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A GEOLOGICAL RECONNAISSANCE OF THE TOWNSVILLE-BOWEN REGION, NORTHERN QUEENSLAND

by

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SUMMARY

This report contains the results of brief geological investigations carried out in conjunction with the Land Research and Regional Survey Unit to provide information on land types and their distribution in the Burdekin River Valley. A geological map and sections at the horizontal scale of 4 miles to 1 inch, have been compiled from air-photo interpretation controlled by widely spaced land traverses. An account of the stratigraphy is given, and 4 palaeontological reports on the fossils collected appear as appendices.

The nomenclature of stratigraphical units has not been revised. Existing names have been used where possible, and the remaining units have not been named.

The Region contains sediments and volcanics of Devonian and Permian age, large areas of coarse-grained igneous rocks, and Quaternary alluvia. The igneous rocks are post-Devonian and in one locality they intrude the basal beds of the Permian sequence.

INTRODUCTION

General.

A Commonwealth Inter-Departmental Committee, established to examine the possibilities of the Burdekin River Irrigation Project, requested the Land Research and Regional Survey Unit, C.S.I.R.O., to make a survey of the lower Burdekin River valley. From previous work of the Unit, it has been realized that geological mapping provides one of the fundamental frameworks of a land-system map, and the task of the geologist in the Burdekin Survey was therefore to provide data on the regional geology as a background for soil investigation and botanical work.

The Region surveyed has an area of approximately 6,000 square miles; it stretches along the Queensland coast from Bowen to Townsville and extends approximately 50 miles inland to the Leichhardt Range.

The fieldwork was carried out in seven weeks, in September and October 1950, and the scientific personnel of the party were :- Mr. C.S. Christian, Leader of the Party; Mr. G.A. Stewart, Pedologist; Mr. R.A. Perry, Mr. S.T. Blake, and Mr. L.C. Smith, Botanists; and the writer.

Climate.

The Region lies between latitudes 19°S and 21°S, and is bounded on the east by the ocean. The annual rainfall varies from 20 to 50 inches, with the maximum monthly rainfall occurring during the summer.

Most of the rain comes from variable cyclonic storms from the north-east and in any locality the variation from the mean annual rainfall may be large.

Table I gives the mean annual rainfall for some of the towns within the Region.

TABLE I.

MEAN ANNUAL RAINFALLS.

Town.	No. of Annual Records	Mean Rainfall in inches.
AYR	62	41,65
BOWEN	61	39.65
COLLINSVILLE	26	26.24
GIRU	11	48.14
STRATHMORE	22	27.86
TOWNSVILLE	54	42.46

Interpretation of the figures in Table I shows that on the coast the annual rainfall is 40-50 inches and that it diminishes westwards so that the western border of the Region receives a rainfall of 20-30 inches. Isolated mountain peaks, both near the coast and inland, may cause local variations from this general condition.

The normal maximum temperature for the summer months ranges from 80°F to 95°F, and the normal minimum temperatures for the winter are from 50°F to 60°F. The humidity is generally high near the coast and decreases inland.

Vegetation.

The vegetation is described in detail in other reports of the Unit, and it is sufficient in this report to state the three main vegetational divisions: the blue-grass grasslands and salt meadows, the open, eucalypt forest, and the isolated patches of soft-wood scrubs in the more mountainous parts of the Region.

Geological Mapping.

The system ofmapping followed that used in previous surveys. Before fieldwork was begun, vertical air photos of the region were obtained and laid out in rough mosaics, each mosaic approximately covering the area of a 1-mile Military map. Photo patterns indicating changes in geology and soils were delineated, and land traverses planned to give the most effective cross-sections. In the field the geology along the traverses was plotted on to the photos, and after the completion of field-work, mosaics compiled by the National Mapping Section, Department of Interior, and by the Australian Survey Corps were studied, and the geological map completed by photo-interpretation. The mosaics were then photographically reduced to a scale of four miles to one inch, and the boundaries traced onto a four-mile map compiled by the National Mapping Section. Necessary adjustments were made to the boundaries where edges of mosaics did not coincide.

Previous Investigations.

Very few geological investigations have been carried out, as the Collinsville coal-field is the only mining field of economic importance in the Region. Farther to the west, the Charters Towers and Ravenswood gold-fields have received more attention.

In the latter part of the nineteenth century R.L. Jack (1979, a,b,c,d), (1887), traversed much of the country between Charters Towers and the coast, and also worked in the Collinsville area. Early in the twentieth century, fieldwork was carried out in the Collinsville district, and culminated in the extensive report on the Bowen River Coalfield by H.H. Reid in 1929.

The Great Barrier Reef Committee has published various papers, some of which include discussion of the coastal belt.

In recent years, interest in the area has been stimulated by the proposed Burdekin River Irrigation Scheme, and F.W. Whitehouse and C. Gloe have investigated suitable positions for dam-sites on the Burdekin and Bowen Rivers.

TOPOGRAPHY

The Region may be divided into three broad topographical units trending parallel to the coast - the coastal unit, the central hilly unit, and the Leichhardt Range unit. The coastal unit is mainly composed of low-lying, flat country which runs along the coast and extends up the major river valleys. It also includes high mountain peaks such as Mt. Elliott (3,903 feet), Cape Cleveland

(1,828 feet), and Cape Upstart (2,420 feet). This unit is broadest between Townsville and Ayr and narrows towards Bowen. It is crossed by numerous rivers which meander over the alluvia and form deltas on flood out into swamps.

The second or central hilly unit is narrow to the west of Mt. Elliott, but widens towards the south-east. Rugged hills and mountains are predominant, with some small valleys and flats. The unit includes such mountain ranges as Clarke, Herbert, Bogie, and Gregory, all between 2,000 and 3,000 feet. In the south, near Collinsville, Permian sediments give rise to a rolling or flat topography with an elevation of 500 to 1,000 feet above sea level. Many of the small streams rise in this unit and flow north-east towards the coast or west into the Burdekin River.

The Leichhardt Range, extending down the western boundary of the Region, forms the third unit. This range, in which many of the coastal streams have their source, varies in height from 1,000 to 2,000 feet.

The Burdekin River has cut a gorge through this range.

TABLE 2 : STRATIGRAPHY OF THE TOWNSVILLE-BOWEN REGION.

AGE	STRATIGRAPHICAL DIVISIONS		THICKNESS	LITHOLOGY	
QUATERNARY			100 ± feet.	Alluvia.	
PERMIAN	UPPER BOWEN FORMATION		9,600 feet.	Lacustrine tuffaceous sandstones with shales limestones, and coal seams, with one marine horizon.	Glossopteris flora.
	MIDDLE BOWEN FORMATION	Marine Series.	2,400 feet.	Sandstones.	Brachiopods, gastropods, Bryozoa, lamellibranchs.
		Collinsville Coal Measures.	700 feet.	Sandstones, shales, coal seams, with one marine horizon.	Glossopteris flora.
	LOWER BOWEN FORMATION		5,400 feet.	Volcanics, sandstones, and coal seams.	Glossopteris flora.
			-	Granites, granodiorites, diorites.	
UPPER DEVONIAN			-	Lavas, tuffs, bedded porphyries & porphyrites and agglomerates.	
MIDDLE DEVONIAN	Reid Beds.		-	Limestones, tuffs, agglomerates, and sandstones.	Corals, brachiopods, and cephalopods.

GENERAL GEOLOGY

General.

The geology of the east coast of Queensland is closely connected with the Tasman Geosyncline, which came into existence in early Palaeozoic time, persisted through the Palaeozoic Era, and finally completed its cycle at the end of Permian or in early Triassic time. The Townsville-Bowen Region is situated in the northern portion of the old geosyncline, and the geology of the Region conforms to the general pattern found in coastal Queensland.

The oldest sediments known to have been deposited in the geosyncline, equivalent to the Brisbane Schists, were not found in the Region, where the oldest rocks exposed are the Reid Beds (Jack 1884) of Middle Devonian age. These beds consist of limestones, tuffs, agglomerates, and sandstones; the limestones probably formed as reefs bordering numerous islands in the geosyncline.

In Upper Devonian, or possibly Lower Carboniferous time, there was intense volcanic activity, and the resulting lavas, tuffs, and agglomerates, cover a large area. In the Townsville-Bowen Region very few sediments were deposited during this activity, but, farther to the south-west, sandstones are interbedded with the volcanics.

During the Permian Period, the geosyncline entered the last phase of its cycle, and the paralic sediments and volcanics of the Bowen syncline were deposited. Farther to the south, Triassic lacustrine sandstones were deposited over the Permian rocks, but in the Townsville-Bowen Region, except for the Quaternary alluvia deposited along the coast, the close of the Permian Period saw the end of sedimentation and since then the Region remained part of the land mass of the continent.

Nomenclature.

As explained above, the geology of the Townsville-Bowen Region forms a small part of the geology of the Tasman Geosyncline. Previous workers in Queensland, working in small areas, have named different rock units without much endeavour to trace and correlate groups and formations, so that a bewildering array of names has crept into the geological literature of the State. The need for re-organizing stratigraphical nomenclature, throughout the State has become increasingly evident, and the work is now being carried out by the State Geological Survey and the Queensland University. As this revision is still in progress, it was decided that no attempt should be made in this report to revise existing nomenclature or to add new names to the already crowded list. Where names exist, such as the Reid Beds, the Lower Bowen Formation, the Middle Bowen Formation divided into the Collinsville Coal Measures and the Marine Series, and the Upper Bowen Formation, they are used in the text, although their use does not necessarily signify that the writer is in agreement with the terminology.

Stratigraphy.

The short time allowed for this reconnaissance survey prevented detailed work on the stratigraphy, so that measured sections and thickness of units cannot be given. All lithological descriptions of units are from field determinations of hand specimens.

Middle Devonian - Reid Beds.

Jack (1884) first used the term "Reid Beds" for the sandstones, bedded traps, and limestones, that outcrop at Reid Gap, approximately 30 miles south of Townsville. He also used the term "Reid Limestone" for the basal limestone bed. Hill (1942,43) collected fossils from the limestones at Reid Gap, but did not formally name the limestones. Bryan and Jones (1944) defined the Reid (Gap) Beds as the limestones near Reid Gap, Townsville district,

conformably underlying sandstones. In this report the term Reid Beds will be used for the full section of Middle Devonian found in the vicinity of Reid Gap, that is, in the sense originally used by Jack.

The Reid Beds outcrop in small isolated areas near Reid River township and to the west of Kopi and Calcium. To the east, isolated outcrops of sediments extend to Mt. Woodhouse and form part of Mt. Benjonney and Mt. Dalrymple. These sediments have been provisionally included in the Reid Beds.

The relationship of the Reid Beds to other sediments was not seen, as in all places examined the outcrops were surrounded by alluvia or granite.

The Reid Beds consist of limestones, overlain by sandstones, agglomerates, and tuffs. The limestones are massive and are of reef, or reef-talus origin with abundant marine fossils. The outcrops are isolated, owing to their origin as reefs and to the faulting which has taken place in the area. Some of the limestones have been metamorphosed by the adjacent granite and have been intruded by veins of quartz and porphyry. Lime-pits and kilns have been established near Philps Siding and to the west of Calcium. Limestone will be obtained from this source for the proposed cement works at Townsville.

The sandstones vary from fine to very coarse grain, and in places have been highly silicified to form quartzites. In the hills 4 miles south-west of Mt. Woodhouse, fine to very coarse sandstones crop out and dip gently to the north. Bands of fine conglomerate are interbedded with the sandstones. These sediments have been intruded by a quartz reef which trends north-west; and is associated with some mineralization.

The sediments of Mt. Dalrymple are very highly silicified, but probably originated as sandstones. The hills to the west of Ellenvale are composed of agglomerate dipping to the north. Farther to the east, east of Reid River township, agglomerate and tuffs are predominant. The rhyolitic tuffs on the south-south-eastern slopes of Mt. Elliott are included in the Reid Beds.

All the limestone outcrops in the area are highly fossiliferous. Hill (1942, 43) has described fossils from numerous localities, and Appendix 2 gives a list of fossil determinations from a locality approximately 2 miles south of Ellenvale homestead.

On fossil evidence, the age of the Reid Beds is Givetian, that is, Middle Devonian, and these Beds may be correlated with the limestones of Burdekin Downs and Fanning River.

Upper Devonian.

No group or formational names have been given to rocks of this Unit by previous workers. The rocks to the east of the Bowen syncline, forming the Clarke Range, have been mapped by Queensland geologists as "Metamorphics", and the rocks to the west of the Bowen syncline generally have been included in the Lower Bowen Formation. David refers to the Clarke Range as "Schists of Uncertain Age", and the rocks in the Burdekin Gorge and in part of the Leichhardt Range as Lower Bowen. Whitehouse (1947), when selecting dam-sites in the Burdekin Gorge, described "a series of interbedded lavas, tuffs, and sediments."

In this report rocks referred to as Upper Devonian include the volcanics in the Burdekin Gorge and the Leichhardt Range, and the altered volcanics and metamorphosed sediments of the Clarke Range and their extension northwards towards Home Hill.

There is no direct evidence for grouping the volcanics of the Burdekin Gorge with the outcrops to the east of the Bowen syncline but, on lithology and field relationships, it seems likely

that these two areas are of the same age and could be included in the one unit. It is possible that the rocks of the Clarke Range and their north-ward extension may be older than the rocks of the Burdekin Gorge.

In the Gorge and in the Leichhardt Range, the outcropping rocks are rhyolitic, trachytic, andesitic, and dacitic, lavas, bedded porphyries and porphyrites, agglomerates and tuffs, with a preponderance of rhyolitic and andesitic lavas. These rocks are folded into broad synclines and anticlines, basins and domes, and are faulted in many places. Inclination of bedding in the vicinity of faults is noticeably higher than elsewhere. In some places these rocks have been intruded by aplitic and basic dykes and even partly or wholly digested by granite.

During this reconnaissance no sediments were seen interbedded with the volcanics, but interbedded sediments have been reported to occur farther to the west.

The Clarke Range, which forms the eastern border of the Bowen syncline, contains altered andesites and other lavas, and sediments which have been silicified and metamorphosed, to produce quartzites and slates. The strike is generally north-west with moderate dips. These rocks unconformably underlie the Permian volcanics and sediments, and, although along this eastern edge of the syncline the Permian rocks dip steeply in many places, they can generally be distinguished from the older rocks, which are more metamorphosed. Towards Home Hill, andesites, porphyries, and porphyrites are predominant. Large areas have been intruded or digested by granites, granodiorites, and diorites, so that mapping is difficult. At Mt. Louisa, approximately 18 miles north-west of Home Hill, rhyolites outcrop. These rhyolites show very marked flow structures (Plate 3. Fig. 1) and are comparable in lithology with the flow rhyolites of the Lower Bowen Formation, south of Strathbowen. The outcrop may be a Permian outlier, but its position tends to favour a Devonian age, and in this report the outcrop has been included with the Upper Devonian.

No fossils were found in the rocks mapped as Upper Devonian, but Whitehouse (1947) reports that interbedded sediments, south-west of the Burdekin Gorge, contain abundant plant fossils which indicate a very late Devonian or very early Carboniferous age.

Granitic Rocks.

Granites, granodiorites and diorites outcrop in many places throughout the Region, and, for simplicity in mapping, all these outcrops have been included within the one unit. This does not mean that the rocks are thought to be all of the same age, but rather that they represent a number of phases in a period of granitic injection which probably extended fromthe end of the Devonian Period to Lower Permian time.

Many of the granitic rocks are relatively resistant to erosion and now form the higher topographical features of the Region. Castle Hill at Townsville is composed of a medium-grained, pink, acid granite and porphyry both intruded by numerous basic dykes of porphyrite. Mt. Elliott, to the south-east of Townsville, is mainly composed of a medium to coarse-grained pinkish hornblende granite, intruded by numerous acid to basic dykes. Large aplite and porphyrite dykes were examined on the southern slopes of Mt. Elliott.

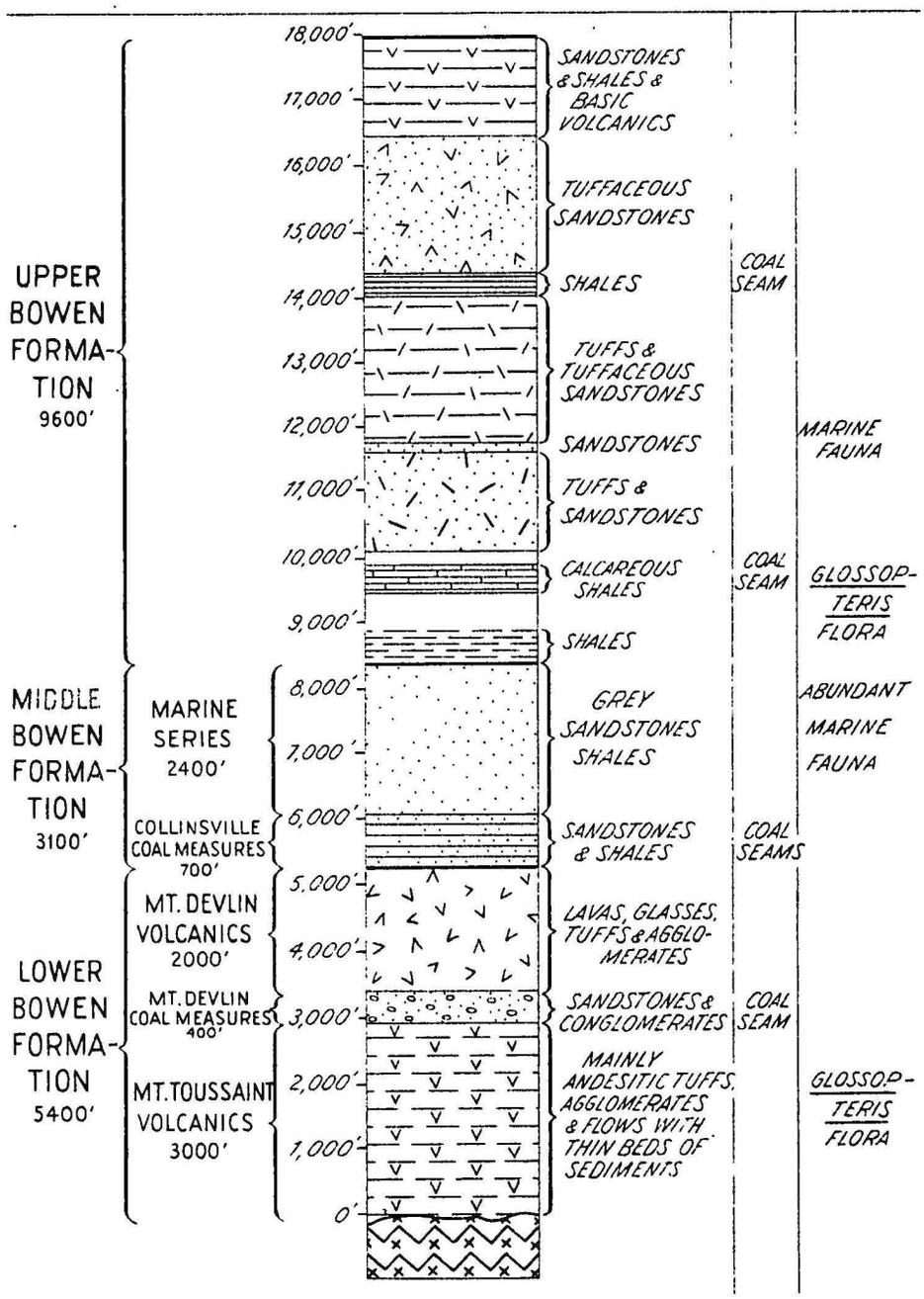
Mt. Stuart, south of Townsville, is more complex, but contains some pink granite, porphyry, and undigested residual beds of quartzite. Jardine (1928) mentions the occurrence of syenite near the summit. Mt. Cleveland and the surrounding hills are composed of a coarse-grained, pink, biotite granite, rather similar to that examined at Cape Upstart, where xenoliths, basic segregations, and basic dykes are numerous.

In the vicinity of Bowen most of the igneous rocks are medium-grained biotite and/or hornblende granite, and farther south,

PLATE 1

GENERAL STRATIGRAPHICAL SECTION OF BOWEN COALFIELD

AFTER J.H.REID



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along the Don River, granodiorites, heavily intruded by acid and basic dykes and containing remnants of the older volcanics, are predominant. (Plate 2. Figs. 1,2)

Between Bowen and Collinsville, the granodiorite is more gneissic and contains more basic areas of diorite. Many of the hills south of Home Hill are composed of granite and granodiorite, and diorite intrusives are common in the Devonian volcanics between Home Hill and Strathalbyn. The Leichhardt Range, near the Burdekin Gorge consists mainly of medium-grained granite and granodiorite, but contains some areas of fine-grained aplitic granite similar to that observed on the Hillsborough road, south-west of Mt. Benjonney. Near Mingela, the Leichhardt and Hervey Ranges are composed mainly of granodiorite and diorite with a gneissic appearance. In this area roof-pendants of quartzite are responsible for numerous trend-ridges in the igneous rock. These residual quartzites form ridges up to 50 feet high and many miles in length, with a north-easterly trend.

The relationship of this igneous complex to the surrounding rocks has been discussed for many years. It is generally thought that the granites, granodiorites and diorites intrude the Devonian rocks but not the Permian. However, Jack and, later, Jardine reported that granite phases in the Townsville area intruded the Permian rocks. As mentioned previously, at King Creek, south-east of Mt. King, a section of the Lower Bowen Formation; on the edge of granite, has been intruded by veins which were traced to the nearby granite. This was the only locality examined where the Lower Bowen was intruded by granite.

Many of the Permian conglomerate beds, including those of the Lower Bowen Formation, contain pebbles of granite, so that most of the granite phases were older than Permian and formed land surfaces during the deposition in the Bowen trough.

Whitehouse (1947) in a discussion of the volcanics in the Burdekin Gorge, lists an older and a younger granite but on this reconnaissance no granites older than Devonian were seen, nor were any granite pebbles, seen in the Devonian sediments.

The period of granitic injection and digestion contains many phases and possibly began during the folding of the Devonian volcanics and sediments in early Carboniferous time and ended in the Lower Permian.

Lower Permian - Lower Bowen Formation.

The Lower Bowen Formation is the name given by Reid (1929) to the volcanics and sediments forming the lower beds in the Bowen syncline. In this report the term "Lower Bowen Formation" will be used in this sense.

Daintree (1872) gave general references to theBowen coal-field but Jack (1879 c,d) was the first to publish a report on the coal-field. Jack's stratigraphy was sound, and only minor alterations and regroupings were made by Reid (1929), whose report is very comprehensive and still remains the most complete work on the area. Reid included the Mt. Toussaint Volcanics, the Mt. Devlin Coal Measures, and the Mt. Devlin Volcanics, in the Lower Bowen Formation. He estimated a thickness of over 3,000 feet for the Mt. Toussaint Volcanics, which consist of andesitic and rhyolitic agglomerates, tuffs, and thin beds of sandstone; a thickness of 400 feet for the Mt. Devlin Coal Measures of conglomerates, sandstones, and inferior coal seams; and a thickness of 2,000 feet for the Mt. Devlin Volcanics of rhyolites, andesites, basalts, tuffs, and agglomerates, with some shale and sandstone beds. This gives the Lower Bowen Formation a thickness of over 5,400 feet.

The Formation extends over a large area to the north-west of Collinsville. On the eastern and western limbs of the syncline, steeply dipping beds outcrop over an area up to four miles in width, but to the north, in the synclinal trough or chute, where the dips are

gentle, the formation outcrops over a large area, and forms the rolling downs around Strathmore Station and the hilly country to the north, which includes the Bogie Range, Mt. Pollux, Mt. Castor and Mt. Herbert.

In most places the Lower Bowen rocks overlie granite, but in some places they unconformably overlie the Devonian rocks. In the Clarke Range this unconformity is evident, and the lithology is different, but, in the Bogie Range, it is very difficult to determine the boundary between the Permian and Devonian volcanics. The Permian conglomerates usually contain granite pebbles which shows that the Permian sediments are younger than most of the granite phases, but in King Creek, to the south-east of Mt. King, veins from a pink granite intrude the basal beds of tuffs, agglomerates, and lavas, of the Lower Bowen Formation. This was the only granite-Permian contact, observed where the granites intruded the Permian rocks.

In the Gap, south of Strathbowen, a small section in the volcanics exposes glasses and lavas with excellent flow structures (Plate 3, Fig. 2). Here the beds dip gently to the north-east. Coarse to fine sandstones and shales, interbedded with volcanics, crop out at the crossing of the Bowen river near Strathbowen. These sediments contain abundant plant fossils which include Glossopteris browniana Brongn., G. ampla Dana, Gangamopteris cyclopteroides Feistm., Nummulospermum bowenense Walkom, and Noeggerathiopsis hislopi (Bunbury), and contain well-preserved shallow water features such as ripple marks, swash marks, and current bedding. At the bridge the beds strike 350° and dip 20°E, but a few hundred yards to the north the strike swings towards the west to give an almost northerly dip.

A few miles south of Mt. King, sandstones and shales crop out in a small gully. The shales contain carbonaceous material with indeterminable plant fossil fragments.

A brief examination of a creek bed to the east of Mt. Wickham showed interbedded tuffaceous sandstone, andesite, and conglomerate (Plate 4. Fig. 1) Permian sediments and volcanics outcrop in the area between Townsville and Stuart Creek and are included in the Lower Bowen Formation. Acid Lavas, porphyrites, and tuffs, are predominant, but there are some shales and sandstones which contain at least one small coal seam. Much of the area to the south of Townsville is covered by a deep mantle of alluvia, but from bore-logs it is known that Permian sediments are found about 120 feet below the surface. The exact age of these sediments is not known, but the lithology resembles that of the Lower Bowen Formation with which it has been mapped. Ball (1906) and, later, Reid (1928) both assigned a Lower Bowen age to these rocks. The plant fossils found in the Lower Bowen Formation have a wide range and do not give an exact age. Jack (1879 d) regarded this formation as Permo-Carboniferous, Jensen (Reid 1929) proposed an Upper Carboniferous age, and Reid (1929) followed Dunstan in assuming an age equivalent to that of the Lower Marine Series of New South Wales. Bryan and Jones (1945) placed it in the Lower Permian, which is probably the most correct position.

Middle Bowen Formation.

Reid (1929) divided the Middle Bowen Formation into a Lower, Collinsville Coal Measures and an upper, Marine Series.

(a) Collinsville Coal Measures.

The Collinsville Coal Measures outcrop in a semi-circle round the Bowen syncline with Collinsville situated at the northern portion of the syncline. These Measures are essentially a lacustrine arenaceous facies except for one brief marine transgression, and consist of sandstones, tuffaceous sandstones, shales, and conglomerates, with coal seams. The coal seams, named in ascending order, are Blake, Bowen, Potts, Denison, Scott, and Garrick. The marine horizon of sandstones, containing shell fragments, is approximately two-thirds up the section, between the Scott Seam and the Garrick Seam. None of the shell fragments

has been determined because of the poor preservation.

Reid has estimated the thickness of the Coal Measures as 700 feet, and gives a complete section from bore-logs and field mapping. The Measures lie conformably above the Lower Bowen Formation. Being essentially arenaceous, the Coal Measures do not contain abundant plant fossils. However, Reid reports that Glossopteris and Noeggerathiopsis(?) are abundant in the sandy shales lying close to the Bowen Seam, and that other shale beds contain the Glossopteris flora.

As the Glossopteris flora has such a wide range, the exact age of these beds is not known, but they are assigned to the Middle Permian. Reid correlates the Collinsville Coal Measures with the Lower or Greta Coal Measures of New South Wales.

(b) Marine Series

At the end of deposition of the Coal Measures, the syncline was invaded by a transgressive sea from the south which gave rise to the only marine deposition of any duration - the Marine Series. Marine sandstones, rich in marine fossils, were laid down conformably on the Coal Measures, and contain many valuable fossil marker beds.

The distribution of outcrops of the Marine Series is similar to that of the Coal Measures and it flanks the syncline, forming almost a semi-circle from the Bowen River northwards.

Sandstones are the principal rock types although some sandy shales, mudstones, and conglomerates, occur.

One of the prominent features of the Marine Series is the "Wall Sandstone" (Plate 4. Fig. 2, Plate 5. Fig. 1) which occurs near the base. On the eastern side of the syncline, near Clarke Range, the beds dip steeply at 40° to 80°, and the more resistant band of sandstone forms a well-defined ridge or wall which is a conspicuous topographic feature in the otherwise flat or gently undulating country. This wall bears a striking resemblance to that called "The Great Wall of China" - a steeply dupping bed of limestone which stands up about the flat country at the edge of the Cambrian basin in the East Kimberley Division of West. Australia. The Big Strophalosia horizon and the Derbya horizon provide excellent marker beds within this Series. A large collection of marine fossils was made from between Scottville and Collinsville but, as yet, these specimens have not been named or described. Reid (1929) describes a number of fossil localities with fossil lists compiled by Whitehouse. The Marine Series may be assigned to the Middle Permian, and Reid correlates this Series with the Upper Marine Series of New South Wales.

Upper Bowen Formation.

The Upper Bowen Formation is the name given by Reid (1929) to the "formation extending from Coral Creek south to, and beyond the Leichhardt and Denham Ranges, and identical with the "Lower Freshwater Series" of the Dawson and Mackenzie Rivers, as mapped by Cameron immediately south of the Bowen watershed".

After the recession of the sea in which the Marine Series was deposited the Bowen trough once again returned to lacustrine conditions, and freshwater sediments were laid down. The exception is one small marine horizon which occurs in the middle of the Upper Bowen. In the Townsville-Bowen Region sub-horizontal or gently dipping Upper Bowen sediments are exposed along the axis of the syncline in an area that extends from the Bowen River towards Collinsville, as far as Coral Creek.

These sediments are the youngest, but are covered in plaçes by deep residual soils or shallow alluvia.

The Formation consists chiefly of tuffaceous sandstones with some shales, coal seams, limestones, conglomerates, and, to the south, interbedded basic lavas and tuffs. Reid (1929) estimated the thickness as 9,600 feet, but did not have sufficient evidence either to give an exact section or to place many of the isolated outcrops. Limestone horizons may be traced around the syncline, by the thin patches of brigalow forest which favour the more calcareous sediments and are conspicuous in the open forest or grassland. On air photos these trend lines, marked by brigalow, are easily seen.

Many of the shale beds contain abundant plant fossils, and the following is a list of fossils, named by Dr. Brunnschweiler, collected from shales along the Causeway road, south-south-east of Collinsville:

Glossopteris browniana Brongn.
G. Indica Schimpe
G. augustifolia Brongn.
Gangamopteris cyclopteroides Feistm.
Sphenopteris lobifolia Morris.

Dr. Brunnschweiler's report on the plant fossils appears as Appendix I.

Reid reported that the marine horizon contains abundant specimens of Derbya senilis and impressions of Stenopora, and Etheridge has recorded Derbya senilis, Productus brachythaerus, and Goniatites sp. ind., from a collection by Jack. The Upper Bowen Formation is placed in the Upper Permian.

QUATERNARY ALLUVIA.

Large areas of alluvia, forming the present coastal belt and extending up the major rivers valleys, have been mapped as one unit, although the alluvia are complex both in origin and texture. The alluvia include off-shore marine, estuarine, lacustrine, flood-plain, levee, and Fan deposits.

The texture varies from fine to coarse, depending on the character of the parent material and mode of deposition. The alluvia may be divided into two groups:- older alluvia with mature soils, uplifted above present depositional level and dissected by stream-bed entrenchment; and younger alluvia with immature soils in an environment in which deposition is still active.

The older alluvia may be divided into :-

(a) Fine-textured sediments. These are probably of mixed origin and may include flood-plain, old deltaic, littoral, offshore, and possibly lacustrine sediments. Examples of such sediments are the alluvia between Giru and Brandon.

(b) Medium-to coarse-textured sediments of major stream levees. These are well illustrated by the levees of the Burdekin River in the Clare area.

(c) Coarse sediments of alluvial fan deposits. These are generally found near the foothills of granite country and are well illustrated along Expedition Pass Creek and the Upper Ross River.

The younger alluvia can be divided into two groups:-

(a) Delta deposits, as, for example, the Burdekin Delta. These are generally variable in texture, and range from sands to clays. Deposition is still active during floods.

(b) Littoral deposits. These are also variable and range from sand dunes to heavy mud flats.

STRUCTURAL GEOLOGY

The structures within the sediments, as well as their distribution are largely controlled by lines of weakness associated with the Tasman geosyncline. No tightly folded rocks were found in the Region but the oldest rocks deposited in the geosyncline are not exposed. The Devonian sediments and volcanics have been folded into broad anticlines, synclines, domes, and basins, and are faulted in many places. The dips vary from gentle to medium, and only in the drag-zone of faults do they become steep to vertical.

The northern portion of the great Bowen syncline, which contains Permian sediments an d volcanics, extends into the Region. This structure is an asymmetrical syncline with the axis trending north-north-west and plunging towards the south. In the eastern limb the dips in the basal beds are steep, ranging from 40° to vertical, while in the western limb the dips are gentle and in the vicinity of 5-10°.

Many of the granite outcrops are strongly jointed (plate 5. Fig. 2) with the main joint patterns running north-north-west, although this generalization does not apply in all places;

However, throughout the Region, it is evident that the lines of weakness parallel to the axis of the geosyncline have controlled the pattern of deformation.

GEOLOGICAL HISTORY AND GEOMORPHOGENY.

The geological history and geomorphogeny of the Region are largely governed by the tectonics of the Tasman geosyncline. The oldest sediments exposed are the Reid Beds of Upper Devonian age. These were deposited as marginal facies around islands in the geosynclinal sea. Towards the end of the Devonian Period there was an outburst of volcanic activity which gave rise to numerous flows and deposits of tuffs and agglomerates. There are no sediments of definite Carboniferous age so that in this Period most of the Region was probably above sea level.

In late Carboniferous or early Permian time, the sea again invaded the Region in a shallow basin or embayment, following the meridional structural trends of the geosyncline. Permian sediments were laid down in this depression, which has persisted as a structural low to the present time.

After deposition of the paralic Permian sediments, the Region was uplifted, and back-seas subsequently developed to the west to give transgressive deposition during the Mesozoic Era.

In the Cretaceous Period, the large epeiric sea covered most of Western Queensland and the eastern coast belt formed the uplands. The Cretaceous divide must have been situated to the east of the present divide, because the latter is capped in places by Cretaceous and Jurassic sediments. In the orogeny at the end of the Mesozoic Era, or perhaps withthe folding and uplift of the Eyrian sediments in Eocene time, there was a gentle warp which formed the present-day divide. This warp formed a trough between the new divide and the old coastal divide, and in this, Tertiary sediments were laid down. Outcrops of these sediments still exist at Little Red Bluff (Morton, 1945) and Cape Campaspe (David, 1950). Later, by overflow through gaps in the coastal ranges, or through river capture by the coastal streams, the lakes were drained, and by Miocene time the land surface had reached maturity, and during this epoch was lateritized severely. Morton reported a laterite-capping on the Tertiary sediments of the Little Red Bluff.

About the end of the Miocene Epoch, the block on which the Great Barrier Reef subsequently formed began to sink and possibly the block between the present coast-line and the divide rose, so that the mature lateritized land surface was rejuvenated during the Pliocene and Pleistocene Epochs, the rivers cut back, and erosion

reduced most of the coastal ranges, leaving only a few high, resistant peaks. The Leichhardt Range formed a barrier to the down-cutting of the Burdekin River, and the topography tothe west remained mature with some truncation and entrenchment of the rivers, but with little dissection.

At the end of the Pleistocene Epoch, the drowning of the coast and estuaries of the rivers gave rise to large-scale deposition of alluvia; - marine along the coastal strip and estuarine up the rivers. A eustatic emergence brought most of these alluvia above sea level although even at the present time some deposition is possible in flood-time, especially in the delta of the Burdekin River.

Erosion has greatly reduced the coastal range, but remnants such as Mt. Elliott and Mt. Aberdeen still form high peaks. The Burdekin River has a mature course in its upper reaches, a youthful course in the gorge through the Leichhardt Range, and a mature course in the lower reaches. The Gorge has formed a base level for the upper course of the river, where the topography today is much the same as it was in Pliocene time.

Most movements have followed old lines of weakness in the Tasman Geosyncline and thus have been parallel to the present-day coast-line and the drainage followed structural weaknesses.

ECONOMIC GEOLOGY.

Introduction.

Very little time was available to study the economic geology of the Region so that only a brief general account is possible. No metallic minerals are mined in the Region at the present time, although prospectors from the goldfields of Charters Towers and Ravenswood have explored the area. Many old shafts and costeans are still visible on the margins of granitic bodies and in quartz reefs. Traces of copper and lead were seen in the Devonian volcanics between Heidelberg and Glendon. Sands in the Burdekin River Gorge have been washed for alluvial gold, but no workings were in operation when the Region was investigated.

Non-metallic minerals of economic importance in the Region are coal, limestone, and salt. These will be described below.

Underground water is of some importance, and will also be described under a separate heading.

Coal.

At the present time coal is mined at the State Coal Mines at Collinsville and at the Bowen Consolidated Mine at Scottville; coal at both mines is taken from the Coal Measures of the Middle Bowen Formation. The following list gives the established seams and their thicknesses in the Coal Measures in descending order:

Garrick	6	feet	9	inches
Scott	6	"	0	"
Denison	5	"	6	"
Potts	4	"	0	"
Bowen	14	"	0	"
Blake	8	"	4	"

Coal seams are found in the Mt. Devlin Coal Measures, in the Townsville district, and in the Upper Bowen, Formation, but these seams are of no economic value at present.

In an area of 20 square miles around Collinsville Reid (1929) estimated the coal reserves in all seams of Middle Bowen age as about 420,000,000 tons, of which about 110,000,000 could be extracted. In the Powell Duffryn Report (1949) these figures are queried, as it is pointed out that on the one hand it is impossible to estimate the amount of coal included by igneous intrusives and on the other that, the proved reserves in the future may be far greater than those proved now.

The coals of the Bowen Coalfield may be classified as medium-volatile, bituminous coals.

The production from the Collinsville Coal-field, as quoted in the Powell Duffryn Report, (1949) and the estimated future production is :-

1947	267,000	tons
1948	238,500	"
1950	238,800	"
1955	296,200	"
1960	372,500	"

Limestone.

The Reid River District contains numerous outcrops of Devonian limestone, which have supported a lime-burning industry for the past 60 years.

Jack (1879) first reported the occurrence of limestone in the area; later Morton (1928) and Denmead (1949) reported on the localities and reserves. The limestones, owing to their origin as reefs and to subsequent dislocation by faulting and intrusions, are scattered over an area of approximately 50 sq. miles, although the main outcrops of economic value are to the west of Calcium on the railway from Townsville to Charters Towers. The proposal for the establishment of a cement works at Townsville has given more importance to these deposits, and Denmead estimated a reserve of $3\frac{1}{4}$ million tons of available limestone at the Ryan Co. Quarry. This is probably the largest and most convenient quarry, but many others could be established.

Rather an unusual occurrence of lime was examined at a locality south of Mt. Leslie and east of Mt. Louisa. There, agricultural lime is being quarried from a small deposit of amorphous limestone resting on, and impregnating, rotten granite. Other such deposits were seen in the area and can be easily recognized by the change in soil types. The main soil type of the granites is a light-textured soil, whereas the limestone deposits form a self-mulching black Rendzina.* The deposits occupy an area too small to be included in the geological map, but they are of some economic importance. The amorphous limestones have been deposited from mound springs or shallow lakes and ponds in the Quaternary Epoch.

Salt.

Salt is produced by the solar evaporation of sea water at the Bowen Salt Works, which is the main producer of salt in Queensland.

The salt-works is situated on the salt flats bordering Port Denison, on the outskirts of the deep-water port of Bowen. Low retaining walls enclose the sea water, which after evaporation and treatment, yields a product containing 99.7% salt. The tonnage of salt produced is dependent on climatic conditions, and the average annual production is approximately 10,000 tons. Extension is planned to enable these works to produce the salt requirements of Queensland.

Underground Water.

Useful supplies of underground water exist in most of the coastal alluvia. Although the rainfall is abundant, (approximately 40 inches per annum) the distribution throughout the year is poor, so that irrigation from underground water supplies is necessary to support much of the agriculture in the Region.

---

* Rendzina is a soil group developed on a calcareous parent material, generally of a dark colour and with a profile varying from 20 to 30 cm. in thickness.

The irrigation waters of the Burdekin Delta have received considerable attention. Cassidy (1937) and later Kemp (1949) have published papers on this problem, and at the present time experiments are in progress. It is generally recognized that the water is stored in the lighter variants, that is the sands and gravels of the coastal alluvia. There are many beds, lenses, and old stream-lines, of these light-textured alluvia which have not been completed mapped.

The depth of the spears tapping the underground supply varies from 10' to 100', although water is obtained at a very shallow depth in most places.

Cassidy (1937) refers to the water as sub-artesion, but does not give any figures to show that it is under pressure, and ground water would probably be a more accurate name.

The source of the groundwater has been a subject of considerable discussion. The supply is primarily from rainwater, but its mode of entering the porous strata has not been conclusively explained. Cassidy concludes that replenishment is by lateral penetration of flood-water from the river and from creek beds. More recent experiments show that lateral permeation from the Burdekin River through the porous beds is poor - Nimmo (in Kemp, 1949) states that "the evidence seems more favourable to general replenishment directly from rainfall than from the river, but infiltration from the river is undoubtedly an important source of supply to wells near the river."

The rise in level of the water table follows almost immediately after heavy rainfall, so that penetration must be fast, and this points to replenishment locally by vertical and lateral seepage from the surface, and to recharging of the porous strata exposed at the surface and in small gullies and creeks.

Salt water may enter some of the wells close to the coast, particularly near Rita Island. This happens when over-pumping has lowered the water table, especially in dry years when replenishment is poor.

At the present time there are more than 900 spears of wells in the Burdekin Delta. Maximum output of water for the basin was reached in 1935 but the heavy rainfall of the last two years have increased the reserves above the present output, despite an increase in the number of working bores.

Information on bore data in other areas of the Region is sparse. In the Bowen syncline, south of Collinsville, sandstone aquifers should exist and, when tapped, provide good supplies of water. Agglomerate beds in the Devonian volcanics may be porous enough to serve as aquifers.

ACKNOWLEDGMENTS.

The writer gratefully acknowledges the discussions with officers of the Bureau of Mineral Resources, the palaeontological reports in the appendices by Dr. Brunnschweiler and Dr. Hill, and the co-operation and assistance of all members of the Land Research and Regional Survey Unit. Sincere thanks are tendered to members of the Queensland Geological Survey, Main Roads Commission, and Co-ordinator-General's Department, for information provided; to Dr. Hill, Professor Whitehouse, and other members of the Queensland University Staff; and to Mr. Gloe and Mr. Calvert, Department of Irrigation and Water Supply, for their most helpful discussions.

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APPENDIX 1.

Report on Permian Plant Remains from Collinsville Queensland.

by Dr. R.O. Brunnschweiler

Records No. 1951/21

A b s t r a c t.

A small collection of rock samples containing Gondwana-type fossil plants from three localities near Collinsville is discussed. All assemblages - although with some conspicuous differences - show the characteristic Permian Glossopteris Flora. On the determination of the representatives of this flora alone, however, it cannot be said to which particular horizon within the Permian Bowen Series the samples from Collinsville belong. Modern statistical methods are suggested.

I n t r o d u c t i o n

The Australian Gondwana-type flora has been described extensively by well-known palaeobotanists (O. Feistmantel, A.B. Walkom, B. Sahni, and others) and accordingly the bibliography lists a considerable number of papers. Yet, as A.C. Seward (1910) has stressed, the introduction of too many species has rather blurred the important relationships of the Gondwana Flora. As to Glossopteris, for example, Seward (1910) does not recognize more than four different species, and he writes :-
"The arbitrary separation of sterile leaves, which differ by small degrees from one another in form and in the details of venation, by the application of specific names, is a thankless task necessitated by custom and convenience; it is, however, idle to ignore the artificial basis of such separation".

Such arbitrary separation, incidentally, has not yet been proved to be of any help in more accurate age-determinations and correlation questions. The various Glossopteris species occur together and almost all of them have a rather wide time-range. Thus the Queensland Glossopteris flora shows similar assemblages all through the so-called Bowen Series; that is, from the Late Upper Carboniferous to the Late Permian. Not one of the present known species is therefore characteristic for a particular stage in the sequence. The Glossopteris flora is only useful as a whole; marking with its appearance the Upper Carboniferous Epoch. Its upper limit again, however, is rather uncertain, because Glossopteris has been recorded from as high as the Rhaetic (Liassic ?) in Tonkin (Zeiller, 1903), while in Gondwana Land proper the genus becomes rather scarce after Permian times. Other assemblages gradually replace the Glossopteris flora proper.

In Queensland, as elsewhere in Australia, the well developed Glossopteris flora is essentially of Permian age, although Reid (1930) recorded it from below beds with the typical Carboniferous coral Monilopora nicholsoni Eth. fil. At the present moment the finer subdivision of the whole Permian sequence in the Bowen Trough is still best made by means of the interbedded marine strata.

S t r a t i g r a p h y.

The present material was collected in 1950 by D.M. Traves, Geologist of the Commonwealth Bureau of Mineral Resources. The three localities from which samples come and which the writer has not seen himself, are :-

Locality A : Causeway Road, SSE of Collinsville.

Locality B : Bowen RiverCrossing, S of Strathmore Station.

Locality C : Causeway Road, SSE of Collinsville.

According to the plant assemblage as well as the petrographic appearance the only sample from locality C appears to be from the same horizon as the samples from locality A. From both A and C, the rock is a rather hard, darkish grey to brown, in places calcareous shale, which splits well along the embedded ochre-coloured plant remains.
A and C samples contain the following flora :

Glossopteris browniana Brongn.
G. Indica Schimper
G. angustifolia Brongn.
Gangamopteris cyclopteroides Feistm.
Sphenopteris lobifolia Morris

None of these forms is of any use as a zoning species. All are found in the Lower as well as in the Middle and Upper Bowen Formations. The rock from locality B is a yellowish white, rather hard, argillaceous and fine sandy marl and contains the following flora :

Glossopteris browniana Brongn.
G. ampla Dana
Gangamopteris cyclopteroides Feistm.
Nummulospermum bowenense Walkom
Noeggerathiopsis hislopi (Bunbury)

Glossopteris ampla is predominant. This is rather unusual, as G. ampla is regarded as far less abundant than the other species of the genus. Some of the G. ampla specimens, incidentally, look, at first glance, very much like Danaeopsis hughesi Feistm. Closer observation reveals, however, that the secondary venation is anastomosing in extremely long and narrow meshes. Only very close to the midrib are the meshes short and somewhat wider.

D i s c u s s i o n

The differences between A/C and are of no value for subdividing this Permian sequence on the evidence of floral assemblages. Every species of the above lists is known to occur all through the Permian.

In conclusion it may be said that there are certainly some differences in the fossil flora of the Bowen Series. Such differences, after all, may still be useful for the subdivision of the Permian, but unless modern statistical methods on the basis of very careful bed-for-bed collecting are applied, it is idle to discuss the various possibilities any further.

(Sgd.) R.O. Brunnschweiler.
19th Dec. 1950.

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APPENDIX 2.

Report on Devonian Fossils

The following are fossil determinations from specimens of Devonian limestone collected from a locality approximately two miles south of Ellenvale Homestead, Reid River District:

Lyrielasma curvatum Hill (common)
Favistella rhenana (Frech)
Spongophyllum sp. nov. cf. torosum Schluter
Spongophyllum sp. nov. cf. parvistella Schluter
Alveolites sp. cf. suborbicularis Lamarck
Coenites sp.
Thamnopora sp.
Litophyllum koninckii Eth. and Foord
Romingeria foordi Eth.
Heliolites porosus Goldfuss
Stromatoporoids numerous
Sections of a large brachiopod, possible Stringocephalus burtini
Coiled cephaloped, probably a goniatite.

The facies of the collection is reef or reef talus, either fore reef or back reef. Field studies would be required to determine the precise environment.

The age is Givetian and is that of the Reid R. and Burdekin Limestones.

Dr. D. Hill
University of Queensland
1950.

FIGURE 1.

Basic dykes and zenoliths in granodiorite at the Don River Crossing near Mt. Danger.

FIGURE 2.

Aplite dyke intruding granodiorite at the Don River Crossing near Mt. Danger.

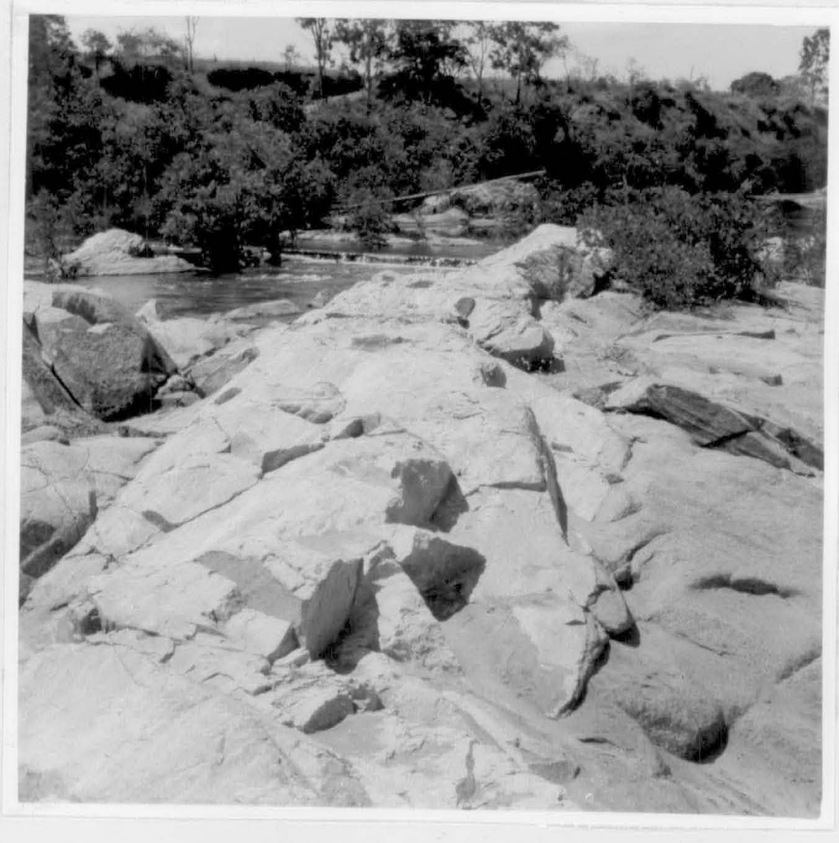


FIGURE 1.

Flow structures in rhyolite at Mt. Louisa.

FIGURE 2.

Flow structure in volcanic glass and rhyolite at the Gap, south of Strathbowen.

FIGURE 1.

Permian conglomeratic sandstones outcropping in a creek, east of Mt. Wickham.

FIGURE 2.

The "Wall" sandstones of the Marine Series outcropping near the Collinsville-Haville Crossing road.

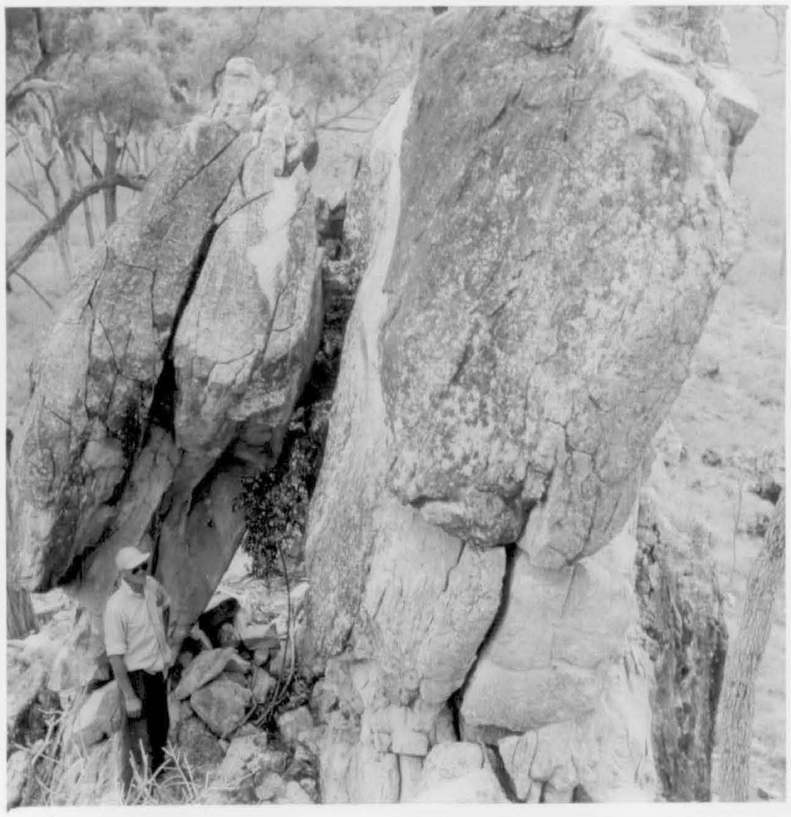


FIGURE 1 PLATE 5

"The Wall" sandstones of the Marine Series outcropping near the Collinsville-Mavilah Crossing road.

FIGURE 2.

Jointing in granite in a hill near the Diversion Weir Site on the Burdekin River.

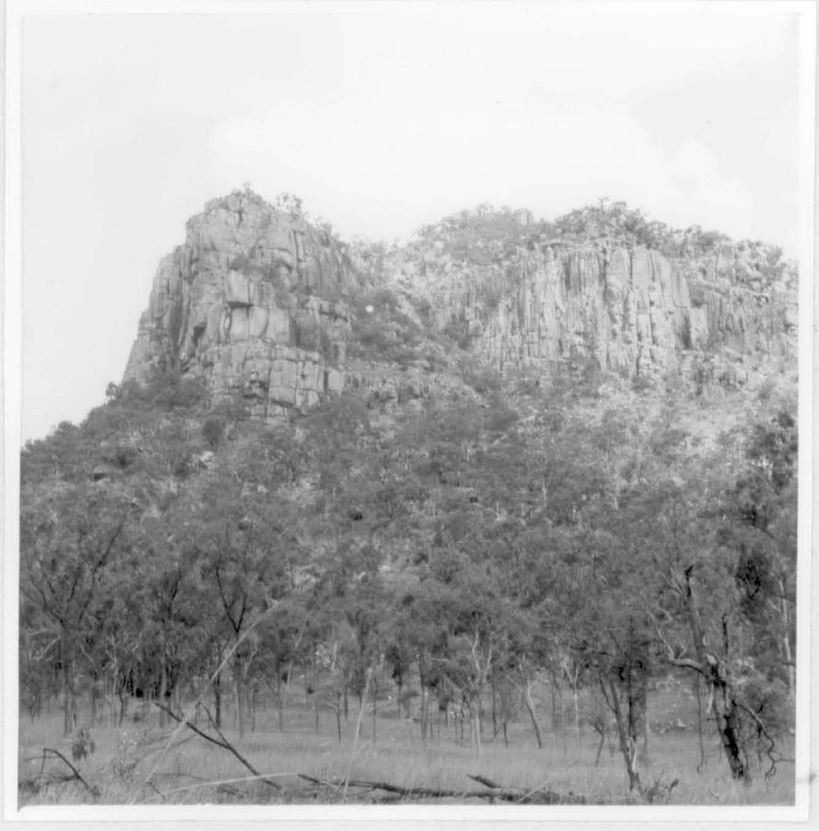


FIGURE 1.

Granite topography, Cape Upstart

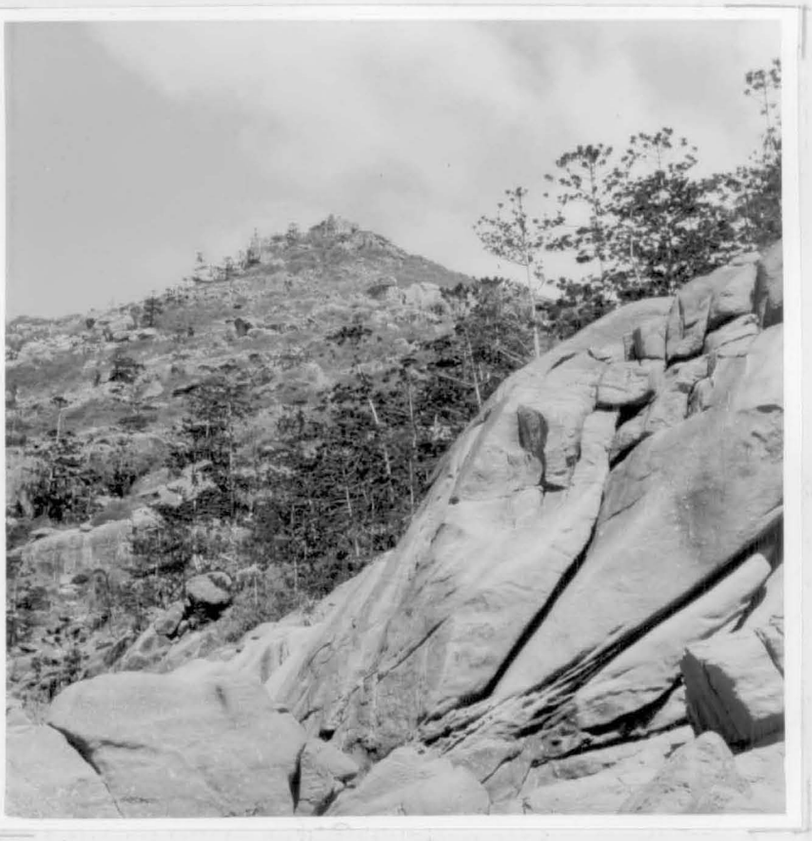


FIGURE 2.

View of Diversion Weir Site
Burdekin River.

PLATE 7.

View of topography looking east from the top of the Leichhardt Range on the Heidelberg-Glendon Road.

RECONNAISSANCE GEOLOGICAL MAP OF THE TOWNSVILLE-BOWEN REGION QUEENSLAND

Scale

4 3 2 1 0 4 8 12 16 20
MILES

Geology by D.M.Traves

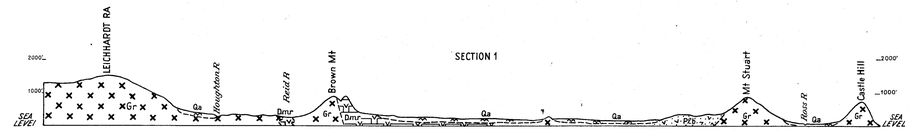
Based on widely spaced land traverses and air photo interpretation carried out in conjunction with the Land Research and Regional Survey Section, Commonwealth Scientific and Industrial Research Organisation 1950.

Topographic Base Map by National Mapping Section, Dept. of the Interior.

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS, MAY 1951

N. M. 52/009

SECTION 1



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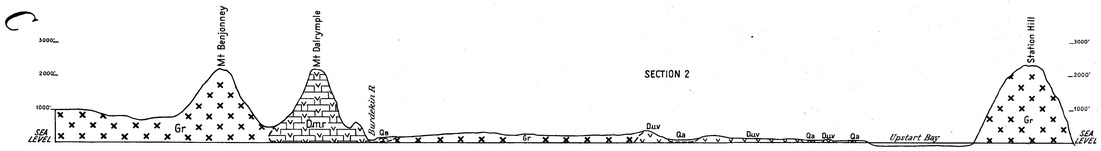

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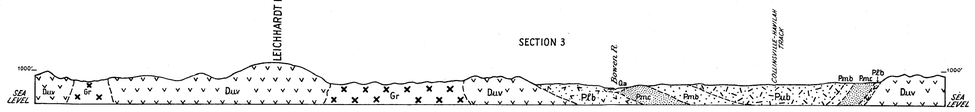
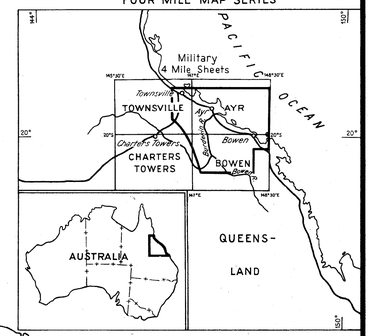


Scale of Sections

Horizontal 4 Miles to 1 Inch
Vertical 2000 feet to 1 Inch

MAP SHOWING POSITION OF AREA DEALT WITH IN REPORT AND REFERENCE TO AUSTRALIAN FOUR MILE MAP SERIES



Reference

Quaternary		Qa	Alluvia
Permian	Upper Bowen	Pub	Lacustrine tuffaceous sandstones with some shales and limestones
	Middle Bowen — Marine	Pmb	Sandstones
	Middle Bowen — Coal Measures	Pmc	Sandstones, shales, coal measures with one marine member
	Lower Bowen	Pb	Lavas, tuffs, agglomerates, sandstones coal measures
		Gr	Granite, grano-diorite, diorite
Upper Devonian		Duv	Lavas, tuffs, bedded porphyry, porphyrite, agglomerate
Middle Devonian	Reid Beds	Dmr	Limestones, tuffs, agglomerates, sandstones

Established geol. boundaries – position approximate

Trend lines

Strike and dip of strata

Dip of strata determined by photo interpretation — dip 0–15° / dip >45°

Fossil localities: Marine; Lacustrine

Dykes: aplite; quartz; diorite

Topographic Symbols: Road; Vehicle Track; Railway line

Q30-3
W.K.