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Progress Report on the Bowen Basin Regional Survey, Season 1960.

GEOLOGY OF THE MT.COOLON 4-MILE AREA.

by

E.J.Malone, D.W.P.Corbett and A.R.Jensen.

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SUMMARY

In 1960, the Bureau of Mineral Resources, in association with the Geological Survey of Queensland, commenced a programme of regional mapping of the Bowen basin, Queensland. The primary aim of this programme 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, the Mt.Coolon party, which mapped most of the Mt.Coolon 4-mile area. The Mt.Coolon sheet will not be published in the Australian geological 4-mile series as yet. Further mapping in adjacent areas is required to resolve some outstanding problems.

The oldest rocks in the Mt.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 Beds, were deposited in the Drummond Basin west of the Anakie High, during Devonian to Carboniferous time. Some of these beds crop out in the south-west of the Mt.Coolon area, dipping west off the Anakie High.

The acid volcanics and minor sediments of the Devonian/Carboniferous Bulgonunna Volcanics crop out east of the Anakie High. These thick volcanics constitute a massive block which forms the western basement of the Bowen basin.

Deposition in the Bowen basin commenced in late Carboniferous or early Permian time with the deposition of the Lower Bowen Volcanics. These consist of a very great thickness of mainly andesitic volcanics, 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 about the top of the Lower Permian. All three faunas are found in the north-east of the Mt.Coolon area where the unit consists of a deep-water, quartz greywacke-siltstone assemblage, from 4,500 feet to 8,000 feet or more thick. Only the youngest fauna occurs in a quartz sandstone on the western side of the basin, where about 2,000feet of this shelf-type deposit unconformably overlies the Bulgonunna Volcanics; they represent a late stage transgression of the Middle Bowen sea onto 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 sand tone, siltstone, donglomerate, 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, 1,500 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 unconformably cover the older rocks in many areas. These areas, some of which are quite large, are remnants 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 Beds and the Bulgonunna Volcanics. A suite of intrusives, ranging from granodiorite to gabbro in composition, intruded the Bowen basin succession. These are possibly late or post Triassic in age.

The relationship of the Eungella-Broken River Igneous 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 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

The Mt. Coolon 4-mile area is located 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 parallels of south latitude and by meridians 147° and 148°30' of east longitude.

The Clermont-Mackay highway crosses the south-east corner of the area. Elsewhere, a network of graded roads and vehicle tracks link Mt. 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 with the exception of the very rugged and thickly timbered ranges in the north-east corner of the sheet.

The annual rainfall ranges from 20 inches per year in the west to 30 inches per year in the east of the area, and is considerably higher in the Eungella Ranges. 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 butare often 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, are located along the road through the Eungella Range, which, at Eungella, lies just within the eastern edge of the Mt. Coolon area. The timber is cut in the rain forest, partly within the Mt. Coolon area, and the timber-cutters tracks give some access to this most inhospitable area.

The Mt. Coolon area is covered by R.A.A.F. air photos, photographed 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 R.A.A.F. photos. Geology, drainage, topography and cultural detail were transferred to the photo-scale compilations and these were reduced to 1:125,000 scale to produce the map accompanying this report.

This report and map are almost entirely based on field work done between June 9th and October 14th, 1960, as part of the first stage of a programme of regional mapping in the Bowen basin.

The field party members were E. J. Malone, D. W. P. Corbett and A. R. Jensen of the Bureau of Mineral Resources and P. E. Bock, from June 9th to September 9th, and L. G. Cutler, from September 9th to October 14th, of the Geological Survey of Queensland.

J. M. Dickins, palaeontologist, and J. J. Veevers, the Clermont party leader, visited the party from the 18th to 25th September. They made large collections of fossils from the various localities discovered by party members and made some preliminary correlations.

M. A. Condon, Assistant Chief Geologist, and W. B. Dallwitz, senior petrologist, visited the party from the 27th September to 8th October. They toured most of the Mt. Coolon area, examining and commenting on the geology and suggesting further work. Mr. Condon gave party members instruction on some techniques of section measuring.

G. Tweedale, of the Geological Survey of Queensland visited the party from the 12th to 15th of October. He had previously led members of both the Mt. Coolon and Clermont parties, together with Dr. N. H. Fisher, N. J. Mackay and W. J. Perry on a reconnaissance of the northern part of the Bowen basin, from 31st May to 5th June.

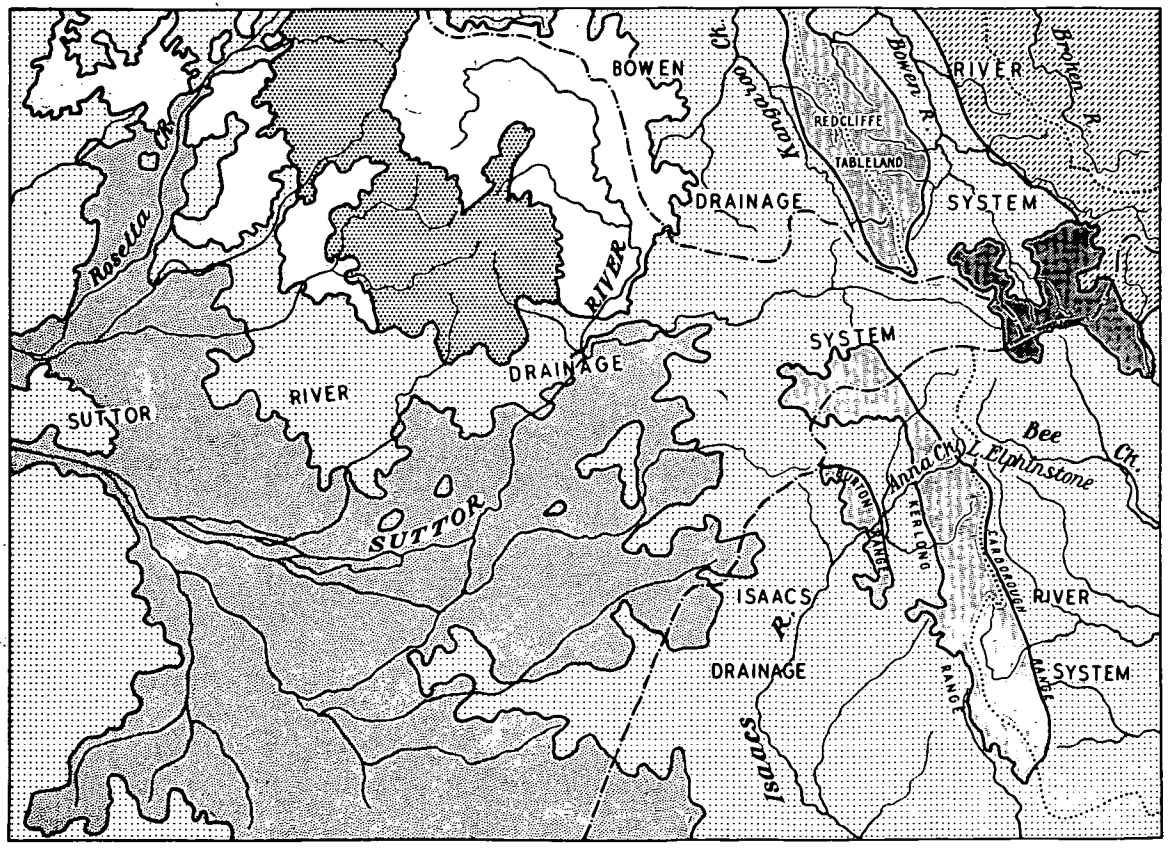
PREVIOUS INVESTIGATIONS

A number of authors have referred to the units cropping out in the Mt. 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 Mt.Flora gold and mineral field. Morton visited the area in 1935 to map the Mt. 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 to a diamond drilling programme to test the coal reserves of this area. The results of this programme are recorded in the Powell Duffryn Technical

Text Figure 1.

PHYSIOGRAPHIC SKETCH MAP
MT. COOLON AREA



Reference

- Eungella and Broken River Ranges.
- Highlands
- Lowlands.
- Plains.
- Inclined plateau
- Tableland and mesas.
- Carborough, Karlong and Burton Ranges and Redcliffe Tableland.

- *Boundaries between physiographic 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.

F5537/1

Services report 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 Mt. Coolon area, in reconnaissance detail. He revised 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 Mt. Coolon area. These are the Eungella and Broken River Ranges, three types of topography designated as highlands, lowlands and plains, an inclined plateau, a tableland and several mesas, the Carborough, Kerlong and Burton Ranges and the Redcliffe Tableland. The distribution of these is shown on Text Figure (1).

The three main drainage systems in the area are also shown on Text Figure 1. These are the Sutter River, the Isaacs River and the Bowen River drainage systems.

Eyngella and Broken River Ranges.

The Eungella and Broken River Ranges include the highest elevations in the area. They rise to about 3,000 feet above sea level near Eungella. 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. These do not fully occupy the bottoms of their valleys, but the valley sides are still steep. Some of the drainage is linear and apparently fault controlled. Razorback ridges are common in the area.

This very youthfull 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 further west.

Highlands

The highlands are an area of moderately rugged topography, located north-east of Mt. Coolon. The elevation of the area is probably nowhere greater than 2,000 feet above sea level. Local relief in the area 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, and bounded by steep slopes. The plateaux are separated by deeply incised streams. Some isolated hills rise above the general level. The topography is the result of a long periodof 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 extremely widespread in the western half of the Mt. 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 extremely 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 that of the highlands and that of the plains. In places, 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 following 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 areas. 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 are recognised in the north-west of the area. These 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 which drain the tableland. 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 separately 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 the ranges 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, having a relief of 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.

The Suttor River drainage system is the most important of the three in the area. It drains over 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 Mt. Coolon area. A minor divide separating the two parts of this system, is shown on the physiographic sketch map. The two parts are the Isaacs River and tributaries which drain first south and then south-east. The second includes 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 these two 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 Mt. Coolon area. Kangaroo Creek, on the other hand is non-permanent and is typical of most of the drainage in the Mt. Coolon area.

GEOLOGY

General

The Mt. Coolon area includes parts of the Anaki Metamorphics, the Drummond Beds, the Bulgonunna Volcanics, and the Permian - Triassic succession of the Bowen basin. A comple.. 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 Mt. Coolon area are listed and briefly described in Table 1.

TABLE 1. - ROCK UNITS OF THE MT. COOLON 4-MILE SHEET - AREA.

AGE	PERIOD	ROCK UNIT AND LETTER SYMBOL	THICKNESS	LITHOLOGY	DISTRIBUTION	TOPOGRAPHY	PALAEONTOLOGY AND AGE	STRATIGRAPHIC RELATIONSHIP	DEPOSITIONAL ENVIRONMENT.
CAINOZOIC		Czr	up to 100'	River channel and flood plain deposits	Large plain extending south from Blenheim H.S.	Now being eroded into rounded hills and deep narrow gullies but the hilltops are at a uniform elevation.	Deposition of these units commenced in the Tertiary and in some cases is continuing now.		
		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.			
	TERTIARY	Suttor Formation (Ts)	Variable about 200' locally up to 400'	Medium to coarse grained cross-bedded quartz sandstone, lenses of fine 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'	Med. 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	Overlain by basalt, unconformably overlies Permian	Deposited in lakes formed in depressions in Permian rocks
MESOZOIC	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, felspathic in places, some quartz fine and pebble 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.

TABLE 1. Sheet 2.

ERA	PERIOD	ROCK UNIT AND LETTER SYMBOL	THICK-NESS	LITHOLOGY	DISTRIBUTION	TOPOGRAPHY	PALAEONTOLOGY AND AGE	STRATIGRAPHIC RELATIONSHIP	DEPOSITIONAL ENVIRONMENT.
PALAEOZOIC	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 the sheet area, except the 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:- Gl[illegible]opteris indica. [illegible]sch. G. browniana. Brong. G. augustifolia. Brong. G. conspicua. Fm. Phyllotheca australis. Brong. Rhipidopsis dawsoni (Shirley)	Conformably overlies the Middle Bowen beds.	Shallow water, probably freshwater at times.
		Middle Bowen Beds (Pbm)	Variable 4,500' to 8,000' 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. Some glacial erratics.	Long narrow zone trending north-west across Stockton and Hillalong 1 mile areas.	Mainly rounded to moderately steep hills, very rugged in places.	Abundant marine fossils belonging to three distinct faunas:- [illegible]rtiniopsids [illegible]trophalosia [illegible]ptoleda [illegible]danthus [illegible]rydesma [illegible]rtenids	Overlies Lower Bowen Volcanics with a disconformity, probably representing only a short time break, and in places some evidence of an angular unconformity.	Marine; no shallow-water structures. Eastern limit of Bowen basin was much further east.
			Probably 8,000'	ANNANDALE AREA Meta sediments include knotted schist, slate, graphitic schist hornfels. Sediments as above.	South-east corner of 4-mile area.	Rugged near the intrusion, rounded hills grading into plains elsewhere.		Intruded and domed by Kamarra Intrusion.	Marine; no shallow water structures.
			abt. 2,000'	WESTERN EDGE OF BOWEN BASIN Current bedded, quartz sandstone, quartz fine and pebble conglomerate.	Discontinuous outcrops extending south across middle of Mt. Coolon 4-mile Sheet.	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.

ERA	PERIOD	ROCK UNIT AND LETTER SYMBOL	THICK-NESS	LITHOLOGY	DISTRIBUTION	TOPOGRAPHY	PALAEONTOLOGY AND AGE	STRATIGRAPHIC RELATIONSHIP	DEPOSITIONAL ENVIRONMENT.
P A L A E O Z O I C	P E R M I A N	Lower Bowen Volcanics (Pbl)	Not known. Possibly 20,000' but certainly 10,000'	Andesite flows, sills, tuffs, 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 Mt. Coolon 4-mile area	Very rugged topography, steep hills, short ridges and narrow valleys.	Rare plant remains including Glossopteris. Marine fossils in tuff near top of the unit. Fossils include Eurydesma, Deltopecten Martiniopsids. Unit may extend down into the carboniferous.	The volcanics plunge south-west from igneous complex of Eungella Range. Relationship with igneous rocks is not known but possibly is an intrusive relationship.	Definitely marine in part. Some sedimentary structures suggest deep water and moderate distance from source.
	DEVONIAN - CARBONIFEROUS	Drummond ~~Group~~ Beds (Cd)	Not well developed in area but is about 20,000' thick further west	Feldspathic quartz sandstone buff siltstone and claystone, rhyolite flows, rhyolitic agglomerate, quartz greywa cke, siltstone.	South-west corner of Mt. Coolon 4-mile area	Produces hills and ridges of moderate relief in an area of generally very mature topography	Fish remains. Plants including Protolepidodendron linearе. Walk., found at base of unit west of Mt. Coolon, suggests unit commenced in Upper Devonian.	Unconformably overlies Anakie metamorphics. Not seen in contact with Bulgonunna Volcanics 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.
		Bulgonunna Volcanics (D/Cbv)	Not known possibly 15,000'	Flow banded rhyolite, porphyritic rhyolite, quartz feldspar porphyry, acid tuff and agglomerate; tuffaceous greywacke, siltstone. Intrusive acid to intermediate stocks and bosses, and some intrusive rocks, probably equivalents of the extrusives.	Extends from north to south across Mt. Coolon area, between the Bowen basin sediments and the Anakie Metamorphics.	Rugged topography in north of area. Further south, forms isolated hills and ridges of moderate relief.	Plant fossils are found near base of unit, a few miles east of Anakie Metamorphics. Plants include Protolepidodendron walwalense Walk. Psilophytites sp. Stigmaria ficoides Brong. Age is Devonian, possibly Upper Devonian.	Unconformably overlies Anakie metamorphics. Relationship to Lower Bowen Volcanics not known, but is overlain with marked unconformity by Middle Bowen Beds.	Very thick pile of volcanics with minor sediments. Sediments at base are waterlain, possibly freshwater; later volcanics may be terrestrial in part.
		Anakie Metamorphics ($P_Z$la)		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-west 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 are not determinable	Oldest rocks in the area.	Several rock units involved Environment of deposition not known.

ANAKIE METAMORPHICS

Summary

The Anakie metamorphics crop out in the long, narrow Anakie High, which extends across the western edge of the Mt. Coolon area. The rock types present in the area include siltstone, quartz greywacke, quartz sandstone and quartz pebble conglomerate. They probably belong to more than one rock unit. These rocks have been metamorphosed to quite 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 unconformably older than middle Devonian, and are referred to as Lower Palaeozoic.

Nomenclature

The name Anakie was first applied to these rocks by Jensen (1921) who called them the Anaki 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 miles long, narrow structure extending from Anakie to north-west of Mt. Coolon, in which these rocks are found.

They were referred to as the Anakie metamorphics in the Geological Map of Queensland (1953) and as the Anakie Complex in the Geology of Queensland (1960). The informal name Anakie metamorphics is preferred because of the probability that a number of rock units are involved, and because of the possible difference in metamorphic grade between the rock types in the Mt. Coolon area and those in the Anakie area.

Distribution

The Anakie metamorphics crop out in the western part of the Mt. Coolon 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 Mt. 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 of the Mt. Coolon area, where the topography is less mature, the Anakie metamorphics crop out in hilly country. Mesas are also present, formed of resistant, lateritised, flat-lying Tertiary sediments unconformably overlying the metamorphics. The mesas have a relief of 200 to 300 feet. The metamorphics commonly crop out in the lower flanks of the mesas, though in a few places these 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 Mt. 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 Bungabine Homesteads, and west of Yacamunda Homestead, outside the area.

(a) 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.

These sediments have been weakly metamorphosed Strongly schistose, laminated siltstone appeared in hand specimen to be highly metamorphosed; however, thin section examination revealed this rock to consist of laminae, composed almost entirely of quartz grains, separated by micaceous laminae. The mica was mainly flaky sericite, replacing the original argillaceous material. In places, the sericite flakes were draped around quartz grains or blebs of iron ore to form small augen structures. The sericite flakes were oriented parallel to the laminations, giving the rock its schistose appearance. The quartz grains showed strain extinction, and some signs of re-orientation and solution. A small amount of possibly authigenic feldspar was present in the matrix; small blebs of iron ore were numerous throughout the rock.

This rock was subjected to mild deformation after the development of the schistosity. During this, the schistose laminae were folded into small folds whose axes strike at about 100°, nearly at right angles to the north-south strike of the schistosity.

Some other siltstone specimens were examined in thin section. They consisted mainly of quartz grains in an argillaceous matrix, with some sericite flakes. The rocks were deeply weathered and iron-stained. Iron-staining was very noticeable in the Anakie metamorphics in outcrop.

A specimen of fine quartz greywacke was examined. It consisted of sub-angular quartz grains in a calcitic and chloritic matrix and contained small amounts of plagioclase. The rock contained some bands rich in sericite. Opaque iron ore was common, particularly in the sericite - rich bands.

(b). 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 joint lineation. In one specimen the quartz grains were 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 contained a very small amount of chlorite and sericite in the matrix.

A specimen of Anakie metamorphics collected near Mt. Coolon was found to be a crushed, sericitized quartzite, containing veinlets of quartz - goethite - sericite. This rock was collected near the contact between the Anakie metamorphics and the overlying Bulgonunna 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 Mt. Coolon area where they are abundantly quartz veined 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 re-silicified.

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 Mt. 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 Mt. 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 middle Devonian and younger rocks. Within the Mt. Coolon area, the high is overlain by the Devonian- Carboniferous Drummond Beds dipping off the high to the south-west, and by the Devonian Carboniferous Bulgonunna Volcanics, welded against the eastern side of the high. The actual unconformities between the Anakie metamorphics and the overlying Drummond Beds and Bulgonunna Volcanics were not seen. However, there is sufficient evidence to confirm their existence.

This includes the regional structure of the units and the presence of schistosity, phyllitic cleavage, lineation and secondary crenulation in the Anakie metamorphics and the absence of such signs of dynamic metamorphism, from the Drummond Beds and Bulganunna Volcanics.

Not much is known of the structure within the Anakie High. Schistosity and bedding were found to be parallel in most cases where bothwere visible. Strike of schistosity and

bedding was generally north, ranging to 30° east of north, and dips ranged from 50° to vertical.

Age.

The age of the Anakie metamorphics is not known, except that it is older than middle Devonian. It is probably no older than Lower Palaeozoic

DRUMMOND BEDS

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 Mt. Coolon area. The name Drummond Beds will be used in this report, in preference to Drummond Group used in the Geological Map of Queensland, 1953, pending further mapping of the Drummond Basin.

Distribution

The Drummond Beds crop out only in the south-west of the Mt. Coolon area, and are not well exposed. For the most part, they 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 to coarse grained rock, silicified in places producing fairly prominent strike ridges. 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 were 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. These volcanics are similar to the Bulgonunna Volcanics developed

to the east of the Anakie High. Apparently, the Bulgonunna Volcanics transgressed the Anakie High, a few miles south of the Mt. Coolon area, in the Clermont area, and acid volcanics were poured out on the western side of the high. These volcanics appear to lense out northwards. The Drummond Beds in the Mt. Coolon area appear to consist of a mixture of quartz sandstone and siltstone and acid volcanic detritus and flows.

Structure

The unit unconformably overlies the Anakie metamorphics. Its structure is fairly simple in this area The strike of the beds and of the unconformity are parallel to the Anakie High and trend 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 Mt. Coolon area.

Environment

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

Thickness

It was not possible to measure the thickness of the Drummond Beds in the Mt. Coolon area. The unit was estimated to be up to 20,000 feet thick by Randal (Veevers et alia, 1961) on the basis of sections measured in the Clermont 4-Mile area.

Age.

Deposition of the Drummond Beds commenced in the Devonian and continued into the Carboniferous. Plant fossils were collected near the base of the unit, 10 miles west of the Mt. Coolon area, near the St. Ann's crossing of the Suttor River. These plants (see specimen MC886F Appendix B) were identified as Protolepidodendron lineare Walk. and are probably Upper Devonian in age. Abundant lepidodendroid material has been collected in the Drummond Beds, indicating deposition continued into the Carboniferous.

BULGONUNNA VOLCANICS

Summary

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 Mt. Coolon to Eaglefield Homestead Road and forms scattered outcrops south of Eaglefield Homestead.

The unit consists of rhyoliteflows, porphyritic rhyolite, rhyolitic tuffs and agglomerates, andesite, and miner acid intrusions. Some tufaceous grewacke and silstone crop out near the base of the unit; these contain plant fossils of Upper Devonian age.

The Bulgonunna Volcanics unconformably overlie the Anakie metemorphics. They 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 deposition commenced in the Upper Devonian but may have continued into the Carboniferous.

Nomenclature and distribution.

Bulgonunna Volcanis is a new name proposed in this report. The type area is along Bulgonunna Creek, from the Mt. Coolon to Collinsville Road crossing, at lat 21°19'S, Long. 147°27' E., to the vicinity of Bulgonunna Peak.

The unit is well exposed north of the road between Mt. Coolon and Eaglefield Homestead. To the west, it is bounded by the Anakie High; to the north-east its area of outcrop is limited by outcrop of the Tertiary Suttor Formation which unconformably overlies it. Scattered outcrops of the volcanics are found protruding through Cainozoic deposits southwest from Mt. Coolon to the southern margin of the 4-mile area.

In the northern area, the Bulgonunna Volcanics produce high, undulating plateaux with steep slopes. Valleys are deeply incised, and are generally youthful. Some isolated hills rise above the general level of the volcanics, for example Bulgonunna Peak and Mt. McKinlay. 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 baded, 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-obigoclase range. Anarthoclase occurs in some rocks.

The proportion of phenocrysts to groundmass is variable; it was so high in one rock type that the rock was mapped as an intrusive porphyry. Thin section examination revealed flow banding in the groundmass. There is some doubt as to the actual nature of this rock, which is tentatively described as porphyritic rhyolite.

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 speciment examined.

The porphyritic rhyolites fall into two groups: some have a scattering of phenocrysts in a dark, fine, weakly flow handed grounmass; 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. They are totally unlike the plenocryst-rich porphyritic rhyolites.

Andesite laves are found in the Bulgonunna Volcanics in the vicinity of Mt. Coolon. They are typically fine grained with scattered plagioclase laths as phenocrysts.

Tuffs and other pyroclastics constitute a small proportion of the unit. They are most common near the base of the unit in the Rosetta Creek area. There, they include a wide variety of rock types including fine grained, grey, siliceous tuff; medium to coarse grained, grey, white or mottled pink and grey, poorly to well bedded tuff; white, tuffaceous conglomerate or agglomerate with rounded cobbles and boulders up to 4 feet long of flow banded rhyolite and porphyritic rhyolite. In places, a buff, fine grained silicified ash was interbedded with some of the finer grained tuffs.

A number of specimens identified in the field as tuff were found in thin section to show the characteristics of both flow rock and bedded tuff. They consisted of angular fragments of quartz feldspar, devitrified volcanic glass and other volcanic rocks in a very fine grained matrix of quartz, sericite, and amorphous or cryptocrystalline silica. The groundmass shows

some flow banding. Vague depositional layering was visible in some specimens. These rocks are possibly flow breccias. Two specimens contained rare lapilli up to 4 cms long by 2 cms. across. The lapilli consist of very fine grained devitrified lava and appear to grade into the very fine grained quartz, sericite and amorphous silica of the groundmass. The remainder of the rock consists of angular fragments of quartz, devitrified volcanic glass and aggregates of sericite possibly after feldspar. These rocks are possible lapilli tuff in which some flowage occurred prior to final consolidation.

Sediments crop out at the base of the unit near Rosetta Creek. The sediments include fine to coarse grained, thin to medium bedded, khaki-brown, poorly sorted, hard tuffaceous greywacke, containing fragments of devitrified volcanic glass. The greywacke is interbedded with siltstone, acid tuffs and thin flows, and a dark, basic tuff containing inclusions of secondary minerals. The greywacke, and to a lesser extent the siltstone, contain abundant plant fossils. These fossils (Collection MC81F) are described in Appendix A. They include Psilophytites sp., Protolepidodendron yalwalense Walk., and Stigmaria ficoides Brong.

The Bulgonunna Volcanics are intruded by small acid intrusions. These are similar in composition to some of the volcanics and in places grade into them. The limits of these intrusives are difficult to map and they are included in the Bulgonunna Volcanics. They may represent intrusive equivalents of the extrusives.

Structure

The Bulgonunna Volcanics are essentially a massive, structureless block. The most common rock type, prophyritic 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 the sediments and tuffs at the base of the unit near Rosetta Creek and in interbedded rhyolite flows, tuffs and agglomerates cropping out in the headwaters of Parrot Creek. Dips in the Rosetta Creek area are at angles of 15° to 45°; they indicate moderate folding. In Parrot Creek, dips up to 80° are seen indicating moderately tight, possibly asymmetrical folding. The folding in these areas is unimportant when compared to the main mass of the unit.

Near the northern edge of the Mt. Coolon area, the Bulgonunna Volcanic are faulted against the Anakie Metamorphics, Sediments at the base of the volcanics are stood on end by the faulting and dip east at about 80°. The contact between these two units

in the Mt. Coolon area also is probably faulted.

In places, the Bulgonunna Volcanics are cut by close spaced groups of joints. The joints form no recognizable pattern; 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 be connected with intrusion into the volcanic pile. This jointing was visible on the aerial photographs and was useful in identifying the Bulgonunna Volcanics in nearly all places.

The Bulgonunna Volcanics unconformably overlies the Anakie Metamorphics. The contact was faulted in the one place exposed. However, the existence of an unconformity could be deduced from the greater structural complexity and the evidence of dynamic metamorphism of the underlying Anakie Metamorphics. It was supported also by the regional trends of both units.

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°. 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

The sediments near the base of the Bulgonunna Volcanics contain abundant plant remains in places indicating deposition in a possibly freshwater, aqueous environment. The bedded tuffs and agglomerates in this part of the unit were also water lain. However, the main mass of the unit, the rhyolite lavas and porphyritic rhyolites or ignimbrites, may have been extruded subaerially.

Thickness

The thickness of the Bulgonunna Volcanics is not known.

Age

The plant fossils found near the base of the unit are Devonian, probably Upper Devonian. Other plant fossils were collected near the top of presumably equivalent rocks in the Clermont 4-mile area; these are of Lower Carboniferous age. This gives a possible range for the unit from Upper Devonian to Lower 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-divideding some of the units. Reids classification was as follows :

Upper Bowen Series.
Middle Bowen Marine Series
Co[illegible] Coal Measures.

Lower Bowen Series { Mt. Derlin Volcanic Series
Mt. Derlin Coal Measures
Mt. 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 Mt. Coolon area.

The Geological Map 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 Mt. 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, namely 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. Till 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 and are best described by lithological terms. These 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 consists of intermediate to basic flows, tuffs and agglomerates, with interbedded sediments and volcanics and minor acid flows. Some sills and small intrusive bosses are included in the unit. 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 Mt. Coolon area. The Lower Bowen Volcanics are underlain by the igneous complex of the Eungella-Broken River area. The nature of this contact is not established but 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 mainly deep water environment. They contain rare plants throughout and marine fossils at one locality near the top of the unit.

Nomenclature and distribution

Reid (~~1929~~ 1928b.) applied the name Lower Bowen to equivalent volcanics cropping out near Collinsville. He subdivided the unit into 3 parts, but these are not recognised in the Mt. Coolon area.

The Lower Bowen Volcanics crop out in a belt cutting across the north-east corner of the Mt. 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, and in places round-topped, steep-sided hills rise from these plains. 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 particularly well exposed in the larger streams. Good exposures were examined in Lizzie and Hazlewood Creeks, over 800 feet of section being measured in the former (Plate 3).

Lithology

The Lower Bowen Volcanics include a wide variety of rock types. Flows make up about one third of the unit. These are mainly andesite, though some specimens examined were slightly more basic and were on the border line between andesite and basalt. The flows are usually medium to coarse grained, rarely fine-grained, and vary 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 Eungella-Broken River Igneous Complex, but are rare elsewhere in the unit.

Pyroclastics comprise 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 coloured rock, showing graded bedding from coarse 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" across. This tuff is similar to the matrix of the agglomerate.

Lapilli and crystal tuff 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 in colour.

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 thinly interbedded black siltstone and tuff such as occurs in the unit. 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 thin to medium bedded sequences, 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, felspathic 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 extremely 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 lacoliths 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. In some cases, the intrusive body seemed 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 Mt. Barker Granodiorite, and overlying the Eungella-Broken River Igneous Complex. This pile of volcanics is practically structureless, is rather poorly exposed where accessible and elsewhere is not easily accessible. It was not mapped in detail.

Structure

The relationship between the Lower Bowen Volcanics and the Eungella-Broken River Igneous Complex is not known. It is probably an intrusive relationship. 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 suggest that it was 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 conforms to this structure but is affected by more secondary folding than affects the Middle Bowen Beds. The volcanics are folded into a large anticlinal structure west of the Mt. 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 is due to a push from the north-east which may be

connected with the intrusion of the Eungella-Broken River Igneous 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 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 these sediments were deposited a considerable distance from source and probably 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. This indicates that the environment was marine near the end of deposition of the Lower Bowen Volcanics; it may have been marine throughout.

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 thick.

Age

One fossil collection, MC426, was made near the top of the Lower Bowen Volcanics, just north of the Lizzie Creek Road. The fossils are contained in andesitic tuff overlain by andesite flows. Fourteen species are present in this collection and are listed in Appendix A by J.M. Dickins. 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 suggest that a disconformity separates the Lower Bowen Volcanics from the Middle Bowen Beds. This disconformity is probably only of short duration.

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 Shales, 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 4,500 to 8,000 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 2,500 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°.

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

General

The Middle Bowen Beds crop out in three areas in the Mt. Coolon 4-mile area. These are: the Stockton-Hillalong area, a north-west trending belt cutting across the north-east corner of the area; the Bundarra area, a roughly circular area surrounding the Bundarra Granodiorite; the western shelf area, a discontinuous area of outcrop trending from north to south down the centre of the Mt. Coolon area. The rocks cropping out in these areas will be dealt with separately.

(1) THE STOCKTON-HILLALONG AREA

Distribution

In this 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 Lizzie Creek 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, 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 aerial 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 to a few feet thick beds and contains close 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.

Quartz greywacke is the dominant rock type 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 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 the previous two lithologies, and is most common about the middle of the section. It is a dark, grey-blue, micaceous, thick bedded, medium hard, fine 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" 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 comprising about 10% of the total section. Some cross-bedding was observed and some minor cross-lamination. In a few places, it is poorly sorted, ranging from fine 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 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 were fine grained, dense, grey rocks containing a considerable quantity of clastic material. Limestone was observed near Mt. Cona. It contained 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 (4).

The thickness of the unit was computed along six section lines, the locations of which are shown on Plate (4). Observations of bedding strike and the bedding trends visible on the aerial 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 aerial photographs and the plan thickness of the unit was measured off the aerial 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	8,000 feet
"	" B	6,400 feet
"	" C	5,250 feet
"	" D	4,500 feet
"	" E	4,650 feet
"	" F	5,500 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 these computed thicknesses are probably reasonably accurate. At all events, the errors in these 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 volcanics were 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 Beds 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, lense out as they approach it.

The fossils collected indicate that the basal part of the Middle Bowen Beds is present throughout the zone of thinning. Five large fossil collections were made, located as follows:

MC485F	About 1000' above base. Section line A
MC657F	In basal 500' of section. Between section lines C and D
MC1065F, MC1414F	In basal 500' of section. Between section lines D and E
MC421F	In basal 500' of section. Section line F.

These collections contain essentially the same fossil assemblages, and belong to the same stage. Therefore, transgressive overlap of the Middle Bowen Beds onto 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° to 50° but becoming steeper near Blenheim Homestead. Near Blenheim Homestead, the beds are overturned and dip north-east at about 75°. South of Hazlewood Creek, they are involved in some minor folding but the regional dip is still south-west.

It is suggested that the thinning of the Middle Bowen Beds is due to deposition on an uneven basement of Lower Bowen Volcanics. This implies that 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.

Environment

The environment of deposition of the Middle Bowen Beds cropping out in the Stockton-Hillalong area is 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 varies from 8,000 feet to 4,500 feet, as already discussed. 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.

(2) THE BUNDARRA AREA

The Middle Bowen Beds crop out in the south-east of the Mt. Coolon 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. Further 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 deposits 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. These sediments were 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 are somewhat like those found in the Stockton-Hillalong area. They include roughly bedded, thick to thin bedded, medium 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; thinly interbedded, fine 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 a gneissic layering of 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 aerial 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 5,000 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 many of those found had been recrystallized by metamorphism. The fossils included bryozoa, crinoid stems and fragments of brachiopods and pelecypods. None of this material was suitable for accurate determination but indicated a Permian age for the sediments. Fossils were found in these beds a few miles to the south in the Clermont area. These were 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 difficult access and thick cover, was not sufficient for accurate mapping.

(3) 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 Mt. Coolon area. 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 unit in this area consists mainly of quartz sandstone, siltstone and minor conglomerate. In Parrot Creek, it consists of medium to thick bedded, white, micaceous, cross-bedded quartz sandstone interbedded with 6 inches to 1 foot thick 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 contained worm tracks in places, but no other fossils were found. The quartz sandstone was case hardened in the creek, but elsewhere was medium hard to slightly friable, with little matrix or cement.

Further south, outcrop was very poor. Rock types seen include medium to coarse grained quartz sandstone, commonly grading into quartz fine 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 was 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 this 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°. The unconformity cuts across these structures and dips east at angles of less than 5°.

Six inches to 1 foot thick patches of pebble and cobble conglomerate marks the unconformity in places. The pebbles are fragments of the Bulgonunna Volcanics. The conglomerate is overlain by the assemblage described above. These sediments dip east at angles of 5° or less.

Further south, bedding in the Middle Bowen Beds is rather obscure. In the few places where bedding was observed, it was sub-horizontal to east dipping, at angles of 5° 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 environment of deposition is a marine, shallow-water shelf environment. Well sorted, current bedded quartz sandstone is the characteristic lithology, indicating 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. This surface sloped east at a gentle angle or was downwarped to permit the transgression. The unconformity surface on the Bulgonunna Volcanics is irregular in detail though the irregularities appear to have a low uniform relief. The surface is not as dissected as the pre-Tertiary surface of the Bulgonunna Volcanics further west. The smoothness of the unconformity surface may be due to shore line erosion by a slowly advancing sea.

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 on to the Clermont 4-mile area, where it is over 2,000 feet thick (Veevers et alia, 1961).

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 are given in Appendix A by J.M. Dickins.

The oldest fauna is represented by the following fossil collections: MC485, MC878, MC1414, MC421, MC1065 and MC657. At least 24 species are present in these collections. This fauna is almost certainly not older than 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 Mt. Coolon area, this fauna is found only in the basal 1,000 feet of the Middle Bowen Beds in the Stockton-Hillalong area. The same fauna is found at Homevale, east of the Mt. Coolon area.

The middle fauna is represented by only two collections, MC669 and MC420, from about 1,500 feet above the base of the Middle Bowen Beds in the northern part of the Stockton-Hillalong area. At least 10 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 Mt. Coolon area is represented by the following collections: MC423A, MC423B, MC802, MC803, MC311, MC292A, MC293, MC553, MC575. All of these collections except MC311, came from the upper 2,000 to 2,500 feet of the Middle Bowen Beds in the Stockton-Hillalong area. MC311 was made 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; 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 4, relative to the computed thicknesses of the Middle Bowen Beds.

THE 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 Mt. Coolon area, bounded by outcrop 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 micro-diorite.

Rock types in the unit 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:

16 million tons in an area north-east of Lake Elphinstone;
7 million tons in 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 Mt. Coolon 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 aerial 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, the proportions of the main lithologies are:

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

So, in outcrop, the proportion of lutite to arenite to conglomerate 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 Mt Coolon four-mile area, east of the Redcliffe Tableland, a development of conglomerate occurs about four thousand 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 vary in size from 1/10th inch to six inches; the rock itself is fairly hard and compact and in some cases is fractured across 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 are rounded in many cases and consist

mainly of volcanic detritus. Volcanic glass is common and this, together with the tuffaceous material present, shows signs of attrition. Some conglomerate has shale partings and these contain abundant plant remains.

Elsewhere in the Upper Bowen Coal Measures conglomerates do occur as fairly persistent beds. For example 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 fifty percent of the rock. The second type is a lithic sandstone in which rock fragments and feldspar comprise up to seventy percent of the rock.

The first type contains up to sixty 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 glossy 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 has been dropped volcanic detritus. It may best be called a calcareous lithic sandstone.

The second type is a lithic sandstone. It consists of about 30% quartz, 30% rock fragments, 10% feldspar, 20% mica and 5 to 10% matrix. The rocks of this group are well sorted but the grains are subangular to subround. The porosity of these rocks is low. Festoon bedding is common as well as normal current bedding. Outcrops of this sandstone occur as thick bedded lenses which is in contrast with finer, thin bedded, sediments. Calcareous concretions, up to two feet in diameter, occur within this lithology. These concretions have a hard calcareous core surrounded by concentric layers of lithic sandstone.

Finer sediments occurring within the Upper Bowen Coal Measures consist of siltstone, calcareous siltstone, silicified siltstone and phosphorite. The siltstone varies both in colour and grain size: the colours vary from white to grey, black, grey-blue, brown, or yellow; the grain size varies through all sizes of the siltstone range. Much of the siltstone is calcareous but it is not known whether this is primary or secondary.

Silicification is noted in some siltstone, particularly those rocks which show very fine current lamination. 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 Mt. Coolon four mile 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 RJ1 in Plate 5 . The coal is thin and contains many shale partings. In some occurrences the coal is reported to be as much as twenty five feet thick. Coal reserves, suitable for open cutting were proved by drilling in two areas: 16 million tons in an area north-east of Lake Elphinstone; 7 million tons in an area west of Kemmis Creek Homestead.

Structure

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 scavanger action, and a fossiliferous calcilutite. Immediately above the sandstone, and structurally quite conformable with it, is a series of thinly bedded siltstones which contain 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 located west of the

Redcliffe Tableland may be traced for a distance of twelve miles. The axis of the elongate dome located south of the Redcliffe Tableland may be traced for a distance of almost 20 miles though the amplitude of the fold decreases rapidly with distance from 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° east to 50° east and then decreases to 25° east.

Intrusives crop out in the cores of a few domes, such as that about the Gotthardt Granodiorite. The intrusive is more or less concordant with the structure which is elongated roughly parallel to the trend of the fold axes. The intrusion was possibly contemporaneous with the folding of the sediments.

The Upper Bowen Coal Measures, east of the Carborough Range, are folded into complex minor folds. These structures are characterized by rapid reversals of plunge. Outcrop is confined to creek sections, and it is not always possible to sort out the structure from the array of disconnected strike and dip observations. A somewhat similar situation exists west of Byerwen and Weetalabah homesteads. In this area 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 unit appears 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 environment of deposition of the Upper Bowen Coal Measures was that of a rapidly sinking restricted basin. The environment was such as to permit 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 off the air-photos. Reid estimated a thickness of 9,600 feet.

Palaeobotany and age

Fossil plants were collected from a number of localities in the unit. The reference numbers of the collections are MC225(a)F, MC233(a)F, MC233(b)F, MC1017(a)F, MC236(a)F, MC292(b)F, MC755F, MC62F, MC46F, MC535F, MC727F; these are described in Appendix B by Mary E. White. Species identified include Glossopteris indica Sch., G. browniana Brong., G. augustifolia Brong., G. conspicua Fm., G. spathulato - cordata Fm., Phyllotheca australis Brong., Nummulospermum bowenense Walk., Sphenopteris lobifolia Morr. Cladophlebis roylei Arber., Samaropsis dawsoni (Shirley), Vertebraria sp.

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 1,500 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° 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 unit 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, respecitvely; 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 to over 600 feet above the surface of the Upper Bowen Coal Measures. Outcrop is fairly good, though true dips are commonly difficult to measure, owing to the amount of crossbedding. Many outcrops were 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% of chert, quartzite and rock fragments, minor feldspar and mica. The grains are subrounded, medium to coarse grained 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° 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. The unit 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. It was commenced at the lowest outcropping bed but did not reach the top of the unit. The total thickness is estimated to be at least 1,500 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 least 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 Ellensfield Homestead to Kemmis Creek Homestead track which crosses the unit for a distance of three miles, about Lat. 21°42'S., Long. 148°16' E. It lies between the Carborough and Kerlong

Ranges in the Burton Downs 1-mile area. No sections have been measured in the unit.

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 Redcliffe Tableland.

Lithology

The unit 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 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 comprising up to 40% of the rock. Elsewhere, it is completely ferruginised, possibly due to replacement of calcite by iron oxides. In many specimens, the sandstone has no cement and little or no matrix. These types are semi-friable, and brown to reddish in colour.

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

The micaceous siltstone is not well exposed. It is generally a brown, medium 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°. It 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 unit is unconformably overlain by Tertiary sediments and basalt flows.

Environment

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

Thickness

The thickness of the Teviot Formation is not known. There is about 400 feet present between the Carborough and Kerlong Ranges, but the top of the unit 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 unit at one locality and are described in Appendix B by Mary E. White (Coll'n. MC697F). These were identifiedas Dicroidium feistmanteli (Johns.) Gothan and Dicroidium odontopteroides (Morr.) Gothan, and indicate a Triassic age.

TERTIARY

EXEVALE FORMATION

Summary

Exevale Formation is a new name proposed for presumably Tertiary lake deposits. These unconformably overlie Permian and Triassic sediments and intrusives, and are conformably overlain by basalt flows. The unit crops out around Exevale Homestead and on the Redcliff Tableland, in the north-east of the Mt. Coolon area. It consists mainly of quartz sandstone and siltstone.

The name is derived from Exevale Homestead, located about 40 miles north-west of Nebo, 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 is located 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 unit generally forms low rolling country with little or no outcrop. Some outcrop is found in the creeks but many have cut through to the underlying rocks. The topography of the unit is more rugged on the flanks of basalt-capped mesas and in those areas recently denuded of the basalt cover. The type area is an example of the latter.

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 were poorly sorted. Bedding was poorly displayed.

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

The quartz greywacke is a fine 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 were poorly sorted in places, containing scattered pebbles. The pebbles were usually flat with rounded edges and included quartz, quartzite, hard rock fragments and some smaller fragments of siltstone. In places, the pebbles were numerous forming thin beds of conglomerate which were rarely thicker than two or three pebbles.

A white, argillaceous quartz siltstone was the only other abundant rock type in the unit. Generally, the siltstone was friable and weathered to a fine, white dust, particularly on the vehicle tracks. In a few places, it was 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 conformably overly it.

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

Environment

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

Thickness

A thickness of 260 feet was measured with a barometer at one place but this did 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 unconformably younger than the late 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 which was interrupted by the basalt outpourings and continued over a much greater area, though further 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". (Geology of Queensland, 1960).

BASALTS

Basalts of probably Tertiary age cover an extensive area in the eastern half of the Mt. 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. These are located east and west of the Redcliffe Tableland and the Carborough-Kerlong Ranges. The eastern area extends south-east from near Exevale Homestead to beyond the eastern margin of the sheet-area. The western area lies between the Redcliffe Tableland and the Leichardt 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. Further south, they are covered by rich dark soil with scattered basalt float.

In the eastern area, the basalts crop out over an area of about 100 square miles east, west and south of Exevale Homestead. The thickness of the basalt in this area 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. The plugs vary considerably in size, the largest being Mt. Cona. Thick vegetation around the summit of the plugs is a characteristic feature which is very useful in photo-interpretation. Mt. Roberts has the appearance of a twin vent. 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 than in the eastern area. 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 basalts are lateritised; they crop out in the lower benches of mesas capped by a laterite profile more than 50 feet thick. The thickness of basalt 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 Mt. 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 were found in the basalt flows but they maybe present. Typically, very fine grained basalt forms most of the plugs but at Mt. Roberts the rock is quite coarse grained and is a gabbro.

Relationships

In the Exevale area and on the Redcliffe Tableland, the basalts overlie the Exevale Formation and in places are found infilling channels in that formation. West of the Redcliffe Tableland, the Suttor Formation apparently overlies the basalts. 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 basalts are not the result of a single outpouring. They probably represent several phases of extrusion from a large number of vents, during a fairly restricted period of time. The flows unitedto form a more or less continuous sheet of basalt.

Thickness

The thickness of the basalt is about 400 feet near Exevale and probably thins to the west. It thickens southward and Reid records 1,000 feet of basalt on Mt. Fort Cooper, east of the area.

SUTTOR FORMATION

Summary

Suttor Formation is a new name proposed for a widespread, thin, flat lying sequence of freshwater sandstone, argillaceous siltstone and conglomerate. The unit contains rare dicotyledonous leaves indicating a Tertiary age. It is best developed in the northern part of the Mt. Coolon area where it unconformably overlies Permian sediments, the Bulgonunna Volcanics and the Anakie metamorphics, and disconformably overlies probably Tertiary basalt flows.

Dissected, lateritized, poorly outcropping sediments which overlie the Permian succession in the southern part of the Mt. Coolon area are included in the Suttor Formation. The Suttor Formation has been extensively lateritised 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 Mt. Coolon area. The type area extends along the Byerwen Homestead to Cerito Homestead track, from the foot of the Leichardt Range, at Lat. 21°10'S., Long. 147°50'E., to the Suttor River. About the Suttor River, outcrop is poor, due 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 Mt. Coolon-Collinsville Road. The eastern limit of the tableland is a 100 feet high scarp, where the unit overlies Tertiary basalt. Further east, the unit occupies depressions in the basalt surface. The western limit of the tableland is north-east of Mt. 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 4-mile 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. Further south, however, similar sediments appear to overly 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, and this overlain by about 70 to 100 feet of sandstone, clayey sandstone and sandy claystone.

The sandstone at the base of the unit 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 conglomerate 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 to coarse grained quartz sandstone. This sandstone is clayey in places, grading into a sandy claystone.

The entire section is not 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 Mt. Coolon to 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 Mt. Coolon 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 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 Mt. 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 Bulgonunna Volcanics, the Middle Bowen Beds, the Upper Bowen Coal Measures, and the Triassic Carborough Sandstone.

The Suttor Formation crops out in the Leichardt Range overlying thebasalt flows. South-east of the range, near the abandoned Newlands Homestead, the relationship between

the two is not so clear. Basalt and Tertiary sediments were found at the same elevation on opposite sides of some valleys which were 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 basalt may be occupying 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 thickness of the Suttor Formation is 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 leaf was found in the formation during the 1960 season. This was identified as a dicotyledenous leaf, establishing the Tertiary age of the unit.

UNDIFFERENTIATED CAINOZOIC

Cainozoic deposits, apart from the three Tertiary units, are shown on the map to cover about half the Mt. Coolon area. Their distribution in fact is considerably greater. In many soil covered areas, it was possible to map trends of the underlying rocks on the aerial 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 were delineated where they completely masked the underlying rocks.

The bulk of these deposits are grouped on the map under the letter symbol Czs. These 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 was operative at possibly several times in the history of the area; the most widespread profile was developed in post Suttor Formation times. 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 the Czs. These crop out in mature plains and it is impossible to tell on what unit the laterite developed.

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 large plain extending south 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. These 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 were seen, though not shown on the map, 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. This indicates fairly recent rejuvenation of the drainage system; this rejuvenation is evident throughout the Mt. Coolon area, but is most noticeable in the north-east.

The coarse alluvial deposits found in the plain 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 Mt. Coolon area was uplifted in post-Exevale time. This uplift reached its maximum in the Eungella and Broken River Ranges and decreased with distance to the south-west of the ranges. Such a recent uplift would account for the extremely rugged and youthful topography of the ranges.

IGNEOUS INTRUSIVES

INTRUSIVES INTO THE ANAKIE METAMORPHICS

Two igneous masses intrude the Anakie Metamorphics in the north-west of the Mt. Coolon area. Only one body was seen in outcrop and sampled and the extent of both was photo-interpreted. Specimens were collected from a third mass intruding the metamorphics a few miles west of the Mt. Coolon area. All the specimens collected were hornblende biotite granodiorite, and probably these intrusions are related.

The age of these intrusions is not known. The most northerly of the two is part of a very large igneous mass cropping out mainly north of the Mt. Coolon area. This mass is in contact with the Bulgonunna Volcanics; it may intrude the volcanics or be older than them. The relationship should be established during the 1961 field season.

Devonian-Carboniferous Intrusives

A number of igneous bodies intrude the Bulgonunna Volcanics and the Drummond Beds. These probably represent an intrusive epoch during the Carboniferous, prior to the deposition of the Bowen basin succession. Some of these intrusives may be contemporaneous with the Bulgonunna Volcanics.

A granite is exposed along the Mt. Coolon-Collinsville Road, intruding the volcanics though the relationships are obscured by a blanket of Tertiary sediments. This mass is extremely variable. In 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, there appeared to be a transition from intrusive rock to the adjacent flow banded rhyolite.

Several masses intrude the Bulgonunna Volcanics near Mt. Coolon. One of these, a quartz diorite mass, has intruded and metamorphosed the Anakie Metamorphics as well as the volcanics. This intrusive produced the Mt. Coolon gold lode, mineralizing andesites of the Bulgonunna 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 Mt. Coolon area, intruding the Drummond Beds. They are mainly fine to medium grained rocks, in places containing phenocrysts of feldspar and hornblende. One contained vughs partly infilled by secondary quartz and other minerals. in this

area, several small basic masses intrude the Drummond Beds. These include a fine grained, dark rock, possibly a diabase, and a coarse, dark hornblende gabbro.

Eungella-Broken River Igneous Complex

The Eungella-Broken River igneous complex includes rocks varying through a wide range of texture and composition. Alkali granite is the most common rock type in the north-west of the complex. In it, albite or oligoclase is the dominant feldspar, the potash feldspar content is variable but small and the ferromagnesian minerals 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 4 miles north-east of Eungella Homestead. This was generally similar to the alkali granite and adamellite described above but differed 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 consisted of plagioclase, about An60, augite, green hornblende, biotite and traces of interstitial quartz.

The area of outcrop of this igneous complex is very rugged and inaccessible and only a few traverses were made into the area. 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.

Mt. Barker Granodiorite

The Mt. Barker Granodiorite crops out a few miles south-west of the Eungella-Broken River igneous complex. It is a biotite hornblende granodiorite, conspicuously unlike the rocks of the complex in hand specimen, though less dissimilar in thin section. The granodiorite is two-pronged in outcrop area, 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. These 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 by the gabbro intrusion gently doming 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 granodiorite are generally quartz poor but their ferromagnesian content seem 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 lacoliths. 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 and this is very similar to some of the preceding group of intrusives.

Bundarra Granodiorite

The Bundarra Granodiorite lies partly within the south-east corner of the Mt. 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 is 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 or post Triassic; that is they were intruded during the orogeny which folded the Bowen basin succession.

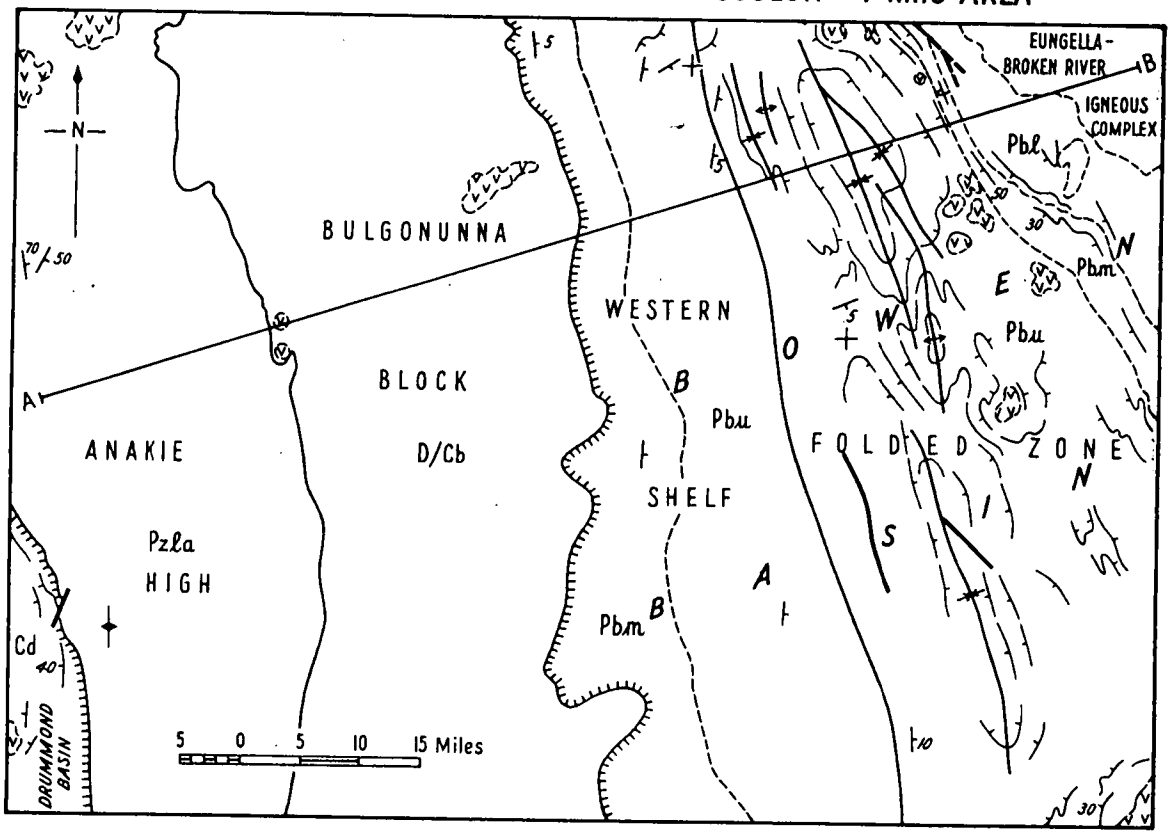
Several sills and dykes of porphyritic micro-diorite and dolerite were found intruding the Upper Bowen Coal Measures in the western shelf area of the Bowen basin. No large intrusive bodies were seen in this area, however.

STRUCTURAL GEOLOGY

Six structural units are recognised in the Mt. Coolon area. These are the Anakie High, the Bulgonunna Volcanics Block, the Drummond Basin, the western shelf of the Bowen basin, the folded zone of the Bowen basin and the Broken River-Eungella Igneous Complex. Their distribution is shown on the structural sketch map, Text Figure 2.

TEXT FIGURE II

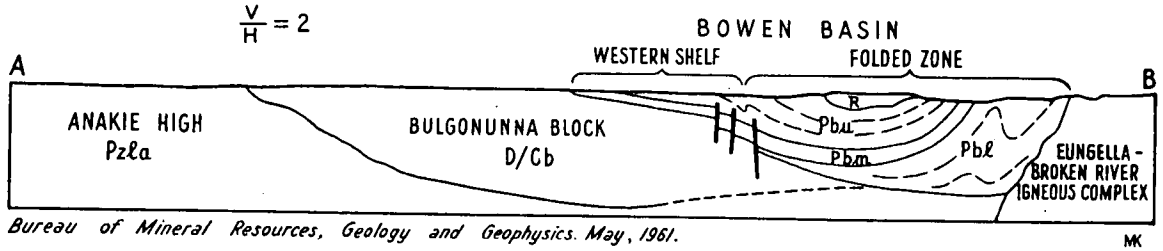
STRUCTURAL SKETCH MAP of Mt COOLON 4-mile AREA



REFERENCE

- Dip and strike of bedding
- Horizontal bedding
- Vertical schistosity
- Boundary of structural unit
- Edge of sedimentary basin
- Igneous intrusion
- Geological boundary
- Trend lines showing dip
- Synclinal axis
- Anticlinal axis
- Faults

DIAGRAMMATIC CROSS SECTION



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

MK

Anakie High

The Anakie High is a long, narrow structure separating the Bulgonunna Volcanics from the Drummond Basin. It probably existed at the time of deposition of the Bulgonunna Volcanics and the Drummond Beds. 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 Bulgonunna Volcanics to the east. The concordance of the Anakie High and the Drummond Basin structures indicate that both were affected by the same folding. This folding movement, mainly an east-west compression, accentuated the structurally high position of the Anakie High.

Bulgonunna Volcanics Block

The Bulgonunna Volcanics Block is so named because it acts as a solid block of volcanics welded onto 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 of the basin.

Drummond Basin

The Drummond Basin developed west of the Anakie High, and only a small part of it lies within the Mt. Coolon area. The structures within the basin trend north-north-west, parallel to the Anakie High. The structures are the result of a nearly 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 onto a fairly regular surface of Bulgonunna Volcanics. The present unconformity surface slopes eastward at an angle of less than 5°. It is not much steeper than the slope of the original surface of deposition, indicating that the Bulgonunna Volcanics Block was virtually unaffected by the folding of the Bowen basin.

Within the shelf area, the beds dip east at angles of 5° or less. Some folding is found near the eastern margin; 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 Bulgonunna Volcanic Block slopes underneath the Bowen basin at an angle of 5° or less in the western shelf area. This rate of descent of the basement must be greatly increased 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 Mt. Coolon area.

Text figure 2 is a diagrammatic section across the area, illustrating this theory. Faulting, which affects the Bulgonunna Volcanics Block near the eastern margin of the shelf area, was probably periodically active 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 Mt. Coolon area. It is essentially a synclinorium; the syncline was noted quite early and was responsible for the structure being called the 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 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 Mt. Barker Granodiorite. It dips at varying angles, ranging from 30° south-west to vertical, and near Blenheim Homestead is overturned, dipping at about 70° to the east. This overturning is possibly due to the intrusion of the Broken River and Eungella Ranges igneous complex. The relationship of this 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 being 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 fold structures 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 probable 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.

The sixth structural unit in the area is the Broken River-Eungella Igneous 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 this unit consist mainly of a system of joints and faults visible on the aerial photographs. It may include some areas of sedimentary or volcanic rocks.

Faulting

Faulting is not common in outcrop in the Mt. Coolon area, 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 which 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 normal fault. Other faults were mapped in the Carborough Sandstone. They are mainly normal faults with displacements of only 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 such displaces the contact between the Anakie Metamorphics and the Drummond Beds in the south-west of the area. The Bulgonunna Volcanics are faulted against the Anakie metamorphics near the northern margin of the Mt. Coolon area. The relationship of these two units suggests that their contact may be faulted in the Mt. Coolon area also.

A summary of the geological history of the Mt. Coolon area follows. This summary briefly records major tectonic and depositional events and the approximate times at which they occurred.

SUMMARY OF GEOLOGICAL HISTORY

Widespread lateritization probably continued throughout period.	CAINOZOIC late Tertiary	Rejuvenation of drainage Widespread deposition of alluvium, soil and sand. Uplift of north-east of area, followed by deposition of conglomeratic Czr.
	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.
Shallowing of Bowen basin and development of estuarine conditions.	Mid-Triassic Lower Triassic	Deposition of Carborough Sandstone and Teviot Formation.
	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	
Deposition of Drummond Beds, followed by intrusion and folding.	Devonian-Carboniferous	Deposition of Bulgonunna Volcanics with some contemporaneous intrusion, followed by some folding and further intrusion.
	About middle Devonian	Development of Anakie High and Drummond Basin to west and Bulgonunna basin of deposition to east.
	Unconformity	
	pre-Middle Devonian ?	Deposition, folding and possibly intrusion of the Anakie Metamorphics.

ECONOMIC GEOLOGY

Minerals

The Mt. Coolon 4-mile area has not been an important mineral producer. The only mine of any size in the area is the Mt. Coolon gold mine located in the north-west of the area. The gold was won from a single lode system contained in a local development of andesites within the Bulgonunna 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. Source of the silicification and mineralization was 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 ozs. Approximately 60,000 ozs. of silver was produced after 1930; silver production, prior to that date, is not recorded.

Other mineral producers in the area are on an extremely small scale. The Mt. Barker silver lead mine, located north of the Mt. 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 4,000 ozs. of silver and seventy 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 located south of Eungella, near the eastern edge of the Mt. Coolon area. A few parcels of gold ore were won from them in the 1930's but they have been abandoned since.

Part of the Mt. Flora gold and mineral field lies within the south-east corner of the Mt. Coolon area. This field produced small quantities of copper, silver and gold in the early part of this century. 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

A large number of bores has been drilled in the Mt. Coolon area. Most are reported to produce about 1,000 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 to five months wet season but some rainfalls during the winter. Thus, the dependence on underground water is not as great as in drier areas further 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 by too fast a rate of production but usually recover if left for a short time.

Coal

At least 25 separate occurrences of coal are reported from the Mt. Coolon area but most are relatively unimportant. The two most promising occurrences are in the Lake Elphinstone area, situated immediately south-east of the abandoned Lake Elphinstone Homestead, and in the Kemmis Creek area, situated a few miles further 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 commenced by the Power and Traction Co. Ltd., represented by Powell Duffryn Technical Services Ltd. 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.

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% moisture at 105°C as compared to 1.5% for the remaining 26 feet 9 inches of coal.

Further prospecting and some drilling has been done in areas south and east of the above and this 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. A large number of 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 area, may be worth prospecting. Some geophysical data on the shape of the basement to the Bowen basin would be required as a first step.

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APPENDIX A

PERMIAN MACROFOSSILS FROM HOMEVALE AND FROM THE AREA OF MT. COOLON 4-MILE SHEET

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 Mt. Coolon Field Party (E.J. Malone, D.W.P. Corbett, A.R. Jensen from the Bureau of Mineral Resources and L.G. Cutler from the Geological Survey of Queensland). 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 of the material was collected by members of the field party.

The pelecypods and gastropods are identified, where possible, at the specific level. The brachiopods, in most cases, are identified at the generic level. K.S.W. Campbell of the University of New England has examined some of the martiniopsids and is working on the dielasmatids and it is hoped that at least some of the other brachiopods will be referred to other experts in this field. The other fossils are listed without generic or specific identification.

Homevale is not on the Mt. Coolon 4-mile sheet, but fossils have been collected from here 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 1,000 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 1,500 feet of strata, from which no fossils were collected, separates it from Fauna III. This fauna extends over about 2,000 feet of strata to the top of the Middle Bowen Beds (from MC802 I to MC292 a & b in Plate 5 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. In New South Wales, the affinities of Fauna I seems to be with the Dalwood Group (Lower Marine).

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 (MC657) 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 common. 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 tocontain species related or identical with 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 Artkinskian age rather than Sakmarian (Dickins, 1961).

Fauna III (in middle part of Middle Bowen Beds)

This rather small fauna is characterized by Glyptoleda, Platyteichum, Stutchburia cf. costata and 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 Springsure area. Campbell (pers. comm.) considers that the martiniopsids may be intermediate between those of the Cattle Creek and the Ingelara.

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

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 and on the west side of the Basin on the Mt. Coolon 4-mile sheet (MC311) in beds resting directly on the Upper Devonian to Lower 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 MC423A, except possibly Aviculopecten sp., are found at CL12/1 which immediately overlies the "Clarkei Bed" in the Mt. Lebanon area on the Clermont 4-mile sheet (for CL12/1 see Dickins in Veevers, Randal, Mollan and Paten).

This fauna is also found in the Flat Top Formation of the Banana area (identifications in Dickins, 1957). 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 423A, 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, Randal, Mollan and Paten).

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 Formations 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 and 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 are also absent - a feature more difficult to explain.

IDENTIFICATIONS

Fauna I

MC 479 - ¾ mile north-west of Lizzie Creek road crossing of Hazelwood Creek.

Pelecypods

Astartila cf. gryphoides (de Koninck) 1877 (some specimens are similar to Megadesmus nobilissima)
Pachymyonia cf. etheridgei Dun 1932
Myonia cf. davidis Dun 1932
Chaenomya sp.
Eurydesma hobartense (Johnston) 1877
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 and 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 and 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)
Cyricardinia? sp.

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

Brachiopods

Terrakea
Cancrinella
Anidanthus
Strophalosia
Taeniothaerus
"Chonetes"
Neospirifer
Trigonotreta
Ingelarella
Notospirifer

Pseudosyrinx ?
Rhynchonellids
Dielasmatids
An inarticulate brachiopod

Bryozoans
Fenestellids

Straight Nautiloid

MC 421 - 3 miles east of Nebo-Collinsville road crossing of Bowen River.

Palecypods
Aviculopecten sp. nov.

Brachiopods
Terrakea
Anidanthus?
"Chonetes"
Ingelarella
Pseudosyrinx?

MC 484 - west bank of Hazelwood Creek, about 1½ miles upstream from Lizzie Creek road.

Brachiopods
Ingelarella

MC 485 - 1½ miles south-east of Lizzie Creek road crossing of Hazelwood Creek.

Pelecypods
Parallelodon sp. nov. A
Astartila cf. gryphoides (de Koninck) 1877
Myonia cf. davidi Dun 1932
Merismopteria sp. ind.
Eurydesma hobartense (Johnston) 1877
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.) (1900)
Cypricardinia? sp? (strong radial ribbing perhaps different to C? sp.

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

Pelecypods

Parallelodon sp.ind.
Eurydesma hobartense (Johnston) 1877
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 878 - 5 miles east-south-east of Lizzie Creek road crossing of Hazelwood Creek.

Pelecypods

Aviculopecten sp. nov.

Brachiopods

Taeniothaerus
Trigonotreta
Ingelarella

MC 1065 - in Creek 1½ miles north-north-west of Blenheim Homestead.

Pelecypods

Megadesmus? cf. nobilissima (de Koninck) 1877 (may be a variant of A. graphoides)

Brachiopods

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

MC 1414 - in Creek 1½ miles north-north-west of Blenheim Homestead.

Brachiopods

Anidanthus
Strophalosia
"Chonetes"
Trigonotreta
Ingelarella

Fauna III

MC 420 - 2½ miles east of Nebo-Collinsville road crossing of Bowen River

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

Gastropods

Platyeichum? sp.ind.

Brachiopods

Ingelarella

Fauna IV

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

Brachiopods

Ingelarella

MC 293 - 400 yards down creek from Blenheim Homestead

Brachiopods

Terrakea

Neospirifer

Trigonotreta

Ingelarella

Plekonella?

Bryozoans

Fenestellids and cylindrical branching forms.

MC 311 - alongside Nebo-Mt.Coolon road, 13 miles past Dabin Homestead.

Pelecypods

Schizodus sp.nov.

Brachiopods

Strophalosia ovalis Maxwell 1954

Terrakea solida (Etheridge and Dun) 1909.

Bryozoans

Fenestellids

Blastoids or Crinoids

Plates

MC 423A - about 3 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?
Diplasmatids

Bryozoans
Fenestellids

Crinoid Ossicles
This locality has pebbles up to 1½" across.

MC 423B - as for 423A, 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 553 - Creek crossing on Elphinstone-Homevale road, ¼ mile before junction with Nebo-Collinsville road.

Brachiopods
Terrakea
Strophalosia cf.clarkei (Etheridge Snr.) 1872

Bryozoans
Cylindrical branching forms

MC 575 - immediately west of foot of Mt.Cone in small creek.

Corals
Cladochonus

MC 802 I - 3 miles north-north-west of Blenheim Homestead

Brachiopods

Strophalosia clarkei (Etheridge Snr.) 1872

S. cf.brittoni var. gattoni Maxwell 1954

MC 803 - 2½ miles north-north-west of Blenheim Homestead

Pelecypods

Nuculopsis (Nuculopsis) sp. nov.

Nuculopsis (Nuculanella) sp.

Glyptoleda cf. reid_ 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 957 - 1 mile north of Mt.Cona in small creek.

Brachiopods

Productid spines

Strophalosia sp?

Ingelarella

Bryozoans

Fenestellids and cylindrical branching forms

Crinoids

Stems

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MT. COOLON

PLATE 1

Reference

CAINOZOIC	Tertiary		Czs	Soil, sand, alluvium, laterite, lateritic soils and gravels
			Czr	River channel and flood plain deposits
				Laterite over underlying formation
		Suttor Formation	Ts	Cross bedded quartz sandstone, lenses of fine and pebble conglomerate, sandy claystone, silicified claystone, river channel conglomerate
			Tb	Basalt flows and rare plugs; few trachyte flows, plugs and dykes
		Exevale Formation	Te	Friable quartz sandstone with scattered pebbles and some thin conglomerate bands, silicified quartz sandstone, white friable siltstone
PALAEOZOIC OR MESOZOIC		Broken River — Eungella Igneous Complex	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
		Gotthardt Granodiorite	Mgg	Biotite hornblende granodiorite
		Bundarra Granodiorite	Mgb	Leuco granodiorite
		Mt. Barker Granodiorite	Mgm	Biotite hornblende granodiorite
	Triassic	Teviot Formation	Rt	Micaceous lithic sandstone, calcareous in places, and micaceous siltstone
		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
		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.
		Lower Bowen Volcanics	Pbl	Andesite flows, sills, tuffs, crystal and lithic tuffs, agglomerate, black siltstone, coarse tuff grading into volcanic ash.
			Pbli	Sills and lacoliths of diorite, micro-gabbro and dolerite
	Carboniferous		Ci	Granite, diorite, hornblende gabbro, acid to intermediate stocks and bosses.
			Pzg	Biotite hornblende granodiorite
	Devonian-Carboniferous	Drummond Beds	Cd	Feldspathic quartz sandstone, buff siltstone and claystone, rhyolite flows, rhyolitic agglomerate, quartz greywacke, siltstone.
		Bulgonunna Volcanics	D/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.
	Pre-Middle Devonian	Anakie Metamorphics	Pzl'a	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.

- 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 (28)
- Prevailing dip
- Vertical strata
- Horizontal strata
- Overturned strata
- Dip slope
- Dip < 15°
- Dip 15° — 45°
- Dip > 45°
- Trend of bedding
- Joint pattern
- Macrofossil locality
- Plant fossil locality
- Conglomerate bed
- Dyke or sill
- Ag Silver
- Au Gold
- Pb Lead
- Bore
- Windpump
- WH Waterhole
- Tank or Dam
- Dam
- Township
- Homestead
- Yard
- Fence
- Airfield
- Road
- Vehicle Track

MT. COOLON EAST

PLATE 2

Scale

2 1 0 2 4 6 8 10 12 14 Miles

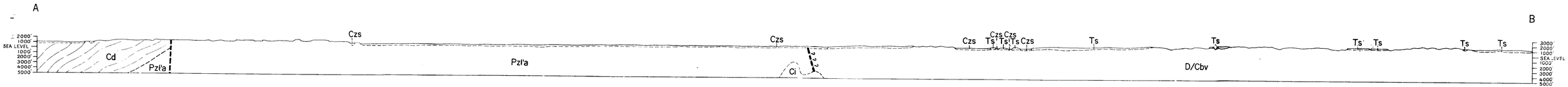
5 0 5 10 15 20 Kilometres

MT. COOLON WEST

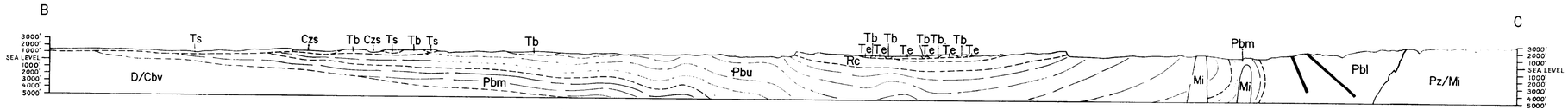
PLATE 3

PLATE 4

Section A - B



Section B - C



BRITISH MADE "ALLIANCE"

SECTION IN 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.

DC 3.

No Outcrop.

828'
Pt 1208

Poorly exposed andesite flows.

718'
45°

Interbedded black siltstone and very fine tuffs, overlain by andesite flows which transgress bedding in places.

Concealed.

Andesite flows, mainly medium to coarse grained.

MC 428BP
MC 428CP

520'
36°

Interbedded black siltstone and thin flows.
Fine to med. grained andesite flow.
Poorly exposed, weathered black siltstone
Lenticular flow
Weathered siltstone, with finely laminated black siltstone at base.

498'
Pink ish green flow with calcite-filled vesicles

Pt 428

Poor outcrop of very weathered and jointed, thinly laminated grey, black, yellow and white siltstone, with 1' thick bed of med. to coarse tuff, as indicated.

472'
Med. to coarse grained brown tuff.
Interbedded black siltstone and khaki tuff.
to
46°
Interbedded black siltstone, white fine tuff and med. brown tuff, and lenses of agglomerate, to 1' thick.

447'
Green-blue flows, up to 4' thick.

434'
to
Black siltstone overlain by interbedded black siltstone and tuff

422

Concealed

405'
Interbedded micaceous calcareous gritty, green mudstone with invertebrate trails, and greenish fine tuff.

Poor outcrop of interbedded black siltstone, graded white tuff and med. to coarse brown tuff.

MC 428PD 380'
Calcareous felspathic tuff.

MC 428P,E,F,G.
Interbedded black siltstone, white tuff showing graded bedding from coarse to fine grain, and dense white volcanic ash, with some interbeds to 4" thick of med. to coarse brown tuff.

360'

MC 428HP
Lensing, mainly thick bedded, green tuff with fragments and slabs of hard, black thin-bedded siltstone and/or volcanic glass, and round, hard, limestone boulders, to 9" across.

328'
Coarse, dark green tuff.

313'
to
Poor outcrop of interbedded black siltstone and white tuff, showing graded bedding from coarse to very fine grained, some beds of med. to coarse tuff, and some beds, to 1' thick, of dark green agglomerate.

278'
Lens of lapilli tuff, coarse grained to fine conglomerate size.

to
Poor outcrop of interbedded agglomerate, in slump masses from 1' to 2' thick, med. to coarse grained crystal and lapilli tuff, in beds from 1' to 18", and some sequences, to 2' thick, of thinly interbedded black siltstone, white fine tuff and coarse tuff.

246
Large slump mass of coarse green-blue agglomerate, containing large fragments and slabs of thinly interbedded black siltstone and fine white tuff.

MC 429DP
MC 429EP
MC 429GP
Interbedded black siltstone and white fine tuff, with some thin beds of coarse tuff.
Partly slumped green agglomerate, with some sequences of thinly interbedded black siltstone and white tuff.
Interbedded black siltstone and white tuff.
Lens of green very coarse tuff or agglomerate.

MC 429BP
Interbedded, med. to very coarse grained, hard green-blue tuff and black siltstone.

Pt 429 32° 183'
MC 429AP
Interbedded black siltstone and white fine tuff, with 18" thick bed of coarse lapilli tuff at top.
Interbedded med. to very coarse, hard green-blue tuff and black siltstone. Some hard round cobbles in tuff.

160'
Poor outcrop of interbedded, crystal tuff and black tuffaceous siltstone.
Roughly med. bedded, exfoliating coarse dark tuffaceous siltstone
Hard crystal tuff.
Interbedded black siltstone, white tuff and thin flows.

139'
Crystal tuff containing fragments of black siltstone and colour-banded siltstone.

53° 124'
Concealed

112'
Black siltstone, in places interlaminated with white tuff.
Lens of crystal tuff, containing fragments of black siltstone.

Black siltstone, with thin interbeds of tuff and flows.

93'
Roughly bedded, exfoliating greenish-brown tuff

Eo
Very jointed coarse black siltstone, containing some tuffaceous material and some hard, round nodules, up to 1' long and 6" thick.

63° 76'
2' thick buff to green intermediate flow.
Black coarse siltstone, tuffaceous in part, with some beds and lenses of tuff, and some hard, round nodules, to 9" across.
1' thick bed of crystal tuff

55'
Concealed

Very jointed, dark green crystal tuff & fragments of indurated black siltstone.

Closely jointed black siltstone, in places interlaminated to thinly interbedded with white tuff, showing graded bedding from medium to very fine grained.

58°

Pt 1207 0'
No Outcrop

SCALE 1" = 50' APPROX.

REFERENCE

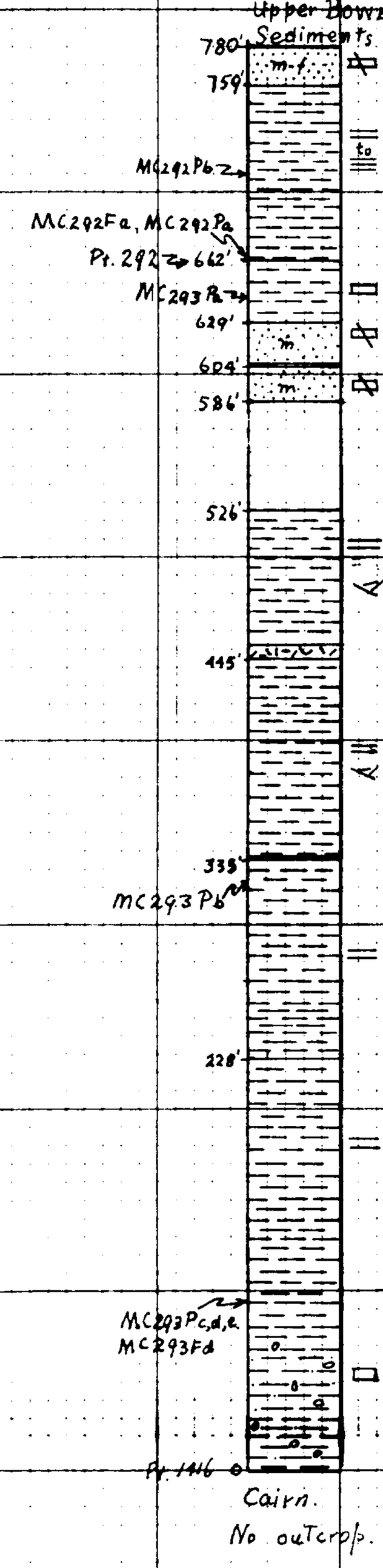
- Siltstone.
- Interbedded siltstone and tuff.
- Tuff
- Crystal tuff
- Lapilli tuff
- Agglomerate
- Intermediate flows.

BEDDING

Very Thick	> 40"
Thick	12"-40"
Medium	4"-12"
Thin	0.4"-4"
Laminated	< 0.4"
Jointed	

MEASURED SECTIONS IN THE MIDDLE BOWEN MARINE SEDIMENTS.
STOCKTON 1-MILE AREA
MT COOLON 4-MILE AREA.

SECTION RJ.4.
BLENHEIM CREEK



Conformably overlain by Upper Bowen Sediments.

Grey-white qtz. sandstone.

Grey to black micaceous siltstone, showing scavenger action, and containing fossils at the base.

Micaceous, brown and white siltstone, slightly calcareous.

Well-sorted, grey to dark grey green, micaceous qtz. sandstone.

1' thick acid sill.

Well sorted, grey to dark grey green, micaceous qtz. sandstone.

Concealed.

Brown and grey, closely jointed micaceous siltstone.

8' thick acid sill.

Grey, closely jointed, micaceous siltstone.

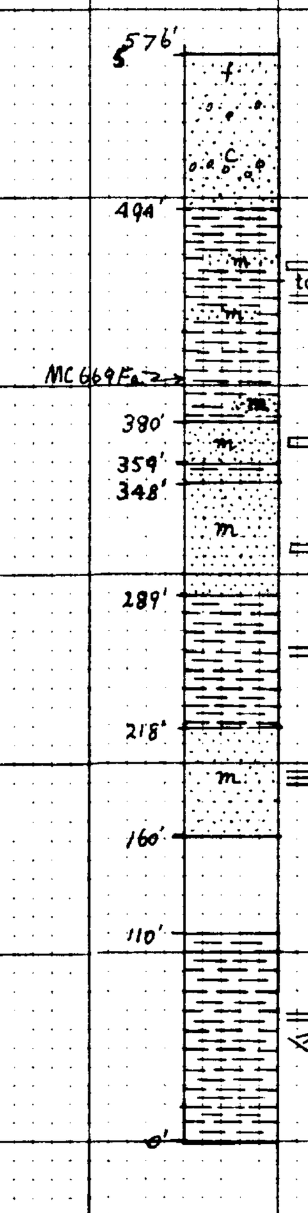
2' thick acid sill.

Grey micaceous siltstone, mainly thinly bedded but with some very thick beds.

Blue, calcareous, richly fossiliferous fine grained micaceous siltstone, becoming ill-sorted near the base and in places grading into micaceous greywacke containing scattered pebbles, cobbles and boulders up to 12" across.

Cairn.
No outcrop.

SECTION RJ.5.
2 MILES NORTH-EAST OF TURRAWALLA HOMESTEAD



Ill-sorted qtz. sandstone; in places coarse grained and containing pebbles and cobbles up to 3" across; in other places, fine grained, micaceous and fossiliferous.

Fossiliferous siltstone, with lenses of med. grained qtz. sandstone and containing fossil wood in places.

White qtz. sandstone.

Interbedded coarse qtz. sandstone and siltstone.

White to brown, quartz sandstone.

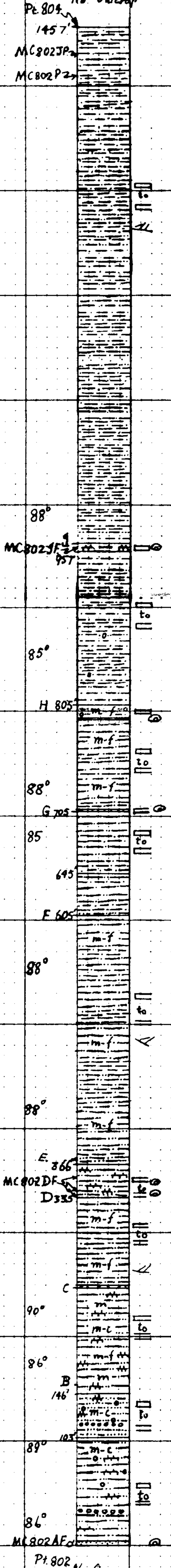
Coarse white micaceous siltstone.

Well sorted qtz. sandstone, containing fossil wood in places.

Concealed.

Closely jointed grey micaceous siltstone, containing scattered qtz grains.

SECTION EM.1.
2 MILES NORTH-WEST OF BLENHEIM HOMESTEAD



Dark grey-blue micaceous siltstone grading into fine gwke, with some 1' thick beds of hardened, blue, medium grained micaceous greywacke. Thick beds of siltstone are very closely jointed. Fragmental crinoid remains are common in places.

Outcrop poor.

Very fossiliferous lens of hard, calcareous dark grey-blue micaceous siltstone.

[illegible] siltstone, grading into fine to med. grained micaceous gwke, and containing fossils in places. The greywacke contains scattered small pebbles, in places.

Dark grey-blue micaceous gwke. with rounded to subrounded pebbles and cobbles.
2' thick lens of fossiliferous calcareous qtz. gwke.

Dark grey-blue, med. to very fine grained micaceous gwke. grading into micaceous siltstone.

1' thick lens of fossiliferous brown calc. qtz. gwke.

Dark grey-blue micaceous gwke., med. to very fine grained, grading into micaceous siltstone.

Very poor outcrop of micaceous gwke. and siltstone.

Red flecked, dark grey-blue micaceous gwke., med. to fine grained and grading into micaceous siltstone.

Very close jointing in places.

Dark grey-blue micaceous gwke. and siltstone, fossiliferous at the base and containing fossiliferous, brown, calcareous qtz. gwke. lenses, up to 6" thick.

Dark grey-blue, red-flecked micaceous gwke., med. to fine grained and grading into siltstone.

Some calcite is present along joint planes.

Green, fine grained, acid sill.

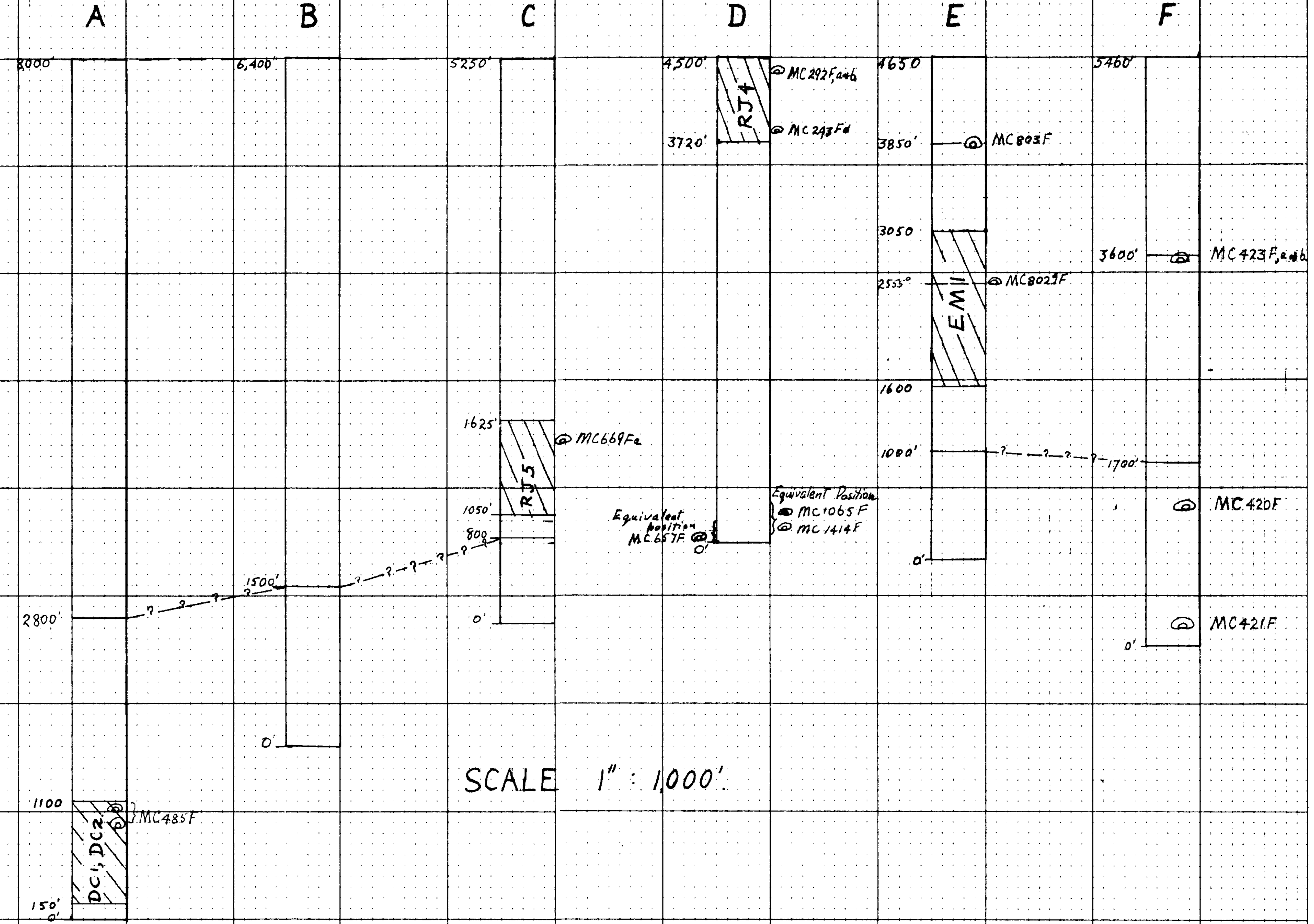
Dark grey-blue micaceous greywacke, mainly med. to fine grained, but with some beds and lenses of coarse grained gwke., and some lenses, to 6" thick of brown calcareous qtz. gwke.

Interbedded hard light coloured, med. grained qtz. gwke and coarse, friable qtz. gwke with pebble conglomerate bands; some lenses, from 2" to 6" thick, of hard, brown calc. qtz. gwke.

Dark grey-blue med. to coarse grained micaceous gwke. with 1' to 2' thick beds of very coarse gwke. containing scattered rounded pebbles and some pebble conglomerate bands. Lenses, to 6" thick of fossiliferous, hard brown calcareous qtz. gwke.

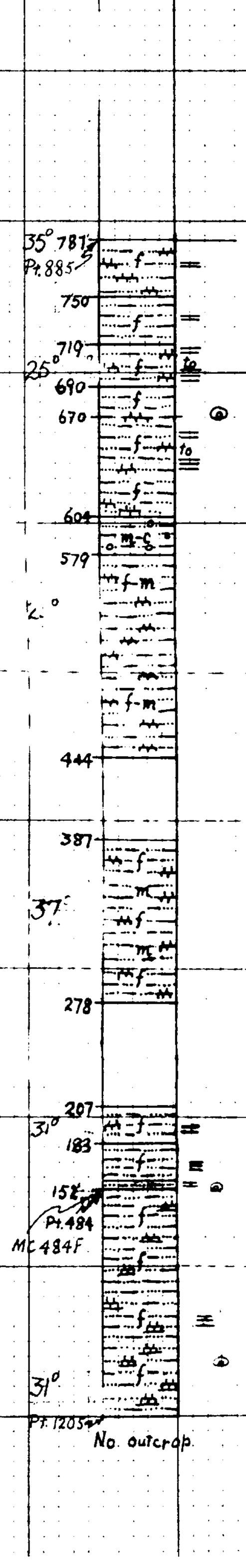
Basal 3' consists of med. grained qtz. sandstone with fossiliferous, hard, brown calcareous qtz. gwke. in thin bands and lenses.

ESTIMATED COMPLETE SECTIONS THROUGH THE MIDDLE BOWEN MARINE SEDIMENTS SHOWING THE VARIATIONS IN THICKNESS OF THE UNIT ALONG STRIKE AND SHOWING THE RELATIONSHIPS OF THE MEASURED SECTIONS, AND LOCATION OF MAIN FOSSIL COLLECTIONS.



SCALE 1" : 1,000'.

SECTION DC1.
HAZELWOOD Ck. AREA



Qtz. gwke. c̄ hard, fossiliferous calc. qtz. gwke. interbeds. Abundant fossils near top, including pectinids, Aulosteges.

Poor outcrop. Friable qtz. gwke.

Hard calc. qtz gwke c̄ friable qtz. gwke. interbeds. Rare fossils.

Semi-friable qtz. gwke. c̄ hard calc. qtz. gwke interbeds, to 3' thick, with numerous fossils in places.

Med. hard, med. to very coarse grained qtz. gwke. c̄ scattered small pebbles. Some cross bedding. Outcrop is iron stained and superficially silicified.

Poor outcrop. Grey, semi-friable qtz. gwke. c̄ many hard beds and lenses of calc. qtz. gwke. Coarse sand size material is more prominent than below.

Concealed.

Grey, semi-friable qtz. gwke. c̄ beds, of med. hard, med. grained qtz gwke. Many calcareous beds and lenses, and some zones, to 3' thick, of calcareous nodules.

Concealed.

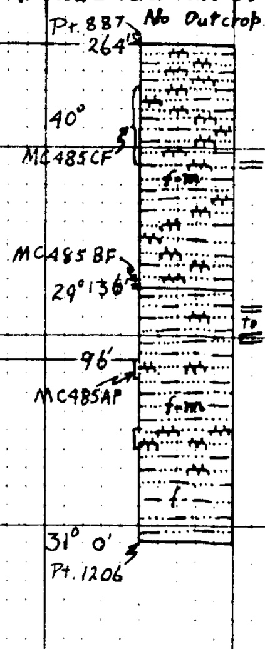
Quartz gwke. c̄ minor calc. beds and lenses.

Semi-friable, grey to dark grey roughly laminated quartz gwke. and coarse siltstone.

Fossiliferous calcareous qtz. gwke. c̄ spiriferids, etc.
Fossil collection MC484F

Grey green, semi-friable qtz. gwke. Bedding consists of very rough laminations c̄ irregular streaks of carbonaceous and silty lithologies. Many thin calcareous beds and zones, to 3' thick, of calcareous nodules containing rare fossils.

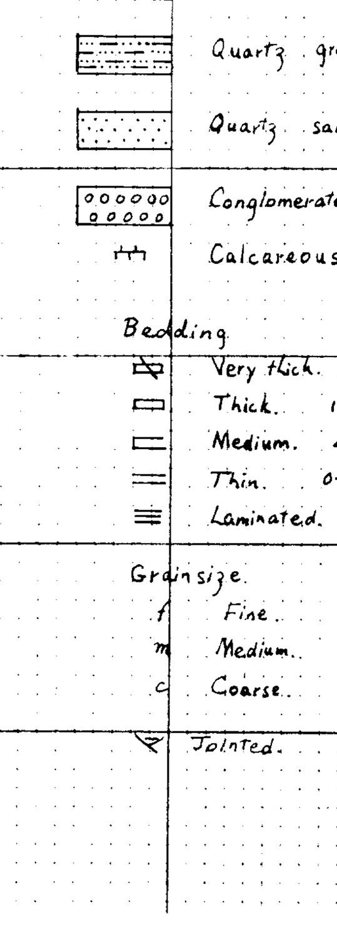
SECTION DC2.
¼ MILE SOUTH OF DC1, ALONG STRIKE.



Very numerous, richly fossiliferous, thin to 2' thick, beds and lenses of calcareous qtz gwke. interspersed with friable fossiliferous qtz. gwke.

Poorly exposed, semi-friable qtz. gwke., fossiliferous in places, with beds and lenses of medium-hard, calcareous qtz. gwke., containing abundant fossils, mostly weathering out as ferruginous casts and steinkerns.

REFERENCE

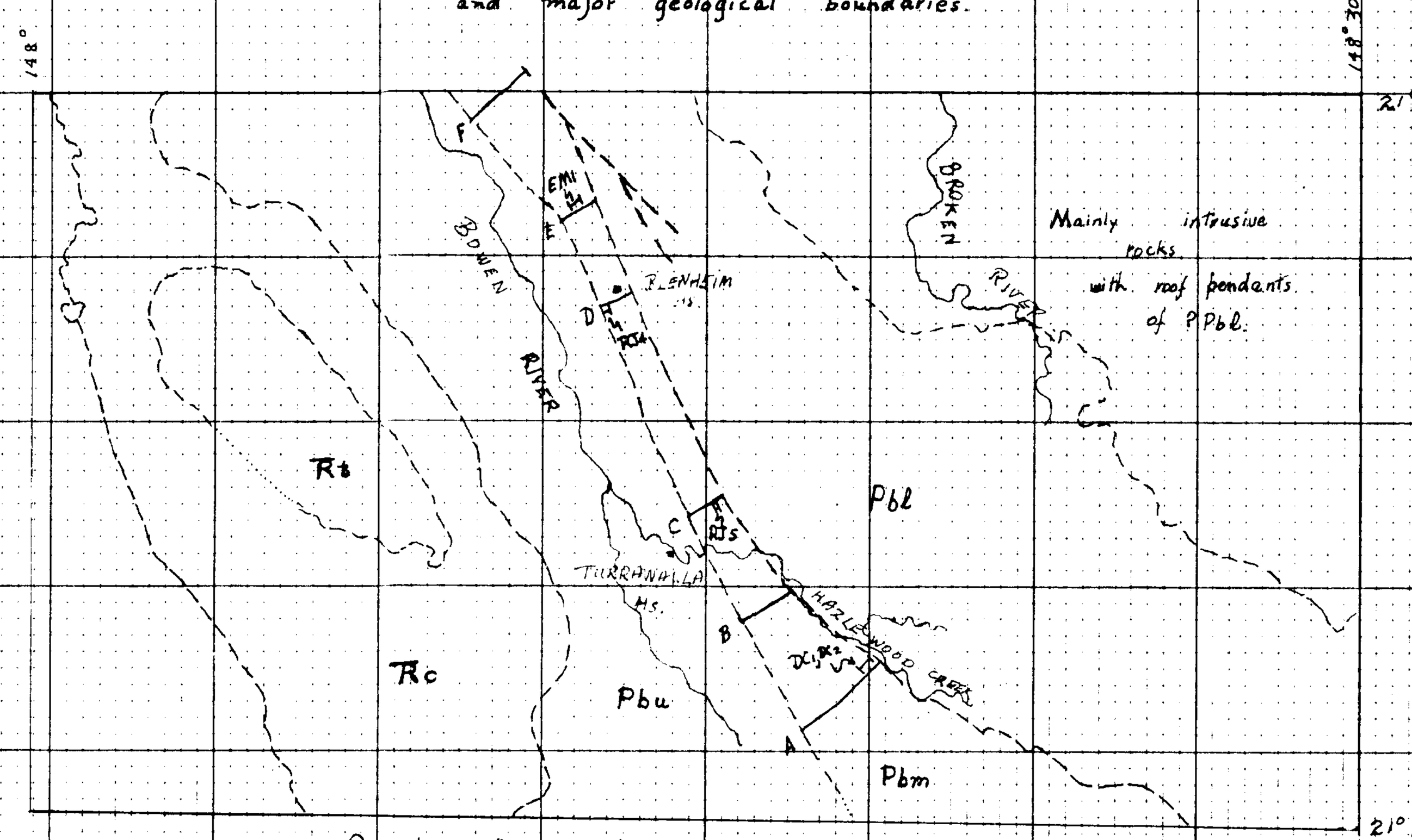


MC.293Pc. Petrological specimen.
MC.802AF. Fossil collection.
Marine fossil locality.

Abbreviations.
qtz. quartz.
gwke. greywacke.
calc. calcareous.
med. medium.

LOCALITY DIAGRAM.
STOCKTON 1-MILE AREA

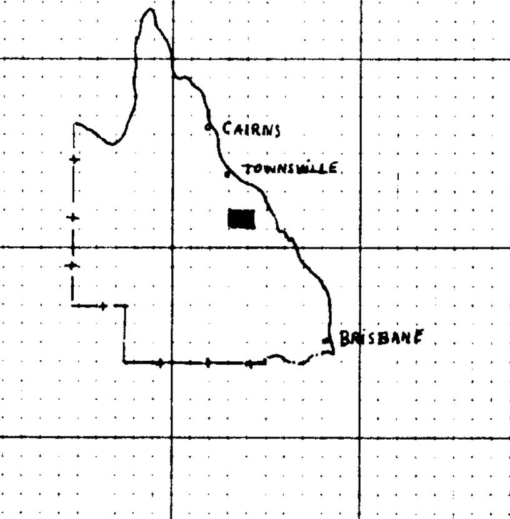
Showing location of measured sections and estimated sections and major geological boundaries.



Scale 1" : 4 miles approx.

MT COOLON 4-MILE AREA.
Showing 1-mile areas.

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



BRITISH MADE "ALLIANCE"
BRITISH MADE "ALLIANCE"

UPPER BOWEN STRATIGRAPHIC SECTIONS

RJ7

Measured 4 miles south of Blenheim Hs.

- Intermediate intrusive.
- Thin bedded, finely laminated, chert. Intermediate intrusive.
- Thin bedded, soft brown, siltstone with fossil plant material. Some thin beds of white, finely laminated chert. Closely jointed.
- Intermediate intrusive sill.

RJ1

Measured about 1 mile south of Weetalabob Hs.

- Cross bedded, lensing, white and grey-green, fine to coarse grained, well sorted and bedded greywacke with short thick lenses of hard greywacke, up to six feet thick and fifteen feet along strike. Some thin pebble conglomerate bands. Some thin lenses of brown, fine grained greywacke, to 4" thick. Some fossil wood.
- Very little outcrop. Some weathered carbonaceous shale and siltstone exposed in creek bank.
- Current bedded, lensing, white and grey green, fine to coarse grained, well sorted and bedded greywacke. Short, thick lenses of hard greywacke up to 6 feet thick and 15 feet along strike. Some thin lenses of fine, brown greywacke up to 4" thick.
- Thin to medium bedded, fine to medium grained greywacke, current bedded in places, interbedded with dark blue siltstone and carbonaceous shale.
- Acid sill. Thinly interbedded siltstone and carbonaceous shale. Acid intrusion - transgressive sill.
- Coal with yellow sulphur stainings thinly interbedded with carbonaceous shale and grey siltstone.
- Thinly interbedded carbonaceous shale, siltstone and minor fine quartz greywacke, quartz sandstone and coal.

RJ6

Measured 6 miles South of Blenheim Hs.

- No outcrop.
- Thin to medium bedded, brown to khaki, fine to medium grained greywacke.
- Closely jointed, brown siltstone. Ill sorted medium to thick bedded, brown greywacke with rounded pebbles. Intermediate intrusive sill.
- Ill sorted, medium to thick bedded, brown greywacke, with rounded pebbles. Intermediate intrusive.
- Thin bedded, closely jointed, brown siltstone.
- No outcrop.
- Ill sorted, greywacke, medium to coarse grained and medium to thick bedded showing current bedding. Rock fragments up to six inches.
- Intermediate intrusive sill.
- Thick bedded, brown, well sorted greywacke, angular fragments. Current bedded.
- No outcrop. Brown medium grained pebble conglomerate. No outcrop.
- Brown, thick bedded, poorly outcropping greywacke.
- No outcrop.
- Intermediate intrusive.
- Thin bedded siltstone and carbonaceous siltstone. Poorly outcropping soft brown greywacke.
- Thinly bedded, closely jointed, soft brown and grey siltstone which is calcareous in part and contains some coarser lenses of greywacke up to one foot.
- No outcrop.
- Coarse to medium grained intermediate sill.
- Thin interbedded closely jointed siltstone and white chert. The chert contains fossil leaves and is finely laminated.
- Medium to thin bedded, fine to medium grained greywacke with angular grains and with lenses of closely jointed brown siltstone which could be tuffaceous.
- Brown, medium bedded, closely jointed siltstone, with fossil leaves. Intermediate, intrusive sill. Grey white, hard, chert bands with fossil leaves. Medium grained brown greywacke. Poorly outcropping brown and grey siltstone. Fine pebble conglomerate - angular grains.
- Current bedded, medium bedded, medium to coarse grained, greywacke with angular to subangular grains. Slightly calcareous.
- Coarse grained intermediate intrusive.
- Thinly bedded grey and blue siltstone with fossil wood. Brown ill sorted greywacke, medium to fine grained, thick bedded.
- Alternate bands of grey chert and fine grained brown greywacke siltstone. The chert is thinly laminated and contains fossil leaves - it is ripple marked. Brown, banded, intermediate sill. Fine grained, blue grey closely jointed finely laminated siltstone, which may be tuffaceous. Contains fossil shrimps, completely replaced by silica. No outcrop. Grey acid flow or intrusive. Thick bedded, fine to medium grained greywacke, with fossil wood. Closely jointed. Minor green calcite fracture filling. Medium grained and medium bedded, light brown, micaceous, quartz greywacke. No outcrop. Medium grained and medium bedded, light brown, micaceous quartz greywacke. Very weathered intermediate intrusive sill. Medium to thick bedded, light brown, quartz greywacke. Intermediate sill. Light brown, ill bedded quartz greywacke with a great deal of matrix. No outcrop.

RJ8

Measured 2 miles south west of Blenheim Hs.

- Thin to medium bedded, light brown, siltstone and very fine greywacke. Friable and easily weathered. Ill sorted in places.
- Cobble conglomerate with cobbles up to 3 inches. It has a friable brown matrix. The cobbles are rounded.
- No outcrop.
- Khaki greywacke. Medium to thick bedded.
- No outcrop.
- Coarse grained, ill sorted, greywacke. Pebble bands with pebbles up to half inch. Hard. Medium to thick bedded; current bedded.
- No outcrop.
- Intrusion.
- Thin bedded, soft, grey and brown, ill sorted, siltstone.
- Hard, well sorted greywacke, thick bedded, but in places finely laminated.
- Very soft, easily weathered, black siltstones, which weather white. Calcareous in part.
- Hard, medium to thick bedded, brown greywacke; ill sorted and containing rounded pebbles and some shaley material. Fossil wood fragments.
- No outcrop.
- Intermediate intrusive sill.
- Soft, easily weathered, white and grey, calcareous siltstone, with minor beds of chert, greywacke and shale; closely jointed.
- Hard, thick to medium bedded, brown greywacke; ill sorted and containg rounded pebbles and some shaley material. Fossil wood fragments.
- No outcrop.
- Current bedded medium to fine grained, brown, medium bedded greywacke. Some brown siltstone.
- No outcrop.
- Current bedded, medium to fine grained brown, medium bedded greywacke.
- No outcrop.
- Ill sorted greywacke with some pebble bands.
- No outcrop.
- Extremely tough, medium grained, grey greywacke. Pebble conglomerate with pebbles up to one inch.
- No outcrop.
- Black friable siltstone. Medium to thick bedded greywacke. Intermediate intrusive.
- No outcrop.
- Hard, medium to thick bedded greywacke.

RJ3

Measured in Blenheim Ck.

- Dark micaceous siltstone.
- Medium grained, poorly sorted, grey greywacke with little matrix.
- Thin bedded, brown siltstone, with pods of blue grey fine grained calcilutite.
- Thin bedded, grey brown micaceous siltstone.
- Acid sill. Medium grained, poorly sorted, angular grained quartz greywacke. Thin and medium bedded, grey and black shales; soft; thinly laminated. Grey, thinly laminated thick bedded, greywacke.
- Thin to medium bedded, closely jointed, grey brown siltstone.
- Intermediate sill. Black indurated shale with plant fragments. Medium bedded, green grey, well sorted greke: minor silt bands.
- Thin bedded brown and black siltstone, micaceous and closely jointed.

Base of Upper Bowen.

- Coarse, hard, intermediate intrusion.
- Sheared and slightly indurated, black, thin bedded shale.
- No outcrop.
- Hard, medium to thick bedded greywacke.

Base of Upper Bowen

FEET — Top of Upper Bowen

REFERENCE

Sections RJ3, RJ6, RJ7 and RJ8, are at a scale of one inch to one hundred feet.

Greywacke	Chert	f	Fine grained
Quartz greywacke	Igneous intrusion	m	Medium grained
Siltstone	Thin bedded 2–6 inches	c	Coarse grained
Calcareous siltstone	Medium bedded 6–12 inches	15°	Dip of strata
Conglomerate	Thick bedded 12–40 inches	MC 140 SP	Petrological specimen number
Shale	Very thick bedded >40 in	MC 140 SF	Fossil specimen number