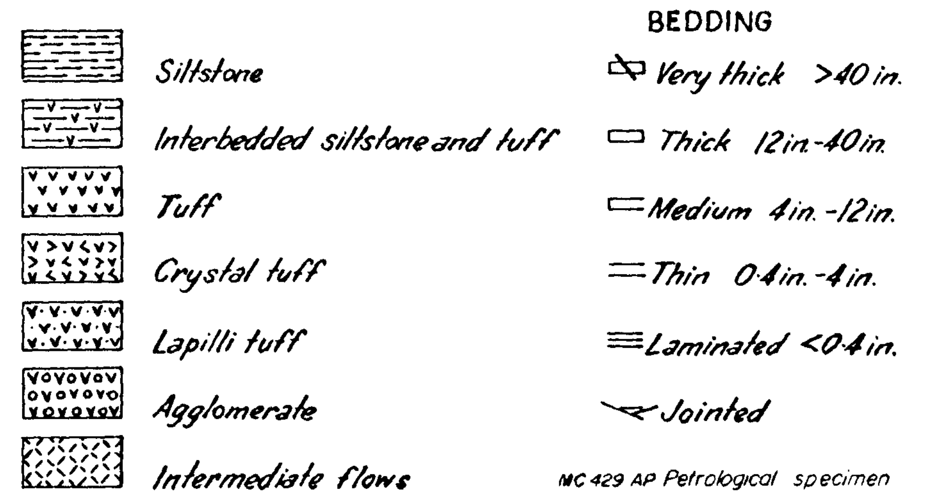
LOCATION: LIZZIE CREEK, STOCKTON 1-MILE AREA

STRATIGRAPHIC POSITION: TOP OF SECTION IS ABOUT 1100' BELOW POSSIBLE UNCONFORMITY SEPARATING LOWER BOWEN VOLCANICS FROM OVERLYING MIDDLE BOWEN MARINE SEDIMENTS



" = 50' APPROX.

REFERENCE



To accompany Report No 1963/64
...sources, Geology and Geophysics April 1963

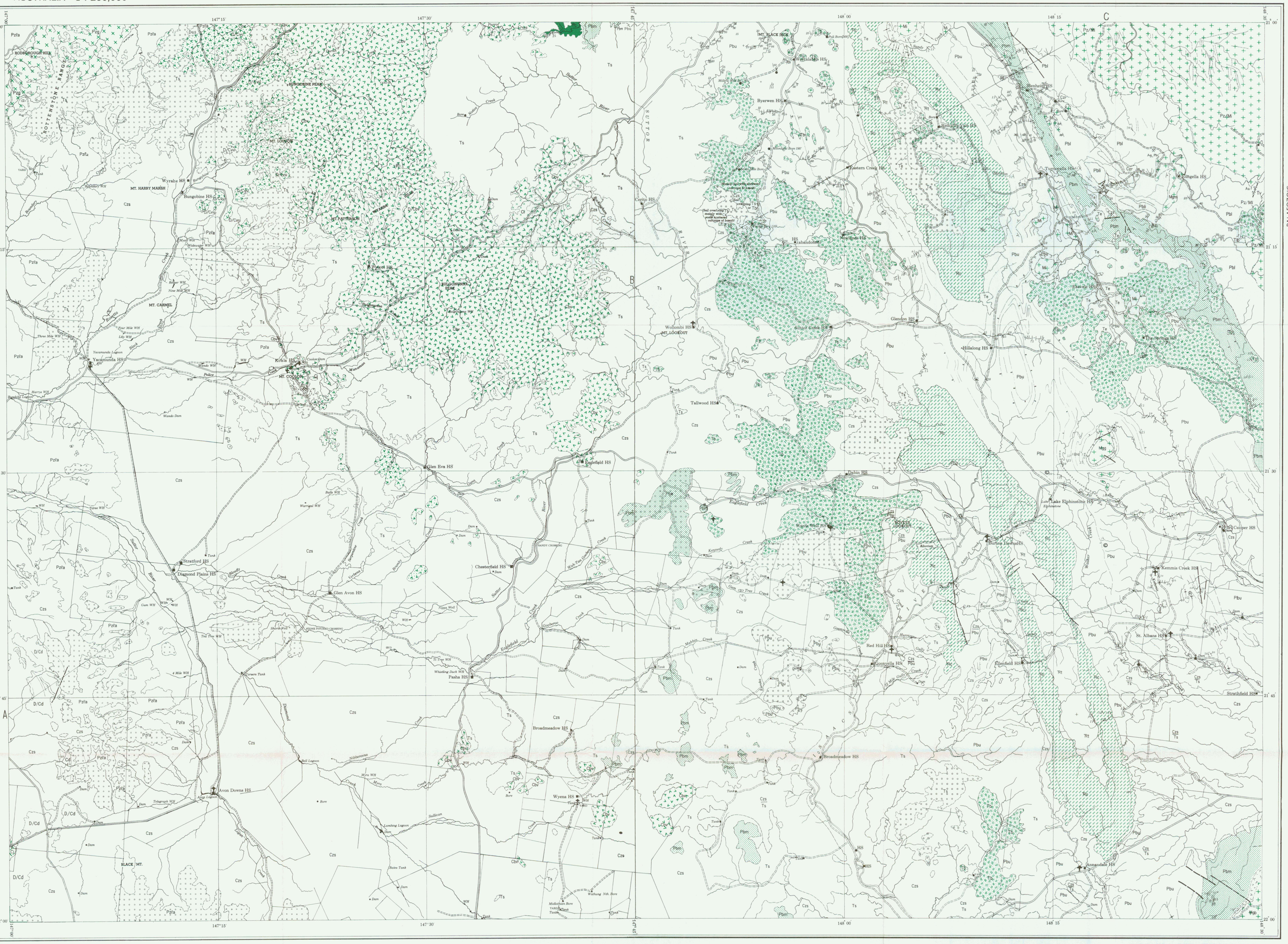
F 55/7/4

MT. COOLON
QUEENSLAND

AUSTRALIA 1 : 250,000

1 : 250,000 GEOLOGICAL SERIES SHEET SF 55-7

PLATE 1
SUBJECT TO AMENDMENT



Reference

CAINOZOIC			Czs	Soil, sand, alluvium, laterite, lateritic soils and gravels
CAINOZOIC			Czr	River channel and flood-plain deposits
CAINOZOIC			(o o o o)	Laterite on underlying formation
CAINOZOIC	Tertiary	Suttor Formation	Ts	Cross-bedded quartz sandstone, lenses of fine and pebble conglomerate, sandy claystone, silicified claystone, river channel conglomerate
CAINOZOIC	Tertiary		Tb	Basalt flows and rare plugs; few trachyte flows, plugs and dykes
CAINOZOIC	Tertiary	Exevale Formation	Te	Friable quartz sandstone with scattered pebbles and some thin conglomerate bands, silicified quartz sandstone, white friable siltstone
PALAEOZOIC OR MESOZOIC			Pz/Mi	Alkali granite, adamellite, aplite, gabbro
MESOZOIC			Mi	A possibly differentiated series of intrusives including leucocratic anorthite gabbro, leuco-diorite, quartz hornblende diorite, porphyritic micro-granodiorite, granodiorite, alkali granite; dolerite and porphyritic plagioclase dolerite sills and dykes
MESOZOIC		Gotthardt Granodiorite	Mgg	Biotite hornblende granodiorite
MESOZOIC		Bundarra Granodiorite	Mgb	Leuco granodiorite
MESOZOIC		Mt. Barker Granodiorite	Mgm	Biotite-hornblende granodiorite
MESOZOIC	Triassic	Teviot Formation	Rt	Micaceous lithic sandstone, calcareous in places, and micaceous siltstone
MESOZOIC	Triassic	Carborough Sandstone	Rc	Cross-bedded quartz sandstone, feldspathic in places, some fine and pebble conglomerate
PALAEOZOIC	Permian	Upper Bowen Coal Measures	Pbu	Cross bedded, well sorted lithic sandstone, siltstone, carbonaceous shale, some coal seams, pebble and cobble conglomerate beds, dolomitic and calcareous greywacke
PALAEOZOIC	Permian	Middle Bowen Beds	Pbm	Brown-grey quartz greywacke, grey blue greywacke grading into micaceous siltstone, blue grey and brown siltstone, quartz sandstone, calcareous quartz greywacke. Locally metamorphosed to knotted schist, slate, graphitic schist, hornfels. Current-bedded quartz sandstone, conglomerate, siltstone
PALAEOZOIC	Permian	Collinsville Coal Measures	Pc	Quartz sandstone, pebble conglomerate, siltstone
PALAEOZOIC	Permian	Lower Bowen Volcanics	Pbl	Andesite flows, sills, tuffs, crystal and lithic tuffs, agglomerate, black siltstone, coarse tuff grading into volcanic ash
PALAEOZOIC	Permian		Pbli	Sills and laccoliths of diorite, micro-gabbro and dolerite
PALAEOZOIC	Carboniferous		Ci	Granite, diorite, hornblende gabbro, acid to intermediate stocks and bosses
PALAEOZOIC	Carboniferous	Bulgonunna Volcanics	Cbv	Flow-banded, porphyritic rhyolite, quartz-feldspar porphyry, acid tuff and agglomerate, tuffaceous greywacke, siltstone. Intrusive acid to intermediate stocks and bosses; some intrusive rocks, probably equivalents of the extrusives
PALAEOZOIC			Pzg	Biotite-hornblende granodiorite
PALAEOZOIC	Devonian-Carboniferous	Drummond Group	D/Cd	Feldspathic quartz sandstone, buff siltstone and claystone, rhyolite flows, rhyolitic agglomerate, quartz greywacke, siltstone
PALAEOZOIC	Devonian-Carboniferous	Undifferentiated Volcanics	D/Cvu	Tuff, siliceous tuff, porphyritic lavas, conglomerate, tuffaceous sandstone
PALAEOZOIC	Devonian		Dus	Tuffaceous lithic sandstone, sandstone, conglomerate, siltstone
	Pre- Upper Devonian	Anakie Metamorphics	Pzla	Mica schist, phyllite, schistose and lineated siltstone, closely jointed quartz greywacke, sheared feldspathic sandstone; silicified quartz sandstone and fine conglomerate, brecciated and quartz veined in places. Includes rocks of Middle Devonian age in north-west of area

Geological boundary
Anticline, showing plunge
Syncline, showing plunge
Fault

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

Strike and dip of strata
Prevailing dip
Vertical strata
Horizontal strata
Overturned strata

Air-photo interpretation:
- Dip slope
- Dip < 15°
- Dip 15° — 45°
- Dip > 45°
- Trend of bedding
- Joint pattern

Macrofossil locality
Plant fossil locality

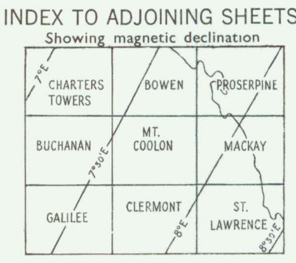
Contact metamorphic zone
Conglomerate bed
Dyke or sill

Mines:
- Ag, Pb — Silver, Lead
- Au — Gold
- Coal - unexploited

Bore
Windpump
WH — Waterhole
Tank or Dam
Dam
Township
Homestead
Yard
Fence
Airfield
Road
Vehicle Track

Compiled and published by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Topographic base compiled by the Division of National Mapping, Department of National Development. Aerial photography by the Royal Australian Air Force; complete coverage at 1:30,000 scale. Transverse Mercator Projection.

INDEX TO ADJOINING SHEETS
Showing magnetic declination

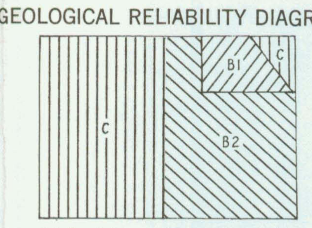


Scale 1 : 250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

GEOLOGICAL RELIABILITY DIAGRAM

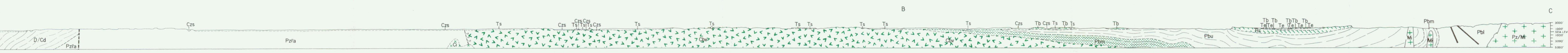


B 1 Detailed reconnaissance mapping. Very many traverses
B 2 Reconnaissance mapping. Numerous traverses
C Sketchy. Some traverses and air-photo interpretation

Geology, 1960, by: E.J.Malone, D.W.P.Corbett and A.R.Jensen of Bureau of Mineral Resources and P.E.Bock and L.G.Cutler of Geological Survey of Queensland.
Compilation, 1961, by: E.J.Malone, D.W.P.Corbett and A.R.Jensen
Drawn by: R.Szentes, R.J.Molloy and A.B.Fenner

Section

SCALE: $\frac{V}{H} = 1$



MT COOLON
SHEET SF 55-7