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GEOLOGY OF THE MOUNT RAMSAY 1:250,000 SHEET AREA, E/52-9, WESTERN AUSTRALIA.

by

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AREA E/52-9. WESTERN AUSTRALIA

SUMMARY

This Record describes the geology of the Mount Ramsay 1:250,000 Sheet area, an area of some 7,000 square miles which lies in the Kimberley Land Division in the northern part of Western Australia. The description is based on regional geological mapping conducted in 1964 by a joint Geological Survey of Western Australia - Bureau of Mineral Resources field party.

Precambrian rocks are exposed extensively in the Sheet area and provide a record of substantial intervals of the Precambrian time-scale.

The oldest rocks are the tightly folded sediments and metamorphics of the Halls Creek Group which are intruded by granites and basic and ultrabasic rocks of the Lamboo Complex. The Halls Creek Group and the Lamboo Complex are unconformably overlain by the Kimberley Basin succession, an essentially conformable sequence up to 16,000 feet thick containing arenites, lutites and basic volcanics, with acid volcanics at the base - the latter have an age of about 1,800 million years. This succession is unconformably overlain in places by the Colombo Sandstone (300 feet thick), and elsewhere by the Glidden Group which consists of 1,850 feet of lutites and arenites. The Glidden Group is thought to pre-date the Kuniandi Group - a sequence about 4,000 feet thick consisting of lutites and arenites with a tillite at the base. The Kuniandi Group is unconformably overlain by the Louisa Downs Group which is up to 13,000 feet thick, and contains lutites and arenites and - near the base - tillite. The presence of tillite at the base of the Kuniandi Group and near the base of the Louisa Downs Group provides the first clear-cut evidence of two distinct Precambrian glacial episodes in the Kimberley region; both tillites are underlain by striated pavements.

The Louisa Downs Group is unconformably overlain by the Lally Conglomerate (420 feet thick) which is overlain conformably by the Antrim Plateau Volcanics. Both units are of probable Cambrian age.

The Precambrian and Cambrian rocks are unconformably overlain by little deformed sediments of Devonian and Permian age. These lie in the Canning Basin in the western part of the Sheet area.

Small amounts of gold, tin and lead have been produced in the area and occurrences of copper, chromite and asbestos are known. Water is, for the present, the main economic mineral resource.

INTRODUCTION

LOCATION AND ACCESS

The Mount Ramsay 1:250,000 Sheet area lies between latitudes 18° and 19°S and longitudes 126° and 127°30'E, in the Kimberley Land Division in the northern part of Western Australia. The Great Northern Highway - which links the ports of Wyndham and Derby - crosses the southern part of the Sheet area and provides the main means of access. In recent years the Highway has been re-routed and, although unsealed, it is maintained in good condition, and is readily negotiable except after heavy falls of rain. A largely unformed track follows the Halls Creek-Derby telegraph line, which crosses the northern part of the map area, but is now rarely used and is negotiable only by four-wheel-drive vehicle. Station tracks provide good access to the low-lying districts.

There are no towns in the area, but Halls Creek township is 80 miles by road east of Louisa Downs and Fitzroy Crossing is 110 miles to the west.

HABITATION AND INDUSTRY

There are four main centres of permanent habitation in the area - Louisa Downs, Margaret River, Lamboo and Moola Bulla Homesteads; Bohemia Downs, an out-station of Louisa Downs and Mount Amherst, an out-station of Moola Bulla are also occupied. The population is probably in the vicinity of 300 - mainly aboriginal - and is engaged chiefly in the cattle industry. Apart from small quantities of gold won from alluvium after each wet season there is no mineral production.

CLIMATE AND VEGETATION

According to Fitzpatrick and Arnold (1964) the Sheet area lies in a region having semi-arid and arid monsoonal climates with distinct wet and dry seasons. The average annual rainfall ranges from about 16 inches in the south to more than 20 inches in the north; the average annual rainfall at Margaret River Homestead is 17 inches. Almost all of the rain falls between November and April but light, sporadic rains occur during the rest of the year. The 'wet' season is accompanied by high humidity.

The normal daily maximum temperature in January is from 95° to 100°F and the minimum is about 75°F; the normal daily maximum temperature in July is about 80°F and the minimum 45° to 50°F.

Speck and Lazarides (1964) describe the vegetation of the area as being characterised by a spinifex grass layer with sparse stunted trees and shrubs and suggest that the species distribution is influenced greatly by the amount and availability of water supply and that the physical properties and depth of soil in many cases exert a greater influence on plants than the chemical properties of the soils. Moderately dense woodlands are confined to the major watercourses.

SURVEY METHODS

The mapping of the Mount Ramsay 1:250,000 Sheet area was conducted jointly by the Geological Survey of Western Australia and the Bureau of Mineral Resources as part of a programme of regional mapping designed primarily to encompass the Precambrian rocks of the Kimberley region.

Most of the area was investigated by means of Land Rover and foot traverses, but the inaccessible northern part was covered by helicopter - about forty flying hours were logged.

Air photographs and base maps covering the area, and available during 1964 were - air photographs at a scale of 1:50,000 flown by the Royal Australian Air Force in 1947 and a planimetric map at a scale of 4 miles to 1 inch compiled by the Department of Lands and Surveys, Perth, from slotted template assemblies at photo-scale (60 chains to the inch). The accompanying map was compiled initially on the photo-scale assemblies which were then reduced photographically to a scale of 1:250,000, and redrawn at this scale.

PREVIOUS GEOLOGICAL INVESTIGATIONS

Prior to 1879 virtually nothing was known of the Kimberley region apart from the outline of its coast. In that year Alexander Forrest and party struck inland from near Broome, and after trying unsuccessfully to cross the King Leopold Ranges, passed through the central part of the Mount Ramsay Sheet area, and eventually arrived near Katherine in the Northern Territory. A geologist was attached to the party but made no report on his observations.

The first recorded observations on the geology of the area were made in 1883 by Hardman (1883,4,5) who was attached to survey parties led by Brooking in 1883 and Johnston in 1884.

The discovery of gold in the Halls Creek district in the early 1880's attracted many prospectors. Production of gold soon began and in 1886 the area was officially proclaimed a Goldfield. Woodward (1891) and Neil-Smith (1898) reported on the mining activity.

While conducting hydrological investigations in the Kimberley Region, Jack (1906) crossed the Mount Ramsay Sheet area along the route of the telegraph line.

Wade (1924) made a reconnaissance of the Kimberley Region including parts of the Mount Ramsay Sheet area; he subsequently made numerous contributions to the knowledge of the geology of the Fitzroy Basin (Wade 1936, 1937, 1939). Maddox (1941) examined the north-east part of the Fitzroy Basin and Reeves (1947) reported on the Canning Basin.

Finucane (1938 a,b) described the gold workings near Mount Dockrell and occurrences of cassiterite and columbite nearby; Finucane and Sullivan (1938) reported on the gold shows in the headwaters of the Mary River and Jones (1938) described galena-bearing deposits in the Mount Amherst Homestead district.

In 1948 the Bureau of Mineral Resources began the systematic regional mapping of the Fitzroy Basin. This project was completed in 1952 (Guppy, Lindner, Rattigan and Casey, (1952, 1958)). As part of the project Matheson and Guppy (1949) made a reconnaissance survey of the Mount Ramsay Sheet area and the Noonkanbah and Mount Bannerman Sheet areas, which adjoin the Mount Ramsay Sheet area were mapped (Thomas, 1958; Wells, 1960).

Harms (1959) made an appraisal of the geology of the entire Kimberley region and the adjoining part of the Northern Territory on behalf of the Broken Hill Pty. Co.; this work has provided an excellent basis for the present regional mapping project.

Veevers and Wells (1961) described the geology of the Canning Basin (including the Fitzroy Basin) and discussed the Palaeozoic rocks of the Mount Ramsay Sheet area.

P.E. Playford and D.C. Lowrie of the Geological Survey of Western Australia have subsequently completed a detailed study of the Devonian reef complex of the Fitzroy Basin (Playford and Lowrie, in prep.) and although their work has not yet been published they have kindly provided their maps for incorporation into the accompanying sheet

PRESENT INVESTIGATIONS

As part of the current regional mapping project which is being conducted jointly by the Geological Survey of Western Australia and the Bureau of Mineral Resources, the Gordon Downs 1:250,000 Sheet area was mapped in 1962 (Smith, 1963); the Dixon Range, Lissadell and Cambridge Gulf areas in 1963 (Dow and Gemuts, 1964; Dunnet and Plumb, 1964; and Plumb and Veevers, in prep.) and the Lansdowne Sheet area in 1964 (Gellatly and Derrick, in prep.; Gellatly, Derrick and Plumb, in prep.). Dow, Gemuts, Plumb and Dunnet (1964) have compiled a comprehensive summary of the geology of the four easternmost Sheet areas.

Most of the Mount Ramsay Sheet area was mapped in 1964 by the authors and D.B. Dow, but the Devonian strata in the western part of the area were mapped in 1962 and 1963 by Playford and Lowrie (in prep.).

The contributions made to this report by each of the authors is signified in the Table of Contents.

PHYSIOGRAPHY

The Mount Ramsay Sheet area is situated at the junction of the two dominating features of north-western Australia, the high, dissected region of the Kimberley Plateau, and the vast sand plains and dune fields of the Canning Desert.

Apart from brief references in earlier geological reports, Jutson (1950) and Wright (1964) furnish the only comprehensive studies of the physiography of the southern part of the Kimberley Region. Thus the present Sheet area includes portions of Jutson's Fitzroyland and Wright's North Kimberley and Fitzroyland Divisions. It is proposed to follow Wright's broad divisions and to subdivide them as shown in Table I.

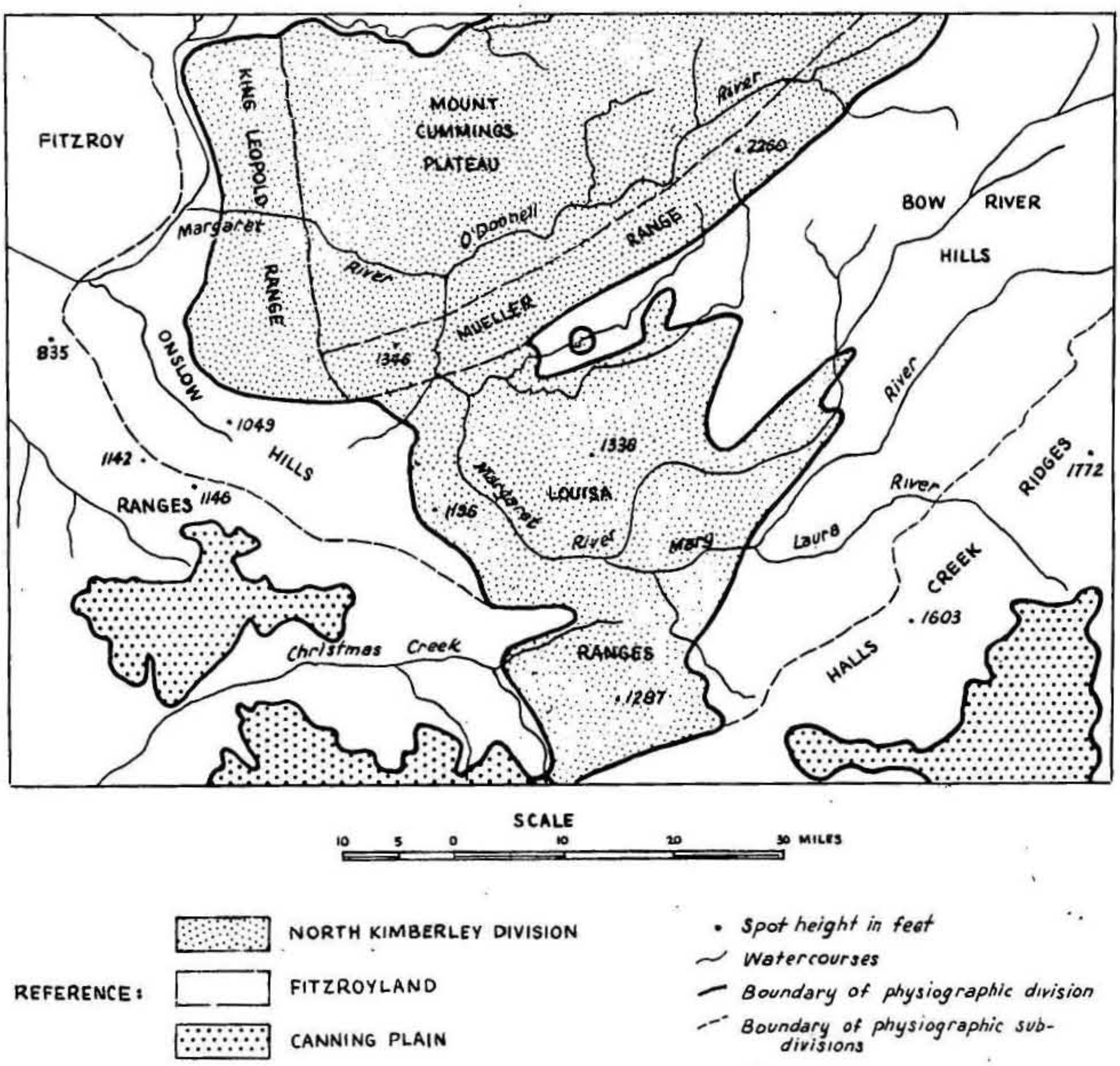
TABLE I: PHYSIOGRAPHIC SUBDIVISIONS - MOUNT RAMSAY SHEET AREA

Wright (1964)	NORTH KIMBERLEY DIVISION	Eastern Ranges	Mount Cummings Plateau	
			Meuller Range	
			King Leopold Range	
			Louisa Ranges	
	FITZROYLAND DIVISION	Eastern Uplands	Bow River Hills	after Dow et al., (1964)
			Halls Creek Ridges	
			Onslow Hills	
		Fitzroy Ranges		
	CANNING PLAIN (Veevers & Wells, 1961)			

The distribution of the physiographic divisions is shown in figure 1. Notes on the physiographic expression of the various rock units are given in the various stratigraphic tables (Tables 4 to 10 and 12 to 14).

FIGURE 1

PHYSIOGRAPHIC SKETCH MAP - MOUNT RAMSAY SHEET AREA



North Kimberley Division

The Mount Cummings Plateau occupies a triangular area in the north-central part of the Sheet area. It has an undulating surface at a general altitude of 1000-1500 feet, with some higher peaks, and the surface relief is precisely controlled by the gentle folding of the underlying coarse sandstones. The country is more rugged towards the west, where the folding is more intense.

It is drained by the Margaret River and its tributaries the Nellie, O'Donnell and Leopold Rivers. In the dry season there is little water available except in the major streams, though small rockholes contain water at a few localities.

Included in the Plateau are two low-lying and almost completely enclosed basins, known as the McKinnon Depression in the north and the larger Margaret-O'Donnell Depression in the south. The Margaret-O'Donnell Depression is surrounded by steep hills and is floored by river gravels and alluvium. The McKinnon Depression is not so well marked, and is drained by McKinnon Creek and other tributaries of the Leopold River.

Although it is not physically connected to the Kimberley Plateau, which lies to the north, the Mount Cummings Plateau can be regarded as a remnant of the former, modified by strong dissection and differential erosion of various lithologies.

The Mueller Range borders the Mount Cummings Plateau on its southern and eastern sides, and consists of long escarpments and cuestas with an incised drainage which is largely structurally and lithologically controlled. It is a continuation of the Kimberley Foothills of Dow et al (1964). Mount Amherst (2,260 feet), the highest point in the Sheet area, lies in the Mueller Range, and is probably an erosional residual.

The Margaret River breaks through the Mueller Range near Me No Savvy Yard, and this northward trending course is thought to be superimposed on the strong east-north-east trending structure of the region. It could well be due to the consequent drainage developed on the northerly plunging syncline of the Louisa Ranges.

The King Leopold Range forms the western margin of the Mount Cummings Plateau, and consists of strong, northerly trending steep-sided ridges and escarpments, which are deeply dissected. The streams are structurally and lithologically controlled, and faulting is responsible for most of the breaks through the Range.

The Louisa Ranges lie in the central part of the Sheet area, and include the Kuniandi, Lubbock, Ramsay and Egan Ranges, the Matheson Bluffs and other smaller ridges and cuestas. They are developed in the gently folded shales and sandstones of the Glidden, Kuniandi and Louisa Downs Groups. The broad synclinal structure, together with the variation of lithology, gives the characteristic landforms of long escarpments and cuestas with wide intervening valleys.

The Lubbock Range, which is composed mainly of arenites, is the most prominent feature of the area. It is bounded on the west, south and east by a steep escarpment which separates it from the surrounding, broad, low-lying plains which are developed on the McAlly Shale.

Fitzroyland

The Bow River Hills extend onto the Sheet area from the north-east, where they have much greater relief and elevation (Dow et al., 1964). The Hills occupy a broad tract of country trending south-south-west from the north-eastern corner of the area to around the Laura River. Most of the area consists of low, sand-covered rises, but in places the granite bedrock is exposed as isolated hills and tors, and massive low rounded ridges: isolated exposures of rocks of the Kimberley Group form ridges in the Moola Bulla area and to its south-west.

Remnants of a laterite surface are common in the Bow River Hills, particularly in the region between Moola Bulla and Mount Amherst Homesteads. It seems likely that much of the area was once covered by a laterite sheet. The main drainage elements probably developed on the laterite surface; they have since been superimposed on the granite, where a subsidiary dendritic drainage system has developed.

The <u>Halls Creek Ridges</u> bound the Bow River Hills to the south-east. This division, which includes the Cummins and Woodward Ranges of the Mount Ramsay Sheet area, trends north-east and forms a continuous and distinctive physiographic unit over one hundred miles long, and from 10 to 20 miles wide. The Ridges are composed chiefly of tightly folded rocks of the Halls Creek Group and the variety of rock types and their rapid alternation have produced a close-knit series of ridges and valleys. Relief is up to 300 feet; the general elevation of the Ridges is between 1200 and 1700 feet.

The Ridges form a drainage divide - streams flowing north-westwards are part of the Fitzroy River System - those flowing to the south-east (confined to the south-eastern corner of the area) are part of the inland-flowing Sturt Creek system.

The Ridges are drained by a complex system of streams - the main channels drain to the north-west and are fed by an intricate system of subsidiary streams. The subsidiary streams drain either from the north-east or from the south-west, parallel to the structural grain.

The <u>Onslow Hills</u> consist largely of rugged granite masses with narrow, incised streams, surrounded by broad sand and gravel flats on the eastern side. The higher peaks of this division, e.g. Onslow Peak and Mount Fairbairn, occur on prominent wide quartz-filled shears in metasediments and crystalline rocks of the Lamboo Complex.

A narrow zone of alluvial flood plain and eluvial flats occurs between the King Leopold Range and the Fitzroy Ranges. The area is underlain by rocks of the Lamboo Complex; low, rounded hills of cleaved metasediments and large barren outcrops of granite are characteristic of this part of the division.

The <u>Fitzroy Ranges</u> embrace a variety of topographic forms. Much of the eastern margin of the area is marked by long, barren, round-topped ranges, e.g. the Sparke Range. These are composed of conglomerate and are in strong contrast to the country to their west, particularly in the northern and central parts of the Sheet area where parts of an exhumed Devonian reef complex are displayed. The topography in this area is one of dramatic contrast; in places walls of reef, back-reef and fore-reef limestone rise sharply from plains underlain by inter-reef and fore-reef strata, in others atolls stand isolated almost in their original form. To the south, in the Christmas Creek drainage system, horizontal or gently dipping Permian sediments have been dissected to form prominent mesas and plateaux.

Canning Plain

The Canning Plain extends on to the Sheet area from the south. Red or orange sand blankets most of the area, although isolated pockets of black soil and stretches of alluvium occur in the east. Sand dunes several miles in length, and up to 20 feet high, occur to the south-east of Bohemia Downs; the dunes trend east-west and are fixed by a light growth of spinifex.

Drainage

The drainage of the map area falls into two basins. A small area in the south-east corner drains through Wolf Creek into the Canning Basin while the main rivers, e.g. the Margaret River and its tributaries, serve the northern and western portions. The Margaret joins the Fitzroy River about 55 miles west of the Sheet boundary, and flows north-westward to reach the sea in King Sound. Christmas Creek, one of the tributaries of the Fitzroy, serves the south-western portion of the Sheet. All the rivers are deeply incised, particularly in the North Kimberley Division, where gorges and rockbars are a common feature. In Fitzroyland the rivers generally have well defined channels cut into shallow alluvium or soil, though immature rocky sections and steep-sided, narrow interfluves are a feature of the Halls Creek Ridges.

None of the rivers is permanent. The area is subject to sudden floods in the wet season and this has given rise to the wide alluvial flats along the main streams. In the dry season the smaller streams dry up, and the main rivers break up into permanent pools and rockholes. Any permanent water in the higher country occurs in such rockholes.

Development of Landforms

In his account of the West Kimberley district, Wright (1964) gives a detailed account of the development of the landforms. He recognises two land-surfaces, the Kimberley Surface, which is the older, and the Fitzroy Surface. He subdivides the Kimberley Surface into the High Kimberley Surface (H.K.S.) at 2000-2200 feet A.S.L., and the Low Kimberley Surface (L.K.S.) which extends as gently sloping plains ranging from 100 feet A.S.L. near the coast to 1750-2000 feet in the east. The junction of these two divisions is at the escarpment bounding the King Leopold and Mueller Ranges. He concludes that the L.K.S. predates the Jurassic Fitzroy Volcanics, and that the H.K.S. could represent an uplifted and degraded Jurassic surface, with the uplift and the volcanism having perhaps a common origin.

In the map area the highest laterite sheet is seen as small remnants overlying the Pentecost Sandstone, one near the Goat Paddock, the other 12 miles to the north, and a small patch near Mount Ramsay. There is also a general concordance of levels in this area at about 1300 feet. This could possibly represent the H.K.S., though it is lower than expected. The most easily recognised level, represented by laterite, leached bedrock, or slightly indurated gravels, dips gently to the south over most of the southern part of the map area. This level is frequently covered by Lawford Beds. Where it has been dissected, the surface is preserved on flat-topped mesas and buttes, which have steep, cliffed edges. This is Wright's Low Kimberley Surface, and a few miles west of Me No Savvy Yard, seems to abut against the King Leopold Range, though this is not certain. Erosion of this surface has given rise to extensive plains, which lie 40-80 feet below the mesas, e.g. Moola Bulla-Margaret River Station-Louisa Downs area, and is presumably the Fitzroy Surface. These plains are equivalent to the general level of erosion in the east. Rejuvenation has dissected this surface, to give incised rivers, steep-sided gullies, narrow interfluves and other allied features. Palynological analysis of river gravels from Mount Dent, the O'Donnell River and the Mary River show that this rejevenation is of Pliocene or post-Pliocene age (Edgell, 1964).

STRATIGRAPHY

The rocks of the Mount Ramsay Sheet area provide a record of vast intervals of the geological time scale; representatives of the contents of at least four major separate and distinct sedimentary basins or geosynclines are exposed.

The oldest rocks are those of the Halls Creek Group; these appear to be the relics of a period of geosynclinal sedimentation and are tentatively assigned to the Archaean (2500 m.y.+). Subdivision of the Group is possible in some places, but not in others. The rocks are generally only slightly metamorphosed, but locally they reach a high metamorphic grade; they are invariably tightly folded.

The Lamboo Complex contains a variety of igneous intrusive rocks including granites, gabbros and ultrabasic rocks, as well as small bodies of high grade metamorphic rocks. All of the igneous rocks post-date the Halls Creek Group, and the metamorphic rocks are probably derived from the Halls Creek Group. The Complex may include rocks of Archaean age, but most are probably Lower Proterozoic (2500-1800 m.y.); some may be much younger.

The Halls Creek Group and at least parts of the Lamboo Complex are overlain with major structural discordance by the Whitewater Volcanics, which consist essentially of acid extrusive rocks. Elsewhere in Northern Australia similar acid volcanic rocks, holding a similar structural attitude, and occupying identical positions in the gross stratigraphic column are taken as signalling the beginning of Middle Proterozoic time; they yield radiometric ages of about 1800 m.y. The Whitewater Volcanics yield similar ages (V.M. Bofinger, pers. comm.) and are placed in the Middle Proterozoic.

The Volcanics are locally intruded by porphyry ("Watery River Porphyry") and are unconformably overlain by arenites and lutites of the Speewah Group, the first strata deposited in the Kimberley Basin. The Speewah Group is up to 5600 feet thick and is overlain - in places unconformably - by the Kimberley Group, which is composed of arenites, basic volcanics, lutites and carbonate rocks and is up to 9500 feet thick. The Kimberley Group is overlain conformably by the Crowhurst Group, a succession of lutites with minor arenites and carbonate-rocks. The top of the Crowhurst Group is eroded and the maximum preserved thickness is 500 feet; the strata are the youngest remnants of the Kimberley Basin succession and are probably about 1500 to 1600 million years old.

The Crowhurst Group is unconformably overlain by the Colombo Sandstone, which is at least 400 feet thick; this unit is of doubtful age, but may fall within the Middle Proterozoic (i.e. 1800-1400 m.y.).

Rocks of the Speewah and Kimberley Groups are intruded by dolerite (mapped as the Hart Dolerite), but the timing of the intrusive event or events cannot be firmly established.

The rocks of the Kimberley Basin succession, and perhaps, the Colombo Sandstone were faulted, folded and severely eroded prior to the deposition of the Glidden Group, which rests unconformably on strata low in the Kimberley Group. The preserved part of the Glidden Group (its top is eroded) is about 1850 feet thick, and consists of lutites and arenites. The Group is thought to have been deposited at some time within the lower half of the Upper Proterozoic - the Upper Proterozoic is here taken to imply the time interval between about 1400 million years and about 600 million years.

The Glidden Group is thought to have been faulted, folded and eroded prior to the deposition of the Kuniandi Group. The Kuniandi Group is up to 4000 feet thick and contains glacigene strata (near the base) lutites and arenites. It is unconformably overlain by the Louisa Downs Group - a succession up to 13000 feet thick consisting of lutites, arenites, carbonates, rudites and - again near the base - glacigene strata. The Kuniandi and Louisa Downs Groups were probably deposited during the later part of the Upper Proterozoic.

The Upper Proterozoic strata are unconformably overlain by the Lally Conglomerate, which is up to 420 feet thick and is overlain conformably by the Antrim Plateau Volcanics. The Volcanics consist of a series of basalt flows and reach a thickness of at least 5000 feet.

Evidence outside the Sheet area suggests that the Volcanics are of Lower Cambrian age and because of the conformable relationship between the Volcanics and the underlying Lally Conglomerate, the latter is also tentatively regarded as being Lower Cambrian.

A period of faulting, folding and erosion preceeded the next record of sedimentation - the development in the Canning Basin, of a superbly exposed Devonian reef complex In adjoining Sheet areas carbonate sedimentation continued into the Lower Carboniferous.

Slight erosion followed the deposition of the Devonian rocks and they are overlain unconformably by the Grant Formation - a sequence of rudites, arenites and lutites which is thought to be partly of glacial or fluvioglacial origin. The Grant Formation is of Lower Permian age; its exposures are bounded to the south-east by the Pinnacle Fault and nowhere in the map area can its relationship to the Noonkanbah Formation (Lower Permian) or Liveringa Formation (Lower and Upper Permian) be demonstrated.

The younger Palaeozoic rocks are unconformably overlain by laterite; limestone and chalcedony (Lawford Beds); and a variety of superficial deposits which are all probably of Cainozoic age.

Detailed descriptions of the various rock units mapped in the Sheet area are given below. Some of the units are well established and described in publications, others have been described in adjoining regions in unpublished Bureau of Mineral Resources records and still others are newly recognized units. Summaries of the stratigraphy of each of the major rock groupings are given in Tables 4 to 10 and 12 to 14.

The classification of sandstones used in this report is largely adopted from the classification proposed by Dapples, Krumbein and Sloss (1953). The nomenclature used is shown in figure I, Appendix I.

The nomenclature used to describe the thickness of stratification and the parting intervals of the stratified rocks is shown in Table 1, Appendix I.

For convenience we adopt the convention of describing details of stratigraphic sections in ascending stratigraphic order.

ARCHAEAN(?)

HALLS CREEK GROUP

Tightly folded and regionally metamorphosed sediments and volcanics, which crop out at widely separated localities in the map area, are placed within the Halls Creek Group. A summary of the nomenclature applied to rocks of the Group by previous authors is given in Table 2.

Dow and Gemuts, (in prep.) recognize four formations in the Group's type area in the Gordon Downs 1:250,000 Sheet area. Their subdivisions are applicable in the present area. A comparison of the rock types in the type area and in the present area is given in Table 3.

The rocks of the Halls Creek Group include geosynclinal sediments and marine basic volcanics. Dolerite and ultrabasic sills (mapped as part of the Lamboo Complex) were intruded into this sequence before the rocks were deformed and metamorphosed. In the type area, metamorphism grades from low to high greenschist facies, but the rocks generally still retain primary features, such as pillow structures in the lavas, and ripple marks, load casts and graded bedding in the sediments. Higher grade metamorphic rocks derived from the Halls Creek Group to the north of the type area were called Tickalara Metamorphics by Dow et al., (1964); small exposures of the Tickalara Metamorphics occur in the Mount Ramsay Sheet area and they are included in the Lamboo Complex. Apart from these, the Halls Creek Group rocks remain largely unaltered, except in the vicinity of contacts with the Bow River Granite and in the McLintock and Cummins Ranges where the rocks have been metamorphosed to high greenschist facies.

A summary of the stratigraphy of the Group is given in Table 4.

DING DONG DOWNS VOLCANICS

The Ding Dong Downs Volcanics contain the oldest strata in the Sheet area; the unit is exposed in the core of two anticlines in the Cummins Range. Both anticlines have been intruded by granite and the Volcanics are metamorphosed and partly digested. Consequently the thickness of the unit is not known. It is assumed that rocks of the Saunders Creek Formation overlie the Volcanics conformably, as in the type area.

TABLE 2 : INVESTIGATION AND SUBDIVISION OF THE HALLS CREEK GROUP

	Forman (1936-37)	Finucane (1938)	Matheson and Guppy (1948)	Traves (1955)	Smith (1963)	Dow, et al (1964)	Dow & Gemuts (in prep.) and present authors.
Age	Archaean	Archaean		Lower Proterozoic	Lower Proterozoic	Older Proterozoic	Archaean
Terminology	In part comparable to Mosquito Creek Series and in part to the Warrawoona Series and Kalgoorlie Greenstones.	Equivalent to Mosquito Creek Series.	Halls Creek Group (metasediments and volcanics) McClintock Greenstones (mainly basic lavas)		Halls Creek Metamorphics	Halls Creek Group	Halls Creek Group
					Moola Bulla Fm.	Moola Bulla Fm.	
					Koongie Fm.	Koongie Fm.	
					Olympio Creek Fm.	Olympio Creek Fm.	Olympio Formation
					Biscay Fm.	Woodward Fm. Biscay Fm.	Biscay Formation
					Saunders Ck.Fm.	Saunders Ck.Fm.	Saunders Ck. Fm.
					Ding Dong Downs Fm.	Ding Dong Downs Fm.	Ding Dong Downs Volcanics.
	Conclusions reached after a brief visit to Halls Creek area.	Conclusions reached after detailed investigation of various mining centres in the Kimberley Gold field.	Subdivided after a brief reconnaissance in the Mt. Ramsay 1:250,000 Sheet area.	Traves could not differentiate between the two units proposed by Matheson and Guppy (1948); Traves mapped the Ord-Victoria River Region in conjunction with the C.S.I.R.O. Land Research and Regional Survey Unit.	First detailed subdivision of Halls Creek Metamorphics, after regional mapping undertaken by B.M.R. G.S.W.A. in 1962.	The name "Metamorphics" was discarded and "Group" substituted; Woodward Formation was separated from the Biscay Fm. Followed regional mapping by B.M.R.-G.S.W.A. in 1963.	It was found that Smith's two top formations were unconformable on underlying units and were in part equivalent to Speewah and Kimberley Groups. Woodward Fm. was incorporated in Biscay Formation. Followed regional mapping by B.M.R.-G.S.W.A. in 1964.

TABLE 3. COMPARISON OF LITHOLOGIES - HALLS CREEK GROUP: GORDON DOWNS-MOUNT RAMSAY SHEET AREAS

	TYPE AREA	
	GORDON DOWNS 1:250,000 SHEET	MT. RAMSAY 1:250,000 SHEET
Olympio Formation	Quartz greywacke, feldspathic greywacke, arkose, subordinate shale and siltstone. Minor quartz pebble conglomerate. Intruded by uralitised dolerite and ultrabasic dykes and sills.	Quartz greywacke, feldspathic greywacke, siltstone, shale and carbonaceous siltstone. Subordinate jasper conglomerate and quartz pebble conglomerate. Intruded by uralitised dolerite and ultrabasic sills.
Biscay Formation	Pillow basalt, minor andesite, greywacke, siltstone, slate and carbonaceous slate. Limestone, dolomite and calc-silicate rocks occur in the middle and at the top of the formation. Intruded by dolerite and ultrabasic dykes and sills, and rare microgranite dykes and stocks.	Uralitised basic volcanic rocks and basic volcanic agglomerate intercalated with greywacke, siltstone, carbonaceous shales, dolomite, marble, calc-silicate rocks, chert, quartzite, epidosite and jaspilite. Rocks are carbonitised and sheared. Locally intruded by dolerite and ultrabasic sills and dykes.
Saunders Creek Formation	Quartz sandstone interbedded with quartz greywacke. Pebble conglomerate at base.	Quartz sandstone and feldspathic sandstone. Thin quartz-pebble conglomerate at base.
Ding Dong Downs Volcanics	Amygdaloidal epidotised basalt intercalated with basic crystal tuff and tuffaceous greywacke. Minor rhyolite and acid crystal tuff and quartz-mica-schists and slate.	Uralitised and epidotised basic, ?volcanic rocks.

The unit consists of dark green uralitised and epidotised coarse-grained, and amphibole-rich basic, (?)volcanic rocks and are cut by ramifying epidote veins. In thin section individual amphibole made up of minute feathery, blue green laths, is set in a groundmass containing granular quartz and spongy plagioclase (albite) associated with granular epidote. The accessories include tiny garnets and ilmenite.

SAUNDERS CREEK FORMATION

Two small arcuate sandstone ridges outlining anticlines in the Cummins Range area have been tentatively correlated with the Saunders Creek Formation. The beds are about 650 feet and consist of pink to white, thick bedded, medium to coarse-grained quartz sandstone and feldspathic sandstone. The rocks are sheared, metamorphosed and intruded by granite. Micaceous partings and cross bedding (which is paralleled by hematite flakes) are common features of the sandstone, and quartz pebble conglomerate bands are present at the base of the unit.

In thin section the quartz sandstone consists of intersutured quartz grains, interspersed by ropy muscovite flakes that define a secondary foliation. Euhedral and dendritic hematite blebs are the only accessories. The feldspathic varieties consist of coarse irregular grains of microcline and quartz, with biotite/chlorite wisps which define the foliation. Zircon and hematite are the dominant accessory minerals.

BISCAY FORMATION

In the type area the Biscay Formation consists of basaltic pillow lavas, with minor andesite, greywacke, tuffaceous greywacke, siltstone, slate and carbonaceous slate. Limestone, dolomite and calc-silicate rocks occur in the middle and at the top of the formation. A similar succession occurs in the Mount Ramsay Sheet area, but the calc-silicate rocks are poorly defined and the volcanic rocks are so altered that it is generally impossible to recognise any primary features or the original mineralogy. By analogy with the type area the epidotised basic volcanic rocks are thought to be metamorphic derivatives of basic volcanic lavas; sheared basic agglomerates have been recognised near Mount Dockrell Well.

The thickness of the Biscay Formation cannot be accurately determined in the map area but it is thought to be about 500 feet, and is much thinner than in the type area. The formation appears to be conformable with the overlying and underlying units.

The unit crops out in four main localities in the map area:-

1. In a long anticline extending from Hangmans Creek to Willy Willy Creek.
2. In a syncline in the Cummins Range.
3. In a small, intensely deformed belt, west of the Kuniandi Range.
4. In two anticlines south of the Woodward Range; one of these is the southern extension of a structure in the Biscay Formation on the Gordon Downs Sheet area, and the other is an irregularly shaped outcrop of basic rocks which has undergone cataclastic deformation and carbonatisation.

In the first three localities the formation crops out as closely spaced, dark, low-lying ridges which are accentuated by quartzite and carbonate rich bands.

The basic volcanic flows are altered, green, fine-grained massive rocks rich in epidote. Close to shear zones they are cleaved and partly altered to form calcareous rocks. In thin section the basic volcanics are fine-grained and have a decussate texture; light green rosettes of amphibole (actinolite(?)) interfinger with chlorite, quartz, and minor carbonate, while epidote and sphene form euhedral grains. Some of the rocks contain abundant carbonate and quartz.

The agglomerates are sheared, dark green, coarse-grained rocks, and contain abundant irregular feldspar phenocrysts and irregular fragments of chert and quartzite (fig. 2). In thin section the rocks are foliated and contain plagioclase feldspar (albite-oligoclase) phenocrysts replaced by sericite and carbonate, set in a fine-grained groundmass of carbonate, epidote and magnetite; the (?)primary foliation is emphasised by irregular quartzite fragments.

Figure 2: Sheared coarse-grained volcanic agglomerate of the Biscay Formation at Mount Dockrell Well. Large angular chert and quartzite fragments, and small euhedral, lathlike feldspar phenocrysts are set in a fine-grained groundmass.

Various sedimentary rock types and their low grade metamorphic equivalents occur throughout the Formation. They form lenses and bands of varying dimensions, and some are entirely enclosed by basic rocks, whereas others persist through the whole strike length of the unit. The following rock types have been noted:-

1. Greywacke and siltstone: these rocks occur as continuous beds throughout the formation and have exactly the same mineralogy as the greywacke and siltstone in the overlying Olympic Formation.

2. Carbonaceous shale: Black shales, which may be altered tuffaceous rocks, crop out as thin bands in volcanic flows. A strong foliation and lineation is developed in these rocks. In thin section the siltstones are fine-grained and foliated; arcuate wisps of graphite paralleled by tiny tremolite laths, are set in a fine-grained epidote and silica rich groundmass. Iron ore minerals are the only accessories.

3. Dolomite, banded marble and calc-silicate rocks: These crop out as bands parallel to shear-planes in volcanic rocks or - with chert - as discontinuous lenses in massive volcanic rocks. The dolomites are yellow to light green in colour, and the banded marble consists of yellow and red alternating laminae up to ¼" across. Calc-silicates form irregular blebs and bands within the marbles (fig. 3 and 4).

In thin section the dolomites consist of an irregular carbonate mosaic in which are set eye-shaped carbonate porphyroblasts. Irregular quartz and tiny granular sphene are speckled throughout the rock. The marbles are fine-grained and banded. Dark bands rich in hornblende and epidote are interspersed by leucocratic quartz- and carbonate-rich bands.

4. Chert and quartzite: Although it is impossible to distinguish these two rock types in the field or under the microscope, it is thought that the quartzite is a metamorphic equivalent of primary chert. These rocks are fine-grained and vary in colour from yellow, through brown to green; with calcareous rocks (fig. 3) they form discontinuous bands in volcanic rocks. In thin section the quartzite consists of a fine-grained, and slightly foliated, granular quartz mosaic with subordinate mica laths interspersed with euhedral quartz phenocrysts which have secondary overgrowths. Angular tourmaline and zircon, and euhedral pyrite and other opaque minerals are the accessories.

5. Epidosite: These granular and banded rocks are thought to be derived from chert and quartzite by carbonate metasomatism, the carbonates being derived from the surrounding basic volcanic and calcareous rocks. The epidosites are bright green, fine to medium-grained foliated rocks. In thin section they have a banded granular texture, with idioblastic epidote or clinozoisite interbanded with granular quartz and interstitial chlorite. Poikilitic sphene and ilmenite (in epidote) are the only accessories.

6. Jaspilite: three bands (100 feet wide and 4 miles long) of isoclinally folded jaspilite are intercalated with red siltstone and white chert west of the Kuniandi Range. These rocks consist of alternate bands of hematite and silica.

Figure 3: Axial plane cleavage (parallel to match) in banded calc-silicate (dark bands) and marble in the Biscay Formation, two miles west of Mount Dockrell.

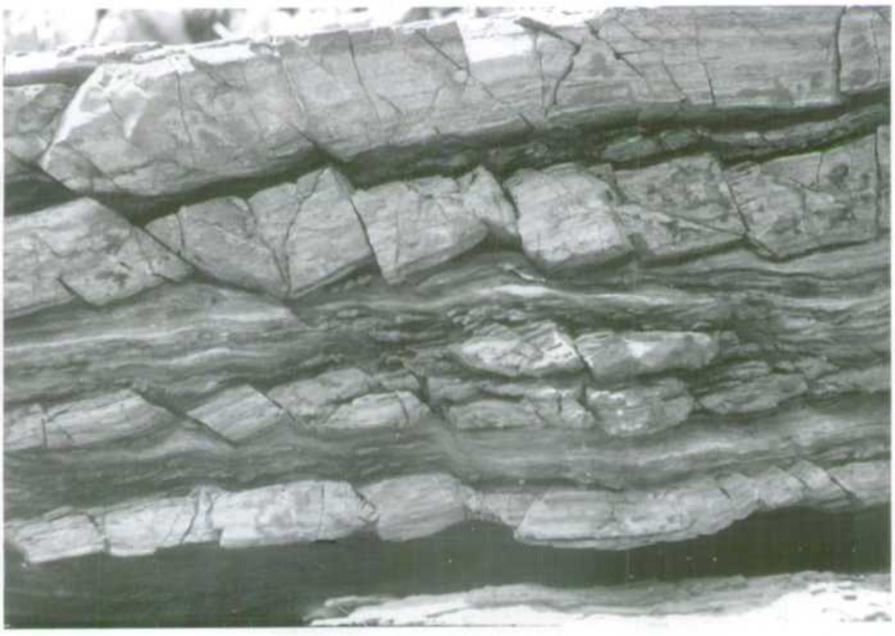


Figure 4: Fracture cleavage in thin bedded quartzite intercalated with marble, which contains small calc-silicate lenses; in the Biscay Formation, two miles west of Mount Dockrell.

Carbonatised Biscay Formation:

An irregularly shaped, east-trending, overturned anticline of carbonatised and cataclastically deformed basic igneous and sedimentary rocks occurs ten miles south of Woodward Range, on the eastern margin of the Sheet area. The structure of this anticline is very complex and tight isoclinal folds, at all scales, occur throughout.

The following rock types have been examined from this area:-

1. Carbonate rich amphibolite: These are black or dark green, coarse-grained, foliated and banded rocks; dark green amphibole-rich bands alternate with white carbonate-rich vughs and schlieren. In thin section the rocks show a decussate fabric; blue-green shredded amphibole and subordinate xenoblastic diopside form chevron like bands parallel to the foliation; minor quantities of granular quartz and tiny brown biotite laths are also present. Granular epidote, idioblastic sphene and coarse carbonate crystals define the calcareous bands. These rocks have the same mineralogy as altered dolerite dykes intruding the Olympio Formation.

2. Carbonate-rich biotite schist: The rocks are black, fine-grained and foliated, and contain abundant carbonate vughs and schlieren. In thin section dark brown biotite-rich foliae wrap around eye-shaped concentrations or bands of carbonate; in some of the rocks carbonate encloses coarse plagioclase and quartz. Accessories include ilmenite (being replaced by sphene), and angular tourmaline.

3. Epidosite and quartzite: Green, medium-grained, banded and foliated, epidote-rich rocks, intercalated with porous and gossanous quartzite define bedding in the amphibolites. Both rock types contain epidote, but the epidosites consist almost entirely of this mineral. The foliation of the quartzites may be defined by biotite laths or graphite flakes and it is possible that some of them are derived from carbonaceous shales.

A number of hypotheses can be formulated to explain the presence of carbonate in these rocks:-

1. that it has been derived from sheared basic volcanic rocks;

2. that it has been derived from calcareous sediments associated with the basic volcanic rocks;

3. that it has been introduced during shearing from an external source, possibly from metamorphosed calcareous rocks at depth.

OLYMPIO FORMATION

Greywackes, siltstones and schists of the Olympio Formation occupy large tracts of country in the south-eastern part of the area and are a direct southerly extension of the type exposures in the Gordon Downs 1:250,000 Sheet area. Rocks of similar lithology which extend in a north-easterly direction along the base of the Mueller Range from Mount Amherst Station to One Tree Palm Gorge, and along the Leopold River east of Mount Winifred have been interpreted as belonging to the unit.

The Formation is overlain unconformably by Middle Proterozoic sediments or volcanics and conformably overlies the Biscay Formation. The thickness of the unit is probably in excess of 10,000 feet.

The sedimentary rocks of the Olympio Formation include very thick-bedded, massive quartz-rich and feldspathic greywackes intercalated with thin-bedded siltstones, fissile shales and carbonaceous siltstones. Conglomerate bands with pebbles of quartzite and jasper occur throughout the sequence. Graded bedding, load casts and cross bedding were noted but most of the rocks are tightly folded and transposition of bedding into cleavage makes it impossible to use such features as facing evidence.

The greywackes are coarse to medium-grained and their colour varies from grey to brown; most are quartz-rich and micaceous and some contain feldspar fragments. In thin section they consist of subangular, poorly sorted minerals and rock fragments set in a fine grained and probably reconstituted decussate chloritic and siliceous matrix. Fragments of chert, shale, quartzite, and granite or quartz-feldspar porphyry make up less than 10% of the rocks. The usual clastic minerals (up to 60%) are quartz with undulose extinction and Böhm lamellae, and albite (less than 10%) with checkerboard twinning. Accessory minerals include angular zircon, tourmaline, ilmenite and magnetite.

Fine-grained greywacke siltstone and siltstone are interbedded in the greywackes; their colour ranges from black through grey to red. In thin section they contain angular and poorly sorted mineral and rock fragments; the matrix consists of tiny white mica laths and quartz granules. The siltstones are a fine grained version of the greywackes, but contain few rock fragments; the major clastic constituent is quartz. Accessories include ilmenite, magnetite, zircon and tourmaline. In the black siltstones thin graphite-rich bands are interspersed with mica-rich bands.

The mineralogy of the greywackes and siltstones is constant throughout the Olympio Formation, although the rocks exposed in the Leopold River region have a better sorting and contain less rock fragments than the main belt of sediments in the south-east of the Sheet area.

Very little can be said about the source area of the detrital material in the Olympio Formation, but fragments of shale, chert, quartzite and jaspilite indicate a sedimentary terrain while granite fragments, and detrital tourmaline suggest the presence of granites.

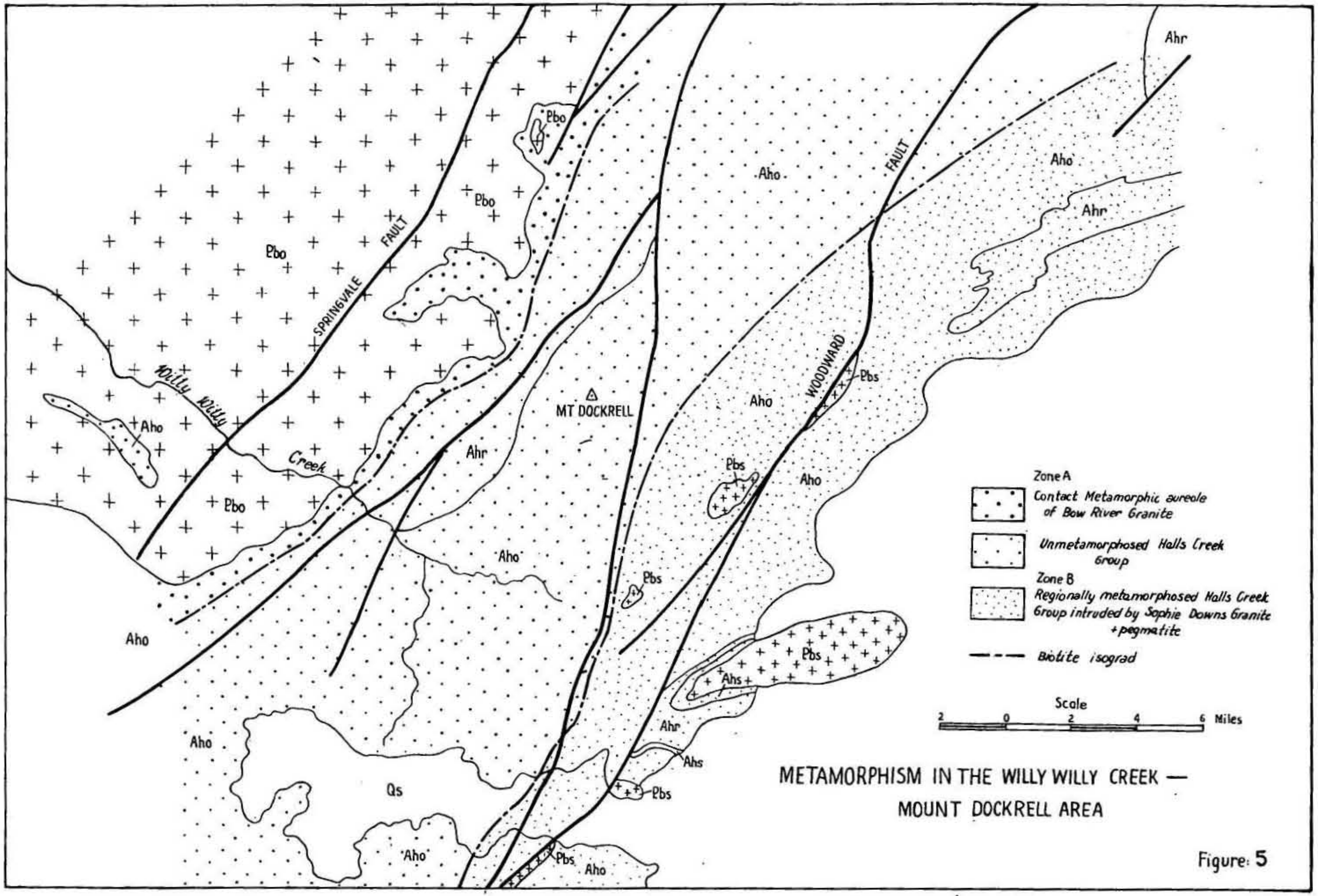
In the south-east of the Sheet area, greywackes and siltstones of the Olympio Formation have been metamorphosed to quartz-biotite-muscovite and quartz-biotite-muscovite-garnet schists in two well defined areas (fig. 5). These rocks are discussed in more detail below.

UNDIFFERENTIATED

Small, isolated exposures of rocks of the Halls Creek Group occur south of the Mueller Range, and west of the King Leopold Range. The dominant rock types are sub-greywacke, sericite schist, amphibolite and uralitised dolerite. It is impossible to assign these to any specific formation but since they have a general structural and lithological similarity to the Halls Creek Group, and are intruded by granites, they have been mapped, (partly as a matter of convenience) as "Undifferentiated" Halls Creek Group.

METAMORPHISM WITHIN THE HALLS CREEK GROUP

Two zones of metamorphic rocks, separated by unmetamorphosed sediments, have been delineated in the Willy Willy Creek-Mount Dockrell area (fig. 5). The zonal boundaries are defined by the appearance of biotite in metamorphosed greywackes and siltstones.



METAMORPHISM IN THE WILLY WILLY CREEK — MOUNT DOCKRELL AREA

Figure: 5

TABLE 4 - SUMMARY OF STRATIGRAPHY - HALLS CREEK GROUP

ROCK UNIT	MAP SYMBOL	THICKNESS IN FEET	LITHOLOGY	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION OF EXPOSURES	STRATIGRAPHIC RELATIONSHIPS	REMARKS
Undifferentiated	Ah	-	Sub-greywacke, sericite schist, amphibolite, uralitised dolerite.	Isolated, poorly resistant, alluvium covered outcrops.	South of Mueller Range and south and west of King Leopold Range.	Unconformably overlain by Speewah Group and younger rocks. Intruded by Lamboo Complex.	
Olympio Formation	Aho	?10,000+	Grey to brown, thick bedded, massive, quartz greywacke and feldspathic greywacke intercalated with thin bedded siltstone, fissile shale and carbonaceous siltstone. Subordinate jasper and quartz pebble conglomerate.	Resistant and poorly resistant; generally rounded steep hills, also low rises with poor outcrop.	In south-east corner of Sheet area; along the base of Mueller Range; along northern boundary of Sheet area.	Unconformably overlain by Whitewater Volcanics Intruded by rocks of Lamboo Complex.	In Willy Willy region, gold mineralisation occurs within or on the margins of basic sills. Alluvial gold occurs in streams crossing these rocks.
Biscay Formation	Ahr	?500+	Uralitised basic volcanic rocks and basic volcanic agglomerate intercalated with greywacke, siltstone, carbonaceous shales, dolomite, marble, calc-silicate rocks, chert, quartzite, epidosite and jaspilite. Rocks are carbonatised and sheared.	Closely spaces, low lying ridges.	In three localities in the south-eastern corner of the Sheet, and a locality west of Kuniandi Range.	Conformably overlain by Olympio Creek Formation.	Much thicker in Gordon Downs Sheet area.
Saunders Creek Formation	Ahs	About 650'	Pink to white, thick bedded, medium-coarse grained quartz sandstone and feldspathic sandstone. Thin quartz pebble conglomerate beds at base.	Resistant ridges up to 200' high.	In the Cummins Range.	Conformably overlain by Biscay Formation.	Micaceous partings and cross-bedding which is accentuated by hematite flakes, common. Unit intruded by Sophie Downs Granite.
Ding Dong Downs Volcanics	Ahd	Unknown	Uralitised and epidotised basic ?volcanic, rocks.	Poorly resistant; small outcrops in alluvium.	In the Cummins Range.	Oldest unit on Sheet, conformably overlain by Saunders Creek Formation.	Unit is intruded by Sophie Downs Granite.

<u>Zone A</u>: This zone is about one mile wide and parallels the Bow River Granite contact; it defines the contact aureole. Greywacke and siltstone in the Olympio Formation have been metamorphosed to form biotite rich schists. The rocks are dominantly brown, fine to medium-grained, quartz-biotite-muscovite schists, which are foliated and lineated and in some cases possess a crenulation cleavage. In thin section xenoblastic quartz grains are randomly distributed and wrapped by brown biotite and muscovite laths which define the foliation. Angular zircon and tourmaline grains represent detrital sedimentary relics in these rocks. Mineral assemblages rich in sillimanite and andalusite occur close to the Bow River Granite.

<u>Zone B</u>: This zone is eight miles wide and extends in a north-east trending belt along the Cummins and McClintock Ranges. Rocks of the Halls Creek Group have been regionally metamorphosed and intruded by the Sophie Downs Granite and its associated pegmatite dykes. The biotite isograd shown in figure 5 is also the western limit of distribution of the pegmatites.

Greywacke and siltstone within the Olympio Formation have been metamorphosed to form fine to medium-grained, foliated and lineated schists. The foliation is parallel to the bedding and is accentuated by alternating mica-rich and mica-poor bands. The bedding is cut by a steep axial plane cleavage.

The following mineral assemblages were noted:

1. Quartz-muscovite-biotite;
2. Quartz-biotite-muscovite-albite;
3. Quartz-biotite-muscovite-garnet;
4. Quartz-biotite-muscovite-epidote-garnet.

In these rocks dark brown biotite and muscovite laths defining pelitic bands or axial plane cleavage, are interspersed with bands or areas of granular quartz. Most of the schists are garnetiferous; the garnets occur as tiny grains or large spongy porphyroblasts. The formation of garnet may pre-date or post-date the axial plane cleavage. Ovoid twinned albite porphyroblasts also post-date this cleavage, and epidote is marginal to, or replaces, the feldspar. Accessories include zircon, tourmaline and iron ore grains. In some schists the tourmaline is a detrital relic, but in others, e.g. close to pegmatite dykes, euhedral grains are developed by metasomatism.

Other metamorphic rock types in zone B include graphite schists, amphibolites and calc-silicate rocks. The graphite schists are derived from carbonaceous siltstones, and consist of granular quartz interfoliated with subordinate graphite and ragged muscovite. The amphibolites and associated calc-silicate rocks are derived from metamorphosed dolerite dykes and volcanics in the Biscay Formation; these rocks have already been discussed under the various formation headings.

ARCHAEAN AND PROTEROZOIC

LAMBOO COMPLEX

The name Lamboo Complex was first used by Matheson and Guppy (1949) and was later defined by Guppy et al., (1953) to include granite, granitic gneiss and metasediments. Traves (1955) used the name to include all the granitic rocks in the East Kimberley area, but excluded the metasediments. Dow et al., (1964), and Dow and Gemuts (in prep.) follow the original definition of Guppy et al., and include high grade metamorphics, as well as basic and acid plutonic rocks in the Complex. This approach is justified because there are areas within the Complex where it is impossible to delineate a boundary between igneous and metamorphic rocks.

In the Mount Ramsay Sheet area the Lamboo Complex crops out in a hook-shaped belt which extends from north of Gnewings Well in the north-east, to Mount Hawick in the south; from here it trends north-westwards to Mount Fairbairn and then north to beyond Mount Winifred. The Complex occurs within the Halls Creek Mobile Zone. The folding and faulting on the margins of the Complex may be assumed to be connected with tectonism in the Mobile Zone. The complex is overlain by younger sediments on its ~~s~~ northern and southern margins.

The metamorphic rocks of the Lamboo Complex are called the Tickalara Metamorphics and were originally defined on the Dixon Range 1:250,000 Sheet area (Dow and Gemuts, 1964). These rocks are regarded as the high grade metamorphosed equivalents of the Halls Creek Group. In the Mount Ramsay Sheet area they generally form large roof pendants in coarse grained porphyritic granite, and have a limited distribution.

The igneous rocks of the Complex intrude the Halls Creek Group and the Tickalara Metamorphics, and are overlain unconformably by Middle Proterozoic sediments and volcanics. They include ultrabasic, gabbroic and granitic rocks. Their nomenclature on this Sheet area follows for the most part that set up by Dow and Gemuts (1964) in the East Kimberley Region, although new terms are used in the north-west.

The Alice Downs Ultrabasics and McIntosh Gabbro generally occur as flat differentiated sheets which are intruded by granitic rocks. It is thought that they are co-magmatic and that they have been intruded along the major zones of dislocation.

The Bow River Granite was intruded as a batholith along the Halls Creek Mobile Zone, incorporating pendants of Tickalara Metamorphics, Halls Creek Group and gabbroic rocks. Small granite bodies defining anticlinal cores in the Cummins Range region are thought to be part of the Sophie Downs Granite (Smith, 1963) which occurs 80 miles to the north-east, in the Gordon Downs Sheet area. The Bow River and Sophie Downs Granites have late stage pegmatite and aplite dykes associated with them. The final phase of igneous activity in the complex was marked by the intrusion of the Violet Valley Granite and dolerite dykes. The Chaneys Granite which crops out in the north-western part of the area may be related to the Violet Valley Granite; the other granites in this area (the Mulkerrins and Long Hole Granites) may possibly be related to the Bow River Granite.

A summary of the features of the rocks of the Lamboo Complex is given in Table 5.

TICKALARA METAMORPHICS

The Tickalara Metamorphics are sparsely distributed on the Mount Ramsay Sheet area. Their main outcrop is in the extreme north-east corner, where they form large roof pendants in coarse-grained porphyritic granite. Small outcrops of high grade rocks also occur between Mount Amherst Station and Me No Savvy Yard, and to the west of the Kuniandi Range, but they have not been differentiated on the accompanying map; they are generally associated with gabbro and porphyritic granite intrusions into undifferentiated Halls Creek Group sediments or metamorphics.

The most common rock type in the Metamorphics is paragneiss which is generally well foliated, and, in some areas, banded. Needles of sillimanite and cordierite spots can be seen in the hand specimen. Two assemblages were noted:

1. Microcline-quartz-cordierite-biotite-sillimanite;
2. Quartz-biotite-sillimanite-staurolite-(muscovite).

The first assemblage was noted in a poorly foliated xenolith in porphyritic granite. Cordierite occurs in round grains, surrounded by yellow pinnitic margins, and large plates of sillimanite are intimately associated with red-brown biotite. In the second assemblage, red-brown biotite and fibrolitic sillimanite define the foliation and are interlathed with minor amounts of secondary muscovite, while euhedral staurolite is wrapped by these minerals. This rock is a good representative sample of paragneiss from the Mount Amherst region. Small bands of calc-silicate rocks and amphibolites are intercalated with paragneiss in some areas.

The porphyritic Bow River Granite seems to have had little effect on the Tickalara Metamorphics. Small xenoliths of the metamorphics were observed in the granite. These always have a prominent secondary foliation and compositional banding. Garnet, sillimanite and cordierite pre-date the foliation. The xenolith-granite contact is knife-sharp and no obvious contact effects were noted, but it is probable that the effect of white mica replacing cordierite may be directly related to the granitic intrusives.

ALICE DOWNS ULTRABASICS

The Alice Downs Ultrabasics crop out as an elliptical body (4 miles wide by 6 miles long) four miles north of Lamboo Homestead. The rocks are fine to coarse-grained, dark green or black and generally consist almost entirely of serpentine. The southern margin of the Ultrabasics contains rhythmic banding that dips away to the south at 60°. This primary banding is marked by chromite-rich laminae up to six inches thick and 50 yards long, and chromite-poor laminae. Along the eastern and western margins the primary structure is disrupted by shearing, which gives the body an overall foliation striking NNE and dipping 60°E. This secondary foliation is defined by pod-like, yellow, magnetite ensheathed asbestos veins.

In thin section most of the rocks consist of decussate serpentine pseudomorphs after alivine and pyroxene; the chromite bands consist of closely set euhedral hexagonal or pentagonal chromite grains.

UN-NAMED BASIC AND ULTRABASIC INTRUSIVE ROCKS

Numerous basic and ultrabasic sills and dykes intrude rocks of the Halls Creek Group. Where practicable these have been delineated on the accompanying map; they have been given the symbol Bbd.

For convenience those which intrude the Biscay Formation will be discussed separately from those which intrude the Olympio Formation.

The Biscay Formation is intruded in two main localities - the first is south of the Woodward Range in the southern part of a structure which extends on to the map area from the adjoining Gordon Downs Sheet area. The margins of the structure are intruded by large dolerite sills and dykes; these will be discussed in full by Dow and Gemuts (in prep.). The second main area is west of the Kuniandi Range where the Formation is intruded by thin ultrabasic sills. Since they crop out poorly no contact relationships are known. The main rock types are dark green and massive with a red, pitted, weathering surface. In thin section they have an allotriomorphic granular texture with clinopyroxene and amphibole relics set in a fine-grained decussate serpentine-rich groundmass.

Many folded and altered sills of dolerite and ultrabasic rocks occur within the Olympio Formation. These have generally been intruded along the bedding of the sediments, but areas of local transgression occur, where dyke-like apophyses invade the sediments. The Formation has been folded during or after the intrusion of the sills.

It is possible that these sills are of the same age as the McIntosh Gabbro and Alice Downs Ultrabasics, but since they are altered, it is impossible to relate them mineralogically to these rocks.

The sills range from a few hundred feet to eight miles in strike length and range from 50 feet to about 5000 feet in thickness. There is a concentration of thin sills to the east and west of Woodward Range, east of Mount Dockrell and in the McClintock Ranges. A large, folded sill extends from Mount Dockrell to Willy Willy Creek; most of the gold shows in this area occur within or on the margins of this sill. Close to the Bow River Granite, sills which intrude the sediments are sheared, metamorphosed and attenuated parallel to the granite contact.

Contacts between the sills and the country rock are not well exposed, but in some cases the sediments seem to be unaltered; chilled margins up to 20 feet wide have been observed in the intrusives. There is considerable variation in texture in these sills; they range from fine-grained and massive at the edges, to vesicular, coarse-grained and porphyritic towards the centre.

The least altered dolerite sills are massive, dark green, and have a relict coarse allotriomorphic granular, or medium-grained, ophitic texture. Most of the rocks are thoroughly uralitised and contain no traces of the original minerals. In thin section light green decussate and rosette-like tremolite or hornblende is randomly distributed among spongy plagioclase (albite), epidote and quartz crystals. Chlorite replaces hornblende and skeletal ilmenite and sphene are accessories.

The ultrabasic sills are completely altered and no relict minerals were noted. The ultrabasic rocks are dark green or black, fine to coarse-grained, and are usually almost entirely serpentinised.

Within the contact aureoles of the Bow River and Sophie Downs Granite, dolerite sills have been metamorphosed to form foliated amphibolites and carbonate rich rocks.

The amphibolites are dark green, medium-grained rocks which are slightly foliated, lineated and sometimes banded. In thin section, ragged to idioblastic blue green hornblende is interspersed with irregular clear plagioclase (albite to labradorite) and quartz grains. Epidote is intergrown with the feldspar and the hornblende is speckled with ilmenite replaced by sphene. The abundance of the various minerals varies from area to area; some of the amphibolites are quartz rich while others have eye-like pods of epidote parallel to the foliation.

The carbonatised dolerite dykes are black or dark green, coarse grained rocks. They are foliated and banded in hand specimen, with alternate bands and pods of light green epidote and white carbonate in a background of dark pyroxene and amphibole. In thin section the rocks show needle-like light green amphibole and tabular diopside interbanded with xenoblastic epidote, sphene and carbonate. Clear xenoblastic checkerboard-twinned albite, together with quartz grains, form porphyroblasts enclosed by carbonate.

McINTOSH GABBRO

Gabbro and uralitised gabbro which have been mapped as parts of the McIntosh Gabbro crop out in the region between Mount Fairbairn and the Kuniandi Range, where they are intruded by the porphyritic Bow River Granite, and aplite and pegmatite veins or dykes. In some parts of this area granitic intrusives are so numerous, that gabbros occur as xenolith swarms and large, closely disrupted sheets.

Further gabbro bodies crop out in a zone extending from Me No Savvy Yard eastwards to Mount Amherst Station, where they occur as small stocks which intrude Halls Creek Group sediments. The gabbros in turn are locally intruded by coarse-grained granite.

A large gabbro body which is exposed to the west of the Laura River is intruded by coarse-grained granite.

Three gabbroic types have been recognised:-

1. Gabbros: These rocks are black, medium to coarse grained, and have an allotriomorphic granular texture. Rhythmic layering of pyroxene-rich bands alternating with plagioclase rich bands, is developed locally (fig. 6). These relatively unaltered rocks occur as relict patches in uralitised gabbro terrains. In thin section, clinopyroxene, surrounded by brown amphibole and biotite coronas, is associated with randomly oriented euhedral saussuritised plagioclase (bytownite) laths. The biotite is secondary in these rocks and probably formed concurrently with the alteration of plagioclase.

Figure 6: Layering in the McIntosh Gabbro four miles west of Mount Bertram. Dark pyroxene rich bands are interposed with light plagioclase rich bands.

2. Uralitised Gabbros: These are black, fine to coarse-grained amphibole and biotite rich rocks, with an allotriomorphic granular to ophitic texture. They show various stages of uralitisation; some still retain relict pyroxene crystals and rhythmic banding whereas others are completely altered to form hornblende rich rocks. Some of the basic rocks show lit-par-lit structures and admixture with the coarse-grained granites which intrude them.

In thin section the most common rock type has an allotriomorphic granular texture, and contains large ragged plates of light green hornblende interlathed with saussuritised plagioclase (labradorite). Minor amounts of irregular quartz, chlorite and opaques are also present.

The uralitisation of these rocks is probably associated with the intrusion of the Bow River Granite. Hydrothermal solutions emanating from the granite may have acted as agents in altering the primary texture of the gabbros.

3. Sheared Gabbros: Eight miles west of Kuniandi Range, where local shear zones are well developed, the texture of the gabbro is saccharoidal. Narrow shear zones are developed in the gabbro which are surrounded by massive coarse-grained uralitised gabbro. The sheared rocks are dark green, coarsely foliated and quite commonly interbanded with sheared granite or paragneiss.

In thin section the sheared gabbros have a honeycomb texture; idioblastic laths of brown amphicole and granular clinopyroxene (diopside?) are interfoliated with xenoblastic plagioclase (bytownite). Accessories include a little quartz, granular sphene and epidote. These dynamically deformed gabbros have a composition and fabric which is similar to that of basic granulites of the Tickalara Metamorphics in the Dixon Range 1:250,000 Sheet area (Dow and Gemuts, 1964).

BOW RIVER GRANITE

In the eastern part of the Sheet area, the Bow River Granite crops out from Mount Hawick in the south to Gnewing's Well in the north. It varies from a coarse-grained, porphyritic granite to an even-grained granite and granodiorite. In the western part of the Sheet area, the same rocks extend westwards from Kuniandi Range to beyond Mount Fairbairn.

The Granite crops out in the form of large exfoliated whalebacks or in weathered mesas overlain by laterite. West of Mount Fairbairn large granite tors form scattered inliers in alluvium.

The rocks are usually homogeneous in composition and texture over large areas and range from leucocratic to melanocratic types. In the coarse-grained porphyritic varieties, lathlike, ovoid or rhombic feldspars, up to two inches across, are set in a fine-grained groundmass of quartz and feldspar. Potash-feldspars commonly enclose small euhedral plagioclase crystals. In some areas phenocrysts are aligned into a primary foliation, and lenses of feldspar rich segregations are common. Biotite-rich granite predominates but in areas close to intruded gabbro bodies hornblende is developed. Tectonic foliation and shearing parallel to major faults is evident in some of the rocks, and mylonites have formed in some areas.

In thin section the granites have clear euhedral microcline and subsidiary amounts of saussuritised albite-oligoclase phenocrysts, which are set in a finer grained base of quartz and plagioclase feldspar with interstitial epidote and biotite-chlorite rosettes and clots. Ilmenite, magnetite and zircon are the main accessories.

The granodiorite contains euhedral to subhedral oligoclase-andesine phenocrysts set in a base of subordinate potash-feldspar, quartz and biotite-chlorite rosettes. Plagioclase is replaced by sphene, epidote and chlorite aggregates. Accessory minerals include garnet, zircon, apatite and iron ore minerals.

Contact Relationships

Three types of contact relationship have been noted in specific areas where the Bow River Granite intrudes sediments or gabbros:

1. Faulted contact between granite and country rock: The granite is unaltered at the contact and the country rocks are unmetamorphosed.

2. Stoped contact between granite and country rock: The granite is fine-grained and leucocratic at the contact and angular and lenticular xenoliths are strewn parallel to the contact. The country rocks are metamorphosed and possess a strain slip cleavage parallel to the contact. Very fine-grained granophyric necks intrude the country rocks. In some areas a massive, closely-jointed aplitic phase occurs at the margin of the granite and intrudes both the main, coarse-grained granite mass and the country rock. Pegmatites also occur as marginal facies of the granite.

Contact altered rocks include:-

(a) Schists: these are generally fine-grained, foliated and crenulated. Mineral assemblages vary from quartz-biotite-muscovite-garnet to quartz-biotite-sillimanite.

(b) Uralitised gabbros and amphibolites: in areas where porphyritic granite intrudes gabbro, incipient quartz and feldspar laths are developed in the gabbro which is completely uralitised and contains abundant hornblende and saussuritised plagioclase. Amphibolites are derived from sheared sills in schists. These rocks are foliated fine-grained and equigranular. They consist of fine-grained bands of idioblastic green hornblende, clear plagioclase (albite-oligoclase) and subordinate quartz. Accessories include ilmenite altering to leucoxene and granular epidote.

(c) Skarns: west of Kuniandi Range, coarse-grained granite intrudes calcareous rocks of the Biscay Formation; banded skarns and marbles have developed. The skarns are granular and coarse-grained and contain garnet, diopside and subordinate epidote cut by quartz veins.

3. Migmatitic contact between granite and sediments: Foliated granite forms lit-par-lit interlayers with paragneiss and amphibolite, to give a migmatite zone which may be up to 400 yards wide. The grade of metamorphism in the country rocks falls away from the contact, while the granite becomes more massive and coarse-grained toward its interior.

Late Dykes

The final phase of the granite intrusion is marked by the development of pegmatite dykes and schlieren, and aplite dykes.

Thin quartz-feldspar-mica pegmatite dykes and schlieren are generally restricted to the intrusive masses themselves. However, in the vicinity of granite contacts, dykes may extend a short distance into country rock, e.g. nine miles north-north-west of Mount Phillip, where pegmatite dykes carrying muscovite and tourmaline intrude quartz-schists of the Halls Creek Group.

Homogeneous aplite dykes range from inches to hundreds of feet in width and intrude various rock types, close to granite contacts, e.g. south of Mount Fairbairn, where coarse-grained gabbro is intruded by a network of aplite dykes. These dykes are fine-grained and saccharoidal consisting of microcline, subordinate saussuritised plagioclase, quartz and interstitial clots of chlorite and epidote.

SOPHIE DOWNS GRANITE

The Sophie Downs Granite is associated with tin bearing pegmatites. The name is derived from the Gordon Downs Sheet area.

Five elongate bodies of the Granite have been mapped in the Cummins and McClintock Ranges. Three of these occur in the cores of anticlines and the other two intrude parallel to the Woodward Fault. All intrude the Halls Creek Group.

These bodies consist of equigranular coarse to medium-grained granites which are white and massive in outcrop. There is no change in grain size at their margins.

In thin section the granites consist of microcline, quartz, subordinate plagioclase (oligoclase to andesine), and irregular clots of interlathed biotite and muscovite. The microcline shows poikilitic inclusions of plagioclase, while the plagioclase is replaced by sericite-epidote-chlorite aggregates. Iron ore minerals and tourmaline are accessories.

The contacts between granite and country rocks are very irregular and generally are discordant with the attitude of the sediments. The granites are bounded by hornfels, which passes outwards into biotite schist. In the McLintock Range the hornfels is fine-grained and banded; the mafic bands contain fine granular epidote, ragged biotite, sphene and iron ore minerals; the leucocratic bands are composed of irregular microcline, altered plagioclase and quartz.

Skarns are formed in the contact aureole of granite intruded parallel to the Woodward Fault. These rocks are massive and brown in outcrop and contain red granular garnet, white diopside and light green epidote cut by ramifying quartz veins. In thin section garnet forms irregular masses and has numerous fractures enclosing diopside and epidote. Epidote forms graphically intergrown, twinned fibrous grains. Sphene and plagioclase are accessories.

Late Dykes

Wherever the Sophie Downs Granite intrudes Olympio Formation pegmatite dykes are developed in the sediments, as discontinuous, randomly oriented bodies, which may be concordant or discordant with the strike of the sediments. Some of them are up to 500 feet in length, and they range from 10 feet to 200 feet in width. The minerals present include varying amounts of microcline, lamellar albite, quartz, greenish-yellow flakes of muscovite and black tourmaline or schorl up to two to three inches in length. Minor accessories include garnet, ilmenite, and almost all of them carry tin and tantalum. Biotite schists at the margins of the pegmatites contain randomly distributed crystals of andalusite and pyrite.

In addition to the pegmatites, small aplite dykes (up to 20 feet across) intrude the granite and also the country rocks close to intrusive contacts.

VIOLET VALLEY GRANITE

Large exfoliated outcrops of an equigranular, medium to coarse-grained biotite granite, which has been mapped as Violet Valley Granite, occur in the vicinity of the junction of the Margaret and Louisa Rivers, the Margaret River and Dead Horse Creek, and along the Mueller Range, from Thursday Creek to One Tree Palm Gorge. This granite is easily distinguished from the surrounding rocks by its characteristic black photo pattern.

In the first locality the Granite intrudes Halls Creek Group sediments. A narrow zone of banded biotite gneisses and hornfelses adjoin the contact. The Granite contains hornfelsed xenoliths up to 1 foot in diameter on its margins, and banding is developed within the granite near the contact.

Along the Mueller Range the granite intrudes the Bow River Granite, with sharp contact: no xenoliths of the country rock are present. One thin section examined from this area indicates that some of the rocks in the Violet Valley Granite may be dioritic in composition. Oscillatory zoned plagioclase (oligoclase to andesine) is the dominant constituent, associated with interstitial quartz and biotite-chlorite clots. No potassium feldspar was noted.

LONG HOLE GRANITE

The Long Hole Granite crops out in the north-western part of the Sheet area, in the low country along the foot of the Burramundi Range. The exposures are extremely poor and are mostly covered by coarse residual sand; the Granite extends on to the Lansdowne Sheet area, from whence the name has been derived.

The Granite is coarse-grained and porphyritic; in weathered outcrop it is characterised by the presence of pink and either white or green feldspar phenocrysts and/or augen up to 4 centimetres long, and grains of quartz up to 1 centimetre across.

Gellatly and Derrick (in prep.) provide petrographic descriptions of the Granite.

Due to the poor exposure the contact relationships of the Granite could not be determined.

CHANEYS GRANITE

The Chaneys Granite is exposed in the north western part of the Sheet area and in the adjoining part of the Lansdowne Sheet area. On the Mount Ramsay map area it crops out as isolated tor-strewn hills along the flats bordering Leopold River and in an area south of Mount Winifred.

The name is derived from Chaneys Yard (Latitude 18°08'S, Longitude 126°14'E), which is near the southernmost exposures of the Granite.

It is a massive coarse and even-grained grey biotite granite and, locally, is weakly foliated. In outcrop it resembles rocks mapped elsewhere as Violet Valley Granite, but differs from these in containing, on weathered surfaces, pits filled with dark green chloritic minerals. No thin sections have yet been made of samples from the Mount Ramsay Sheet area, but Gellatly and Derrick (in prep.) describe samples from the Lansdowne Sheet area as follows:- "Plagioclase (An35) is common and is associated with large grains of perthitic potash feldspar. The plagioclase is zoned and highly altered in the core of the crystal; myrmekite is present in some of the plagioclase rims. Biotite is generally slightly deformed and chloritised and pink zircons are a common accessory".

The contact between the Chaneys Granite and the Bow River Granite several miles to the south-east of Mount Winifred has not been closely examined and the relationship between the two remains uncertain. Similar doubts apply in the interpretation of the contact between the Chaneys Granite and the (?)Whitewater Volcanics several miles north-west of Burramundi Yard - shearing precludes study of the contacts. The Granite intrudes schists and metasediments which have been mapped as Undifferentiated Halls Creek Group.

LERIDA GRANITE (Gellatly and Derrick, in prep.)

The Lerida Granite crops out mainly on the Lansdowne Sheet area, but a small exposure occurs near the northern margin of the Mount Ramsay Sheet area to the north-east of Burramundi Yard.

It is a porphyritic to even-grained grey-green biotite granite, distinguished in hand specimen by the presence of pale creamy-green phenocrysts of zoned feldspar.

The Granite is intruded by the Mulkerrins Granite, which has a micropegmatitic contact phase.

MULKERRINS GRANITE

The Mulkerrins Granite is exposed mainly on the adjoining Lansdowne Sheet area, from whence the name is derived (Gellatly and Derrick in prep.) but the southern part of the main mass extends into the northern part of the Mount Ramsay Sheet area in an area north of Burramundi Waterhole.

The granite is massive, unfoliated coarse and even-grained and leucocratic and is in contact with sheared rocks which have been mapped tentatively as Whitewater Volcanics. The contact between the Granite and the sheared rocks is sharp, but their relationships cannot be determined. Numerous quartz dykes up to 10 feet across and a mile long cut the granite but do not penetrate the country rock; they were probably generated as a late phase during the intrusion of the granite. Gellatly and Derrick (in prep.) describe thin sections of the granite as showing "typical hypidiomorphic granular texture. Plagioclase is zoned and strongly altered to sericite and epidote, albite rims and myrmekite are common and inter-granular albite occurs between grains of perthitic potash feldspar. The small amounts of biotite present are fresh and undeformed. Small euhedral crystals of epidote are a common accessory".

UNDIFFERENTIATED

In areas near Lilly Hole Bore, Me No Savvy Yard, Hot Air Well and the Laura River, it has not been possible to delineate boundaries between intimately associated granite, uralitised gabbro and metamorphic rocks. The areas are shown on the accompanying map as Undifferentiated Lamboo Complex and have the symbol Bb.

LATE DOLERITE DYKES

Dolerite dykes up to 200 feet wide and eight miles long are largely restricted to the eastern half of the Sheet area; they are symbolised on the map by the letters "dl". They outcrop as straight resistant ridges. The dykes strike from north-north-west to north-north-east and they generally intrude small shear zones in the Bow River Granite, but in the extreme north-east they intrude the Tickalara Metamorphics. Chilled margins, seldom exceeding 6 feet in width, occur on the edges of all the dykes.

The most common rock type has an ophitic texture and a dolerite composition. In thin section these rocks contain lath like plagioclase, and a little granular epidote set in a groundmass of pyroxene (titanaugite?) and accessory ilmenite. It is quite common for the pyroxene to be uralitised and the plagioclase saussuritised.

A dyke with an anomalous texture occurs twelve miles north-west of Mulla Bulla Homestead. The texture is porphyritic and coarse zoned plagioclase phenocrysts up to 2 inches across are set in a fine-grained groundmass which contains smaller phenocrysts of amphibole and quartz. In thin section euhedral, oscillatory zoned and partly saussuritised labradorite, quartz and altered pyroxene are set in a fine-grained amphibole and biotite lath groundmass. The pyroxene is altered to pools of biotite, muscovite and amphibole. The dyke may be a deuterically altered porphyritic quartz dolerite.

TABLE 5 : LAMBOO COMPLEX - SUMMARY

ROCK UNIT	MAP SYMBOL	LITHOLOGY	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION OF EXPOSURES	STRATIGRAPHIC RELATIONSHIPS	REMARKS
"Late Dolerite Dykes"	dl	Ophitic, medium grained dolerite, uralitised dolerite, porphyritic quartz dolerite.	Straight, narrow, resistant bars.	Eastern part of Sheet Area.	Intrudes all rocks of Lamboo Complex in the eastern part of the area.	Trend of dykes varies from north-north-west to north-north-east.
Undifferentiated	Eb	An intimate mixture of granite and uralitised gabbro, and minor metamorphic rocks.	Isolated alluvium covered outcrops or boulder strewn hills.	Between Lilly Hole Bore and Me No Savvy Yard and between Hotair Well and Laura River.		
Mulkerrins Granite	Ebu	Massive coarse, even-grained leucocratic granite.	Sandy rises criss-crossed by resistant quartz dykes.	Along northern boundary of map area, north of Burramundi Waterhole.	Intrudes Lerida Granite.	Main exposures are in Lansdowne Sheet area.
Lerida Granite	Ebl	Porphyritic to even-grained grey-green biotite granite.	Low rounded hills.	Single small exposure near northern boundary of Sheet area, north-east of Burramundi Yard.	Intruded by Mulkerrins Granite.	Main exposures are in Lansdowne Sheet area.
Chaneys Granite	Eby	Massive grey coarse, even-grained biotite granite.	Isolated tor-strewn hills.	Along Leopold River and to the south of Mount Winifred.	Intrudes Halls Creek Group.	Chlorite-filled pits characteristic on weathered surface. May be related to Violet Valley Granite.
Long Hole Granite	Ebg	Coarse-grained porphyritic granite.	Low sandy rises.	Confined to area near foot of Burramundi Range.	Intrudes Halls Creek Group.	Pink and green feldspar phenocrysts characteristic. May be related to Bow River Granite.
Violet Valley Granite	Ebv	Coarse-medium grained, equigranular biotite granite and subordinate diorite.	Rough hills with large exfoliated boulder outcrops.	In the vicinity of the junction of Margaret and Louisa Rivers and along the base of the Mueller Range.	Intrudes Bow River Granite and Halls Creek Group.	
Sophie Downs Granite	Ebs	Equigranular, coarse to medium grained granite.	Rough hills with large boulder outcrops.	In the McClintock and Cummins Ranges.	Intrudes Halls Creek Group.	Intruded by pegmatites which are tin bearing and by aplite dykes.
Bow River Granite	Ebo	Coarse-grained porphyritic to equigranular granite and granodiorite; minor fine-grained granite forms chill margins.	Exfoliated whalebacks with large boulder outcrops or laterite covered mesas.	In the region between Mount Hawick and Gnewings Well; and westwards from Kuniandi Range to beyond Mount Fairbairn.	Intruded by Violet Valley Granite and intrudes Halls Creek Group.	North of Lamboo Homestead, large areas of coarse-grained equigranular leucocratic granite. Intruded by aplite and pegmatite dykes.
McIntosh Gabbro	Ebi	Coarse to medium-grained gabbro, uralitised gabbro sheared gabbro and minor diorite.	Rough hills with rounded boulders or black soil plains with rounded boulders.	In the region between Mount Fairbairn and Kuniandi Range; between Me No Savvy Yard and Mount Amherst Station; and west of Laura River.	Intruded by Bow River Granite and intrudes Halls Creek Group.	Rhythmic compositional banding is preserved in some areas.
	Ebd	Uralitised dolerite and ultrabasic rocks.	Low-lying "strike" ridges.	Mainly in south-eastern part of Sheet and to west of Kuniandi Range.	Intrude Olympio and Biscay Formations. Intruded by Bow River Granite.	Amphibolite and carbonitised dolerite developed near contacts with Bow River Granite.
Alice Downs Ultrabasics	Eba	Serpentinised ultrabasic rocks with subordinate chromite bands and asbestos veins.	Dark, closely spaced ridges.	Four miles north of Lamboo Homestead.	Intruded by Bow River Granite and intrudes Halls Creek Group.	Ultrabasics are co-magmatic with the McIntosh gabbro.
Tickalara Metamorphics	Aht	Paragneiss, subordinate calc-silicate rocks and amphibolites.	Isolated, alluvium covered outcrops.	In extreme north-east corner of Sheet.	Intruded by Bow River Granite and late dolerite dykes.	The metamorphics are thought to be high grade metamorphic derivatives of the Halls Creek Group.

MIDDLE PROTEROZOIC

WHITEWATER VOLCANICS

Distribution: The Whitewater Volcanics crop out in the extreme northern part of the Sheet area; they are exposed in two main localities - in an east-west zone to the north of Burramundi Yard; and, further east, around the Little Gold River.

Derivation of Name: The name was first used by Dow et al (1964).

Stratigraphic Relationships: The Whitewater Volcanics unconformably overlie rocks of the Olympio Formation of the Halls Creek Group and are unconformably overlain by rocks of the Speewah Group. They are intruded by the Watery River Porphyry.

Lithology and Thickness: The Volcanics consist entirely of quartz-feldspar porphyry. In hand specimen these rocks are grey, black or red, coarse-grained and porphyritic, and generally contain flow or compaction banding. South of the Watery River, at the unconformity with the Olympio Formation, massive volcanics contain numerous well rounded pebbles and cobbles of sandstone, greywacke and white quartz. Higher in the section the amount of rock fragments decreases and flow or compaction banding becomes evident; the banding is emphasised by alignment of small irregular lensoid rock fragments and quartz and feldspar crystals.

In thin section the rocks contain euhedral to anhedral, embayed and marginally resorbed quartz phenocrysts; sericitised euhedral feldspar phenocrysts (probably plagioclase); irregular chloritic patches (altered ferromagnesian minerals); and small angular, ragged and embayed fragments of granite, altered dolerite, greywacke and quartz feldspar porphyry, set in a chlorite and mica-rich siliceous groundmass. Accessories include zircon and euhedral or dendritic magnetite and ilmenite.

The mineralogical composition and primary structures in the quartz-feldspar-porphyry suggests that the rocks are deuterically altered dacitic lavas.

In the westernmost exposures of the unit the Volcanics are strongly sheared.

The thickness of the unit is not known.

Distinguishing Features: The Whitewater Volcanics are readily recognised, for they are the only acid volcanics in the Middle Proterozoic sequence.

WATERY RIVER PORPHYRY

Distribution: The Watery River Porphyry crops out in the north-central part of the Sheet area, and extends into the adjoining Lansdowne Sheet area.

Derivation of Name: The name is defined by Gellatly, Derrick and Plumb (in prep.).

Stratigraphic Relationships: The Watery River Porphyry intrudes the Whitewater Volcanics (D. Gellatly, pers. comm.).

Lithology: The Watery River Porphyry consists of an orthopyroxene-quartz-feldspar porphyry.

In hand specimen the rocks are massive grey or black, medium to coarse-grained, porphyritic and generally contain angular fragments of granitic and sedimentary rocks up to 1" across. In some areas the abundance of rock fragments increases and the rock resembles a breccia.

In thin section unaltered porphyry contains euhedral to anhedral, fractured and marginally resorbed orthopyroxene phenocrysts, euhedral to anhedral, embayed clear quartz phenocrysts, euhedral sericitised and oscillatory zoned plagioclase (andesine) phenocrysts, and laths of red-brown biotite, set in a fine-grained quartz mosaic which contains irregular tiny muscovite and biotite laths. Accessories include anhedral zircon, euhedral to anhedral ilmenite and magnetite. Most of the orthopyroxene phenocrysts are replaced at their margins by tiny biotite flakes, and in some cases these form coronas. The secondary alteration of these rocks varies; in some cases all the orthopyroxene has been replaced by biotite-chlorite rich aggregates and the feldspars are completely sericitised.

SPEEWAH GROUP

Distribution: Rocks of the Speewah Group crop out throughout the East Kimberley district from Wyndham in the north-east to the Lansdowne Sheet area in the south, and extend into the King Leopold Ranges, in the north-western part of the Mount Ramsay Sheet area.

Derivation of Name: The term Speewah Group was first used by Dow et al (1964) to apply to a succession in the East Kimberley district; its meaning has subsequently been modified by Gellatly Derrick and Plumb (in prep.).

Components: Gellatly et al (in prep.) recognise five rock units in the Speewah Group; these are, in ascending order:-

Luman Siltstone
Lansdowne Arkose
Valentine Siltstone
Tunganary Formation
O'Donnell Formation

Stratigraphic Relationships: The five rock units of the Speewah Group are in conformable sequence. The Group is generally overlain conformably by the King Leopold Sandstone, but in the southern part of the King Leopold Range an unconformity is present at the top of the succession. The Group lies unconformably on rocks of the Halls Creek Group, Lamboo Complex and Whitewater Volcanics.

Lithology and Thickness: The maximum thickness of the Group - 5500 to 6000 feet - occurs in the area between Mount Winifred and McKinnon Creek. The Group consists essentially of arenites and lutites and is commonly intruded by dolerite sills. The lithology will be discussed under the various formation headings; a summary of the stratigraphy of the Group is given in Table 6.

O'DONNELL FORMATION

Distribution: The O'Donnell Formation crops out as a narrow rim to the western and southern edges of the King Leopold Range, from Mount Winifred in the north to Mount Huxley in the south, and eastward from here to beyond Palm Spring.

Derivation of Name: The name was first used by Dow et al (1964) in the Lissadell Sheet area, north-east of the present Sheet area.

Stratigraphic Relationships: At the northern end of the King Leopold Range the Formation lies unconformably on either Whitewater Volcanics or Olympio Formation. Elsewhere in the

Sheet area it lies unconformably on undifferentiated Halls Creek Group rocks and crystalline rocks of the Lamboo Complex. It is followed conformably by the Tünganary Formation, except in its southernmost exposures, where it is unconformably overlain by the King Leopold Sandstone.

Lithology and Thickness: The following section was measured 14 miles east-north-east of Mount Winifred.

450'	Brown siltstone and shale with interbedded medium-grained quartz sandstone.
2300'	Medium-grained dolerite sill (Hart Dolerite)
200'	Blocky, thick bedded siliceous or clayey medium-grained quartz sandstone.

The lower part of the O'Donnell Formation includes medium to coarse-grained, well sorted quartz sandstone, with rounded to subrounded quartz, quartzite, and minor chert grains in a siliceous or silty cement. Very coarse sandstone and granule conglomerate are present and occur throughout these beds.

The upper part of the formation consists of olive and fawn ripple-marked fine-grained sandstone and siltstone, which grade into olive and fawn coloured shale, silty shale and micaceous silty shale. Near the top, they pass into maroon weathering shale, which is interbedded with thin beds of medium-grained quartz sandstone and feldspathic sandstone.

West of Mount Philip, the basal unit is very thin, consisting of about five feet of arkose, and is followed by 300 feet of soft greenish-grey banded shale and silty shale with occasional two-inch bands of white quartz sandstone. Further to the south-east, about five miles west of Me No Savvy Yard a 30-foot bed of ill-sorted conglomerate with cobbles, pebbles and granules of quartz in a feldspathic sandstone matrix, overlies granite of the Lamboo Complex. This is followed by about 80 feet of greenish-grey banded shale, which is in turn overlain by King Leopold Sandstone. This section is probably equivalent to that west of Mount Philip, but could conceivably represent the upper part of the Lansdowne Formation and the lower part of the Luman Siltstone.

Palaeogeographic Significance: The well-sorted, quartz sandstone of the O'Donnell Formation probably represents a mature beach sediment which was deposited in the early stages of development of the Kimberley Basin. The coarser, more feldspathic sediments of the southern outcrops could indicate local movement at this stage, probably due to the nearby faulting. The silty shales which followed indicate that sedimentation with rapid burial followed this early episode; these conditions were to continue throughout most of the deposition of the Speewah Group.

TUNGANARY FORMATION

Distribution: The Tunganary Formation occurs in the King Leopold Range to the north of Macdonald Gorge.

Derivation of Name: From the type area on Lansdowne Sheet area (Gellatly, Derrick and Plumb, in prep.).

Stratigraphic Relationship: The formation conformably follows the O'Donnell Formation, and is overlain conformably by the Valentine Siltstone.

Lithology and Thickness: The following section is present about 14 miles east-north-east of Mount Winifred. Thicknesses are estimated from air photographs.

500'	White to red, poorly sorted, very coarse-grained, medium bedded to laminated, siliceous or ferruginous sandstone. Hematite grains and clots present throughout.
1400'	White, coarse-grained, thick bedded, current bedded, poorly sorted, micaceous feldspathic sandstone with interbedded red micaceous shale and siltstone bands and thin beds of white flaggy quartz sandstone. Hematite flakes present.
700'	Pink, medium bedded to laminated, well sorted, siliceous feldspathic sandstone with interbedded shale and siltstone towards top. Micaceous sandstone is developed near the base.
1300'	Coarse dolerite (Hart Dolerite).
520'	Purple to red, poorly sorted, ferruginous, coarse-grained, feldspathic sandstone with interbedded purple flaggy medium-grained greywacke.
80'	Red coarse-grained siliceous or ferruginous sandstone containing specular hematite. Occasional pebbly beds.
340'	Red, poorly sorted clayey or siliceous quartz sandstone with pebbles. Purple feldspathic greywacke near top.

The Tunganary Formation includes poorly sorted coarse feldspathic sandstone near the base, interbedded with laminated to thin bedded fine-grained feldspathic sandstone and arkose. These rocks are commonly well sorted, with angular to subangular quartz and highly altered feldspar grains in a matrix of sericite and clay minerals. On freshly broken surfaces, the rock has a characteristic powdery white or grey appearance. In the section south of Mount Winifred, coarse quartz sandstone beds (containing slump structures) are present within the feldspathic sediments. In the section west of Mount Winifred, coarse quartz sandstone beds, about 20 feet thick, are present among the feldspathic sediments, slumps and load casts are also seen.

Palaeogeographic Significance: The feldspathic and often poorly sorted nature of these sediments, together with the rapid alternation of shale and sandstone, suggest that subsidence and rapid burial were still the dominant features of the Kimberley Basin. The presence of occasional well rounded, well sorted quartz sandstones may represent temporary periods of still-stand in this process. Slump beds could be due to shocks caused by local fault movements.

VALENTINE SILTSTONE

Distribution: The Valentine Siltstone crops out in the King Leopold Range, north of Macdonald Gorge.

Derivation of Name: The name was first used by Dow et al (1964) for a thin succession of shale, siltstone and tuff developed in the Lissadell Sheet area.

Stratigraphic Relationships: The unit lies conformably between the Tunganary Formation and the Lansdowne Arkose.

Lithology and Thickness: The Valentine Siltstone is poorly exposed, but consists of thin bedded olive and fawn silty shale and fine-grained sandstone. The unit can be readily recognised on air photographs where it is seen as a narrow zone of low ground beneath the more resistant Lansdowne Formation. No trace of volcanic ash or tuff has been seen in these rocks on the Mount Ramsay Sheet, but these are well known from the East Kimberleys (Dow et al 1964).

A typical thin section of the silty shale consists of angular grains of quartz, rare feldspar with interstitial blades of white mica in an abundant sericitic matrix.

Zircon and green tourmaline are the only accessory minerals. The rock is strongly laminated and ferruginised. Because of its poor exposure, the thickness of the unit is not properly known, but is estimated from air photographs to be about 200 feet throughout its outcrop.

Palaeogeographic Significance: The abundant matrix of the silty member suggests that these rocks were probably deposited and rapidly buried, or else were deposited below the level of wave action.

LANSDOWNE ARKOSE

Distribution: The Lansdowne Arkose occurs only in the King Leopold Range, north and east of Macdonald Gorge.

Stratigraphic Relationships: The unit lies conformably between the Valentine Siltstone and Luman Siltstone.

Lithology and Thickness: The Lansdowne Arkose consists mainly of medium and coarse-grained feldspathic sandstone and arkose, which locally grade into feldspathic granule, pebble, and cobble conglomerates; these consist of pebbles of quartz and quartz sandstone in a feldspathic sandstone matrix and often grades upwards into coarse sandstone. The conglomerate horizons vary in thickness along strike and are most common near the top of the succession. Typical thin sections of the feldspathic sandstones consist of large subrounded to subangular grains of quartz and strongly saussuritised feldspar, (up to 1 mm) in a sericitic matrix. Banding and lamination of coarse and fine material (0.1 - 0.2 mm) is well developed.

In the area 14 miles east-north-east of Mount Winifred, an estimated 1100 feet of white, coarse-grained clay-cemented quartz sandstone is present, which is pebbly near the top and more feldspathic and clayey near the base. A similar thickness can be seen eight miles south-east of Mount Winifred.

Palaeogeographic Significance: The pebbly and conglomeratic nature of the formation suggests that it waslaid down closer to shore than the preceding Valentine Siltstone. The presence of feldspar again suggests rapid burial.

LUMAN SILTSTONE

Distribution: The Luman Siltstone occurs only in the King Leopold Range. The southernmost outcrops are near Mount Ball and extend northwards to Mount Winifred, and east from there towards McKinnon Creek.

<u>Stratigraphic Relationships:</u> The unit lies conformably upon the Lansdowne Arkose and is overlain conformably by the King Leopold Sandstone.

<u>Lithology and Thickness:</u> The Luman Siltstone consists of laminated siltstone and shale, which are usually fawn weathering, maroon and ferruginised in outcrop. Typical thin sections consist of fine angular grains of quartz and feldspar in a highly ferruginised fine-grained matrix. Fourteen miles east-north-east of Mount Winifred the thickness is estimated to be 200 feet, and a similar thickness is present ten miles north-east of Macdonald Gorge. At Mount Ball, however, the base of the unit is intruded by the Hart Dolerite, which is here transgressive, and the shale section is cut out beneath the King Leopold Sandstone (see fig.9). The lower part of the Luman Siltstone cannot be traced, either below, or within, the dolerite.

<u>Palaeogeographic Significance:</u> Lithologically, the Luman Siltstone is similar to the Valentine Siltstone, and this probably indicates a return to deeper water sedimentation or conditions of rapid burial.

TABLE 6 : SUMMARY OF STRATIGRAPHY - SPEEWAH GROUP

ROCK UNIT	MAP SYMBOL	LITHOLOGY	THICKNESS IN FEET	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION	STRATIGRAPHIC RELATIONSHIPS	REMARKS
Luman Siltstone	Bpl	Red and maroon weathering fissile silty shale	200	Poorly resistant, forms valley and steep slope.	King Leopold Range, north and north-east of Mount Ball.	Conformably overlain by King Leopold Sandstone.	
Lansdowne Arkose	Bpo	Fine to medium-grained and coarse-grained arkose and feldspathic sandstone. Some conglomerate horizons near top. Interbedded thin silty shale and sandstone beds. Current bedding common.	1100	Resistant; forms strong strike ridges.	King Leopold Range, north and north-east of Mount Ball.	Conformably overlain by Luman Siltstone.	Well exposed. Significant development of conglomerate horizons.
Valentine Siltstone	Bpv	Grey to brown fissile shale and siltstone.	100	Poorly resistant; forms valley.	King Leopold Range, north and north-east of Mount Ball.	Conformably overlain by Lansdowne Arkose.	Usually poorly exposed.
Tunganary Formation	Bpt	Medium to coarse-grained feldspathic sandstone, interbedded with thin shale and siltstone horizons. Current bedding common in arenites.	3540	Moderately resistant; forms strike ridges.	King Leopold Range and western Mueller Range.	Conformably overlain by Valentine Siltstone.	Finer grained rocks are commonly blue-grey in outcrop.
O'Donnel Formation	Bpn	Maroon-weathering olive and brown shale siltstone and silty shale in upper part, medium to coarse-grained siliceous quartz sandstone at base.	650	Resistant at base where strong ridge forms; moderately to poorly resistant higher in column - rounded hills develop.	King Leopold Range and western Mueller Range.	Conformably overlain by Tunganary Formation. Unconformably overlies Whitewater Volcanics and older rocks.	Basal arenite is a good "marker" bed.

KIMBERLEY GROUP

Distribution: Rocks of the Kimberley Group occur throughout the Kimberley Division, and extend from north of Wyndham in the east to the north and north-west coast of Western Australia and as far south as the King Leopold and Mueller Ranges. On the Mount Ramsay Sheet area the Group occupies a large triangular area in the north-central part of the Sheet, from Mount Winifred in the north-west, through Mount Huxley in the south-west to beyond One Tree Palm Gorge in the north-east.

Derivation of Name: The Kimberley Group was defined by Dow et al (1964) following mapping in the East Kimberley District.

Components: In the Mount Ramsay Sheet area, the succession is:-

Pentecost Sandstone (includes Mount Amherst Member)
Elgee Siltstone (includes Teronis Member)
Wooton Sandstone
Carson Volcanics
King Leopold Sandstone

The units are in conformable sequence.

Stratigraphic Relationships: The Kimberley Group generally lies with apparent conformity on the Speewah Group, but in the southern part of the King Leopold Range there is a strong unconformity between the two. In the Mueller Range the Group lies unconformably on the Archaean Lamboo Complex. The Group is overlain conformably by the Crowhurst Group where this is present, or unconformably by the Kuniandi or Louisa Downs Groups, but over most of its outcrop no overlying strata are preserved.

Lithology and Thickness: The Kimberley Group is a conformable sequence of quartz sandstone, shale and siltstone and minor dolomites, with a thick sequence of basic volcanics near the base. The maximum observed thickness of over 7000 feet, was measured east of Mount Winifred, but it is generally thinner than this in the south. Near Me No Savvy Yard an estimated 6000 feet is exposed. These rocks were deposited under shallow-water or shelf conditions in the gently subsiding Kimberley Basin.

The stratigraphy of the Group is summarised in Table 7. The component formations are discussed below.

KING LEOPOLD SANDSTONE

Distribution: The King Leopold Sandstone is exposed in the King Leopold and Mueller Ranges.

Derivation of Name: The Formation was defined by Dow et al (1964) from the Lissadell 1:250,000 Sheet area.

Stratigraphic Relationships: The Formation is overlain conformably by the Carson Volcanics and in most localities lies conformably on the Luman Siltstone. . In the southern part of the King Leopold Range, the formation is unconformable on the Speewah Group, while in the Mueller Range it lies unconformably on rocks of the Lamboo Complex.

Lithology and Thickness: Over most of its area on the Mount Ramsay Sheet area the formation consists of white, blocky to massive, thick-bedded medium to coarse-grained, siliceous quartz sandstone. It is commonly current bedded, and pebble bands and ripple marks are frequently seen. In thin section, the sandstone consists of subangular to rounded grains of strained quartz, occasional chert, and very rare feldspar. The grain boundaries are difficult to detect, due to secondary silica overgrowth, and almost all the interstices are filled with quartz, with a little sericite. Well rounded zircon and tourmaline are the usual accessory minerals.

The King Leopold Sandstone is very variable in thickness. North of Mount Amherst Station, the unit is not developed; near Me No Savvy Yard about 200 feet is intruded by Hart Dolerite, while 600 feet is the estimated thickness near Blackfellow Creek in the north-eastern part of the Sheet area. In the western sections the top of the formation is usually eroded, but 200 feet is exposed in cliff sections near Mount Ball and Mount Huxley (see fig.9) further to the north, in an area fourteen miles east-north-east of Mount Winifred, about 2100 feet is exposed in the section described below.

OVERLAIN BY CARSON VOLCANICS

1700'	Pink to white blocky, thick bedded well sorted medium-grained siliceous quartz sandstone with subordinate feldspathic sandstone.
200'	Scree, possibly overlying shale.
200'	White, blocky to flaggy coarse-grained siliceous quartz sandstone, grading towards the top into purple, flaggy, poorly sorted medium-grained feld-spathic sandstone. Quartz pebbles are common throughout the section.

UNDERLAIN BY LUMAN SILTSTONE

All thicknesses are calculated from air photographs. This section is comparable with those developed on the adjacent Lansdowne Sheet, which are estimated to be 3000 feet thick.

Distinguishing Features: The King Leopold Sandstone forms strong, steep-sided ridges or scarp-and-dip features, depending on the magnitude of the dip, and on air photos can be recognised by its white tone and longitudinally ridged and cross jointed pattern. In the field it is distinguished from the Speewah Group by its general lack of feldspar, and its stratigraphic position.

Palaeogeographic Significance: The King Leopold Sandstone is the first thick, extensive quartz sandstone formation of the Kimberley Basin, and clearly represents a change in conditions from those which existed during the deposition of the Speewah Group. It seems likely that subsidence took place more slowly during the deposition of the Kimberley Group, and as a result quartz sandstone was developed rather than the more feldspathic varieties of the Speewah Group.

CARSON VOLCANICS

Distribution: The Carson Volcanics are exposed in a more or less continuous belt in the King Leopold and Mueller Ranges and along the north-western margin of the Mount Cummings Plateau near the Leopold River. A small faulted outlier is present near Moola Bulla Homestead and the unit is also exposed in the core of a faulted anticline to the north of Mount Amherst.

Derivation of Name: The Carson Volcanics were first defined by Dow et al (1964) who modified the term Mornington Volcanics of Guppy et al (1958) and Harms (1959).

Stratigraphic Relationships: The Volcanics lie conformably between the underlying King Leopold Sandstone and the overlying Warton Sandstone. In the central part of the Sheet area, in the Mueller Range, the King Leopold Sandstone is absent from the succession and the Carson Volcanics rest directly (with unconformity) on rocks of the Lamboo Complex.

Lithology and Thickness: The formation consists of greenish, dark coloured saussuritised fine-grained to coarse-grained quartz dolerite or basalt, which are sometimes amygdaloidal, interbedded with thin beds of pink to mauve, current bedded feldspathic sandstone. The sandstone beds are often impersistent along strike. The topmost part of the succession consists of about 40 feet of highly micaceous fissile siltstone, interbedded with basalt, but this is rarely exposed.

In typical thin sections, the basalt consists of laths of altered plagioclase with interstitial subhedral to anhedral pideonite grains. The pigeonite is largely altered to chlorite, and sometimes shows exsolution lamellae. Magnetite is the only notable accessory mineral.

In other thin sections (e.g. 6.33.10) the basalts consist of numerous partially replaced olivine phenocrysts set in a matrix made up almost wholly of an amphibole with rare epidote (clinozoisite) and opaque minerals. The amphibole is of an indeterminate character although yellow cores of balsatic hornblende or amphibolite are found throughout the rock. The surrounding material is practically all colourless or with a very pale yellowish green pleochroism. This may be ?tremolite-actinolite but has not been confirmed with certainty. Epidote and clinozoisite are developed in minor amounts throughout the rock. A colourless low birefrigent mica thought to be ?margarite is also present. Numerous opaque mineral grains are found.

The sandstones are fine to medium-grained, angular, siliceous and felspathic. Quartz grains are angular to subangular, but some rounded grains with quartz overgrowths are also present. Feldspar grains are mostly plagioclase (though microcline is also present) and are usually fresh. Occasional grains of chert, ferruginised basalt and rare biotite and granophyric material also occur.

Accessory apatite and tourmaline grains are randomly distributed throughout the rock. Accessory muscovite also occurs in isolated laths elongated parallel to the former bedding planes.

The thickness is estimated from air photographs to be 1200 feet in the section north of Me No Savvy Yard; 2000 feet four miles south of Mount Amherst, and about 1400 feet ten miles east of Mount Philip.

Distinguishing Features: The Carson Volcanics generally occupy low ground between ridges and escarpments of King Leopold Sandstone and Warton Sandstone (fig.7).

Figure 7: View north-east along Mueller Range showing McIntosh Gabbro - right foreground overlain by Carson Volcanics, Warton Sandstone - shadowed scarp, Elgee Siltstone and Pentecost Sandstone - left background. Mount Amherst is on the sky-line.

The unit is readily recognised on air photographs by its dark photo-pattern with parallel narrow, light coloured bands which represent the intercalated sandstone beds

Palaeogeographic Significance: The Carson Volcanics are typical flood basalts, and the occurrence of several amygdaloidal phases, and intercalated sandstones show that there are at least several separate flows in the section. They are the product of a widespread volcanic episode which resulted in the accumulation of tholeitic basalts throughout the entire Kimberley Basin.

WARTON SANDSTONE

Distribution: The Warton Sandstone crops out in the King Leopold and Mueller Ranges, along the north-western margin of the Mount Cummings Plateau, and in a faulted outlier near Moola Bulla Homestead. It also occurs in the core of a faulted anticline north of Mount Amherst.

Derivation of Name: The name Warton Sandstone is derived from the 'Warton Beds' of Harms (1959), and was first used by Dow et al (1964).

Stratigraphic Relationships: The formation lies conformably between the Carson Volcanics and Elgee Siltstone.

Lithology and Thickness: In the Mount Ramsay Sheet area the Warton Sandstone consists of massive to blocky, thin bedded, white, off-white or mauve, fine to medium-grained, siliceous quartz sandstone. Interbedded siltstone and flaggy sandstone characterise the top and bottom of the unit. Current bedding is common. In the field, the rock forms a tough, silicified skin on weathering, and outcrops are generally orange brown.

Thin sections show rounded grains of quartz, with rare chert fragments in a siliceous matrix. The quartz grains have silica overgrowths, so the rock appears as an interlocking quartz mosaic. Minor interstitial sericite is also present.

The formation is estimated from air photographs to be 1200 feet thick in the Margaret River area, north of Me No Savvy Yard. Four miles south of Mount Amherst about 1000 feet is present and near the northern margin of the Sheet area, 14 miles east-north-east of Mount Winifred an estimated 1200 feet is present.

Distinguishing Features: The Warton Sandstone forms bold strike ridges or scarp-and-dip features (fig.7) but can be recognised on the air photographs only by its stratigraphic position. The top is marked by a change from arenites to lutites.

Palaeogeographic Significance: The Warton Sandstone represents a return to quartz-sandstone facies following the vulcanism of the Carson Volcanics. In general, the formation is much more fine-grained than the King Leopold Sandstone, but conditions of deposition must have been very similar for both these units.

ELGEE SILTSTONE

Distribution: The Elgee Siltstone crops out in a more or less continuous belt through the King Leopold and Mueller Ranges and along the north-west margin of the Mount Cummings Plateau. This belt is modified by faulting in the King Leopold Range. It also occurs in a faulted outlier near Moola Bulla Station, and in the core of a faulted anticline north of Mount Amherst. A minor exposure is in the core of the Mount Cummings anticline, about eight miles north-northwest of The Goat Paddock.

Derivation of Name: Harms (1959) used the term Elgee Shale for the unit under discussion, but this was changed to Elgee Siltstone by Dow et al (1964).

Stratigraphic Relationships: The Elgee Siltstone lies conformably between the Warton Sandstone and the Pentecost Sandstone.

Lithology and Thickness: The Elgee Siltstone consists largely of maroon shale and siltstone with interbedded thin sandstone bands. A dolomitic phase is represented by the Teronis Member, which occurs near the base of the formation. The following succession was measured through the upper part of the Siltstone (i.e. excluding the Teronis Member) in the Margaret River three miles north of Me No Savvy Yard. A more detailed description is given in Appendix I, (p.).

OVERLAIN BY PENTECOST SANDSTONE

190' Purple, finely laminated shale and silty shale, with occasional minor beds of flaggy, laminated, medium to fine-grained quartz sandstone near base, and occasional green coloured bands in shale near top.

790' Maroon thinly flaggy to fissile laminated siltstone, interbedded with thinly flaggy, laminated pale green shale and silty shale horizons. Bedding planes are irregular in the siltstones. Some cream to white, flaggy to blocky, laminated fine-grained quartz sandstones near base, becoming less frequent towards top. Thin dolomite bands and dolomitic siltstones with slump rolls and ripple marks occur in the siltstones near base.

In this locality the Teronis Member is 180 feet thick, making the Siltstone 1160 feet thick. This thickness is maintained to the east and similar thicknesses have been estimated from the air photographs near Mount Amherst and near One Tree Palm Gorge.

To the west at a locality about five miles west of Mount Philip only about 900 feet are present and near the northern margin of the Sheet area, some 14 miles east-north-east of Mount Winifred, the unit is only about 600 feet thick.

In thin section, the rocks are typically quartzose shale which consist of very finely comminuted angular quartz grains set in a matrix of white mica, chlorite and carbonate.

Bedding is well defined, and graded bedding is common. The red colour is due to an abundant scarlet iron ore, probably limonite, which occurs throughout the sections. The sandstone interbeds are usually fine-grained, angular, laminated, feldspathic sandstones with siliceous cement.

Distinguishing Features: The Elgee Siltstone generally occupies low ground between the strong ridges of the Warton and Pentecost Sandstone, and with its dark maroon colour in outcrop, and dark photo-pattern, this formation is readily recognizable on the air photographs. Its top is marked by the disappearance of siltstone and the development of dominantly quartz sandstone (fig. 8) (see Teronis Member).

Figure 8: Gently folded Elgee Siltstone overlain by Pentecost Sandstone. Note the thin sandstone horizons at intervals in the shale succession. Margaret River, four miles north of Me No Savvy Yard.

Palaeogeographic Significance: The Elgee Siltstone probably represents a deeper-water phase in the development of the Kimberley Basin. Graded bedding and the general lack of current bedding suggests that little reworking took place after sedimentation. The widespread occurrence of limonite, which gives the typical maroon colour to the unit is unique in the Kimberley Group; this could be due to deposition in deeper water, with precipitation of the iron, or to a change in climate in the source area, which seems more likely.

Teronis Member

Distribution: The Teronis Member crops out in the King Leopold and Mueller Ranges and in isolated exposures in the Moola Bulla area.

Derivation of Name: The name has been derived from the Teronis Gorge in the Lansdowne Sheet area. The unit was defined by Gellatly, Derrick and Plumb (in prep.).

Stratigraphic Relationships: The Member forms the basal part of the Elgee Siltstone. It rests conformably on the Warton Sandstone.

Lithology and Thickness: The Teronis Member consists essentially of interbedded dolomite, sandy and in places oolitic dolomite, maroon shale, micaceous siltstone and quartz sandstone. Some beds of dolomite contain abundant stromatolites. The dolomitic strata tend to be concentrated in the upper part of the member where they may form resistant strike ridges.

The following succession was measured through the Teronis Member in an area about three miles north of Me No Savvy Yard:-

OVERLAIN BY REMAINDER OF ELGEE SILTSTONE

35'	Fine-grained white or grey ripple marked micaceous quartz sandstone with occasional grey or fawn weathering sandy ferruginised dolomite beds.
65'	Interbedded olive-weathering cream, blocky fine-grained dolomite with stromatoliths and flaggy, medium to fine-grained grey silicified quartz sandstones. Coarse current bedded dolomitic sandstones are commonly developed between stromatolitic horizons.
80'	Interbedded maroon laminated quartzose shale with graded bedding sometimes with occasional green bands and flaggy, thin bedded fine-grained fawn quartz sandstone. Sandstones occur at irregular intervals, but are more common near base of section.
180'	

UNDERLAIN BY WARTON SANDSTONE

About 8 miles to the east, in an area about 3 miles west-north-west of Mount George, dolomitic rocks are of greater importance; a section measured through the Member in this locality contains the following strata:-

OVERLAIN BY UPPER PART OF ELGEE SILTSTONE

60' Brown weathering dolomite, pink to purple when fresh. Thick bedded grading to coarsely flaggy towards top. Vague oolitic structures.

22' Sandy dolomite. Pink to purple when fresh. Weathers cream. Thinly flaggy, markedly cross bedded.

90' Upper part sandy dolomite, pink to purple when fresh and alternating purple to purple-red dolomitic siltstone. Thinly flaggy, cross bedded near top. Middle part consists of dolomitic sandstone and sandy dolomite; pink to purple when fresh. Thinly flaggy regularly bedded. Lower part purple brown very fine-grained quartz sandstone. Slightly micaceous and probably dolomitic. Thinly flaggy.

30' Mostly rubble or platy to flaggy micaceous fine-grained sandstone alternating with pink dolomite beds 2 feet to 3 feet thick.

13' Fine-grained laminated micaceous quartz sandstone. Colour reddish-brown.

25' Coarsely flaggy dolomite, weathers dark brown, reddish purple when fresh. Slightly brecciated in places, some beds silicified. Capped by domed stromatolite colonies up to 3 feet across.

240'

UNDERLAIN BY WARTON SANDSTONE

Near Thursday Creek, further to the east, in the eastern part of the Mueller Range the same general sequence prevails, but the thickness of the unit is 460 feet.

In thin section some of the sandy beds of the Teronis Member contain angular grains of microcline and plagioclase.

The stromatolites of the Member appear to be only of one type. They are formed of closely packed discrete vertical cylinders ranging in diameter from $\frac{1}{4}$" to $\frac{1}{2}$", traversed by fine, gently domed convex-upwards laminae. Each cylinder is bounded by a wall up to 1/16" thick. In gross form the colonies form continuous beds up to 12" thick, while in the easternmost outcrops tend to occur as domes up to 3 feet across, but these are not always apparent. In thin section fine grains of quartz and feldspar accentuate the laminae.

Distinguishing Features: The Teronis Member is usually poorly exposed, but some beds, particularly the dolomitic strata near the top crop out reasonably well and provide a means of delineating the upper boundary of the unit on the air photographs. The base of the unit is taken at the disappearance of blocky arenites, the top is taken at the change from essentially sandy or dolomitic strata to maroon shale or siltstone.

Palaeogeographic Significance: The Teronis Member represents a temporary shallowing of the basin of deposition of the Elgee Siltstone, which was accompanied by the formation of calcareous or dolomitic sediments. The stromatolitic and current bedded dolomites were probably deposited in the intertidal zone. Normal shale and siltstone forming conditions were re-established after the Teronis Member was deposited and the transition is marked by the occurrence of slump rolls and ripple marks, which suggest an unstable environment at this time. The top of the unit grades into the Elgee Siltstone.

PENTECOST SANDSTONE

Distribution: The Pentecost Sandstone occupies most of the north-central portion of the Mount Ramsay Sheet area, and includes the Mount Cummings Plateau and the King Leopold and Mueller Ranges. There is also a small outcrop in the faulted outlier near Moola Bulla Homestead.

Derivation of Name: The name was first used by Harms (1959) who subdivided the Warton Beds of Guppy et al (1950). The name is derived from the Pentecost Ranges of the Cambridge Gulf 1:250,000 Sheet of the East Kimberley Division.

Stratigraphic Relationships: The unit lies conformably between the Elgee Siltstone and the Hilfordy Formation of the overlying Crowhurst Group, but in most areas the top of the formation is eroded. The upper part of the Pentecost Sandstone has been mapped as the Mount Amherst Member.

Lithology and Thickness: The Pentecost Sandstone consists of a thick series of coarse to medium-grained thinly bedded to laminated quartz sandstone beds, which are generally massive to blocky in outcrop, interbedded with thin sequences of purplish fine-grained sandstone, shale and siltstone. Ripple marks are abundant, and current bedding is a common feature. Glauconite has been recorded from shaley members on the Lissadell Sheet (Dow et al 1964) but has not been encountered in the present area.

A section measured through the Pentecost Sandstone in the headwaters of Dead Horse Creek, about 10 miles north-west of Mount Amherst Homestead contained the following succession.

OVERLAIN BY MOUNT AMHERST MEMBER

260'	Rubble only: purple flaggy fine-grained, slightly ferruginous quartz sandstone. Clay pellets, mud cracks and occasional load casts present. Probably interbedded with purple siltstone and shale.
75'	Purple and, near top, yellow weathering purple flaggy and blocky, moderately well sorted quartz sandstone. Silica matrix in some beds; in others little or no matrix. Iron oxide dust gives purple coloration.
65'	Poorly exposed: purple flaggy fine-grained quartz sandstone containing abundant clay pellets. Probably interbedded with purple siltstone.
25'	Red-brown weathering, white massive and flaggy, well laminated fine-grained quartz sandstone with a silica matrix. Well sorted, cross bedded.
25'	White, friable fine-grained quartz sandstone.
70'	Red-brown weathering, white massive and flaggy, well laminated, fine-grained quartz sandstone with a silica matrix. Well sorted, cross bedded.
150'	Very poor outcrop: probably essentially purple silty sequence.
30'	Yellow surfaced, white, friable, massive to blocky, thick bedded fine-grained quartz sandstone with a clayey matrix.
110'	Orange surfaced, white, blocky to thinly flaggy fine-grained quartz sandstone with thin silty sandstone partings. Silica matrix. Ripple marked, cross bedded.
125'	Dark purple, pink-purple, white and greenish fine-grained sandstone (mainly quartz sandstone with iron oxide dust in the matrix). The purple sandstone is usually micaceous, sometimes siliceous and sometimes friable. Clay pellets are common. Frequent white leached silty sandstone partings occur, but form only a very minor part of the sequence. The beds are capped by a 6 feet thick bed of massive coarse-grained, poorly sorted quartz sandstone containing purple clay and silt pellets and granules.

70' Purple or orange surfaced white and purple blocky thick to thin fine-grained quartz sandstone with a silica or silica-iron oxide matrix.

300' Poorly exposed: white to purple flaggy to blocky coarse-grained quartz sandstone containing abundant purple clay pellets. Friable. Has a fine-grained sand matrix. Ripple marks seen near base.

150' Orange surfaced, white, blocky and massive, friable and silicified, fine and medium-grained quartz sandstone. The fine-grained sandstone has a silica cement, but the medium-grained sandstone tends to have little or no cement. Occasional cross beds.

90' Orange surfaced, white thin bedded, fine-grained, well sorted quartz sandstone with a minor silica matrix. Blocky in lowermost 5 feet, then becomes flaggy and friable.

1645'

UNDERLAIN BY ELGEE SILTSTONE

In this area the overlying Mount Amherst Member is probably about 500 feet thick, so the total thickness of the Pentecost Sandstone is about 2150 feet.

Little lateral lithological variation has been detected in the Pentecost Sandstone (excluding the Mount Amherst Member) in the Mount Ramsay Sheet area.

The Pentecost Sandstone is estimated from air photographs to be 2900 feet thick along Liga Creek and about 2500 feet thick 14 miles east-north-east of the Goat Paddock. Dow et al (1964) give a measured thickness of 3625 feet to the north-east of the present area.

<u>Distinguishing Features:</u> The Pentecost Sandstone is readily recognizable on the air photographs by its broadly banded photo pattern and its overall high degree of resistance to erosion.

The base of the unit is taken at a point in the succession where arenites become the dominant lithology. The top is gradational (see Mount Amherst Member).

Palaeogeographic Significance: The Pentecost Sandstone appears to be the product of deposition on a broad continental shelf - although shallow-water structures are abundant in the finer grained rocks, the arenites are in general lacking in these structures. The more fine-grained rocks may be coastal, lagoonal deposits, while the arenites may be neritic deposits. The deposition of the Pentecost Sandstone probably accompanied a general shallowing of the Kimberley Basin.

Mount Amherst Member

Distribution: The Mount Amherst Member is exposed widely in the Mount Cummings Plateau. It has not been recognized outside the Mount Ramsay Sheet area.

Reference Area: 6.7 miles north 10° east of the confluence of the Margaret and O'Donnell Rivers, to the west of Liga Creek.

Derivation of Name: The name is derived from Mount Amherst, the highest known point in the Mount Ramsay Sheet area.

Stratigraphic Relationships: The Mount Amherst Member is the uppermost part of the Pentecost Sandstone. The Member is conformably overlain by the Hilfordy Formation of the Crowhurst Group.

Lithology and Thickness: The unit consists almost exclusively of white massive and blocky, cross bedded, friable to silicified coarse-grained poorly sorted quartz sandstone. The sandstone is pebbly and cobbly in places, particularly in the eastern part of the area. Pebbles of red jasper are common, but vein quartz, quartzite and quartz-sandstone are predominant; they are invariably well rounded.

Several 5 to 10 foot thick beds of ferruginous quartz sandstone occur at intervals throughout the succession.

In thin section the matrix can be seen to consist of secondary silica overgrowths.

The unit is about 500 feet thick.

Distinguishing Features: The Mount Amherst Member produces a distinctive photo-pattern, marked by prominent joint-lines. The base of the unit is more resistant than the underlying strata and is marked by a change in lithology from an arenite-lutite sequence to an exclusively arenite sequence.

The top of the unit is transitional and indistinct, but is taken at the first appearance of lutites.

<u>Palaeogeographic Significance:</u> The coarse grain of the sandstone comprising the Member is in contrast to the underlying and overlying strata. The Member was probably deposited in a littoral-neritic environment. The abundance of cross beds indicates strong current activity. The abundance of jasper fragments probably indicates some change in the source area.

<u>Distinguishing Features:</u> The Mount Amherst Member is recognised by its coarse, current bedded sandstone lithology, and its stratigraphic position. It is easily recognised on air photographs by its strongly jointed, pale photo pattern; the jointing is due to deformation of the completely arenaceous sequence. The underlying sandstone section is less jointed because of the softer interbedded shaley beds.

TABLE 7 - SUMMARY OF STRATIGRAPHY - KIMBERLEY GROUP

ROCK UNIT	MAP SYMBOL	LITHOLOGY	THICKNESS IN FEET	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION OF EXPOSURES	STRATIGRAPHIC RELATIONSHIPS	REMARKS
PENTECOST SANDSTONE	EKp	Excluding Member: White to Purple, fine, medium and coarse-grained quartz sandstone; purple siltstone and shale. Mud cracks, ripple marks and cross-beds common in parts of sequence.	2150-2900	Resistant; forms series of strike ridges and shallow valleys.	King Leopole and Mueller Ranges and extensively in Mount Cummings Plateau; Moola Bulla district.	Conformably overlain by Hilfordy Formation.	
MOUNT AMHERST MEMBER	Bka	White, massive and blocky coarse grained quartz sandstone, pebbly in places. Cross beds common.	500	Resistant; forms craggy hills, cuestas.		Topmost beds of Pentecost Sandstone	Jointing prominent. Pebbles and cobbles more common in east. Jasper grains and pebbles a prominent component.
ELGEE SILTSTONE	BKe	Excluding Member: Maroon thinly flaggy to fissile laminated siltstone shale and silty shale; minor quartz sandstone.	600-1160	Poorly resistant; forms valley.	King Leopold and Mueller Ranges and around perimeter of Mount Cummings Plateau; Moola Bulla district.	Conformably overlain by Pentecost Sandstone.	Marcon or red colour distinctive, some thin green bands present.
TERONIS MEMBER	Bkt	Dolomite, sandy dolomite, maroon shale, micaceous siltstone, quartz sandstone.	180-460	Poorly resistant; forms valley;low strike ridges near top.		Basal beds of Elgee Siltstone. Rests conformably on Warton Sandstone.	Includes dolomite beds, contain abundant abundant stromatolites.
WARTON SANDSTONE	BKw	Massive to blocky fine to medium-grained quartz sandstone. Cross beds common.	1200	Resistant; forms cuesta.	King Leopold and Mueller Ranges; north western perimeter of Mt. Cummings Plateau; Moola Bulla district.	Conformably overlain by Elgee Siltstone.	
CARSON VOLCANICS	BKc	Green saussuritised basalt or quartz dolerite, pink cross-bedded feldspathic sandstone, minor fissile micaceous siltstone.	1200-2000	Poorly resistant; forms low undulating country with occasional strike ridges.		Conformably overlain by Warton Sandstone. In places sits unconformably on Lamboo Complex.	In places difficult to distinguish from Hart Dolerite. Chalcopyrite occurs in lowermost flows.
KING LEOPOLD SANDSTONE	BKl	White to pink blocky to massive, medium to coarse grained quartz sandstone, pebbly in places. Minor feldspathic sandstone. Cross beds and ripple marks common.	0-2100	Resistant; forms cuesta	King Leopold Range; part of Mueller Range; north eastern perimeter of Mount Cummings Plateau; Moola Bulla district.	Conformably overlain by Carson Volcanics. Rests unconformably on Speewah Group in places, conformably in others.	May contain shale interbeds in places.

CROWHURST GROUP (New Name)

Distribution: Exposures of the Crowhurst Group are restricted to an area extending 12 miles west, 16 miles east, 15 miles north and 5 miles south of the junction of the Margaret and O'Donnell Rivers, in the northern part of the Mount Ramsay Sheet area; the exposures are mostly within the O'Donnell Syncline.

Reference Area: The most complete section can be observed along the eastern bank of Liga Creek around Latitude 18°15' South, and this is designated as the reference area.

Derivation of Name: The name has been taken from Crowhurst Gorge, which is situated on the west-flowing part of the Margaret River, within the King Leopold Range.

Components: The Group contains, in ascending order, the following rock units:-

Hibberson Dolomite
Collett Siltstone
Liga Shale
Hilfordy Formation.

Stratigraphic Relationships: The Crowhurst Group conformably overlies the Kimberley Group and is unconformably overlain by the Colombo Sandstone and rocks of the Louisa Downs Group. The base has been selected at a lithological change similar to that marking the base of the Bastion Group (of Dow et al 1964) in the hope that the two boundaries may be isochronous.

Lithology and Thickness: The only section of the Group measured - to the north of Crowhurst Gorge - contained 475 feet of strata, but as the succession here, as elsewhere, is unconformably overlain by the Colombo Sandstone, this figure can only be regarded as a minimum estimate of the original total thickness. It can, however, be taken as being indicative of the general order of the maximum preserved thickness.

The lithology is discussed in the descriptions of the component formations. The stratigraphy of the Group is summarised in Table .

HILFORDY FORMATION (New Name)

Distribution: The Hilfordy Formation is exposed in the eastern, northern and western parts of the O'Donnell Syncline. It occurs mainly in the hilly perimeter of a wide valley which surrounds the confluence of the Margaret and O'Donnell Rivers, but some outcrops extend eastwards to near Mount Amherst and isolated exposures occur to the north-west of Liga Creek.

Reference Area: A reasonably complete section of the Formation occurs in an area surrounding a point 6.6 miles north 10° east of the confluence of the Margaret and O'Donnell Rivers. The area is designated as the reference area.

Derivation of Name: The name is derived from Hilfordy Creek, a newly named stream which flows into the Margaret River near Crowhurst Gorge.

Stratigraphic Relationships: The Hilfordy Formation conformably overlies the Mount Amherst Member of the Pentecost Sandstone and is conformably overlain by the Liga Shale.

Lithology and Thickness: In the reference area (near Liga Creek) the unit is about 100 feet thick (photo-estimate) and consists of three main, closely interbedded, lithologies. Purple, flaggy and blocky, fine-grained ripple-marked quartz sandstone, with an iron oxide-silica matrix and containing ripple marks, is perhaps the main rock type, but purple, thinly flaggy, laminated, slightly micaceous, ferruginous siltstone is almost as abundant, as is purple, fissile, laminated shale. Some interbeds of pink or white, blocky to massive, fine-grained quartz sandstone containing purple clay pellets occur in the succession, and rare interbeds of purple, coarse-grained quartz sandstone with a matrix of iron oxide and silica and containing conspicuous grains of red jasper, are also present.

In the Crowhurst Gorge area the Hilfordy Formation contains similar lithologies. The base of the unit is gradational from the underlying Mount Amherst Member and therefore difficult to precisely define. A section measured in this area (Photo-reference MR4-45-12) contains:-

OVERLAIN BY LIGA SHALE

5' White surfaced, white to buff flaggy to blocky, laminated, well sorted, fine-grained quartz-sandstone with a silica matrix. Has smooth bedding planes.

8' Purple surfaced, white to purple, flaggy and thinly flaggy, fine-grained quartz sandstone interbedded with purple ferruginous siltstone and shale. Abundant mud-cracks, load casts, ripple marks, clay pellets and grooves of unknown origin.

18' Purple, flaggy, fine to medium-grained quartz sandstone with an iron oxide-silica matrix. Minor interbeds of coarse-grained quartz sandstone and ferruginous siltstone.

10' Purple, blocky, medium bedded, poorly sorted, coarse and very coarse-grained quartz sandstone with a weak silica matrix - iron oxide dust in the matrix gives the purple coloration. Granules and coarse grains of red jasper are common in the rocks. Interbeds of purple medium and fine-grained quartz sandstone. Abundant clay pellets, ripple marks and some cross beds.

28' Purple, flaggy, fine and very fine-grained, ferruginous, micaceous sandstone with purple ferruginous siltstone partings interbedded with white to light purple flaggy and blocky, fine-grained, quartz sandstone with a silica-iron oxide matrix. Ripple marks, load casts and pellet impressions are common.

22' White surfaced, white, blocky to massive, medium bedded, fine to medium-grained quartz sandstone with a silica matrix, interbedded with purple to grey, blocky, coarse-grained quartz sandstone with an iron oxide-clay matrix, and purple, flaggy, fine-grained quartz sandstone with a silica-iron oxide matrix. The latter type contains partings of ferruginous siltstone with abundant clay pellets.

UNDERLAIN BY MOUNT AMHERST MEMBER
OF THE PENTECOST SANDSTONE

Distinguishing Features: In most areas the base of the unit is marked by a sharp change in lithology from white quartz sandstone to interbedded purple sandstone, siltstone and shale, but in the Crowhurst Gorge area the base is not distinct and has been taken at a point in the succession . .. .tion of lithologies becomes pronounced. The top of the unit is distinguished by the appearance of green shale, and the disappearance of blocky arenites.

Palaeogeographic Significance: Shallow water bottom structures and cross beds are common in the Hilfordy Formation, and it seems likely that the unit was deposited mainly on a broad shallow coastal shelf. The unit represents a transitional phase between the deposition of the Pentecost

Sandstone (by traction currents) and the deposition of the Liga Shale (from suspension). The significance of the purple colours which characterise the unit is not clear; whether the iron oxide was deposited in the ferric or ferrous state is unknown.

The degree of lithological similarity between the Hilfordy Formation and the Mendena Formation (the lowermost unit of the Bastion Group, which overlies the Pentecost Sandstone in the north-eastern part of the Kimberley region (Dow, et al 1964)) leaves little doubt that the two are partly, if not wholly contemporaneous. Like the Hilfordy Formation, the Mendena Formation is overlain by green shale. There is no reason to suspect that the depositional surface did not extend continuously from the Mount Ramsay Sheet area to beyond Wyndham.

LIGA SHALE (New Name)

Distribution: The Liga Shale is rarely well exposed, but it crops out in widely scattered localities around the perimeter of the Margaret-O'Donnell Valley.

Reference Area: The best exposure of the unit occurs in an area surrounding a point 6.5 miles north 10° east of the confluence of the Margaret and O'Donnell Rivers; this area is designated as the reference area.

Derivation of Name: The name is derived from Liga Creek, a newly named watercourse which flows from the north, past the reference area, to join the O'Donnell River.

Stratigraphic Relationships: The Liga Shale is conformably underlain by the Hilfordy Formation and is conformably overlain by the Collett Siltstone.

Lithology and Thickness: In the reference area (near Liga Creek) the Liga Shale is about 150 feet thick (photo-estimate) and near Crowhurst Gorge 130 feet has been measured. The unit is laterally uniform in lithology and consists of green fissile shale with minor sandstone and siltstone interbeds in its lower half.

The succession in the reference area is almost identical to that measured near Crowhurst Gorge (Photo Reference MR4-45-13) set out below:-

60' Green, fissile, slightly micaceous shale with occasional purple laminae and blebs. Poorly exposed.

70' Green, fissile, laminated and non-laminated shale, interbedded with minor micaceous green siltstone and very fine-grained micaceous silt sandstone. Poorly exposed. The proportion of sandstone and siltstone decreases upwards.

130'

Mud cracks and oscillation and current ripple marks occur in the lower part of the section in the reference area, but these have not been noted in the Crowhurst Gorge section where the exposure is poor.

A.R. Turner (AMDEL) describes a thin section of a typical shale sample (4.41.108) as consisting of "numerous angular to subangular quartz grains which have a size distribution in the range 0.04 to 0.02 mm set in a recrystallized argillaceous matrix. The quartz has been recrystallized and many of the grains are elongated parallel to the laminations. The argillaceous matrix has recrystallized to form muscovite, sericite and chlorite. These minerals have a marked subparallel orientation and impart the fissility or incipient schistosity to the rock. The laminated texture is formed by alternate relatively high and relatively low concentrations of finely disseminated iron oxides. In some layers the iron forms aggregates but in others only stains the individual mica laths."

Distinguishing Features: The base of the unit is taken at the appearance of green shale; this coincides with the disappearance of blocky arenites. An abrupt colour change occurs at the top of the unit, where green shale gives way to purple siltstone, or purple silty dolomite.

Palaeogeographic Significance: The Liga Shale is clearly the product of an environment quite distinct from that which prevailed during the deposition of the Pentecost Sandstone. The most striking aspect of the shale - its green colouration - suggests that the unit may have been deposited under reducing conditions. Arguments concerning the cause of the green colouration must take into account the abrupt change to purple in the succeeding unit; the two units have experienced similar post-depositional histories and it is reasonable to infer that the colours are the result of the inherent chemical properties of the deposits, although the increase in grainsize and (perhaps) permeability between the Liga Shale and Collett Siltstone could be responsible. The prevalence of oscillation ripple marks and mud cracks in the lower half of the unit shows that the sedimentary surface was sometimes very near, and sometimes, above water-level. Their absence in the upper half of the unit and the disappearance of sandy strata suggest a continual increase in the water depth and, perhaps transgression. Most of the Liga Shale was probably deposited from suspension.

COLLETT SILTSTONE (New Name)

Distribution: Exposures of the Collett Siltstone occur mainly north of the O'Donnel and Margaret Rivers, but some extend to the south of the Margaret from near Crowhurst Gorge.

Reference Area: Excellent exposures of the unit occur in the Crowhurst Gorge area. The reference area is near Crowhurst Gorge, in the vicinity of Latitude 18°17'S, Longitude 126°26' east, a few hundred yards to the north-east of the bed of the Margaret River.

Derivation of Name: The name is taken from the Collett Cliffs, a newly named feature along the course of the Margaret River.

Stratigraphic Relationships: The Collett Siltstone conformably overlies the Liga Shale and is conformably overlain by the Hibberson Dolomite.

Lithology and Thickness: The unit consists predominantly of purple and green siltstone; thin interbeds and lenses of other rock types are present. The following section was measured in the reference area:-

175'	Purple and green, brittle, fissile, laminated siltstone containing rare 2"-12" thick interbeds of white silty dolomite, sandy dolomite and dolomitic sandstone (commonly with "rolling" bedding) and very rare interbeds of green, pyritic, cherty siltstone which are confined to the upper 100 feet.
20'	Purple and green brittle, fissile, laminated siltstone containing nodular pods and thin beds (2"-6" thick) of white silty dolomite.
5'	Purple, saccharoidal silty dolomite(?) with laminae and lenticular interbeds of purple siltstone, purple dolomitic siltstone, and purple shale. Vague stromatolite forms occur in the dolomite.
200'	

Apart from minor increases and decreases in the abundance of the dolomitic strata from place to place the unit shows little lateral lithological variation. The siltstone is predominantly purple in colour, but green bands and laminae are common throughout the sequence; in places the colour change occurs along joints rather than along the bedding.

No bottom structures were noted in the reference area but groove and brush casts have been observed in other areas, particularly near the base of the unit.

A.R. Turner (AMDEL) describes a thin section of a representative sample (4.41.2) of the purple siltstone (which forms the bulk of the unit) as follows:-

"This rock is a ferruginous siltstone consisting of numerous quartz grains having a size distribution in the range 0.1 to 0.02 mm. (i.e., silt-size) set in a ferruginous cement which contains micaceous components. The detrital quartz grains are rounded to subrounded and have been subjected to incipient recrystallization. This has been induced by diagenesis attendant with the deposition of authigenic silica. Muscovite laths having a sub-parallel orientation are found included within the recrystallized quartz. These could have originated as:

a. sedimentary muscovite
b. authigenic muscovite
c. metamorphic muscovite

Although no definite evidence presents itself as to the origin of this mineral its fresh nature, elongated habit and sub-parallel orientation suggest that it may have a metamorphic origin. This would indicate that the rock has been subjected to low grade metamorphism. Numerous aggregates of iron oxides are found throughout the rock. In some areas these have been elongated parallel to the direction defined by the orientation of the muscovite laths. This further suggests that a stress system has been operative accompanied by incipient shearing which would produce synkinematic metamorphism and hence metamorphic muscovite. The detrital quartz grains are metamorphic muscovite.

inclusion free apart from rare apatite needles. However the surrounding authigenic quartz is heavily impregnated with finely disseminated iron oxides. This indicates that the authigenic quartz and iron oxides were being precipitated from solution simultaneously. Accessory mafic minerals including tourmaline and altered pyroxene are randomly distributed throughout."

A thin section (5.81.1A) of the cherty siltstone which occurs as thin interbeds in the upper part of the Collett Siltstone has been described as "a grey micaceous siltstone. It consists of numerous quartz grains which have a size distribution in the range 0.08 to 0.02 mm (i.e. silt-size) set in a matrix of chlorite, muscovite and sericite. The quartz grains are poorly rounded and have been recrystallized under the influence of a stress system. Similarly what must formerly have been an argillaceous matrix has recrystallized to form micas which have become sub-parallelly orientated in the direction of least stress. The effects of crystallization have been to impart a poorly defined fissility to the rock. Accessory aggregates of finely disseminated iron oxides are randomly distributed throughout the rock. There is a marked development of schistosity in the thin-section but this is not as yet apparent in the hand specimen. The micas occupy all interstitial spaces between the framework of quartz grains and are seldom found as inclusions in the recrystallized grains. They often separate individual grains with a fine veneer of micas. Accessory carbonates are found randomly distributed throughout the rock."

Distinguishing Features: The base of the Collett Siltstone is marked by a sharp change from green shale to purple silty dolomite or purple siltstone; the top is marked by the appearance of dolomitic strata (in some places a thin bed of dolomitic sandstone and in others sandy dolomite-breccia).

Palaeogeographic Significance: The apparent absence of diagnostic shallow water sedimentary structures in the Collett Siltstone and the presence of structures, such as brush casts and groove casts suggests that the unit was deposited below wave base and possibly on a sloping floor; the presence of pyrite in the upper part of the unit probably indicates a reasonable depth of water. The significance of the dolomite nodules and bands in the unit is not known but their relative abundance near the base suggests that their deposition may have been connected with the environmental change responsible for the lithological contrast between the Liga Shale and the Collett Siltstone.

HIBBERSON DOLOMITE (New Name)

Distribution: The main exposures of the Hibberson Dolomite occur in the Crowhurst Gorge district, and isolated exposures occur in the Liga Creek district.

Reference Area: Good exposures of the unit are plentiful in the Crowhurst Gorge district. The reference area is nominated as being in the surrounds of Latitude 18°17'30"S and Longitude 126°25'50"E.

Derivation of Name: The name is derived from Hibberson Bluffs, a newly named feature two miles upstream of Crowhurst Gorge.

Stratigraphic Relationships: The Dolomite conformably overlies the Collett Siltstone and is unconformably overlain by the Colombo Sandstone.

Lithology and Thickness: The Hibberson Dolomite is 85 feet thick in the reference area but the top is eroded and greater thicknesses may be present elsewhere. It consists mainly of light grey weathering, pink to yellow, thin-bedded to laminated, dolomite. Sandy (and commonly oolitic) dolomite-breccia occurs as interbeds near the base, which is marked by a 2 foot thick bed of green, fine-grained, dolomitic sandstone containing quartz sandstone laminae.

Numerous stromatolitic zones are present; two main types of stromatolite occur in the reference area. The first occurs in the lower part of the unit and in vertical section superficially resemble ripple-marks with amplitudes of about half an inch and wave lengths of about 1¼ inches. The second type which is common in the middle and upper parts of the unit consists of flat convex-upward sub-circular to elongate domes up to 2 feet across and from 2 to 4 inches high; the laminae present in one dome pass into the adjoining dome but are commonly contorted in the narrow inter-domal zone. The second type has been noted in Liga Creek where it occurs in association with a third type which consists of series of closely spaced hemispherical convex-upwards domes, from 6" to 24" across, attached one to the other by continuous undisturbed laminae. The width of the inter-domal zone is normally much less than the diameter of any of the adjoining domes. One further type which has been seen only as float consists of two inch diameter tubes, each traversed by closely spaced convex lamellae. The tubes are in contact throughout their length.

In thin section (5.81.1B) the dolomite consists of a mass of recrystallized dolomite throughout which is distributed minute angular quartz grains and accessory laths of muscovite. The quartz grains are detrital in nature, have a size distribution in the range 0.08 to 0.02 mm and have a completely random distribution. The dolomite crystals are anhedral and intergrown. . They often form radial crystal aggregates. Accessory finely disseminated iron oxides are randomly distributed throughout. Rarely stylolitic seams traverse the rock and along these alteration has taken place. Iron oxides have been deposited and in some areas the dolomite has been replaced by calcite. In others secondary quartz and calcite have been deposited.

Distinguishing Features: The base of the unit is marked by the appearance of dolomitic strata; the top is eroded.

Palaeogeographic Significance: The Hibberson Dolomite was probably deposited mainly in a marine, shallow-water environment - the breccias and oolitic beds in the lower half of the unit are probably the result of agitation by wave and current action, while the stromatolites in the upper part probably grew in less disturbed intertidal waters.

The deposition of the dolomitic beds probably resulted from a slight epeirogenic uplift of the sea floor - the preceeding unit, the Collett Siltstone, was deposited in much deeper waters.

COLOMBO SANDSTONE

Distribution: The Colombo Sandstone is confined to the Mount Ramsay Sheet area and occurs in an area to the north-west of the junction of the O'Donnel and Margaret Rivers.

Reference Area: No complete exposure of the unit is available for study because the top is invariably eroded. The most accessible exposure caps Colombo Hill, which is designated as the reference area.

Derivation of Name: From Colombo Hill, a newly named feature lying three miles to the north of the junction of the Margaret and O'Donnel Rivers.

Stratigraphic Relationships: The Colombo Sandstone rests unconformably on the Hibberson Dolomite and older rocks of the Crowhurst and Kimberley Groups. The unconformity can be deduced from the regional attitude of the unit, but at most single localities little, if any, structural contrast is apparent. Chert-breccia, stained with iron and manganese oxides is commonly present at the top of the Hibberson Dolomite where it is overlain by the Colombo Sandstone; this may well be a fossil weathering profile. An example of this occurs along Liga Creek.

The Sandstone is unconformably overlain by rocks of the Louisa Downs Group. Its time-relationships to the Kuniandi and Glidden Groups cannot be directly deduced, but it seems likely that it may pre-date them. The unit may possibly be a time-equivalent of the Mount Parker Sandstone (Dow et al 1964) of the East Kimberley region.

Lithology and Thickness: The maximum preserved thickness of the Colombo Sandstone is in the order of 300 feet. In the reference section the lowermost 100 feet of the Colombo Sandstone consists of purple weathering, purple, massive friable to silicified, thick bedded, poorly sorted, cross-bedded, coarse-grained quartz sandstone; the matrix is made up of iron oxide and silica; chert fragments form up to 5% of the rock. The purple quartz sandstone beds are overlain by about 200 feet of white or orange weathering, white massive and blocky, medium-grained quartz sandstone with a silica matrix; chert grains comprise about 2% of the rock.

In thin section (4.41.13A) the purple quartz sandstone consists of "an interpenetrating mass of rounded to subrounded detrital quartz grains set in an authigenic quartz and ferruginous matrix. The grain size distribution of the detrital fraction is in the range 1.7 to 0.06 mm. Original sedimentary graded bedding is apparent in thin-section and these beds define crude laminations approximately 15 mm apart. The grains on deposition have been compacted and diagenesis has caused marked pressure solution effects between grains in juxtaposition. Simultaneously authigenic quartz has been deposited in available voids. The former oxidation surfaces of the detrital core are clearly visible as minute included layers of finely disseminated opaque minerals. Secondary "granular" quartz and chalcedony have also been deposited in some of the voids. Individually the quartz grains show minute powdered inclusions of opaque minerals. They show no strained features. Heavy precipitation of iron oxides has taken place in all interstitial voids probably concurrently with deposition. These have become incorporated in the secondarily precipitated quartz cement and impart the characteristic purplish colouration to the rock. Many of the quartz grains are fractured and occasionally they appear to be partially replaced by sericite." (A.R. Turner, AMDEL).

The overlying white quartz sandstone (4.41.13B) consists of "a mass of rounded to subrounded detrital quartz grains set in an authigenic silica cement. The grains have a size distribution in the range 0.78 to 0.05 mm unimodally skewed towards the coarser sizes. The following differences were observed when this rock was compared with specimen 4.41.13A:

1. no ferruginous material hence colourless
2. better degree of sorting
3. no visible sedimentary structures
4. effects of pressure solution much less marked
5. higher percentage of authigenic silica
6. original sediment not as well compacted
7. accessory sericite aggregates are found throughout. Probably recrystallized from clay minerals
8. no evidence for sericite replacing quartz
9. grains not as extensively fractured

There is a similar deposition of chalcedonic and "granular" silica. In other respects the two are similar. Authigenic quartz surrounds each individual detrital core and occupies all interstitial voids." (A.R. Turner, AMDEL).

In the Crowhurst Gorge district the basal part of the unit includes a coarse conglomerate with rounded cobbles of white quartzite and angular pebble-size angular fragments of chert, which are set in coarse white quartz sandstone matrix. This passes upwards into a white, silicified medium-grained, well-sorted quartz sandstone, with rare feldspar grains. The conglomerate is distinctive because of its chert fragments, and the sandstone matrix differs from the Pentecost Sandstone lithologies by its white, glassy, even-grained texture.

Distinguishing Features: The base of the Colombo Sandstone is marked by an unconformity; the top is eroded and no difficulty arises in distinguishing between the Sandstone and the younger strata.

Palaeogeographic Significance: The Colombo Sandstone was probably deposited on a continental shelf; the poor sorting and general coarse grainsize prevalent in the lower part of the unit are suggestive of a littoral environment in contrast to the overlying strata which may have accumulated in a neritic zone. The chert grains and pebbles present in the unit were probably derived from carbonate rocks such as the Hibberson Dolomite; near Liga Creek evidence of a fossil silicified erosion surface on the Hibberson Dolomite is present.

TABLE 8 : SUMMARY OF STRATIGRAPHY - CROWHURST GROUP AND COLOMBO SANDSTONE

	ROCK UNIT	SYMBOL	LITHOLOGY (In order of abundance)	THICKNESS (In feet)	PHYSIOGRAPHIC EXPRESSION	STRATIGRAPHIC RELATIONSHIPS	REMARKS
	COLOMBO SANDSTONE	Bm	White and purple massive, medium grained quartz sandstone; purple sandy chert-pebble breccia.	300+	Highly resistant; forms mesas and plateaux.	Unconformably overlies Hibberson Dolomite; unconformably overlain by Egan Formation.	Probably pre-dates Glidden Group.
				UNCONFORMITY			
CROWHURST GROUP	HIBBERSON DOLOMITE		Pink to yellow massive, thin bedded to laminated dolomite with minor interbeds of sandy oolitic dolomite breccia and fine-grained dolomitic sandstone.	85+	Resistant; forms rough, craggy hills.	Conformably overlies Collett Siltstone.	Contains at least three stromatolite forms. May be stratigraphic equivalent of part of Wyndham Shale of Dow et al, (1964).
CROWHURST GROUP	COLLETT SILTSTONE		Purple and green fissile, laminated siltstone with minor interbeds, lenses and nodules of purple and white silty dolomite; white sandy dolo-dolomite and dolomitic sandstone; purple siltstone and dolomitic siltstone and green pyritic cherty siltstone.	200	Moderately resistant; forms rounded hills; has weak basal scarp.	Conformably overlies Liga Shale.	Colour changes not always confined to bedding. May be stratigraphic equivalent of part of Wyndham Shale of Dow et al, (1964).
CROWHURST GROUP	LIGA SHALE		Green fissile shale with minor interbeds of green micaceous siltstone and very fine-grained micaceous silty sandstone.	150	Poorly resistant forms valleys and low, undulating treeless rises.	Conformably overlies Hilfordy Formation.	May be stratigraphic equivalent of part of Wyndham Shale of Dow et al, (1964).
CROWHURST GROUP	HILFORDY FORMATION		Interbedded purple and white flaggy and blocky, fine and coarse-grained quartz sandstone; purple, thinly flaggy ferruginous siltstone; purple fissile laminated shale. Sandstones are glauconitic in places.	100	Moderately to poorly resistant; forms low, rounded hills.	Conformably overlies Mount Amherst Member of the Pentecost Sandstone (Kimberley Group).	May be stratigraphic equivalent of Mendena Formation of Dow et al, (1964).

HART DOLERITE

Distribution: The Hart Dolerite is exposed only in the northern part of the Mount Ramsay Sheet area; it crops out in the King Leopold and Mueller Ranges where it generally forms low-lying, partly soil covered boulder-strewn areas. The Dolerite crops out extensively in the Kimberley region, particularly on the northerly adjoining Lansdowne Sheet area.

Derivation of Name: The name was first used by Harms (1959).

Stratigraphic Relationships: In the Mount Ramsay Sheet area the Hart Dolerite intrudes rocks of the Speewah and Kimberley Groups. The youngest stratigraphic unit intruded by the Dolerite in the area is the Carson Volcanics, but to the north, in the Lansdowne Sheet area, the Dolerite is known to intrude the Elgee Siltstone and Pentecost Sandstone (Gellatly, Derrick and Plumb, in prep.) The Dolerite occurs as sills, and mapping has shown that these sills occur at several different stratigraphic horizons and are locally transgressive (figure 9).

Figure 9: View looking south at Mount Ball. Hart Dolerite intrudes Lansdowne Arkose (left foreground) and Luman Siltstone beneath King Leopold Sandstone. The Dolerite is transgressive, and cuts across the Luman Siltstone under Mount Ball. Note folding and axial plane cleavage developed in King Leopold Sandstone.

Lithology: The Hart Dolerite is a massive, greenish-black medium to coarse-grained dolerite which is commonly well-jointed in outcrop. Amygdales have been noted in an area near One Tree Palm Gorge. The ophitic texture of the rock is usually apparent in fresh exposures and minor granophyric horizons occur in several localities. Thin veins of epidote are also developed.

In thin section the rock consists of euhedral laths of slightly epidotised andesine set in a fine-grained groundmass of acicular altered feldspar (?labradorite) and pyroxene. Irregular patches of chlorite or chlorite and quartz in the groundmass probably represent altered pyroxene. The coarser varieties show large, sericitised laths of sparsely twinned plagioclase (?andesine) intergrown with large bladed clinopyroxene. In some cases the pyroxene encloses the feldspar, in others the reverse is the case. Small patches of finer-grained sericitised plagioclase, chlorite, pyroxene and quartz are present throughout the rock, and large skeletal iron ore grains are the only accessory. The pyroxene shows patchy development of diallage and a golden ?ferruginous colouration, which may or may not be a secondary feature.

Thickness of Sills: In places the sills attain a great thickness; to the south-east of Mount Winifred a sill which intrudes rocks of the Speewah Group and which has nearly conformable contacts with the underlying and overlying strata, has, if treated as an interposed succession, a thickness of 3000 feet. Most of the other sills in the Sheet area are probably from 200 to 600 feet thick. They show little "vertical" variation in composition or texture.

UPPER PROTEROZOIC

GLIDDEN GROUP (New Name)

Distribution: The Glidden Group is exposed in two small perched synclines in the central part of the Mount Ramsay Sheet area. The larger syncline forms the Matheson Hills; the smaller lies to the west and forms the Maddox Hills.

Reference Area: The complete section is not exposed in either syncline; for this reason no reference area is designated.

Derivation of Name: The name is derived from the Glidden River, a newly named watercourse which flows west through Mount Amherst Homestead to join the Margaret River.

Components: The Group contains, in ascending order, the following rock units:-

Maddox Formation
Forman Sandstone
Matheson Formation
Harms Sandstone

Stratigraphic Relationships: The Glidden Group rests unconformably on the Carson Volcanics; in view of this it can be inferred that the unit post-dates the Crowhurst Group, and that profound erosion of the Kimberley and Crowhurst Groups took place before the deposition of the Glidden Group. In places the succession rests directly on rocks of the Halls Creek Group and Lamboo Complex. The Group is unconformably overlain by the Egan Formation, the lowermost unit of the Louisa Downs Group; although the relationships between the Kuniandi and Glidden Groups cannot be demonstrated, it is clear from their contrasting lithologies that they are not contemporaneous; the absence of glacigene strata in the Glidden Group lends weight to our opinion that the Glidden Group pre-dates the Kuniandi Group. Further support is gained from a possible correlation which can be drawn between the lower parts of the Glidden Group and the Wade Creek Sandstone (Dow and Gemuts, in prep.) of the East Kimberley Region.

The relationship between the Glidden Group and the Colombo Sandstone is problematical, but it is possible that the Sandstone may be an equivalent of the Mount Parker Sandstone of the East Kimberley District (Dow et al 1964) and thus may pre-date the Glidden Group - (the Mount Parker Sandstone lies unconformably below the Wade Creek Sandstone).

Lithology and Thickness: The maximum preserved thickness of the Group is about 1800 feet; its lithology is discussed under the formation headings. The stratigraphy is summarized on Table 9.

HARMS SANDSTONE (New Name)

Distribution: The Harms Sandstone is exposed in the Matheson and Maddox Hills.

Reference Area: The most complete section of the Harms Sandstone crops out in the southern part of the Matheson Hills and this area is designated as the reference area.

Derivation of Name: The name is derived from Harms Creek, a newly named tributary of Dead Horse Creek.

Stratigraphic Relationships: The Harms Sandstone rests unconformably on the Carson Volcanics and older units; it probably post-dates rocks of the Crowhurst Group and possibly pre-dates rocks of the Kuniandi Group (see discussion under Group heading).

Lithology and Thickness: The Harms Sandstone has been examined in two main areas - the reference area (in the Matheson Hills) and along Dead Horse Creek where it cuts through the Maddox Hills. In the reference area the unit is not fully exposed - less resistant beds in the middle of the unit are rubble covered. The following section was measured in the reference area

OVERLAIN BY MATHESON FORMATION

80' White surfaced, white, blocky thin to thick bedded, moderately well sorted, fine to medium-grained quartz sandstone with a silica matrix. Grainsize increases from base to top. Ripple marks and inconspicuous cross beds are common throughout; near the top large scale ripple marks and bedding rolls are very prominent. Black heavy minerals are present in some zones.

60' No outcrop

60' White, pink to blocky, fine to medium-grained, quartz sandstone with a silica matrix. Grains of feldspar (represented by clay bodies) constitute a few percent of the rock. Ripple- [illegible]; cross beds present but not conspicuous.

200'

UNDERLAIN BY "UNDIFFERENTIATED" HALLS CREEK GROUP

In the Maddox Hills the same subdivisions are recognizable and the same order of thickness obtains. The lowermost beds in this area contain abundant clay pellets and in places give the outcrops a pock-marked appearance. The upper part of the middle, less resistant, subdivision is exposed and consists of purple, laminated, fissile to thinly flaggy shale (with occasional green laminae and bands and minor thin interbeds of purple siltstone). This lithology is probably representative of most, if not all of the less-resistant subdivision.

The uppermost subdivision in the Maddox Hills consists of:-

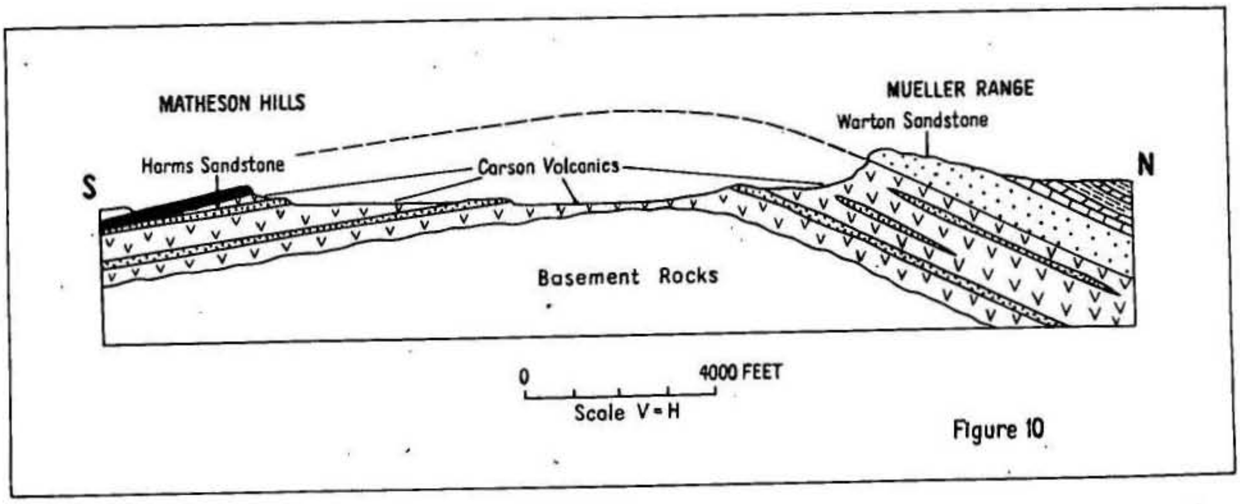
60' Orange surfaced, white poorly sorted fine to coarse-grained quartz-sandstone with scattered black heavy mineral grains. The matrix consists of silica with minor amounts of clay. The sandstone becomes pink towards the top. Cross beds are common.

20' Purple blocky fine-grained quartz-sandstone with a matrix of silica and iron oxide dust.

A.R. Turner (AMDEL) describes a thin section (6.35.10B) of the uppermost quartz sandstone as"consisting of numerous subrounded to rounded quartz grains which have a wide size distribution in the range 2.1 to 0.26 mm. There tends to be a bimodal size distribution between these two imits. The coarser fraction is concentrated into laminations associated with grains of the finer fraction. However in general sorting is only moderate. The framework of the rock is made up of 95% detrital quartz and the majority of the voids are occupied by SiO_2 cement or authigenic quartz. In all cases the original grain shape is preserved by a fine veneer of opaque and clay minerals which coat the detrital components. Many grains of the finer fraction have a low sphericity when compared to the coarser fraction and their long axis have a sub-parallel orientation. The rock has been severely compressed, during diagenesis, causing elongation of the grains in the direction of the minimum stress axis and promoting "pressure solution" whereby individual grains become "knitted" together by mutual solution and precipitation. The resultant interface between grains is serated and reminiscent of a stylolitic seam. Each of the individual grains are, in some areas, coated in finely disseminated iron oxides and in others by <u>clay minerals</u> which have recrystallized on diagenesis to the micas <u>sericite</u> and <u>chlorite</u>. Accessory detrital <u>tourmaline</u> grains are randomly distributed throughout the specimen. Minor parting fractures have developed parallel to the incipient laminations and along these secondary quartz, sericite and rare <u>muscovite</u> have crystallized."

<u>Distinguishing Features:</u> The base of the unit is defined by an unconformity. The top of the unit is marked by the appearance of lutites.

<u>Palaeogeographic Significance:</u> The Harms Sandstone appears to have been deposited mainly in a shallow water environment, although the shale beds in the middle of the unit were probably deposited below the wave-base. The most striking aspect of the Harms Sandstone from the palaeogeographic viewpoint lies in the inferrences that may be drawn from its structural and stratigraphic relationships to the rocks of the Kimberley Group; these are shown diagrammatically on figure 10.



<u>Figure 10:</u> North-south cross section from Mueller Range to northern part of Matheson Hills showing structural and stratigraphic relationships of the Harms Sandstone to rocks of the Kimberley Group.

As far as can be determined no faulting occurs in the zone between the northern part of the Matheson Hills and the foot of the Mueller Range; rather the Carson Volcanics (exposures of which occupy the zone) are folded into a broad east-north-east trending anticline or monocline. The fact that the Harms Sandstone rests unconformably on the Carson Volcanics and, further to the south, directly on the basement rocks, suggests that, prior to the deposition of the Harms Sandstone the Warton Sandstone had been entirely eroded from the area now occupied by the Matheson Hills and that the Carson Volcanics had been completely stripped in the south and partly removed in the north.

Regardless of whether or not the anticline (or monocline) was present before the erosion it seems possible that a topographic relief very similar to the present order of relief was developed prior to the deposition of the Harms Sandstone; thus in this area the scarp of the Mueller Range may be regarded as virtually an exhumed feature, even though it could possibly have undergone a comparatively recent retreat of up to 2 miles.

MATHESON FORMATION (New Name)

Distribution: The Matheson Formation crops out in the Matheson and Maddox Hills in the central part of the Sheet area.

Reference Area: The reference area is in the southern part of the Matheson Hills.

Derivation of Name: The name is derived from the Matheson Hills, a newly named series of hills and ridges in the central part of the Sheet area.

Stratigraphic Relationships: The Matheson Sandstone is conformably underlain by the Harms Sandstone and conformably overlain by the Forman Sandstone.

Lithology and Thickness: The section described below occurs in the reference area. Although the Formation is well exposed the presence of minor faults and flexures makes it difficult to estimate thicknesses accurately.

OVERLAIN BY FORMAN SANDSTONE

250' Purple and grey, flaggy, laminated to medium bedded, fine-grained sub-greywacke and ferruginous feldspathic sandstone, micaceous in parts. Seen elsewhere to be interbedded with dark grey fissile laminated shale and siltstone. Cross beds occur in the sandy strata.

270' White surfaced, white to cream and faint pinky grey and rarely black, very regularly laminated claystone, with notably smooth bedding surfaces. Massive and cherty near base but becomes flaggy and thinly flaggy after first 20 feet. Limonite staining along joints and manganese encrustations are common in some outcrops.

370' Black, fissile, laminated shale interbedded with grey occasionally pyritic, fine-grained sub-greywacke and black laminated micaceous siltstone. Dolomite may be present in the matrix of some of these rocks, Bedding "rolls" and current ripple marks are fairly common in the sandy beds.

150' Dark green and black fissile, finely laminated shale and siltstone containing occasional flakes of authigenic mica and, in places, scattered quartz sand grains. Very minor interbeds (2" to 3" thick) of greenish grey, fine and medium-grained quartz sandstone and sub-greywacke. The black shale occurs mainly near the base.

80' Purple surfaced, purple and olive green thinly flaggy to fissile, laminated, slightly micaceous siltstone interbedded with purple surfaced, flaggy, thin bedded to laminated, medium-grained quartz sandstone with a silica matrix; limonite pellets comprise up to 2% of the rock. Bedding "rolls" and large scale current ripple marks are common.

1120'

UNDERLAIN BY HARMS SANDSTONE

Three thin sections of laminated claystone from the 270 foot thick sequence have been described by A.R. Turner (AMDEL):-

6.31.9A - a cream cherty claystone - consists of a mass of cherty, silica material throughout which is distributed partially recrystallized clay and argillaceous minerals and iron oxides. The iron oxides have been deposited during the initial phase of deposition and impart lineations to the rock. The micaceous components, derived from recrystallization of clay minerals, include, sericite, chlorite and poorly developed muscovite. They impart an incipient schistosity to the rock by their sub-parallel orientation but are not foliated. The quartz is cryptocrystalline and rarely microcrystalline and its origin cannot be determined. However, the delicate and continuous nature of the laminations suggests fluvio-glacial or a lacustrine origin. Rarely parting fractures have developed parallel to the laminations and along these excess precipitation of iron oxides has occurred. The rock is also fractured at an angle of approximately 50° to the bedding and these have been infilled with secondary microcrystalline quartz.

6.31.9B - a bluish-grey cherty claystone - consists of a laminated mass of cryptocrystalline siliceous material throughout which are distributed the micaceous components sericite and chlorite. The sericite is found concentrated into minute layers as well as disseminated throughout the chert. The layers are further accentuated by the precipitation of iron oxides and they impart the laminated texture to the rock. Iron oxides are also irregularly deposited along parting fractures which parallel the laminations. The minute micaceous inclusions within the siliceous material have a sub-parallel orientation suggesting recrystallization under the effects of a stress system. The mechanism of deposition cannot be determined from the one specimen. However a fluvio-glacial or lacustrine origin is suggested.

6.31.96 - a black cherty claystone is almost identical with other rocks, the major exception being its darker colour. This is due to a uniform distribution of carbonaceous material throughout the rock and a non-uniform distribution of iron oxides. The two combined impart the dark laminated texture to the rock. It is otherwise similar consisting of siliceous cryptocrystalline material throughout which is distributed in minute laths of sericite and chlorite which have a sub-parallel orientation."

In the Maddox Hills identical lithologies are represented.

Distinguishing Features: The base of the unit is marked by the appearance of lutites and the top by the appearance of quartz sandstone.

Palaeogeographic Significance: Although current ripple marks are reasonably common in the sandy strata, much of the unit was probably deposited in relatively deep water (and perhaps, in part, on a sloping floor) and certainly below the wave base. The laminated claystone (270' bed towards the top of the unit) is remarkable for the vertical and lateral regularity of its laminae and the complete absence of bottom structures. It is difficult to conceive that this bed could have been deposited in a lagoonal environment as suggested by Turner (AMDEL). We infer that it was deposited in deep, current-free waters, and that the laminations probably reflect seasonal climatic variations.

The presence of pyrite in some of the strata and the association of manganese oxides with parts of the succession are taken as being suggestive of a marine environment. The change in lithology between the Matheson Formation and the overlying Forman Sandstone may have resulted from a marine regression caused perhaps by positive epeirogenic movements either within the basin of deposition or in the source area.

FORMAN SANDSTONE (New Name)

Distribution: The Forman Sandstone is exposed in the Maddox and Matheson Hills in the central part of the Sheet area.

Reference Area: The reference area is in the vicinity of Longitude 126°52'50"E, Latitude 18°25'50"S in the southern part of the Matheson Hills.

Derivation of Name: The name is derived from Forman Creek, a newly named watercourse which flows southwards from the Matheson Hills into the Glidden River.

Stratigraphic Relationships: The Forman Sandstone conformably overlies the Matheson Formation and is conformably overlain by the Maddox Formation.

Lithology and Thickness: In the reference area the unit consists of white surfaced, white, massive to blocky, thick bedded, well sorted, fine-grained quartz sandstone with a silica matrix. Concentrations of black heavy minerals occur in some bands. Apart from bedding, no sedimentary structures are apparent.

A.R. Turner (AMDEL) describes a thin section of the sandstone (6.31.11) as "consisting of rounded to sub-rounded detrital quartz grains having a size distribution in the range 0.45 to 0.15 mm which have been subjected to compaction, diagenesis and cementation by authigenic silica. All voids within the framework of detrital quartz grains have, without exception, been infilled with authigenic silica. The original detrital grain shape is preserved, however, by a fine veneer of opaque and clay minerals which must have coated each of the grains initially but is now found included in the authigenic quartz. The grains themselves contain minute acicular inclusions of apatite and finely powdered opaque minerals. There is no evidence for a stress system having operated during recrystallization. Accessory, altered, detrital pyroxene grains are randomly distributed throughout the rock."

In the Maddox Hills the unit consists predominantly of sandstone identical to that in the reference area, but near the top of the unit iron oxide is present as coatings on the grains (giving the rocks a purple colouration) and large-scale ripple marks and "bedding rolls" are conspicuous.

Distinguishing Features: The base of the Forman Sandstone is marked by the appearance of quartz sandstone; the top is taken at the first appearance of siltstone.

Palaeogeographic Significance: The high degree of sorting, the fine grainsize, the paucity of labile constituents and the general absence of sedimentary structures in the lower parts of the unit, suggest that it may be mainly a neritic deposit.

MADDOX FORMATION (New Name)

Distribution: The Maddox Formation crops out in the Maddox and Matheson Hills.

Reference Area: The reference area is in the Maddox Hills, along the course of Dead Horse Creek.

Derivation of Name: The name is derived from the Maddox Hills.

Stratigraphic Relationships: The Maddox Formation conformably overlies the Forman Sandstone and is unconformably overlain by the Egan Formation. The unit probably pre-dates the [illegible] Group.

Lithology and Thickness: The top of the Maddox Formation is not exposed; the preserved thickness is approximately 300 feet. The lower third of the section in the Maddox Hills consists of purple and grey, flaggy, fine-grained, slightly micaceous feldspathic sandstone interbedded with purple siltstone. Clay pellet impressions and mud cracks are common on bedding surfaces.

The upper two-thirds of the unit consists of black, fissile shale, interbedded with black, laminated micaceous siltstone. The siltstone occurs in beds from 1 to 2 inches thick and makes up about 30% of the total thickness; "bedding rolls", mud cracks and large and small scale current and oscillation ripple marks are common in the siltstone.

A.R. Turner (AMDEL) describes a thin section of the siltstone (6.35.18) as consisting of "numerous silt-size quartz grains having a size distribution in the range 0.09 to 0.02 mm set in an iron-stained, partially foliated, micaceous groundmass. The grains are irregular in shape because of recrystallization and their original detrital nature, together with any primary sedimentary structures, have been obliterated. However a laminated texture is imparted to the rock by concentrations of finely disseminated iron oxides which coincide with incipiently foliated micaceous masses. It appears that the rock has been synkinematically recrystallized. The quartz grains have become considerably elongated, foliation is incipient and schistosity is marked in the direction of the laminations. Considerable amounts of authigenic silica have been deposited in available voids between the quartz grains, forming the framework. Accessory ?microcline feldspar fragments are found throughout the rock together with aggregates of sericite and chlorite which may represent altered feldspar masses. Occasional plagioclase grains are also found. The principal micas are muscovite and sericite with minor chlorite. The micas and iron oxides, which accentuate the laminations in the hand specimen, have imparted a moderate fissility to the rock.

Dark grey cone-in-cone limestone occurs in the upper part of the unit as sporadic, flat, dome shaped bodies, which are circular in plan and up to 2 feet in diameter, and from 2 to 3 inches thick. The limestone bodies have a flat base. Each individual cone rests on its apex; the cones are marked by horizontal laminae (parallel to the inverted base of the cone) and by ribs running along the side of the cone from the apex to the base.

The exposures of the Maddox Formation in the Matheson Hills probably represent only the lowermost beds of the reference area.

Distinguishing Features: The base of the unit is taken at the first appearance of siltstone. The top of the unit is eroded.

Palaeogeographic Significance: The abundance of shallow water bottom structures in both the lower and upper parts of the unit shows that much, if not all of the unit was deposited in shallow water. The dark colours predominant in the upper part of the succession suggest that the rocks may have been deposited under reducing conditions in an area of poor water circulation, but the presence of mud cracks and cross-beds suggest the intermittant interposition of oxidizing conditions and stronger water circulation.

KUNIANDI GROUP

Distribution: Exposures of the Kuniandi Group are restricted to the Mount Ramsay Sheet area; they occur along the Kuniandi Range; in an area half a mile west of Hell's Gate; and in the McKinnon Syncline, near the northern edge of the Sheet area. Further exposures of rocks thought to belong to the Kuniandi Group occur near the southern margin of the Sheet area, to the east of Christmas Creek.

Derivation of Name: The name of the Group is derived from the Kuniandi Range, a newly named feature west of Louisa Downs Homestead.

Components: The Kuniandi Group contains four rock units:-

Mount Bertram Sandstone
Wirara Formation
Stein Formation
Landrigan Tillite

Reference Area: Since reference areas for each of the component formations are in the Kuniandi Range, the Range is designated as the Group's general reference area.

Stratigraphic Relationships: The Kuniandi Group rests unconformably on the Kimberley Group, Halls Creek Group and the Lamboo Complex. It is overlain with probable unconformity by the Louisa Downs Group. Its relationship to the Glidden Group is indeterminate, but it is thought likely that the Kuniandi Group is much younger than the Glidden and separated from it by an unconformity.

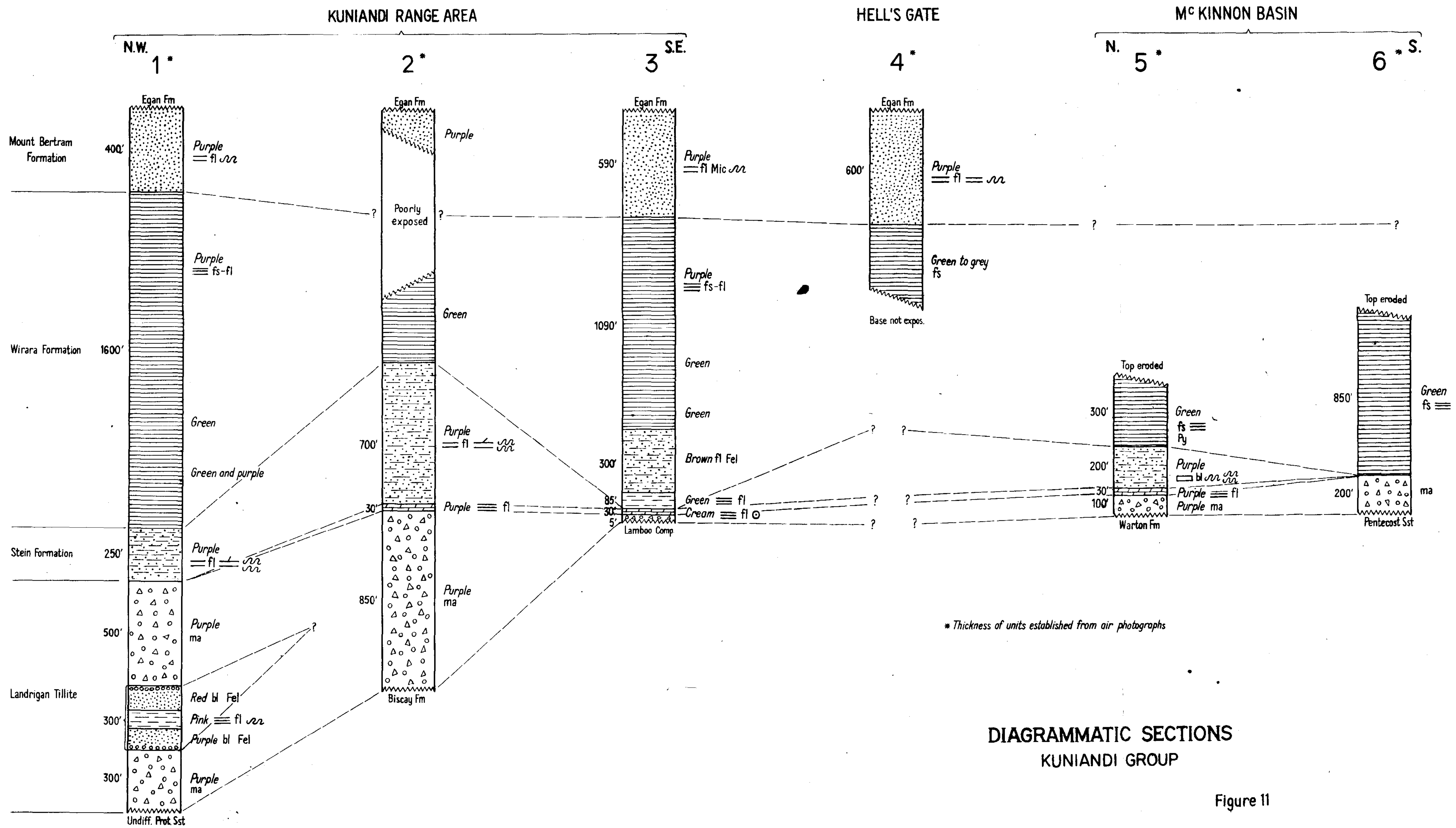
Lithology and Thickness: Lithological and thickness variations in the Kuniandi Group are shown in figure 11. The base of the Group contains a sequence which includes rocks of glacial origin; these strata comprise the Landrigan Tillite and the Stein Formation. The top two formations are regarded as "interglacials" since they are overlain with probable unconformity by glacial rocks of the Egan Formation (Louisa Downs Group).

The maximum thickness of the Group does not exceed 4000 feet. The two lowermost units vary in thickness along strike and in some cases the Stein Formation is missing entirely (as in Section 3 in figure 11).

The various components of the Group are described below; a summary of the stratigraphy is given in Table 10.

TABLE 9 : SUMMARY OF STRATIGRAPHY - GLIDDEN GROUP

	ROCK UNIT	SYMBOL	LITHOLOGY (In order of abundance)	THICKNESS (In feet)	PHYSIOGRAPHIC EXPRESSION	STRATIGRAPHIC RELATIONSHIPS	REMARKS
GLIDDEN GROUP	MADDOX FORMATION		Black, fissile shale; black laminated micaceous siltstone; purple and grey, flaggy, fine-grained slightly micaceous feldspathic sandstone, purple siltstone.	300+	Poorly resistant; crops out in low hills and in creek banks.	Conformably overlies the Forman Sandstone; unconformably overlain by the Egan Formation.	Probably pre-dates the Kuniandi Group. Cone-in-cone structures present.
	FORMAN SANDSTONE		White and purple, massive to blocky, well sorted, fine-grained quartz sandstone.	220	Highly resistant; forms mesa in Matheson Hills, cuesta in Maddox Hills.	Conformably overlies the Matheson Formation; conformably overlain by the Maddox Formation.	Aquifer at base in Matheson Hills.
	MATHESON FORMATION		Cream to pale grey laminated claystone, cherty near base; black green and purple fissile laminated, occasionally micaceous shale and siltstone; purple and grey flaggy fine-grained, occasionally pyritic sub-greywacke and ferruginous feldspathic sandstone; purple medium-grained quartz sandstone.	1120	Moderately and poorly resistant; forms valley except for cherty siltstone beds which produce cuesta-form ridges.	Conformably overlies the Harms Sandstone; conformably overlain by the Forman Sandstone.	
	HARMS SANDSTONE		White, pink and purple fine blocky, medium, and coarse-grained quartz sandstone; purple laminated fissile to thinly flaggy shale interbedded with minor purple siltstone.	200	Resistant and poorly resistant; forms two cuestas separated by valley in Maddox Hills - two benches in Matheson Hills.	Unconformably overlies the Kimberley (and Crowhurst) Groups; conformably overlain by the Matheson Formation.	Probably post-dates Colombo Sandstone.



DIAGRAMMATIC SECTIONS
KUNIANDI GROUP

Figure 11

LANDRIGAN TILLITE (New Name)

Distribution: The Landrigan Tillite crops out along the western margin of the Kuniandi Range and along the northern and south-western parts of the McKinnon Syncline.

Reference Area: An area 12 miles north 60° west of Louisa Downs Homestead is designated as the reference area.

Derivation of Name: The unit is named after Landrigan Creek, which is a tributary of Christmas Creek.

Stratigraphic Relationships: In the Kuniandi Range area the Landrigan Tillite rests unconformably on the Lamboo Complex. In the McKinnon Syncline it rests unconformably on sediments and volcanics of the Kimberley Group. The formation is overlain conformably by either the Stein Formation or the Wirara Formation.

Lithology and Thickness: Over most of the outcrop area the formation consists of tillite overlain by thin beds of dolomite, but in the northern part of the Kuniandi Range the sequence is complicated by a thick lens of sandstone and siltstone which is intercalated in the tillite. The thickness of the formation ranges from 35 feet to 1100 feet.

Descriptions of the lithology of the unit in the Kuniandi Range area and in the McKinnon Syncline are given below:-

Kuniandi Range area: In section 3 (fig. 11) to the west of Louisa Downs, the Landrigan Tillite contains the following strata:-

OVERLAIN BY WIRARA FORMATION

30' Cream, blocky to flaggy, laminated dolomite: In thin section the dolomite consists of euhedral to subhedral recrystallised carbonate grains. The laminations are distinguished by alternation of crystalline and non-crystalline carbonates. Minor fractures traverse the rock and are infilled by secondary calcite and chalcedonic silica. The dolomite contains megascopic structures which might be stromatolites.

5' Tillite: Striated and polished black and red quartzite boulders and subordinate cobbles set in a green chloritic clayey matrix.

UNDERLAIN BY LAMBOO COMPLEX

To the south of the section locality the tillite is not developed and the cream dolomite rests directly on the Lamboo Complex. To the north the dolomite becomes a purple, thinly flaggy, finely laminated rock which contains thin partings of purple silt and shale.

Three miles north of Mount Bertram (Section 1, fig.11) the dolomite is absent but the tillite is much greater in thickness:-

OVERLAIN BY STEIN FORMATION

500' Tillite: Erratic boulders (10%) cobbles (50%) and pebbles (40%), which include sandstone, quartzite, granite and stromatolite-rich dolomite are set in a fine-grained purple and possibly ferruginous matrix. The largest boulders are six feet across and facetting and striations are rare; the boulders of granite and dolomite are of minor importance. The matrix of the tillite is identical in composition to the red greywacke in the overlying Stein Formation.

300' Sandstone and siltstone: These beds thin out and disappear to the south, and although they are regarded as a lens, it is possible that they were truncated by erosion prior to the deposition of the overlying tillite. The following sequence (from top to bottom) occurs within this part of the column:-

(a) Pebble conglomerate underlain by a red to white, blocky, coarse-grained feldspathic sandstone and red flaggy micaceous siltstone.

(b) Pink to yellow, thinly flaggy, finely laminated siltstone containing slump structures and graded beds. In thin section the siltstone consists of fine-grained quartz fragments set in a matrix of primary detrital muscovite, sericite and chlorite. Poorly developed graded bedding is present in the allogenic quartz fraction. The lamination is emphasised by change in grain size and the percentage of quartz to clay minerals, and the colour of the laminations varies with the amount of iron oxide present.

(c) White to purple, blocky, friable, coarse-grained, poorly sorted, feldspathic sandstone overlies a basal quartz pebble conglomerate. In thin section the sandstone consists of sub-angular and poorly sorted quartz grains, subordinate decomposed feldspar and fine-grained volcanic rock fragments, and rare detrital tourmaline set in a matrix rich in chlorite, sericite and saussurite.

300' <u>Tillite</u>: Erratics of quartzite cobbles and pebbles are set in a red ferruginous sand-clay-silt matrix.

10' <u>Quartz sandstone</u>: This bed has been mapped as part of the formation, but it could conceivably represent much older units*. In places it is up to 50 feet thick.

UNDERLAIN BY LAMBOO COMPLEX

<u>McKinnon Syncline</u>: No detailed sections have been measured in this area but two main lithologies are represented-dolomite and tillite.

Purple to pink, flaggy, thinly laminated to blocky, dolomite or silty dolomite defines the top of the Landrigan Tillite; it grades upwards into purple greywacke of the Stein Formation. In thin section the dolomite consists of microcrystalline dolomite and randomly distributed silt-sized detrital quartz grains (2%) and opaque minerals. Laminations are defined by alternate concentrations of dolomite, and dolomite coated by finely disseminated iron oxides which give the characteristic purple colouration to the rock. On the south-western margin of the Syncline this dolomite is absent and the Wirara Formation rests directly on the underlying tillite. The dolomite is usually about 30 feet thick.

The boundary between the dolomite and the underlying tillite is sharp. The tillite which is from 100 to 200 feet thick consists of well polished, striated and facetted boulders (50%), cobbles (30%) and pebbles (20%), set randomly in a purple or green clayey matrix. Towards the base the erratics are smaller and more angular, and the rock

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* I. Gemuts inclines to the latter view.

contains pebbles and subordinate cobbles set in a fine-grained sandy matrix. In thin section this rock consists of a subrounded to angular pebble aggregate set in a fine-grained ferruginous and arenaceous matrix which contains subrounded to angular detrital quartz grains, altered feldspars and clay minerals. The erratics include quartz sandstone, arkose, fine-grained acid igneous rocks, dolerite, and oolitic dolomite, the last having been derived from the Elgee Siltstone.

The tillite rests unconformably on rocks of the Kimberley Group; and in two localities near the northern edge of the basin polished and striated pavements have been observed beneath the glacial rocks. The finely cut, parallel striations are oriented east-west, and quarried surfaces (roches moutonees) in the eastern locality suggest ice movement from the east, although this cannot be established conclusively.

Palaeogeographic Significance: The glacial origin of the tillite is indicated by the presence in it of striated and polished boulders, its poor sorting, and lack of stratification and the presence beneath it of striated and polished pavements. Most of the erratics are of rock types with a wide distribution and for this reason little can be deduced as to their provenance even though in some cases they can be shown to have been derived from particular rock units.

There are no distinctive features to indicate the exact environment of deposition of the tillite, and it may have been formed under both terrestrial and marine conditions. However, the tillite is lithologically similar to terrestrially deposited Pleistocene lodgement and ablation tills (debris left behind retreating glaciers). Striated pavements may be caused by rock particles held in the sole of a glacier or by later submarine sliding and slumping of glacial deposits. In the absence of slumped glacial rocks in the Mount Ramsay Sheet area the first hypothesis seems more likely; the basal part of the tillite, at least, has formed sub-aerially.

The intercalated laminated siltstone and sandstone may represent deposition during an interglacial period. The laminated and slumped siltstones have the characteristics of varves consisting of alternate silt and clay rich laminae, with graded bedding commonly developed in the coarse laminae. The pebble conglomerates and sandstones are probably fluvio-glacial deposits.

The dolomite at the top of the formation may record the onset of warmer conditions and marine transgression.

Distinguishing Features: The base of the unit marked by an unconformity; the top is taken to be at the change in lithology from tillite or dolomite to purple or green well stratified lutites.

STEIN FORMATION (New Name)

Distribution: The Stein Formation crops out along the Kuniandi Range and in the McKinnon Syncline.

Reference Area: The reference area is 7 miles north 80° west of Louisa Downs Homestead.

Derivation of Name: The name is derived from Stein Creek, a newly named tributary of the Margaret River.

Stratigraphic Relationships: The Formation lies conformably between the Landrigan Tillite and the Wirara Formation.

Lithology and Thickness: The Stein Formation consists predominantly of purple greywacke and ranges in thickness from 0 feet to 700 feet. Detailed descriptions of the lithology in the two main areas of outcrop are given below.

Kuniandi Range Area: The formation consists of flaggy, thin bedded, poorly sorted coarse-grained purple greywacke with a ferruginous matrix. In thin section the rocks contain rounded and angular, poorly sorted quartz grains, severely altered feldspar and rare fine-grained igneous rock fragments set in a mica rich ferruginous matrix.

Graded bedding, subordinate cross bedding and ripple marks were noted. The formation lenses out to the north and south; its maximum thickness (700 feet) occurs three miles west of Bullock Paddock Bore. In the central part of Kuniandi Range the formation has been deformed and axial plane folds are commonly developed with a plunge of 10° to the south.

McKinnon Syncline: The dominant lithology in this area is a purple, blocky, thick bedded, poorly sorted ferruginous coarse-grained greywacke; the greywacke is interbedded with a purple powdery fissile siltstone and shale. Towards the top thin bedded, red to purple, flaggy greywacke appears. Sedimentary structures noted include ripple marks, slump rolls, graded bedding and elongate needle like casts.

In thin section the rocks consist of poorly sorted, angular to subangular quartz grains, altered feldspar and pyroxene fragments, fine-grained volcanic rock fragments, and rare detrital calcite and tourmaline grains, set in a matrix of chlorite, sericite and opaque minerals. Finely disseminated iron oxides impart the characteristic purple colouration to the rock.

Palaeogeographic Significance: The Stein Formation represents the final phase of glacial activity in the Kuniandi Group. The greywacke in this unit is identical to the matrix of the underlying tillite. The variations in thickness of the Formation suggests that it may have been deposited only in more strongly subsiding areas.

WIRARA FORMATION (New Name)

Distribution: The Wirara Formation crops out along the Kuniandi Range, within the McKinnon Syncline and in an area half a mile west of Hell's Gate

Reference Area: The reference area is 7 miles north 70° west of Louisa Downs Homestead.

Derivation of Name: The name is derived from Wirara Creek, a newly named tributary of the Margaret River.

Stratigraphic Relationships: The unit is conformably overlain by the Mount Bertram Sandstone, and overlies, with apparent conformity, the Landrigan Formation or the Stein Formation. The truncation of the Stein Formation beneath the Wirara Formation indicates either the non-deposition of the former or a possible unconformity at the base of the Wirara Formation. It is thought the first hypothesis is more likely.

Lithology and Thickness: Detailed descriptions of the Formation in its three main areas of exposure are given below:-

Kuniandi Range Area: The following section was measured through the Formation four miles west of Louisa Downs Homestead (see Section 3, figure 11).

1090' Purple, fissile to thinly flaggy, laminate, micaceous siltstone interbedded with thin bands of purple sandstone. The purple siltstone grades downwards into green to grey, thinly flaggy, laminated shale and siltstone. Green sandy bands with pyrite become prominent towards the base.

In thin section the purple fine-grained siltstone consists of a fine-grained mass of quartz, altered feldspar and disseminated iron oxides, set in a muscovite, sericite and chlorite rich matrix. The iron oxides give the purple colouration to the rock.

300' Brown, thinly flaggy siltstone and feldspathic sandstone with a siliceous matrix. Some of the rocks are dolomitic (towards the base).

85' The top is marked by a green fissile to thinly flaggy, laminated shale and siltstone. In thin section the green shale consists of equigranular well-sorted quartz grains, altered feldspar, with disseminated iron oxides and euhedral pyrite grains set in a muscovite, sericite and chlorite-rich matrix.

Towards the base there is a green, flaggy thin bedded sandstone with a clayey matrix. In thin section these rocks contain equigranular well sorted fine-grained angular quartz grains and subordinate plagioclase, microcline and tourmaline fragments set in a partially recrystallised clay matrix.

Further to the north, along Kuniandi Range the basal lithologies consist of a purple, fissile, micaceous, alternately green and purple laminated shale.

Along part of the Kuniandi Range the Wirara Formation is folded about a steeply dipping, closely-spaced, axial plane (slaty) cleavage; these folds plunge 10° south. In the more deformed areas detrital quartz grains in the siltstone have been rotated and aligned, together with secondary sericite, muscovite and chlorite, parallel to the axial plane cleavage.

Hell's Gate District: In this area the Wirara Formation consists of poorly outcropping green to grey cleaved and fissile chlorite-rich shale and siltstone (Section 4, fig. 11).

McKinnon Syncline: The Formation is represented by poorly outcropping fissile, finely laminated, green to grey shale with thin partings of a green cherty siltstone and fine-grained flaggy sandstone. The sandstone is current-bedded and contains small chert lenses and pyrite; subordinate purple shale partings were noted at the top of the unit. It would seem that only the basal part of the formation is exposed in this area.

Palaeogeographic Significance: The colour change in shales and siltstones of the Wirara Formation is an important indicator of the chemical environment of deposition, and is dependent on the degree of oxidation of iron. In the green shales iron is largely in the ferrous state in the form of pyrite whereas the red shales contain finely divided ferric oxide in the form of hematite.

The Wirara Formation was deposited in a slowly subsiding shallow basin. The alternation of red and green shales in the sequence indicates a rhythmic change from an oxidising to a reducing environment. Sandstone partings in the top of the formation indicate an alternation from calm water, favourable to the deposition of fine material, to strong currents which brought coarser sediments from the shore into the basin.

MOUNT BERTRAM SANDSTONE (New Name)

Distribution: The Mount Bertram Sandstone crops out along the Kuniandi Range and the J13 ridge north of Hell's Gate.

Reference Area: The reference area is 7 miles north 70° west of Louisa Downs Homestead.

Derivation of Name: The name is derived from Mount Bertram.

Stratigraphic Relationship: The Mount Bertram Sandstone is overlain with probable unconformity by the Egan Formation; it is conformable with the underlying Wirara Formation.

Lithology and Thickness: The Mount Bertram Sandstone consists of purple to grey, dominantly flaggy and thin bedded, well sorted, fine-grained, micaceous sandstone and minor siltstone; the matrix is ferruginous. Towards the base purple fissile shale and siltstone interbeds are present. Oscillation ripple marks, graded bedding and clay pellet cavities occur throughout the whole unit.

In thin section the sandstone consists of equigranular, angular to subangular detrital quartz grains and rare tourmaline fragments set in a matrix of muscovite, sericite, chlorite and disseminated iron oxides. The ferruginous minerals are concentrated along the boundaries of individual grains.

Four miles west of Louisa Downs Homestead the Sandstone is 590 feet thick.

Palaeogeographic Significance: The Sandstone marks a transition from the calm water conditions of Wirara Formation to deposition by strong currents which brought coarser sediments from the shore into the basin.

UNDIFFERENTIATED

In the south-central part of the Sheet area, to the east of Christmas Creek, sedimentary rocks rest unconformably on the Olympio Formation of the Halls Creek Group, and are unconformably overlain by the Egan Formation. Some of the rocks in this area closely resemble rocks of the Kuniandi Group; others appear to be atypical. It is thought that the beds may belong to the Kuniandi Group* and for convenience they have been mapped as "Undifferentiated" Kuniandi Group. They are generally poorly exposed and have been faulted prior to the deposition of the Egan Formation.

In the easternmost exposures, in a north-easterly plunging syncline, the following succession is present:-

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* I. Gemuts considers that some of the rocks may belong to the Speewah Group.

TOP NOT EXPOSED

200' (+)	Poorly exposed strata - not seen in outcrop.
150'	White medium-grained siliceous quartz sandstone. Strongly resistant.
500'	Purple, finely laminated siltstone.
200'	Brick red blocky pebble conglomerate. Pebbles up to ¼ inch in diameter are set in a ferruginous clay-silt matrix. Poorly resistant
100'	Pink coarse-grained poorly sorted quartz sandstone, may be slightly feldspathic. Matrix consists of iron oxide stained clay. Poorly resistant.
200'	White to pink strongly cleaved and silicified medium-grained quartz sandstone. Strongly resistant.

OVERLIES HALLS CREEK GROUP

The basal sandstone bed can be identified at several localities to the west and although the overlying coarser-grained, less resistant beds are present they are interbedded with leached laminated siltstone. In some localities in the western exposures the basal sandstone appears to be overlain by flaggy, laminated grey-green cherty siltstone beds, but the rocks may be brought into juxtaposition by faulting.

TABLE 10 : SUMMARY OF STRATIGRAPHY - KUNIANDI GROUP

ROCK UNIT	MAP SYMBOL	LITHOLOGY	THICKNESS IN FEET	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION OF EXPOSURES	STRATIGRAPHIC RELATIONSHIPS	REMARKS
UNDIFFERENTIATED	Bn	Purple laminated siltstone, red pebble-conglomerate, white and pink, coarse and medium-grained quartz sandstone, grey-green cherty siltstone.	About 1350+	Strongly resistant and poorly resistant; forms strike ridges and valleys.	In south-central part of Sheet area, east of Christmas Creek.	Overlain unconformably by Egan Formation; rests unconformably on Olympio Formation.	Identification as Kuniandi Group not certain.
MOUNT BERTRAM SANDSTONE	Bnb	Purple to grey, flaggy thin bedded, well sorted, fine-grained micaceous and ferruginous sandstone and minor siltstone. Towards the base abundance of purple fissile shale and siltstone interbeds increase. Oscillation ripple marks, graded bedding, cross-bedding and clay pellet cavities common.	400-600	Resistant; forms cuesta.	Kuniandi Range and near Hells Gate.	Overlain with probable unconformity by Egan Formation. Lies conformably on Wirara Formation.	Forms main spine of Kuniandi Range.
WIRARA FORMATION	Bnw	At the top purple fissile to thinly flaggy laminated siltstone interbedded with purple sandstone. Grades downwards into green to grey, thinly flaggy laminated shale and siltstone with pyrite. At the base brown thinly flaggy siltstone and green flaggy thin bedded sandstone with pyrite.	1475-1600	Poorly resistant, forms broad low lying flats or undulating country.	Kuniandi Range, McKinnon Syncline and near Hells Gate.	Conformably overlain by Mount Bertram Sandstone; rests with apparent conformity on Stein Formation or on Landrigan Tillite.	May be unconformity at base
STEIN FORMATION	Bns	Flaggy, thin bedded, poorly sorted, coarse-grained, purple greywacke with a ferruginous matrix. Graded bedding, cross-bedding, slump rolls and ripple marks common.	0-700	Moderately resistant; forms rounded, steep hills or low rises.	Kuniandi Range and McKinnon Syncline.	Rests conformably on Landrigan Tillite; overlain with apparent conformity by Wirara Formation.	Matrix of greywacke identical to matrix of tillite in the Landrigan Tillite.
LANDRIGAN TILLITE	Bnl	Unstratified massive tillite with erratic boulders, cobbles and pebbles, which include sandstone, sub-arkose, stromatolite rich dolomite granite and dolerite, all set in a purple clayey or sandy matrix. The tillite contains thick lenses of sandstone and siltstone and is capped by purple or cream, thinly flaggy, laminated dolomite.	55-1100	Moderately or poorly resistant; tillite forms rounded, boulder strewn hills or flats; sandstone forms strike ridges.	Kuniandi Range and McKinnon Syncline.	Rests unconformably on Lamboo Complex; overlain conformably by Stein Formation and with apparent conformity by Wirara Formation.	Glaciated pavements underlie the Tillite at two localities in the McKinnon Syncline. Dolomite contains vague ?stromatolites.

LOUISA DOWNS GROUP (New Name)

Distribution: The Louisa Downs Group crops out extensively in the Mount Ramsay Sheet area. Exposures occupy large tracts of country in the central and south-central parts of the area, and extend, as outlying faulted wedges, into the north-eastern part of the area. Outlying exposures lie in the "core" of the O'Donnell Syncline.

Reference Area: Reference areas are designated for each of the Group's component formations, but since these are at widely separated localities, no Group reference area is nominated.

Derivation of Name: The name is derived from Louisa Downs pastoral lease.

Components: The Group contains five units of formation status:-

Lubbock Formation
Tean Formation
McAlly Shale
Yurabi Formation
Egan Formation

Stratigraphic Relationships: The Louisa Downs Group overlies the Kuniandi Group with probable unconformity; it is unconformably overlain by the Lally Conglomerate which is of probable Lower Cambrian age. Local disconformities occur within the Egan Formation and between the Egan Formation and the overlying Yurabi Formation.

Lithology and Thickness: The Group consists predominantly of shale, sub-greywacke and siltstone; tillite and associated carbonate-bearing rocks (which occur at the base of the Group) and beds of quartz sandstone, arkose and pebble conglomerate are important "marker" units, but make up only a small part of the total thickness of the Group.

The maximum observed thicknesses of each of the component formations combine to give a total thickness of about 13,000 feet, but the top of the succession has been eroded and the original thickness may have been greater.

The component formations are described below and a summary of the descriptions is given in Table 12.

EGAN FORMATION (New Name)

Distribution: The Egan Formation is known only in the Mount Ramsay Sheet area. It crops out in two main areas - one occupies the "core" of the O'Donnell Syncline (fig.12), and the other is to the south, in the central and southern part of the Sheet area, around the margins of a broad faulted syncline. Small, isolated exposures occur east of Lily Hole Bore, at Pavement Hill (fig. 13) and in an area several miles to the east of Lilly Lagoon.

Figure 12: Egan Formation (centre) - O'Donnell Syncline. Thin dark beds of carbonate rocks of Egan Formation capped by sandstone of Yurabi Formation, in turn overlain by McAlly Shale (low ground - right centre). Egan Formation rests on Collett Siltstone (lower part of escarpment), which is in turn underlain by Liga Shale (valley floor) and Hilfordy Formation (dip slope on left). Alluvial flats of Margaret River and sandstone hills of the Mount Cummings Plateau in background. Photo taken eight miles south of Hibberson Bluff.

Reference Area: The most readily accessible exposure of the unit is in the Egan Range, where it is crossed by the Great Northern Highway. Although the section at this locality does not include all the rock types of the Formation, it does contain the best exposures of tillite (an important component of the unit) and for this reason has been designated the reference area.

Derivation of Name: The name is derived from the Egan Range, a newly named feature, which is crossed by the Great Northern Highway near Stockyard Crossing.

Stratigraphic Relationships: The Egan Formation is the lowermost formation of the Louisa Downs Group. It rests unconformably on the Glidden Group, and older rocks, and is thought to rest with unconformity on the Kuniandi Group. No direct evidence of unconformity between the Egan Formation and Kuniandi Group is available in the Kuniandi Range, but near the southern-central margin of the Sheet area, rocks which have been mapped as "Undifferentiated" Kuniandi Group are overlain with angular unconformity by rocks of the Egan Formation. In the Kuniandi Range an examination of the succession within the Egan Formation shows that a disconformity occurs at its base.

The unit is overlain with at least local disconformity by the Yurabi Formation; aspects of this relationship will be discussed in a later section.

Lithology and Thickness: The Egan Formation contains a great variety of rock types which appear to represent a wide spectrum of climatic and environmental conditions. In an attempt to reconstruct the sequence of events responsible for the deposition and preservation of the unit, we have measured (in most cases with Tape and Abney level) sixteen sections through the unit at widely distributed localities. The sections are shown diagrammatically on figure 20; full details of the lithologies and thicknesses are given in Appendix I and the section localities are shown on the accompanying 1:250,000 Sheet, where they are distinguished by the prefix E.

The thickness of the Formation rages from about 100 to 650 feet, but is generally between 170 and 220 feet.

The Formation may be broadly subdivided into three (fig.20) - an upper, carbonate-arenite sequence (subdivisions D to J); a median tillite (subdivision C); and a lower arenite-lutite-carbonate sequence (subdivisions A and B). The lower sequence is present only in the southern and eastern exposures of the Formation.

Subdivision A consists essentially of coarse-grained arkose and is exposed only in the southern and south-eastern areas. It is thickest in section 11 (310 feet), but is absent in the exposures of the Formation further to the south. It is present in the Egan Range and in the reference area, but has not been recognized to the north or west, where (Section 14 and 15) the base of the unit,

(<u>Subdivision A_1</u>), consists largely of sandy limestone or calcareous sandstone. As suggested on figure 20 the beds in A_1 could be a facies equivalent of unit A.

<u>Subdivision B</u> consists of yellow, laminated, cherty siltstone; it is 120 feet thick in section 11, but as with subdivision A, does not occur in the more southerly exposures of the Formation; it is even more restricted in its distribution than subdivision A, and does not occur in the reference area (Section 13), or in areas to its north or west (Sections 14, 15, 16). In view of the porosity in parts of the cherty siltstone it is possible that they may have originally contained carbonate minerals. The dolomite of subdivision B_1 in sections 13-15 is thought to be a stratigraphic equivalent of the siltstone of subdivision B. Rocks which have been placed tentatively in B_1 occur in section 8, and in the western part of the Maddox Hills.

<u>Subdivision C</u> is a tillite. It is up to 120 feet thick (Section 11) and is the first subdivision recognisable over extensive areas. It is assumed that only one tillite occurs in the succession, and that it was deposited more or less simultaneously throughout the area.

Although shown in only one section (section 1) in the northern region, it is also known to occur near Liga Creek and at Pavement Hill. At Pavement Hill (fig.13) and near the Section 1 locality the tillite rests on striated bedrock (figs. 14 and 15); the striations are interpreted as being of glacial derivation and, in both cases, indicate ice movement from the north.

<u>Figure 13</u>: Pavement Hill (on right), viewed from west. Margaret River in foreground. Glaciated pavement cut on slope of Pentecost Sandstone (right): overlain by 5 feet tillite, 50 feet Subdivision H (forms hill on left).

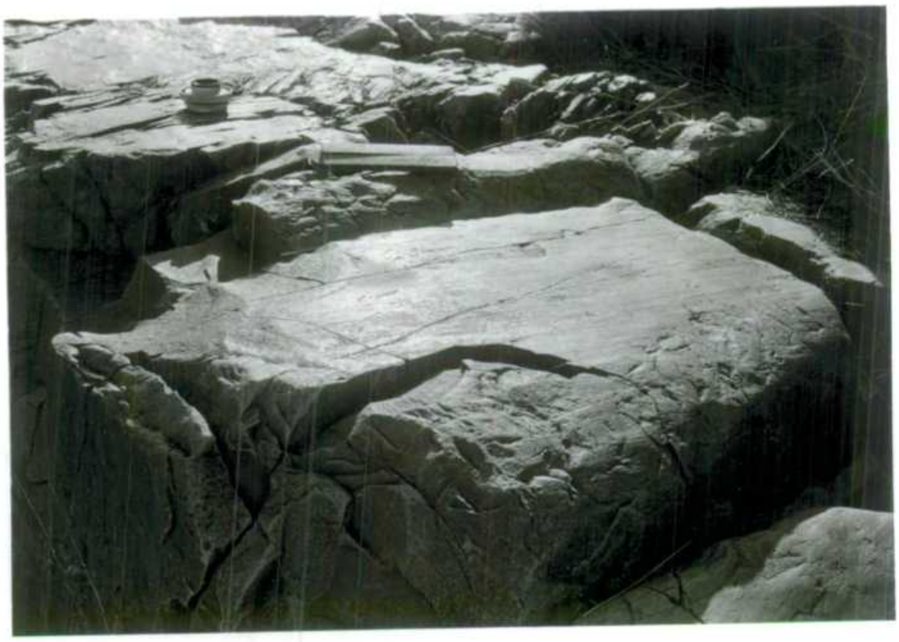

Figure 14: Polished and grooved bedrock (Pentecost Sandstone) at Pavement Hill. Underlies tillite of Subdivision C of Egan Formation.

Figure 15: Close-up of Figure 14

If pre-tillite sediments were deposited in the north, the presence of striated bedrock indicates that they were removed, at least in some places, by erosion prior to the deposition of the tillite, but since there is no exposed and preserved record of pre-tillite sedimentation in this area there is no need to suspect an unconformity or disconformity at the base of the tillite in the southern areas. Thus the accumulation of Subdivisions A, A_1, B and B_1 and C in sections 12 to 15 may have been a continuous and uninterrupted process. The possible representatives of B_1 noted in the Hell's Gate area (Section 8) may have overlapped the "basement" near the northern limit of the sedimentary surface, the areas to the north perhaps remaining sub-aerial.

The tillite is generally poorly exposed; in most places the matrix has been removed by erosion, leaving unconsolidated gravels composed of erratics. However, a sufficient number of exposures are available to indicate that the matrix normally consists of a massive, purple, grey or green mixture of clay and silt sized grains. The only anomaly is in section 12 where the matrix appears, in hand specimen, to consist mainly of silt sized grains. Erratics are invariable scattered more or less at random throughout the matrix but their concentration, size, shape, and composition, vary greatly from place to place. The most common erratics are ovoid, and less commonly angular, boulders, cobbles and pebbles of quartzite and silicified quartz sandstone; these usually have traces of polishing and, less commonly, are striated. Rare boulders are up to 10 feet in diameter. Boulders of a characteristic dark-coloured pebble conglomerate from the Pentecost Sandstone are occasionally seen. Erratics of dolomite (some derived from the Crowhurst Group) are present in some areas, but constitute only a minor part of the total volume of erratics. Similarly, erratics of granite and other igneous rock types are rare (and may be lacking) except in the north-easternmost exposures (section 16).

In the two most north-easterly sections (15 and 16) lenses of dolomitic sandstone occur within the tillite and may represent a brief fluvial interlude; in section 15 a small lens of dolomite-breccia occurs 5 feet above this dolomitic sandstone lens.

Subdivision D: In sections 8 and 10 subdivision C is overlain by yellow and pink flaggy dolomite. In section 9 a similar dolomite rests unconformably on the Lamboo Complex, although nearby it appears to rest unconformably on purple and green shales which may belong to the Kuniandi Group - the exposures of shale are too small to be shown on the accompanying map.

In section 9 the dolomite is overlain by a distinctive 3 foot thick bed of dark grey dolomite, which includes a dolomite conglomerate band. This bed is regarded as the only representative of a succession (subdivision E), which, further to the north (e.g. in sections 4 and 6), rests directly on "basement" and/or on subdivision C. It seems likely therefore that the beds shown as subdivision D pre-date those shown as subdivision E, although the possibility of contemporaneity cannot be entirely dismissed. The presence of dolomitic strata (D?) underlying subdivision E in section 2 tends to support this hypothesis.

The correlation of subdivision D strata from section 9 to sections 8 and 10 is good. The beds shown as subdivision D_1 in sections 12, 13 and 15 are thought to be stratigraphic equivalents of subdivision D - the general lithological association appears in all sections - yellow and pink dolomite is dominant in sections 8 and 9; in sections 10, 13 and 15 purple dolomitic siltstone is associated with similar dolomites, and in section 12 purple dolomitic siltstone becomes the dominant lithology. Thus there appears to be an increase in the importance of siltstone relative to that of dolomite to the south. The southernmost section (section 12) contains the greatest preserved thickness of subdivision D or D_1 strata (40 feet), but it is likely that it does not represent the full succession because erosion probably occurred prior to the deposition of the Yurabi Formation.

Subdivision E is confined to sections 1 to 9 and a probable equivalent (E_1) occurs in section 16. The subdivision and its equivalent are thus restricted to the most northerly parts of the area. In sections 2-7 the top of the subdivision is readily distinguished because it is marked by a sharp, and probably widely isochronous lithological change. Due probably to unconformity, its top is not represented in section 8, and in section 9 the whole subdivision appears to be represented by a 3 feet thick bed of dark grey dolomite and pebbly and cobbly dolomite (figs. 16, 17 and 18).

In section 9 many of the pebbles, cobbles and boulders appear to have been dropped into their cementing medium (dolomite) rather than rolled by traction currents, but "draping" of the dolomite laminae over some of the megaclasts (figs. 17 and 18) shows that the deposition of carbonate minerals and megaclasts proceeded apace.

Figure 16: Conglomerate of Subdivision E, Egan Formation, Section 9. Pebbles and cobbles of dolomite and jointed quartzite set in dolomite matrix. Underlain (on left) and overlain (on right) by laminated dolomite.

Figure 17: Subdivision E, Egan Formation, near section 9. Laminated dolomite (left), overlain by conglomerate with quartzite pebbles and boulders set in dolomite matrix, then by conglomerate with dolomite clasts set in dolarenite matrix.

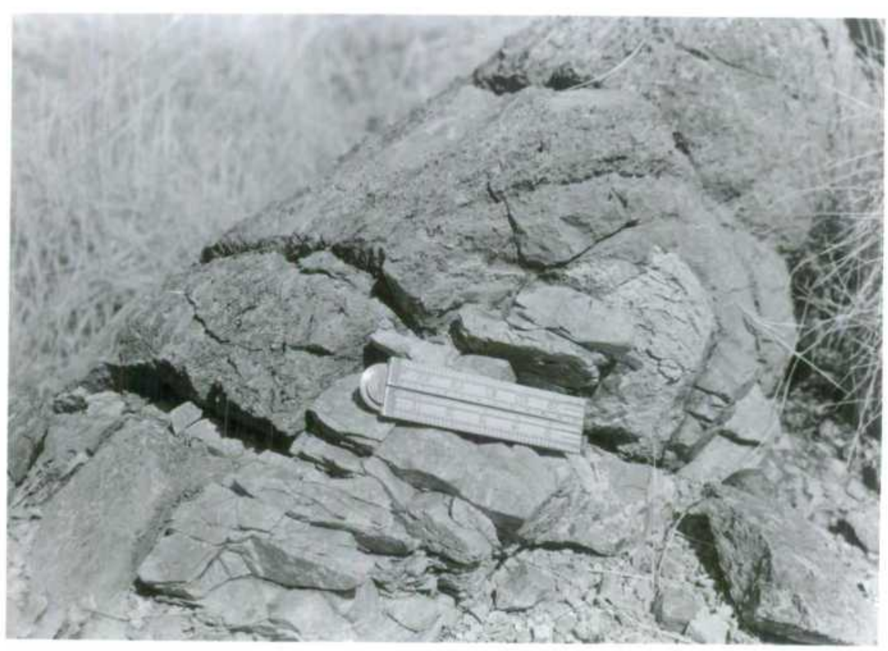

Figure 18: Close-up of Figure 17 showing dolomite matrix around large quartzite boulder.

In the north-west, subdivision E can, in most places, be further subdivided into three - the lowermost beds, which have a maximum observed thickness of 76 feet (in section 1) consist essentially of poorly sorted sandstones, many of which are calcareous. Pebbles occur throughout the beds, but are usually more common low in the succession. The sandy beds are more resistant to erosion than the overlying strata which, in many places, separate them from the upper part of subdivision E.

The less resistant strata are totally obscured by scree in sections 1 and 2, and do not appear to be represented in section 4, where their place is taken by conglomerate. In sections 3, 5 and 7 the beds consist predominantly of pink or yellow flaggy to blocky laminated dolomite; in the latter the dolomite contains conspicuous proportions of terriginous silt and sand. In section 6 the less resistant beds are represented. by a dolomite 32 feet thick containing boulders, cobbles and pebbles of quartzite and other rock types. This distinctive rock-type occurs at the top of the less resistant column in section 5 and at its base in section 7; which strongly suggests that it was deposited in section 6 for the most part contemporaneously with the deposition of the laminated dolomite in sections 3, 5 and 7.

The uppermost beds of subdivision E in the north-west consist of medium-grained, flaggy to massive, slightly calcareous and sometimes pebbly sandstone; they have a maximum thickness of 52 feet (in section 2).

In the north-east (section 16) sandy strata (E_1) overlie subdivision C and are interpreted as being equivalent to subdivision E. The beds consist predominantly of fine to coarse-grained quartz sandstone; some of the beds may have originally contained a carbonate component in the matrix. A 1 foot thick bed of conglomerate occurs near the middle of the subdivision and may be a correlative of similar strata noted in the middle of E in the north west (e.g. in Section 6).

<u>Subdivision F</u> consists of pink and yellow, flaggy, laminated limestone and is usually poorly exposed. It is confined to the northern sections (1-7) but may be represented, in a time sense, by strata near the base of

subdivision G in section 9 and possibly by strata labelled F_1 in section 16. It may have been deposited elsewhere but it has not been preserved. The maximum thickness of the subdivision is 40 feet (section 3). The possible equivalent of subdivision E in section 16 (E_1) consists essentially of the same lithology as E, but contains interbeds of purple calcareous shale.

Subdivision G is of very distinctive lithology. It consists predominantly of grey, regularly laminated, silty or sandy limestone with a maximum observed thickness of 98 feet (in section 2). The contact between subdivisions G and H is sharp and in some places (e.g. in section 7) is marked by a limestone breccia.

Subdivision H consists mainly of massive dark grey limestone. In about the middle of the unit light grey, irregular dolomitic bands become conspicuous and towards the top oolitic beds are commonly present. Stromatolites have been noted at the top of the subdivision in sections 5 and 7 and they are known to occur at or near the base of the beds near Pavement Hill. When freshly broken the dolomite commonly gives rise to a foetid odour, presumably because of the presence of sulphides. This unit is thus a good marker horizon, and has been recognized throughout the northern area, and also at the top of section 14. It has also been observed two miles to the east of section 14, and south of section 12. In the latter locality its stratigraphic position cannot be determined.

The fact that subdivision H rests on subdivision C in section 14, on D in section 10, and on E in section 8 shows that the unit is disconformable on at least some of the older beds; it is not known whether this is due to non-deposition of the missing units or to erosion prior to the deposition of subdivision H.

Subdivision J overlies subdivision H with apparent conformity and consists of pink, cream and occasionally, grey, flaggy laminated silty dolomite with, in places, interbeds of pink and yellow dolomitic siltstone; it is represented in section 10 by purple fissile shale. The beds have a maximum preserved thickness of 100 feet in section 10, but erosion may have occurred prior to the deposition of the Yurabi Formation and the thickness could have been greater. The subdivision is exposed only in the north-western part of the area (sections 1-10). Although the beds may have been deposited elsewhere they have not been preserved.

Distinguishing Features: Except in the Kuniandi Range the base of the Egan Formation is readily distinguished by an unconformity. In the Kuniandi Range its base is marked by tillite, and although this is usually very poorly exposed its presence can usually be detected by the appearance of ovoid boulders in the soil. The top of the unit is marked by the appearance of medium-grained sandstone of the Yurabi Formation, which, in most places, is disconformable on the Egan Formation.

Palaeogegraphic Significance: The strata of the Egan Formation were laid down under a series of contrasting physical, chemical and climatic conditions; although many of our interpretations may be found to be in error, the diversity of rock types and their unusual lateral and superpositional relationships require comment.

For the purposes of this discussion, it is assumed that the superpositional sequence postulated in the preceeding account of the lithology of the Formation is valid. A summary of our interpretations with regard to the environment of deposition of the various components of the Formation is given in Table 11. A summary of the distribution, stratigraphic relationships, composition and possible climatic significance of the various components is given in figure 19.

Subdivisions A, A_1, B, B_1, C, D and E all rest, in places, directly on the basement rocks, and except in the Kuniandi Range district, an unconformity is readily apparent at the base of the Formation. However, in the Kuniandi Range (section 10) subdivision C rests directly on older rocks which have no lithological counterparts in either of subdivisions B or C; the older rocks are part of the Kuniandi Group, indicating that a substantial gap does indeed occur in the sedimentary record.

The arkose comprising subdivision A is generally coarse and very coarse-grained and appears to have been derived predominantly from coarse-grained, and probably porphyritic, granites - the grain-size and the high feldspar content of the subdivision suggest that the granitic terrain may have been reasonably close at hand. The thickness of A undergoes drastic reduction between sections 11 and 12 but maintains its general order of thickness between sections 12 and 13.

Subdivision A_1 (sections 14 and 15), which is thought to be possibly contemporaneous with subdivision A consists essentially of grains of quartz and feldspar sand and finely crystalline calcite; the relative proportions of these constituents vary laterally and vertically. Thus, while coarse-grained arkose was being deposited further to the south, medium-grained quartz-feldspar sands may have been deposited, along with carbonate minerals, in the north.

Subdivisions B and B_1 are regarded as likely to have been deposited more or less contemporaneously. The laminated cherty siltstones which comprise subdivision B, as with the rocks of subdivision A, are found in section 11, but are not present further to the south; their thickest development, as in the case of subdivision A, is in section 12. No sedimentary structures apart from bedding have been recognised in subdivision B, but it is thought that the regular bedding lamellae may indicate that the rocks were deposited in a reasonable depth of water; certainly subsidence in the area around section 12 was more pronounced than elsewhere.

Subdivision B_1, which consists predominantly of pink grey and yellow dolomite appears to be essentially a chemical deposit; vague stromatolite(?) forms have been noted near the base of the subdivision in section 15. The rocks of the subdivision have striking similarity to some of the strata in subdivision D (particularly the beds in sections 9 and 10) and since D overlies the tillite, and B_1 underlies it, their characteristic may be the result of deposition in similar environments.

Subdivision C consists of tillite and is clearly the product of a major period of glaciation. Although north-south striations carved on the bedrock are present in at least two localities in the north, the apparently conformable relationships between B, B_1 and C in the south and east suggest that these areas may have been sub-aqueous throughout the glacial epoch. Sandy lenses present in sections 15 and 16 probably record a brief ice retreat. The final ice retreat probably led to the deposition of the tillite now preserved in the north.

Subdivision D consists mainly of pink, grey and yellow dolomite and is confined to the west (sections 8, 9 and 10) while in the east its probable equivalent (D_1) consists of purple dolomitic siltstone, pink and yellow dolomite and rare sandy beds. The strata may have been deposited in a similar environment to subdivision B_1. The comparative abundance of terriginous detritus in the east suggests that it may have been derived from that direction.

Subdivision E is restricted in its present distribution and is found only in the northern parts of the area. Its absence in the south may be due entirely to erosion, but the marked thinning of the subdivision between sections 7 and 9 shows that - at least in the west - it was lenticular. The presence of slightly polished pebbles, cobbles, and boulders and the poor sorting in the lower part of the subdivision suggests that much of the clastic material may have been derived from a landscape recently relieved of its ice burden. The middle part of the subdivision consists essentially of dolomite, but in places the dolomite is host to megaclasts of quartzite, dolomite and other rock types, some of which appear to have been impacted, suggesting that they may have been deposited from icebergs. In section 6 megaclasts are particularly abundant, suggesting, perhaps, that the locality may have been near the site of a terminal moraine. Thus if ice retreat resulted in the deposition of the lower part of the subdivision, ice transgression may have once again protected the source of the terriginous clastics and permitted only the accumulation of dolomite (and ice-borne erratics). Subsequent retreat may have once again bared the landscape to fluvial erosion, giving rise to the deposition of the upper part of subdivision E.

Subdivision F is reasonably consistant in lithology both laterally and vertically and in contrast to subdivision E it is almost free of terriginous clastic material. It may be a lagoonal deposit.

Subdivision G marks the beginning of a new regime - terriginous silt and sand re-appear and the dolomite becomes dark grey, due probably to the presence of finely dispersed iron sulphide. The volume of carbonate minerals deposited exceeded the volume of terriginous detritus supplied. The latter was deposited at regular intervals and is responsible for the fine lamination which characterises the rocks of the subdivision.

Subdivision H appears to have been deposited under rather similar conditions, but perhaps in shallower waters beyond the reach of the terriginous supply. The presence of sulphide minerals indicates that the unit was deposited mainly in poorly circulating waters. The appearance of oolites in the upper part of the unit records a period of more active circulation. The presence of stromatolites near the top of the unit, and, in places, near its base suggests that organisms may have assisted in the production of sulphur, and with the oolites suggests perhaps that, during this interval, the water was reasonably warm.

Subdivision J contrasts strongly in colour and its bedding characteristics to subdivision H. The unit may have been deposited in a lagoonal environment, but nevertheless in more freely circulating waters.

TABLE 11 : SUMMARY OF LITHOLOGY, SEDIMENTARY STRUCTURES AND POSSIBLE ENVIRONMENT OF DEPOSITION OF SUBDIVISIONS OF EGAN FORMATION

SUB-DIVISION	PRINCIPAL ROCK TYPES[II]	DOMINANT COLOURS	BEDDING[III] PARTINGS	BEDDING[III] STRATIFICATION	SEDIMENTARY STRUCTURES AND OTHER FEATURES	SUGGESTED ENVIRONMENT OF DEPOSITION	SUGGESTED ENVIRONMENT OF DEPOSITION: WATER CIRCULATION	SUGGESTED ENVIRONMENT OF DEPOSITION: CLIMATE
J	Dolomite, silty dolomite.	Pink, yellow, grey.	Flaggy.	Laminated to thin-bedded.		Marine, Lagoonal (?).	Moderate.	Warm(?).
H	Limestone.	Black, grey.	Massive to blocky.	Thick-bedded	Pyrite, oolites stromatolites, cross beds.	Marine, neritic, intertidal.	Poor for most part.	Warm.
G	Sandy limestone, silty limestone.	Dark grey, grey.	Flaggy.	Laminated.	Micro cross beds.	Marine, neritic.	Poor to moderate.	Warm(?).
F	Limestone.	Pink, yellow.	Flaggy.	Laminated.	Micro cross beds.	Marine, lagoonal(?).	Moderate.	Temperate.
	Calcareous sandstone.	Buff, grey.	Flaggy.	Laminated.		Marine, neritic.	Moderate.	Cool.
E	Dolomite, silty, sandy, cobbly dolomite.	Pink, yellow.	Flaggy to blocky.	Laminated	Impacted erratics.	Marine.	?	Glacial
	Pebbly calcareous sandstone.	Buff, brown.	Flaggy to blocky.	Thin-bedded.	Current ripple marks, cross beds.	Marine, littoral.	Strong.	Cool.
D1	Dolomite.	Pink, light grey, yellow.	Blocky.	Thin-bedded.	Stromatolites(?)	Marine.	Weak.	Cool.
D	Dolomitic siltstone, dolomite.	Purple, pink, yellow.	Fissile to blocky.	Laminated to thin-bedded.				
C	Tillite	Purple, grey-green.	Massive.		Abundant erratics.	Marine.	?	Glacial.
B	Cherty siltstone.	Yellow.	Massive to flaggy.	Laminated.		Marine, neritic.	Weak.	Cool.
B1	Dolomite.	Pink, light grey, yellow.	Flaggy to blocky.	Laminated to thick-bedded.	Stromatolites(?)	Marine.		
A	Arkose.	White, pale green.	Massive.	Thick-bedded.		Marine, littoral, neritic.	Strong.	Temperate(?)
A1	Calcareous sandstone, sandy limestone.	Buff, grey.	Flaggy,	Laminated.	Rare cross-beds.	Marine, lagoonal, neritic.	Weak.	

II The nomenclature applied to the carbonate-bearing rocks is based on a very limited number of optical and chemical determinations, and should be regarded only as tentative.

III The nomenclature applied to the parting and stratification intervals is given in Table , Appendix I.

FIGURE 19

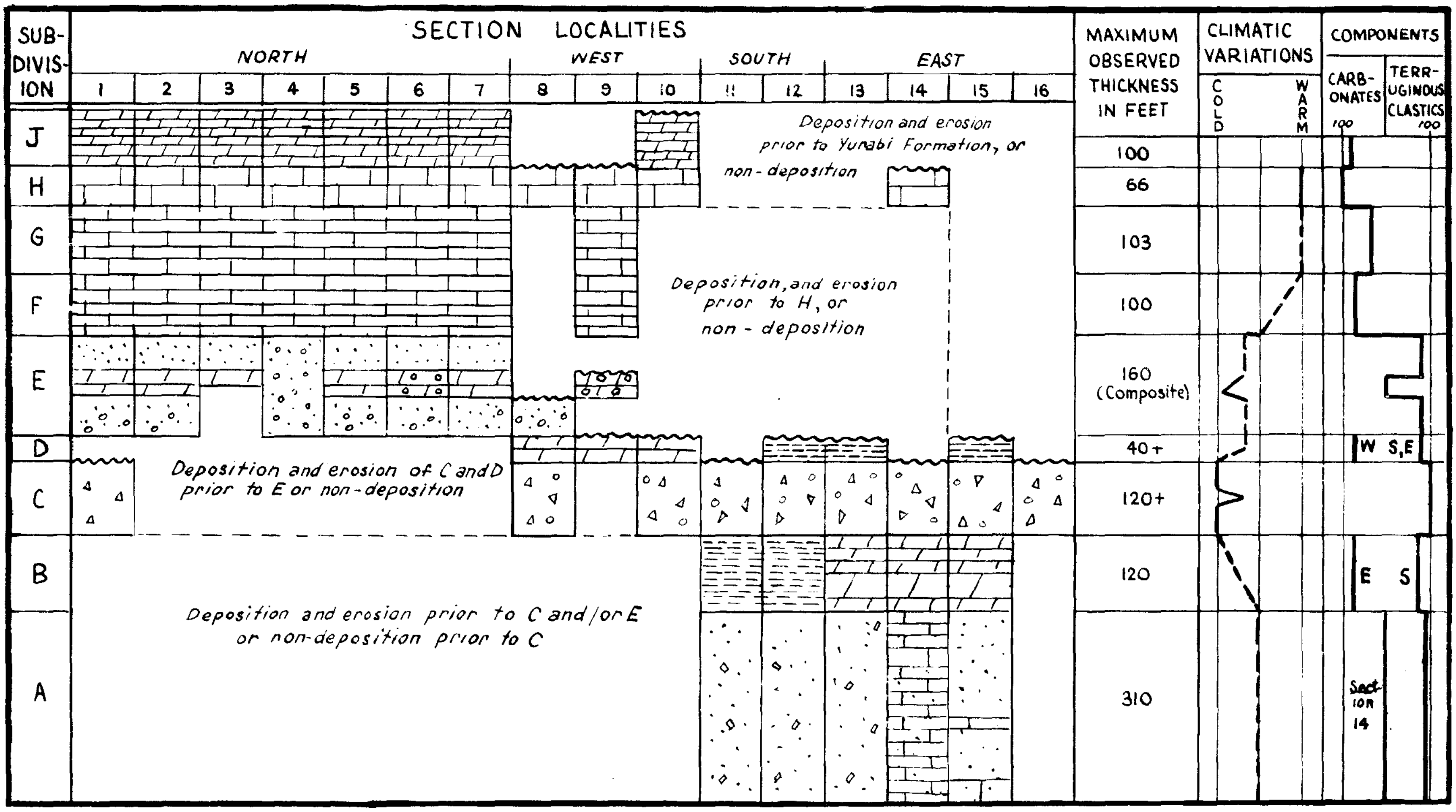

FIGURE 19 : Graphical summary of description of Egan Formation showing subdivisions, their distribution, principle lithologies, maximum thickness, possible climatic significance and gross carbonate content. Key to lithological symbols is given on fig. 1, Appendix I.

FIGURE 20

STRATIGRAPHIC SECTIONS - EGAN FORMATION

Key to lithological symbols is given on fig.2, App.-I. Asterisk (*) denotes stratigraphic position of sample taken for thin sectioning or analysis. Correlations are shown by solid line where evidence is good, broken where uncertain. Section localities are shown on Plate I by numerals prefixed by the letter E.

YURABI FORMATION

Distribution: The Yurabi Formation is known only on the Mount Ramsay Sheet area. It crops out over widely separated areas in the central, southern and north-eastern parts of the Sheet area, and in the O'Donnell Syncline.

Reference Area: Readily accessible exposures of the Formation occur near the Great Northern Highway where it crosses the Egan Range; the area immediately to the north of the Highway is designated as the reference area.

Derivation of Name: From the Yurabi pastoral district.

Stratigraphic Relationships: The Yurabi Formation overlies the Egan Formation with at least local disconformity. Figure 20 shows that a variety of rock types probably representative of different time-intervals, directly underlie the Yurabi Formation, and it is on this evidence that the disconformity is postulated. The Yurabi Formation is conformably overlain by the McAlly Shale, but in places the boundary is time-transgressive and the lowermost beds of the McAlly Shale grade laterally into the uppermost beds of the Yurabi Formation.

Lithology and Thickness: Several sections of Yurabi Formation have been measured at widely scattered localities; the sections are shown diagrammatically on figure 21, and details of the thicknesses and lithologies noted are given in Appendix I. The section localities are shown on the accompanying map by a numeral prefixed by the letter Y.

In most areas the Formation can be subdivided into three, although in the northernmost areas the uppermost subdivision becomes indistinguishable from the McAlly Shale and has been accordingly mapped as part of that unit.

Subdivision A, the lowermost subdivision, consists predominantly of arenite, but siltstone and shale become of greater importance to the north-east. Although subdivision A invariably crops out as a resistant strike ridge it is not always possible to assess the relative abundance of the finer grained rocks; in the reference area (section Y6) exposures in road cuttings show a preponderance of siltstone and shale, while the natural exposures nearby suggest a preponderance of arenites.

The subdivision contains a great variety of arenite types and - particularly in the south and west - considerable lateral lithological variation is apparent. The lower beds are usually white in outcrop, medium-grained and contain ripple marks, cross-beds in the lower part, and an abundance of clay pellets; the upper arenites are purple-brown, yellow, brown, or fawn in outcrop, and although ripple marks are common (notably near the top), clay pellets are rare.

In general the arenites are composed of well rounded grains of quartz, and minor amounts of detrital chert and occasionally feldspar, set in a silica cement. The yellow-weathering sandstones common near the top of subdivision A are porous and have a clayey matrix; they may have originally contained carbonate minerals.

The subdivision is thickest (250 feet) in section Y3; it is of note that the thickest development of A occurs in the area where the most complete section of the preceding Kuniandi Group is preserved.

Subdivision B conformably overlies subdivision A and is overlain in places by subdivision C, and in other places by the McAlly Shale. The subdivision usually crops out poorly and lies at the foot of a dip-slope formed by the arenites of subdivision A, but in sections Y3, Y4 and Y5 the rocks are resistant and in part form a strike ridge.

Carbonate-bearing rocks are present in all sections except the southernmost sections (Y3, Y4 and Y5), where arenties predominate. The arenites in the southern areas are mainly feldspathic sandstone, but sub-greywacke and quartz-sandstone are represented. The rocks are invariably purple in outcrop and either purple or pink when broken. They are usually blocky or flaggy and either fine or medium-grained. Current ripple marks and cross-beds are fairly common. Thin beds of fine-grained sandstone and siltstone occur at the base of the subdivision in sections Y4 and Y5.

Although sandy beds are present in subdivision C in the north, none strongly resemble the arenites in the three southernmost sections. Despite this we are confident that the southern arenites occupy the stratigraphic interval shown on figure 21.

In sections Y6 and Y7 subdivision B consists of two parts - a lower, poorly exposed succession, and an upper siltstone-shale-dolomite sequence. The lower beds, although rarely exposed, are thought to consist almost entirely of purple siltstone or shale. The upper beds consist predominantly of purple fissile to thinly flaggy, laminated, dolomitic (or yellow, ex-dolomitic), siltstone or shale, but contain conspicuous, more resistant beds of yellow and pink silty dolomite and sandy dolomite. The dolomite beds are between two inches and two feet thick.

In section Y8 similar dolomites are interbedded with sandy strata. In sections Y1 and Y2, and in fact throughout the O'Donnell Syncline, dolomite is more abundant in subdivision B than elsewhere. The dolomite is generally flaggy, laminated and either pink or yellow in colour. Sandy laminae and interbeds are common, and large clusters of tabular ?gypsum crystals, of probable primary origin, are occasionally present on bedding surfaces.

The subdivision is, like subdivision A, thickest (195 feet) in section Y3, where arenites predominate. The thickest development of the non-arenite facies (115 feet) is in section Y7.

Subdivision C conformably overlies B and although it can be recognized over extensive areas (e.g. in and between sections Y3 to Y7), it cannot be distinguished from the McAlly Shale in the northernmost areas (e.g. in sections Y1, Y2 and Y8).

Where the subdivision overlies the finer-grained facies of subdivision B it forms a gentle rise; where it overlies the arenite facies it forms a gentle slope at the foot of the dip-slope.

The subdivision consists of closely interbedded siltstone, shale, and very fine-grained sandstone. In good exposures the rocks are mostly grey, fissile, or thinly flaggy and laminated. In poor exposures plates of sandstone obscure all trace of the finer-grained rocks. The top of the subdivision, (and hence, in most places the top of the Yurabi Formation) is marked by a resistant 5-30 foot thick bed of fine-grained, manganese-stained, pyritic sandstone.

As is the case with both lower subdivisions, subdivision C is thickest (270 feet) in section Y3.

Distinguishing Features: The base of the unit is marked by the appearance of medium-grained quartz sandstone containing abundant clay pellets. The top is marked, in most areas, by a thin (5-30 foot) bed of fine-grained pyritic sandstone, but where this bed cannot be recognized, the top is taken arbitrarily at the first appearance of dominantly shaley or silty strata.

Palaeogeographic Significance: The Yurabi Formation records a marine transgression. Before its deposition, much, if not all, of the Mount Ramsay Sheet area may have been subject to erosion. The abundance of oscillation ripple-marks, are evidence of deposition in shallow waters. The arenites of subdivision B were probably also laid down in shallow water, while the lutites and carbonates were laid down in deeper water to the north. Subdivision C differs from subdivision A in that it contains far less sand-sized material and from subdivision B in that it contains no carbonate rocks and it is interpreted as being the product of further marine transgression (i.e. continued epeirogenic subsidence unmatched by the rate of accumulation of the sediments).

FIGURE 21

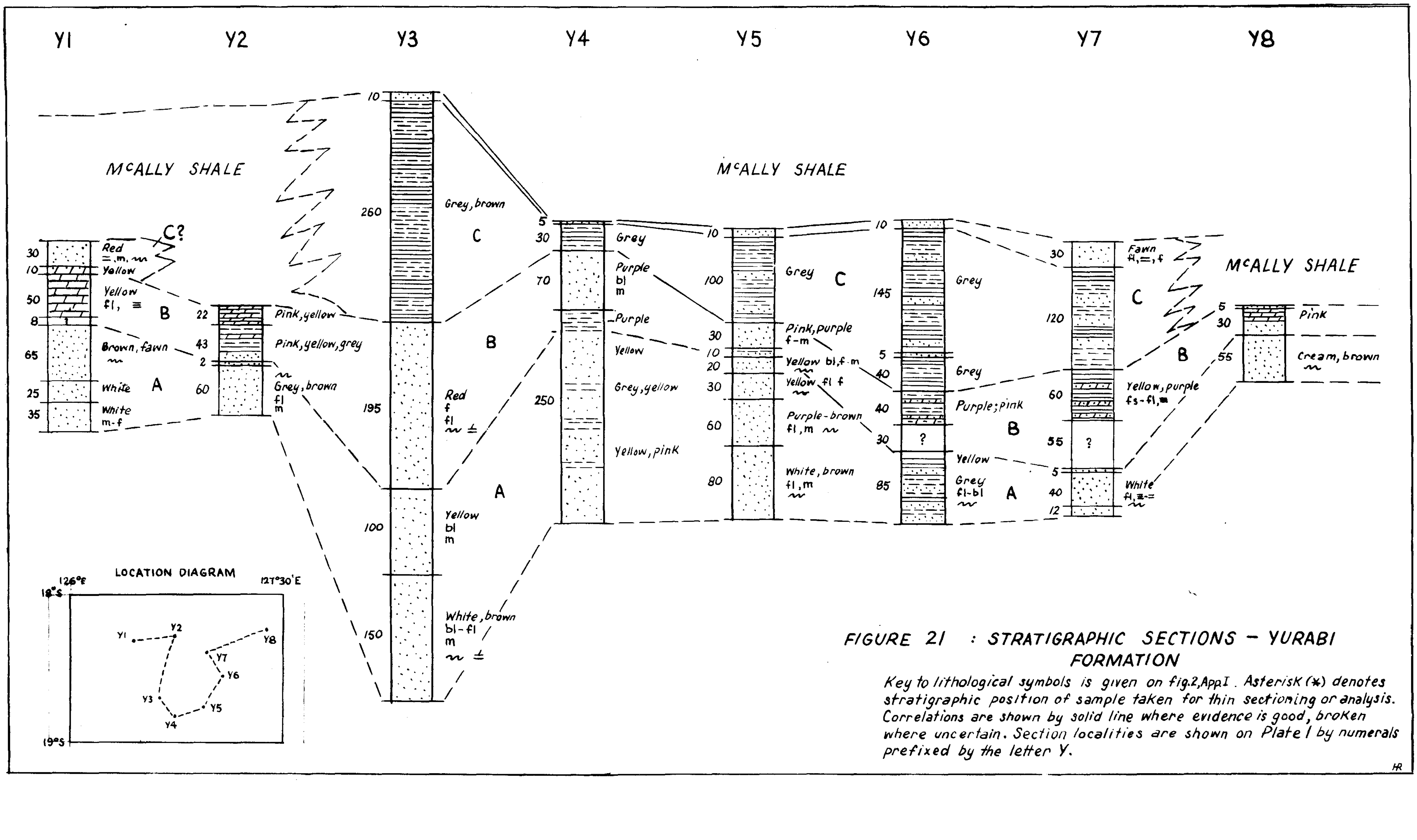

FIGURE 21 : STRATIGRAPHIC SECTIONS – YURABI FORMATION

Key to lithological symbols is given on fig.2, App.I. Asterisk (*) denotes stratigraphic position of sample taken for thin sectioning or analysis. Correlations are shown by solid line where evidence is good, broken where uncertain. Section localities are shown on Plate I by numerals prefixed by the letter Y.

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McALLY SHALE

Distribution: The McAlly Shale crops out extensively in the Mount Ramsay Sheet area. The main exposures are in the central and southern-central parts, but exposures also occur in the Ramsay Range, to the south-west of Moola Bulla, and in the O'Donnel Syncline.

Reference Area: No single completely exposed section is available for study. The most complete exposure is along a north-flowing stream, north of a point 4 miles south-east of Dickie Plains bore, in the south-central part of the Sheet area. This area is designated the reference area, even though small scale faults and flexures, and lateritisation detract from its usefulness.

Derivation of Name: The name is derived from the McAlly Hills, a north-trending range north-east of Margaret River Homestead. Maddox (1941, unpubl.) termed the beds "Mount Frank Shale", but the term has since been published elsewhere, and is invalid.

Stratigraphic Relationships: The McAlly Shale is part of the Louisa Downs Group. It conformably overlies the Yurabi Formation; in places the lowermost beds pass laterally into the Yurabi Formation. The unit is conformably overlain by the Tean Formation.

Lithology and Thickness: The McAlly Shale consists of fissile, finely laminated shale with thin interbeds of finely laminated siltstone and silty sandstone concentrated near the base. The shale, which comprises at least 95% of the unit, varies in colour from black to grey to green; black and grey shales predominate in most areas, but in some places, particularly to the north-west of Louisa Downs, there is a greater proportion of green shale. Where the shale has been lateritised, for example in the mesas to the south and south-east of Louisa Downs Homestead, the colour ranges from white to brick red.

The interbeds of siltstone and silty sandstone near the base of the unit are invariably subordinate to the shale. They are typically one or two inches thick, and are separated by much thicker shale beds. The siltstone is dark grey, laminated, and usually micaceous. The sandstone interbeds are grey, and fine or very fine-grained.

Bottom structures, apart from rare flow casts and groove casts, are lacking in the McAlly Shale. Near the base, channel-infillings stand out as raised graticules on some bedding surfaces; shallow circular impressions up to 1 inch across which show no evidence of organic origin, are found in places. Limonite pseudomorphs after pyrite are common in some localities.

Because of poor exposure, and the prevalence of small-scale structural complexities, it is not possible to measure the thickness of the McAlly Shale. Perhaps the closest estimate (5,000 feet) has been obtained in an area 17 miles south of Mount Tean.

Distinguishing Features: The lower boundary of the unit is transitional - in the south the top of a thin (about 10') bed of fine-grained pyritic sandstone forms a convenient boundary, but elsewhere the base is drawn arbitrarily where shale becomes the dominant lithology. The top of the unit is fixed at a point where pebble conglomerate or medium-grained sandstone becomes the dominant lithology.

Palaeogeographic Significance: The McAlly Shale is laterally and vertically uniform in lithology over wide areas; this, together with its complete absence of shallow water structures, and the presence of pyrite, and its dark colour, suggest that it was deposited in a current free, bathyal, reducing environment. The lithological change between the Yurabi Formation and the McAlly Shale probably resulted from a deepening of the seas which may have been aided by the melting of polar ice, but there is no doubt that it resulted mainly from the epeirogenic subsidence of extensive parts, if not all, of the Mount Ramsay Sheet area.

TEAN FORMATION

Distribution: The Tean Formation is exposed in the central and south-central parts of the Mount Ramsay Sheet area. The most conspicuous exposures of the unit form the marginal scarp of the Lubbock Range.

Reference Area: The most accessible exposures of the unit are immediately to the south of the Great Northern Highway to the south of Mount Tean. This area is designated as the reference area.

<u>Derivation of Name:</u> The name is derived from Mount Tean, which is situated about 6 miles to the east of Louisa Downs Homestead.

<u>Stratigraphic Relationships:</u> The Tean Formation lies conformably between the McAlly Shale and the Lubbock Formation.

<u>Lithology and Thickness:</u> At its reference area the Tean Formation is about 400 feet thick, and this general order of thickness is maintained throughout the area.

The Formation contains four main rock types; the relative abundance of the rock types varies from place to place but it is not possible, with our present data, to fully assess the significance of these lateral variations.

Over half the total thickness of the Formation is made up of brown-red fine and medium-grained leached <u>feldspathic sandstone</u> and <u>sub-greywacke</u>; in most areas these beds are poorly exposed, but in the north, where other, more resistant beds are absent, they are well exposed. The rocks are usually porous and may, before leaching, have contained carbonate minerals. Although not abundant, cross beds, ripple marks, load casts, and clay pellet impressions occur in the strata. In general the abundance of feldspar and derivative minerals, and the relative abundance of the matrix decrease from south to north.

Pebble conglomerate is conspicuous in the reference area and areas to the south, but it is progressively less important to the north. In the south the conglomerate occurs in several separate beds; in most localities three main beds are present in the sequence, but in some places there are only two. In addition small lenses of conglomerate are locally important - these are usually near the base of the unit. In most localities conglomerate makes up about 20 percent of the total thickness of the unit. The megaclasts consist of granules and pebbles with diameters ranging from about $\frac{1}{8}$" to 1"; pebbles up to 3" in diameter occur in places but are rare; the great majority fall within the range $\frac{1}{4}$" to $\frac{1}{2}$". The megaclasts are well rounded and consist predominantly of white milky quartzite or quartz, banded quartzite and black jaspery quartzite. The ubiquitous association of the white and black pebbles provides a ready means of identifying the Tean Formation, as it is only in this unit that the association occurs. The matrix, which makes up from 10 to 40 percent of the rock, consists of fine-grained quartz sandstone; in some places silica - possibly of secondary derivation - cements the sand grains; in others chalcedony, possibly of primary origin, acts as a binding agent. The conglomerate is characteristically massive, and is generally more resistant to erosion than the associated strata.

The third main rock type represented in the Tean Formation is blocky thick-bedded, white, fine to medium-grained, quartz sandstone. Although locally conspicuous, it is not present in all exposures of the Formation; it may grade laterally into conglomerate but this has not been proven. In places quartz sandstone makes up from 10 to 20 percent of the unit.

The fourth, and least well exposed rock type is dark grey or grey-green, fissile, laminated, shale which is commonly interbedded with laminated siltstone. In good exposures of the Formation the shale is invariably present but in most areas it cannot be seen because of soil cover. The shale occurs in the lower part of the Formation and makes up from 10 to 20 percent of the total thickness of the unit. Good exposures of the shale (and interbedded siltstone) crop out along a tributary of the Glidden River 12 miles north 10° west of Margaret River Homestead; here scour channels in the shale are filled by fine-grained, grey, sub-greywacke. The sub-greywacke is commonly slumped, and detached slump "rolls" occur imbedded in a shale matrix.

A thin bed of grey-green flaggy dolomite occurs near the top of the unit to the south of Trigonometrical Station C.32.

<u>Distinguishing Features:</u> The base of the Tean Formation is placed at the first appearance of sandstone or conglomerate. Although in many, if not all localities, this means including black shale - identical to the shales comprising the McAlly Shale - in the Tean Formation the appearance of coarser-grained rocks signals the beginning of the transition which ultimately led to the deposition of the Lubbock Formation. The top of the unit is marked by a change from resistant, fine and medium-grained arenites or rudites, to poorly resistant interbedded arenites and lutites.

Palaeogeographic Significance: The Tean Formation is lithologically transitional between the underlying Louisa Shale and the overlying Lubbock Formation. The transition is of the regressive type - the deposition of shales in deep poorly circulating marine waters eventually gave way to the deposition of arenites and rudites in shallower waters. The ingress of coarser-grained rocks may indicate (1) rejuvenation of tectonism in the source area, (2) the activation of a new and perhaps closer source, or (3) the development of turbidity currents. Although shallow water sedimentary structures are rare in the Tean Formation, parts of the unit were almost certainly deposited above wave base; equally parts of the unit were deposited below wave base in neritic or bathyal environments. The northward reduction in the importance of pebble conglomerate suggests, perhaps, that they, and possibly the other rocks of the Formation, had a southerly provenance.

LUBBOCK FORMATION

Distribution: Exposures of the Lubbock Formation are widespread in the central and southern parts of the Sheet area; the main exposures are in the Lubbock Range.

Reference Area: No complete sections of the Lubbock Formation are known; the thickest section is probably west of Christmas Creek, but here exposures are generally poor; perhaps the best exposures occur in the western part of the Lubbock Range (fig.22) - and this area is designated as the reference area.

Figure 22: Western part of Lubbock Range - reference area of Lubbock Formation. View looking south towards Louisa Downs Homestead - Lubbock Formation (on left) is underlain by more resistant beds of Tean Formation, which are in turn underlain by the McAlly Shale (dark, low areas to right).

Derivation of Name: From the Lubbock Range.

Stratigraphic Relationships: The Lubbock Formation conformably overlies the Tean Formation and is unconformably overlain by the Lally Conglomerate. The unconformity is not apparent locally, but can be demonstrated on a regional basis.

Lithology and Thickness: Varying thicknesses of the Lubbock Formation are preserved beneath the unconformably overlaying Lally Conglomerate. It is likely that the greatest preserved thickness lies either in the Lubbock Range, or in the south-westernmost exposures of the unit (to the west of Christmas Creek). In the latter area its thickness has been estimated to be 6,000 feet. The preserved thickness is much less in the Ramsay Range and further to the north-east. The reduction in thickness is in part, and perhaps wholly, due to terosion prior to the deposition of the Lally Conglomerate.

The most outstanding characteristic of the Lubbock Dormation is the regular lithological alternative displayed within it. The alteration produces a distinctive air-photo pattern (fig.22) and permits ready identification of the unit.

Two main rock types are involved in the alternation-sub-greywacke and siltstone; several hundred alternating sets are present in the formation; the sets generally contain from 5 to 10 feet of sub-greywacke and from 5 to 20 feet of siltstone. The sub-greywacke beds crop out as moderately resistant bars and benches, while the siltstone beds, being less resistant, form intervening recessive areas (fig.23).

Figure 23: Exposures of Lubbock Formation Glidden River, six miles east-south-east, of Me No Savvy Yard. Sub-greywacke beds form resistant bars; siltstone is less resistant.

The high porosity evident in most of the sub-greywacke may be due to leaching out of more soluble components. Thus in a tributary which joins Christmas Creek 16 miles south of Louisa Downs Homestead the sub-greywackes contain appreciable amounts of calcite, but it may have been much more widespread and only fortuitously preserved at this locality. In general the sub-greywacke beds are flaggy or blocky and thin bedded. They consist of fine or medium-grained poorly sorted, usually angular to sub-angular grains of quartz and rare grains of detrital microcline, tourmaline, pyroxene, and fine-grained igneous rock, set in a matrix containing varying proportions of decomposed feldspar, saussurite, sericite, chlorite, unidentified clay minerals, and rare muscovite. Some of the quartz grains contain minute inclusions of tourmaline, apatite and zircon; many are coated with finely disseminated iron oxide which gives the rocks their characteristic grey-brown or red-brown colour in outcrop.

Quartz makes up from 55 to 75 percent of the rock. The remainder includes varying proportions of feldspar and feldspar decomposition products, and allogenic and authigenic matrix materials. Although some of the beds may possibly be feldspathic sandstone and some greywacke (figure 1, Appendix I) it is thought that the great majority are (or were prior to weathering) of sub-greywacke composition.

Graded bedding is commonly visible in thin sections of the sub-greywacke. Clay or silt pellets are common in the rocks.

The siltstone, which makes up alternating sets with the sub-greywacke is probably of essentially similar composition; it is rarely well exposed and its presence is usually expressed by grey-black soil. In outcrop it is normally thinly flaggy or fissile and weakly laminated - and grey or grey-brown but in some cases it is green or purple; shale is commonly interbedded with the siltstone and thin interbeds of fine and very fine sub-greywacke are also common.

A few miles to the east of Mount Tean, in the Ramsay Range, and in the Forman Creek district, thin beds of purple, pink, and yellow, flaggy, laminated dolomite are present in the Lubbock Formation. In each locality they occur in the lowermost 1,000 feet of the succession.

Large scale and small scale cross beds and ripple marks, as well as graded beds, have been noted in the lowermost parts of the unit near Christmas Creek, and cross beds and ripple marks are abundant near the top of the preserved section to the south-east of Trigonometrical Station J.18. However, the middle part of the unit is notably lacking in macroscopic cross beds and ripple marks, but contains frequent macro and micro graded beds.

Distinguishing Features: The base of the unit is marked by the appearance of alternating lutites and arenites. The top is eroded.

Palaeogeographic Significance: The sub-greywacke beds of the Lubbock Formation have many of the features commonly associated with turbidity current deposits. A comparison of the phenomena regarded by Ten Haaf (1959) as being of significance in the identification of turbidities, with the phenomena observed in the sub-greywacke beds of the Lubbock Formation is given below:-

Turbidite Characteristics (after Ten Haaf, 1959)	Sub-greywacke Beds of the Lubbock Formation
1. Vertical grading, combined with poor sorting.	Common
2. Continuous, parallel stratification.	Ubiquitous
3. Inter-stratification with non-turbidites.	Applies throughout
4. Finer fraction comparable in composition with inter-stratified non-turbidites.	Yes(?)
5. Tops vague.	Common
6. Flute casts, groove casts.	Non observed
7. Interstratified non-turbidite inclusions.	Common
8. Preferred orientation of (7).	Not noted
9. Mineral grain alignment.	Common
10. Unidirectional cross and ripple laminations.	Directions not noted
11. Slump structures.	Non observed
12. Absence of shallow water phenomena.	Yes.

The gross features of the sub-greywacke beds (items 1, 2 and 3) conform well to Ten Haaf's criteria, but until much more detailed examination of the succession has been undertaken, their mode of deposition must remain conjectural.

Whether or not turbidity currents have been involved in the deposition of the sub-greywacke beds it seems, in view of their association with apparently deep water marine sediments, that they were, most likely, deposited in a neritic or bathyal environment.

TABLE 12 : SUMMARY OF STRATIGRAPHY - LOUISA DOWNS GROUP

ROCK UNIT	SYMBOL	LITHOLOGY (In order of abundance)	MAXIMUM THICKNESS IN FEET	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION OF EXPOSURES	STRATIGRAPHIC RELATIONSHIPS	REMARKS
LUBBOCK FORMATION	Bil	Grey green or purple. Thinly flaggy or fissile, siltstone and shale alternating with grey-brown, flaggy or blocky, fine and medium-grained sub-greywacke (calcareous in places); minor dolomite.	6000	Moderately resistant and poorly resistant Forms closely benched hills and rises; usually treeless.	Lubbock Range; central south; Ramsay Range.	Conformably overlies Tean Formation; unconformably overlain by Lally Conglomerate.	May contain turbidites. Possibly equivalent to Flat Rock Formation of Smith (1962).
TEAN FORMATION	Bit	Grey, fine and medium-grained feldspathic sandstone and sub-greywacke, pebble conglomerate, white fine to medium-grained quartz sandstone, grey-green laminated shale and siltstone; minor grey-green flaggy dolomite.	400	Resistant and poorly resistant; forms strike ridges and valleys.		Conformably overlies McAlly Shale.	Possibly equivalent to Nyuless Sandstone of Smith (1962).
McALLY SHALE	Bim	Black, grey and green, fissile laminated shale; minor dark grey laminated micaceous siltstone, grey fine or very fine-grained sandstone.	5000	Poorly resistant; forms treeless plains and gentle slopes.	Central part of Sheet area; south-central; Moola Bulla district; O'Donnel Syncline.	Conformably overlies Yurabi Formation.	Provides high quality groundwater in numerous bores. Possibly equivalent to Timperley Shale of Smith (1962).
YURABI FORMATION	Biy	Flaggy to blocky, fine to medium-grained quartz sandstone and feldspathic sandstone; grey laminated siltstone, grey to black fissile laminated shale, purple siltstone, dolomitic siltstone, silty dolomite, sandy dolomite.	100-700	Resistant and poorly resistant; forms strike ridges and valleys.	Kuniandi Range; central-south; Egan Range; McAlly Range; Moola Bulla district; O'Donnel Syncline.	Disconformably overlies Egan Formation, at least locally.	Possibly equivalent to Mount Forster Sandstone, Elvire Siltstone and Boonal Dolomite of Smith (1962).
EGAN FORMATION	Bie	Tillite, arkose, calcareous sandstone, silty and sandy limestone, silty and sandy dolomite; limestone dolomite, dolomitic siltstone and shale, siltstone, shale.	100-650	Poorly resistant and resistant; topography very variable from place to place.		Unconformably overlies Kuniandi Group and older rocks. Disconformities of at least local extent present within the unit.	Includes products of a major glacial epoch. No equivalents known elsewhere in the Kimberley region.

PALAEOZOIC

A summary of the stratigraphy of the Palaeozoic rocks is given in Table 13.

CAMBRIAN

LALLY CONGLOMERATE (New Name)

Distribution: Exposures of the Lally Conglomerate are confined to the Mount Ramsay Sheet area; they occur in four main areas - the Lubbock Range, the Ramsay Range, east and west of trigonometrical station J18, and about 7 miles east of Lilly Lagoon.

Reference Area: The Lally Conglomerate's reference area is near Mount Ramsay, in the central part of the Lubbock Range.

Derivation of Name: The name is derived from Lally Creek, a newly named watercourse which rises near Mount Ramsay and flows into the Margaret River near Margaret River Homestead.

Stratigraphic Relationships: The Lally Conglomerate rests unconformably on the Lubbock Formation and is conformably overlain by the Antrim Plateau Volcanics. The basal unconformity cannot be demonstrated at any single locality, but can be inferred from regional relationships. To the north and east, the unit rests on successively older strata of the Lubbock Formation, and ultimately in its north-easternmost exposures it rests directly on the Yurabi Formation.

Lithology and Thickness: In the reference area the unit is 135 feet thick (fig. 24) and contains, in ascending order:-

80' Brown, purple and red-brown weathering, pink, massive friable medium to coarse-grained sub-greywacke. Consisting of well-rounded to subrounded grains of quartz in a matrix of quartz silt and kaolin which constitutes up to 30% of the rock. Cross beds are ubiquitous. The sequence is capped by an eight inch thick bed of fine-grained, purple, quartz sandstone containing quartz and quartzite cobbles; the basal six inches contains well rounded cobbles of quartz and quartzite.

55' Massive cobble conglomerate consisting of ovoid, well rounded pebbles, cobbles and boulders of pink and purple quartzite, quartz and gneiss (rare) set in a matrix of light-brown, medium-grained quartz sandstone composed of moderately well-rounded to sub-angular grains of quartz, chert and rare jasper and ferruginous rock. The mega-clasts range in size

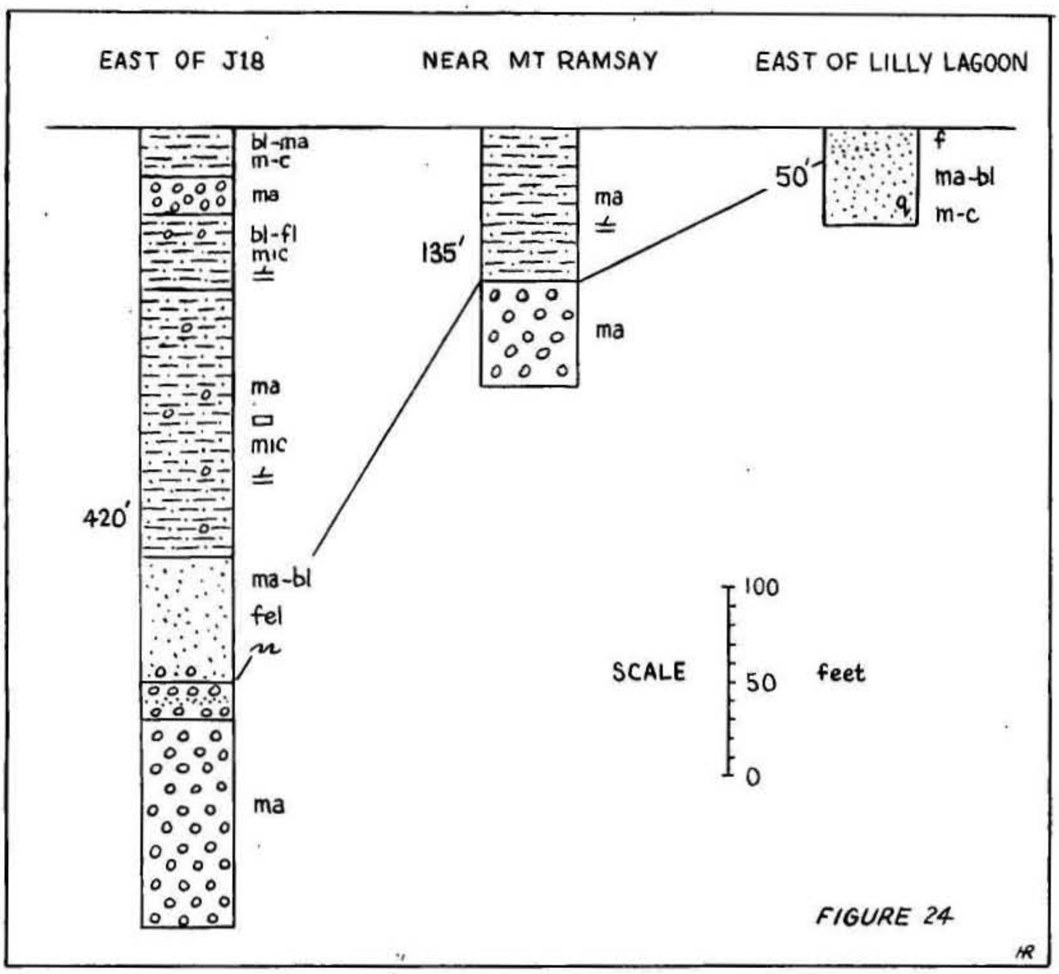

Figure 24: Diagrammatic Sections - Lally Conglomerate.

from pebbles less than one inch across, to boulders two feet across. Rare lenses of quartz sandstone, similar in composition to the matrix, occur in the sequence; they are up to 2 feet thick and 20 feet long.

To the north of the reference area, in the northern part of the Lubbock Range, the unit becomes thinner and in places is represented by about 50 feet of conglomerate and quartz greywacke. The unit ismuch thicker to the south, where 420 feet of section was measured 1.5 miles east of trigonometrical Station J.18. In this area the unit contains the following strata:-

OVERLAIN BY ANTRIM PLATEAU VOLCANICS

25' Pink, red-brown weathering, poorly sorted blocky to massive, thick and medium bedded, medium to coarse-grained sub-greywacke, consisting of sub-rounded grains of quartz and kaolinised feldspar set in a clay matrix. Grades upwards into coarse-grained sub-greywacke, with well rounded granules of quartzite, epidote and siltstone or schist.

20' Massive cobble conglomerate consisting of well rounded boulders, cobbles and pebbles of quartzite and quartz sandstone, set in a matrix of pink, poorly-sorted, medium to coarse-grained feldspathic sandstone with a clayey matrix. Boulders constitute 5% of the rock, cobbles 40% and pebbles 20%.

40' Pink, red-brown weathering, well sorted, blocky and flaggy, rarely cross-bedded, fine to medium-grained pebbly and cobbly micaceous sub-greywacke.

140' Pink, moderately well sorted, massive, jointed, thick bedded, medium-grained pebbly and cobbly micaceous sub-greywacke. Surface weathers red-brown, rare cross-beds present.

65' Pink, red-brown weathering, massive to blocky, medium-bedded, fine to medium-grained, slightly micaceous, friable, feldspathic sandstone with a clayey matrix. Scattered cobbles and pebbles of quartzite and quartz sandstone occur near the base and current ripple marks are present.

20' Massive <u>cobble conglomerate</u> consisting of well rounded boulders, cobbles and pebbles of quartzite and quartz sandstone, set in a matrix of medium-grained, white to grey, friable quartz sandstone. In a 6 foot thick bed in the middle of the unit, pebbles, sporadic cobbles and boulders are set in a resistant, purple, massive, medium-grained ferruginous silicified quartz sandstone.

110' Massive <u>cobble conglomerate</u> consisting of well rounded boulders, cobbles, and pebbles of white, purple, pink and grey quartzite (60% of total) and quartz sandstone (30%) and other rock types, including schist (10%). Some boulders appear to be polished in a matrix of medium-grained white, friable, quartz sandstone. Boulders constitute 5% of the rock, cobbles 40%, pebbles 25%, and matrix 30%, and may be reworked from tillites.

420'

UNDERLAIN BY LUBBOCK FORMATION

In the Ramsay Range (20 miles east of the reference area) the unit is less than 100 feet thick and is represented by a dominantly arenaceous succession. Much of the unit is massive or blocky, purple-brown to pink, medium to coarse-grained quartz sandstone which consists of rounded to sub-rounded quartz grains in a minor kaolinitic and ferruginous matrix. Cross beds are ubiquitous and shale pellet casts are common. Rare thin lenses of quartz cobble conglomerate occur within the sandstone.

North-east of the Ramsay Range, in an area about seven miles east of Lilly Lagoon, the Lally Conglomerate is about fifty feet thick. It consists of brown to grey massive and blocky medium to coarse-grained quartz sandstone with a matrix of silica and iron oxide, which becomes progressively finer-grained and less ferruginous towards the top.

An unusual feature of many of the cobbles and boulders in the conglomerates of the unit is that many of them have developed shallow depressions at their points of contact with other megaclasts. These depressions are up to 1 inch across and ¼ inch deep. Other megaclasts have abnormally highly polished surfaces and may have been derived from the Precambrian glacial deposits. Some bear shallow sub-circular surface cracks generally with a radius of between ¼ and ½ an inch; the origin of the cracks is unknown to the authors; in some cases they occur as isolated examples on a single megaclast but in others the megaclast is virtually covered by the cracks.

<u>Distinguishing Features:</u> In the Lubbock Range and in the J18 area the base of the unit is marked by the appearance of conglomerate, and in the Ramsay Range and the Lilly Lagoon district it is distinguished by the presence of coarse and medium-grained arenites which contrast with the underlying finer grained sediments. The top of the unit is marked by a change in lithology from arenites or rudites to basic volcanics.

<u>Palaeogeographic Significance:</u> In the two measured sections described the lower third consists of cobble conglomerate, but the average size of cobbles is significantly smaller in the type section. Further, the J18 section contains conglomerates and pebbly horizons in its upper parts, and is thicker than the type section. These features suggest that the sediments were derived from the south. Comparison of the strata in the Ramsay Range and Lilly Lagoon districts with the type section shows further decrease in thickness and a corresponding reduction in the relative abundance of megaclasts to the east and north-east. This is accompanied, as might be expected, by an increase in the proportion of coarse-grained sandstone and a decrease in the importance of feldspar. We may thus infer a south-westerly provenance.

The prevalence of cross beds indicate that most, if not all, of the detritus constituting the unit, was delivered by traction currents. Highly polished cobbles and boulders present in the Conglomerate may well have been derived from Precambrian glacial rocks.

<u>ANTRIM PLATEAU VOLCANICS</u>

<u>Distribution:</u> The Antrim Plateau Volcanics crop out extensively in northern Australia; their westernmost exposures in the Mount Ramsay Sheet area have only recently been recognised. In this area the Volcanics crop out in five main districts:

(i) to the north, east and west of trigonometrical station J18;

(ii) to the south of Mount Ramsay in the middle of the Lubbock Range;

(iii) in the northern part of the Lubbock Range;

(iv) in the Ramsay Range; and
(v) in an area several miles to the east of Lilly Lagoon.

Derivation of Name: The name "Antrim Plateau Basalts" was used by David (1932) to apply to the volcanics then known to be extensively exposed in the Kimberley region and in the adjoining part of the Northern Territory. Traves (1955) revised the term to Antrim Plateau Volcanics.

Stratigraphic Relationships: In the Mount Ramsay Sheet area the Antrim Plateau Volcanics rest conformably on the Lally Conglomerate. While no observable contacts between the Volcanics and the rocks of the Canning Basin are available, it is clear from the structural setting that the Volcanics pre-date rocks of at least Devonian age. The relationships of the Volcanics in other areas shows that they are probably of Lower Cambrian age.

Lithology and Thickness: In the area under discussion the top of the Antrim Plateau Volcanics is nowhere exposed. The maximum preserved thickness of the unit is in the northern part of the Lubbock Range, in an area south of the Maddox Hills, where over 5000 feet of section is exposed. Elsewhere the thickness preserved is considerably less.

Dense black or brown weathering basalt makes up about half of the succession; the remainder consists of vesicular and amygdaloidal basalt with very rare sandstone interbeds. The frequency of alternation between the "dense" and "porous" basalts suggests that several hundred separate basalt flows may be represented.

In thin section two representative samples of the basalts have been described by A.R. Turner (AMDEL) as follows:-

MR6.31.18A. This rock is an altered felsite. It consists of numerous chloritized and sericitized feldspar microlites, which have a random orientation, set in a severely iron-stained matrix. Throughout the matrix are minute, isolated masses of primary quartz which contain numerous, acicular needles of ?apatite. The altered nature of the feldspars prevents their optical determination. However, staining suggests that the majority, if not all, are plagioclase. The rock is extremely vesiculate. The vesicles are irregular in shape and have a wide size range some being as large as 40 mm across their widest dimension. The feldspar microlites have a sub-parallel orientation to the vesicle surface for a depth of approximately 0.3 mm around each of the vesicles. The margins show evidence of chilling. Each of the vesicles is infilled with coarsely crystalline secondary quartz, accessory secondary calcite and fibrous crystalline mineral. The degree of crystallinity increases towards the centre of the vesicles. The quartz is often found included with finely powdered opaque minerals. The fibrous mineral associated with the secondary quartz and calcite is a pale coloured epidote which has a low iron content. The colour decreases from the centre to the margins of the crystal and it is possible that the epidote is being converted to clinozoisite by the leaching out of the iron. The epidote tends to be concentrated towards the centre of the vesicles. Lack of definitive minerals make it difficult to classify this rock. However, the mineral assemblage suggests it to be a basalt.

ML6.31.18C. This rock is an altered felsite. It consists of an interwoven felty mass of feldspar microlites which have been subjected to alteration (possibly deuteric). The feldspar microlites have no preferred orientation. The alteration prevents their determination optically. However, staining suggests that both alkali and plagioclase feldspars are present. No primary quartz was observed with certainty. Rarely relatively unaltered plagioclase crystals were observed and their composition appears to be calcic. Much of the feldspar has been altered to epidote and more rarely sericite and chlorite. The groundmass was probably felsitic but but has been substantially chloritized forming a bright greenish chlorite. Anhedral aggregates of opaque minerals are found randomly distributed throughout the rock. The rock contains numerous irregularly shaped vesicles which have been infilled by secondary quartz and chlorite of various forms. The centres of the vesicles are commonly infilled with cryptocrystalline chlorite which has a distinct green colouration. These are sometimes surrounded along the margins by chalcedonic silica. In other vesicles chalcedonic silica infills the whole vesicle and is sometimes surrounded by a narrow layer of ?opaline silica. The chalcedony is found as radiating spherulitic aggregates, The ?opaline silica forms fibrous colloform aggregates which crystallize perpendicular to the vesicle wall. If the stated feldspar composition is correct this rock would be a trachy-basalt.

Distinguishing Features: The contact between the Lally Conglomerate and the Antrim Plateau Volcanics is quite sharp and is marked by the appearance of volcanic rocks. The top is eroded; the Volcanics can be readily distinguished from the younger rocks of the area, none of which contain volcanic rocks.

Palaeogeographic Significance: The Antrim Plateau Volcanics are part of a vast area of flood basalts extending from the eastern margin of the Barkly Basin in the Northern Territory to the Mount Ramsay Sheet area, a distance of 800 miles. They extend north as far as Tipperary in the Northern Territory, and south as far as the 19th parallel, and it is possible that they covered an area of 250,000 square miles.

DEVONIAN

The Devonian rocks of the Mount Ramsay Sheet area form part of a reef complex which crops out around the north-eastern margin of the Canning Basin. The rocks have been described by Guppy et al (1958) and by Veevers and Wells (1961), but recent mapping by Playford and D.C. Lowrie of the Geological Survey of Western Australia, has led to revision and refinement of the concepts held by the earlier workers. While the results of this mapping have been incorporated in the accompanying Sheet, it is not proposed to discuss the Devonian strata as they will be fully described by Playford and Lowrie (in prep.).

PERMIAN

GRANT FORMATION

Distribution: The Grant Formation crops out in an east-south-east trending zone in the south-western part of the Sheet area, from near Old Bohenia Downs Homestead to an area south of Louisa Downs Homestead. The Formation crops out extensively in the adjoining Noonkanbah Sheet area (Thomas, 1958) and also occurs in the Mount Bannerman Sheet area (Wells, 1960).

Derivation of Name: The Grant Formation was defined by Guppy et al (1952).

Stratigraphic Relationships: In the Mount Ramsay Sheet area the Formation unconformably overlies the Fairfield Formation which is of Upper Devonian to Carboniferous age (P.E. Playford, pers. comm.). The unconformity can be demonstrated in the area to the south-west of Nippers Bore, to the south of Christmas Creek, where the Formation transgresses the Fairfield Formation and, locally, rests directly on the Pillara Limestone. To the south of Louisa Downs the Formation rests unconformably on Precambrian rocks. The top of the unit is eroded and no contacts with succeeding Palaeozoic units are exposed. However, McWhae et al (1958, p.55-56) record that the Grant Formation is overlain disconformably by the Poole Sandstone.

Lithology and Thickness: The rocks of the Grant Formation are sub-horizontal in the Mount Ramsay Sheet area and the superpositional sequence cannot be elucidated. However, it seems probable that the strata exposed represent a thickness of about 500 feet.

Most of the exposures consist of fine, medium or coarse-grained quartz sandstone, but in two areas, centred on points 7 and 12 miles east of Nippers Bore, conglomerate is the dominant lithology. The matrix of the conglomerate has been removed by erosion and only the megaclasts remain; they consist of well rounded to angular pebbles, cobbles and boulders up to 3 feet across, of quartzite, quartz sandstone and pebble conglomerate. Some of the megaclasts are faceted and polished, and as glacial and fluvioglacial rocks occur in the Grant Formation in the adjoining Noonkanbah Sheet area (Thomas, 1958), the conglomerate could be glacial or fluvioglacial in origin. However, many of the faceted and polished megaclasts in the Formation could have been derived from the Egan Formation or Landrigan Tillite.

Two small exposures of massive, medium-bedded, cross-bedded, coarse to very coarse-grained quartz sandstone occur to the east of the conglomerate exposures; these have been mapped tentatively as Grant Formation, but their relationship to the conglomerate is not known.

To the south of Christmas Creek a few miles east of Nippers Bore the conglomerate appears to grade laterally into massive, red-weathering coarse-grained pebbly quartz sandstone which crops out extensively between Christmas Creek and the Pinnacles fault and is characterised by strong jointing.

To the east of Mount Talbot about 200 feet of section is exposed; the lowermost strata consist of white, light pink and yellow, orange weathering silicified siltstone and very fine-grained quartz sandstone, and are overlain by beds of yellow to white, orange-red weathering, massive medium-grained quartz sandstone with a clayey matrix.

Age: Veevers and Wells (1961) discuss the stratigraphic position and age of the Grant Formation and conclude that it was deposited in the interval Upper Stephanian to Sakmarian.

NOONKANBAH FORMATION

Distribution: The Noonkanbah Formation crops out to the south-west of Peters Bore, near the western margin of the Sheet area, and occurs a few miles to the south of Bohemia Downs Homestead.

Derivation of Name: The Noonkanbah Formation was named by Wade (1936) from the type locality near Noonkanbah Homestead, to the west of the Mount Ramsay map area.

Stratigraphic Relationships: The base of the Noonkanbah Formation is not exposed in the Sheet area, but to the west it rests on the Poole Sandstone (Veevers and Wells, 1961). The unit is overlain, probably conformably, by the Liveringa Formation but the contact is not exposed.

Lithology and Thickness: The strata exposed in the map area probably represent parts of the uppermost few hundred feet of the Noonkanbah Formation.

In the western exposures (to the south-west of Peters Bore) the main rock type present is yellow-weathering, flaggy, fine-grained, micaceous, gypsiferous, calcareous sandstone; it contains rare shelly fossils and is interbedded with soft, probably silty or shaley strata.

In the east the only rocks to crop out are dark brown weathering, flaggy, ferruginous, fine to coarse-grained sandstones; these are probably interbedded in an essentially silty or shaley sequence.

Guppy et al (1958, p.48) state that the unit has a "reasonably constant thickness of between 1200 and 1500 feet".

<u>Age:</u> On fossil evidence Dicking (1963) places the Formation in the upper Artinskian (Lower Permian).

LIVERINGA FORMATION

<u>Distribution:</u> The Liveringa Formation crops out extensively in the south-western part of the Sheet area, to the south of the Pinnacle fault.

<u>Derivation of Name:</u> The Formation was defined by Guppy et al (1958), who divided it into three units, the lowermost of which they named the Lightjack Member and the uppermost the Hardman Member. Due to the ambiguous description of the members, considerable confusion has arisen, and Veevers and Wells (1961) conclude that the subdivisions in the Liveringa Formation in the Fitzroy Trough "require further study".

<u>Stratigraphic Relationships:</u> In the Mount Ramsay Sheet area the formation overlies the Noonkanbah Formation; the nature of the contact cannot be determined because of soil cover, but elsewhere the units are regarded as being in conformable succession (Veevers and Wells, 1961). No overlying Palaeozoic or Mesozoic strata have been preserved in the map area. A single exposure of massive coarse-grained cross bedded, pebbly quartz sandstone, which rests unconformably on the Liveringa Formation, one mile east of Teapot Bore, mapped tentatively as Cainozoic, could possibly be of Mesozoic age.

<u>Lithology and Thickness:</u> In the Mount Ramsay Sheet area the Liveringa Formation can be divided into five units. The lowermost subdivision probably belongs to the Lightjack Member of Guppy et al (1952) if their description of the Member (p.51) can be taken as excluding the overlying plant bearing sandstone beds; the term has been used in this sense by Wells (1960). The uppermost subdivision has been mapped tentatively as being the Hardman Member of Guppy et al (1958). The intervening subdivisions make up a sequence which, to the south, has been mapped by Wells (1960) as the Condren Sandstone Member.

The Lightjack Member is a poorly resistant unit and in consequence is rarely well exposed. It crops out at the foot of the prominent scarp south of Peters Bore, four miles and eight miles west of Bohemia Downs, and six to eight miles south-east of Bohemia Downs.

The full superpositional sequence cannot be determined because of the poor exposures but the unit appears to consist mainly of olive green leached flaggy, laminated fine-grained sub-greywacke, purple-brown ferruginous siltstone and very fine-grained ferruginous sandstone. Hollow spherical sandy ferruginous concretions up to 2 inches in diameter are commonly associated with exposures of the Member. Shelly fossils occur in the unit to the south of Peters Bore.

Its thickness is probably less than 100 feet.

The Condren Sandstone Member consists predominantly of yellow or orange weathering clay-cemented quartz sandstone but it contains a less resistant sequence of ferruginous strata which has been distinguished on the accompanying map by the symbol Pr_2. The lower part of the Member is shown as Pr_1 and the upper part as Pr_3.

The lowermost beds (Pr_1) are about 150 feet thick and consist of yellow-weathering, white and yellow, flaggy, medium-grained, clay-cemented quartz sandstone, and silty quartz sandstone. The rocks are usually quite friable and are, in part, micaceous; cross-beds are present but are not very common. Rare plant fossils occur in the strata.

The overlying beds (Pr_2) are very rarely exposed; they appear to consist of interbedded ferruginous siltstone and fine-grained ferruginous sandstone. Their position in the stratigraphic column can be demonstrated in two areas - one around a point about four miles south-west of Bohemia Downs Homestead, the other in an area about six miles south-east of the Homestead. The beds have a thickness of from 50 to 100 feet, and although no fossils have been found, their lithological similarity to the Lightjack Member suggests that they could possibly be marine deposits.

The upper part of the Condren Sandstone Member (Pr_3) forms many of the prominent mesas of the Bohemia Downs district. An almost complete section of the subdivision is exposed at Mount Talbot. The contact with the underlying strata is not exposed but the ferruginous soil and ferruginous silty rubble at the base of the hill suggest that the underlying subdivision may be present.

The following section was measured at Mount Talbot:-

OVERLAIN BY HARDMAN MEMBER

30'	White, friable, flaggy, thin-bedded, silty, micaceous, quartz sandstone (or sub-greywacke).
75'	Resistant, massive thin-bedded, cross-bedded, medium and fine-grained clay-cemented, slightly micaceous quartz sandstone grading upwards into flaggy, ripple-marked micaceous fine and medium-grained quartz sandstone containing plant fossils near middle and at top.
140'	Friable, orange and white surfaced, white, flaggy, thin-bedded clay cemented quartz sandstone. Crumbles to yield white sand. Upper 30 feet slightly better-cemented.
15'	Resistant, yellow-weathering, massive, medium-grained, slightly micaceous, clay-cemented, quartz sandstone.
20'	Orange-weathering, massive, medium-grained, slightly micaceous, clay-cemented, quartz sandstone. Contains plant fossils. Upper 10 feet is less resistant to erosion than lower 10 feet,
20'	Moderately resistant, friable, white and orange-weathering, flaggy, thin-bedded, fine and medium-grained, clay-cemented, slightly micaceous, quartz sandstone.
45'	Scree. May be underlain by Pr_2.

NO EXPOSURE

If the lowermost exposed beds directly overlie subdivision Pr_2 as has been suggested, the total thickness of Pr_3 at Mount Talbot is 300 feet. Plant fossils are quite abundant in the subdivision.

The <u>Hardman Member</u> has been mapped tentatively in the Mount Talbot Syncline and in areas about six miles to the south-east of Bohemia Downs Homestead.

Dickins (1963) has suggested that in the Mount Talbot Syncline a disconformity may occur between the strata which we have mapped as Hardman Member and the underlying sequence, and that although the beds contain "marine fossils of the Upper Liveringa type" there remains the possibility that "the Mount Talbot marine horizon is stratigraphically lower than that of the Hardman Member ...... and represents an horizon which has not been recognized elsewhere in the Basin".

At Mount Talbot the lower boundary of the Member has been taken to be at the base of a yellow to red-weathering yellow, friable, medium-grained ferruginous sandstone bed, which is possibly about 20 feet thick. It contains rare shelly fossils. The overlying strata have not been examined but it seems likely that the top of the unit is not exposed.

In the areas to the south-west of Bohemia Downs Homestead identical beds mark the base of the Member and are again about 20 feet thick. The overlying strata have been removed by erosion.

Age: Dickins (1963) places the "lower marine beds" of the Liveringa Formation (the Lightjack Member) in the upper part of the Lower Permian and the remainder in the Upper Permian.

UNDIFFERENTIATED

A conspicuous circular topographic depression (the Goat Paddock), to the east of the junction of the Margaret and O'Donnel Rivers, is rimmed by exposures of rocks which have been tentatively assigned a Palaeozoic age. The attitude of these rocks is such as to suggest that they were deposited in a pre-existing depression.

The sequence is up to 150 feet thick and is broadly divisible into three parts, a lower sand-cemented sandstone breccia; a medium cobble to pebble conglomerate and an upper medium-grained, silty quartz sandstone. The three divisions embody a complete transition. In contrast to the Precambrian arenaceous rocks, the upper sandy strata are not silicified; they are, in the reverse, quite friable, and for this reason they have been assigned tentatively to the Phanerozoic. The similarity of the upper part of the sequence to parts of the Condren Sandstone Member has led us to suggest a Palaeozoic age, although they could equally well be of Mesozoic or Cainozoic age.

A discussion of the Goat Paddock is given in the Structural Geology section of this report.

Three small exposures of limestone and associated strata which occur in an area 10 miles south of Louisa Downs have also been mapped as "undifferentiated" Palaeozoic. The beds dip to the north and could possibly be conformable with the Antrim Plateau Volcanics, but their contact is masked by alluvium. The exposures are bounded to the north by a fault which has been active in post-Devonian times. The top of the beds are eroded.

The strata consist of purple to pink flaggy limestone, leached calcareous sandstone, and purple siltstone. The thickness exposed probably does not exceed 50 feet.

Without the discovery of fossils, there seems little hope that the beds can be dated.

TABLE 13 : SUMMARY OF STRATIGRAPHY - PALAEOZOIC

AGE	ROCK UNIT	MAP SYMBOL	LITHOLOGY	THICKNESS IN FEET	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION OF EXPOSURES	STRATIGRAPHIC RELATIONSHIPS	REMARKS
PALAEOZOIC(?)	UNDIFFERENTIATED	Pz	NORTH: Sandstone-breccia, conglomerate, medium grained silty quartz sandstone.	150	Resistant; forms slopes.	To east of junction of Margaret and O'Donnell Rivers.	Unconformable on Crowhurst Group. Overlain by Tp.	In part resembles Condren Sandstone Member.
			SOUTH: Flaggy limestone, calcareous sandstone, siltstone.	50+	Poorly resistant, forms low rises.	In area 10 miles south of Louisa Downs.	Obscured.	May be in sequence with Antrim Plateau Volcanics.
UPPER PERMIAN	LIVERINGA FORMATION: HARDMAN MEMBER	Ph	Yellow to red weathering medium-grained ferruginous sandstone.	20+	Moderately resistant, forms cuestas or mesas.	Talbot Syncline; south-east of Bohemia Downs.	Conformably(?) overlies Pr_3. Top not exposed.	Contains shelly fossils. Dark air-photo pattern.
	LIVERINGA FORMATION: CONDREN SANDSTONE MEMBER	Pr_3	Yellow-weathering, medium grained quartz sandstone.	300	Resistant; forms mesas and plateaux.	South-western part of Sheet area, to south of Pinnacle fault.	Conformably overlies Pr_2.	Contains abundant plant fossils.
		Pr_2	Ferruginous siltstone, fine-grained, ferruginous sandstone.	50-100	Poorly resistant; yields ferruginous soil.		Conformably overlies Pr_1.	No fossils found. Dark air-photo pattern.
		Pr_1	Flaggy, olive-green, medium-grained, clay-cemented, quartz sandstone, and silty quartz sandstone.	150	Resistant; forms cuestas.		Conformably overlies Lightjack Member.	Contains rare plant fossils. Micaceous in part.
LOWER PERMIAN	LIVERINGA FORMATION: LIGHTJACK MEMBER	Pj	Fine-grained sub-greywacke, ferruginous, siltstone, very fine-grained ferruginous sandstone.	100	Poorly resistant; yields ferruginous soil.	South of Peter's Bore; west and south-east of Bohemia Downs.	Conformably overlies Noonkanbah Formation.	Contains shelly fossils. Dark air-photo pattern.
	NOONKANBAH FORMATION	Pn	Yellow-weathering, fine-grained calcareous sandstone; fine to coarse-grained ferruginous sandstone.	200+ (exposed)	Poorly resistant, forms plains.	South-west of Peter's bore; south of Bohemia Downs.	Conformably(?) overlain by Lightjack Member.	Contains shelly fossils. Known elsewhere to overlie Poole Sandstone (Veevers & Wells, 1961).
LOWER PERMIAN - UPPER CARBONIFEROUS	GRANT FORMATION	Pg	Red weathering, massive, coarse to very coarse-grained quartz sandstone; boulder conglomerate.	500 (exposed)	Resistant; forms plateaux, mesas and rounded hills.	South-western part of Sheet area, north-east of Pinnacle Fault.	Unconformably overlies Devonian rocks.	Known elsewhere to be overlain disconformably by Poole Sandstone (McWhae et al, 1958).
					U N C O N F O R M I T Y			
DEVONIAN		D				Western and south-western part of Sheet area.		Subject of study by Playford and Lowrie (in prep.).
					U N C O N F O R M I T Y			
LOWER CAMBRIAN (?)	ANTRIM PLATEAU VOLCANICS	fla	Massive, amygdaloidal, vesicular and basalt.	5000+	Poorly resistant, form undulating country or flats.	Around Trig. Station J18; near Mount Ramsay; northern Lubbock Range; Ramsay Range; east of Lilly Lagoon.	Conformably overlies Lally Conglomerate. Top not exposed.	Exposures on the Mount Ramsay Sheet area are the westernmost, southernmost and thickest exposures of the unit.
	LALLY CONGLOMERATE	fll	Medium, fine and coarse grained sub-greywacke, cobble conglomerate, feldspathic sandstone, quartz sandstone.	50-420	Resistant; forms strike ridges.	Lubbock Range; Ramsay Range; around Trig. Station J18; east of Lilly Lagoon.	Unconformably overlies Louisa Downs Group. Conformably overlain by Antrim Plateau Volcanics.	Unit derived from a province lying to the south west.

CAINOZOIC

Hardman (1885) referred to the "Pindan" broad red or brown sandy flats in the southern part of the Sheet area and regarded them as Pliocene or Recent. He also referred boulder beds of the Margaret River to the Pliocene or Recent (p.14) but it seems clear that he included the Lally Conglomerate, which is probably of Cambrian age, with the more recent gravel deposits. Woodward (1891) mentioned the "Pindan" and designated it Pliocene or Recent.

Guppy et al (1958) referred briefly to the superficial rocks of the Fitzroy Basin, and Dow et al (1964) give an account of the Cainozoic deposits of the East Kimberley District. The most comprehensive study of the superficial deposits of the area is by Rutherford (1964).

The present survey has shown that large parts of the Mount Ramsay Sheet area are covered by deposits of probable Cainozoic age. Although we have no means of accurately determining the age of any of the deposits it is thought that the only consolidated rocks (Laterite and the Lawford Beds) are possibly of Tertiary age and that the most recent alluvial and aeolian deposits may be of Quaternary age. The divisions recognised are shown in Table 14.

TERTIARY(?)

Tp - (Laterite)

Laterite occurs mainly in the southern and eastern parts of the Sheet area. In general it is not well developed over rocks of the Halls Creek Group, although good developments (up to 40 feet in thickness) occur in the south-central part of the area. The main occurrences are

a) over the granites of the Lamboo Complex in the area between the Laura and Margaret Rivers, where a pisolitic, rather friable duricrust occurs and is capped by lateritic soil; in other areas a thick friable, leached zone is present without a ferruginous or pisolitic capping;

b) over the Permian rocks of the Old Bohemia area where a hard tubular duricrust, up to ten feet thick, is developed on shales and sandstones of the Grant Formation; it is largely covered with sand, or a very sandy soil containing small, round, limonitic nodules;

c) over Cainozoic gravel deposits. East of Old Bohemia, and to the south of Louisa Downs a tubular duricrust covers loosely consolidated gravels. This is an extension of the laterite over the Grant Formation;

d) over McAlly Shale. Several small outliers of a hard duricrust occur in the Louisa Downs-Margaret River Homestead area. These probably represent a much more extensive deposit.

The relations of laterite to other Cainozoic rocks is confusing in that it has been seen to overlie Lawford Beds, and to be capped by Lawford Beds. It also overlies gravels, is overlain by gravels and occasionally contains gravels. The simplest explanation for these phenomena would be to regard the laterite as having been formed at several different stages in Tertiary time, and that its apparently variable stratigraphic position is governed by the water table existing at the time of formation. However, the laterite which pre-dates the Lawford Beds in the Mount Ramsay Sheet area is probably the most important of these deposits.

Only two confirmed laterite occurrences are known within the Kimberley Group, one at The Goat Paddock, the other about twelve miles north of there, though several other small outcrops overlying sandstone of the Mount Cummings Plateau have been recognized on air photographs.

<u>Tl - (Lawford Beds)</u>

The Lawford Beds extend onto the Mount Ramsay Sheet area from the southerly adjoining Mount Bannerman Sheet area where they were mapped by Casey and Wells (1960). They are exposed in isolated localities throughout the southern part of the Mount Ramsay Sheet area.

The Beds form low cliffed plateaux and mesas which in many cases have a gentle southerly dip. They are largely confined to the less elevated parts of the area, but some benches and outliers occur in the Lubbock Range.

The Beds vary in thickness from a few feet to over 70 feet near Ollamurra Yard on the Mary River, where they consist of yellow, brown and white limestone, which is usually represented by white, pale grey, yellowish grey, or orange-brown weathering chalcedony. Manganese dendrites are sometimes present. The silicification of the limestone begins with the development of small stringers or patches of silica in the limestone, with the greatest alteration where joints and bedding planes are most strongly developed.

In the Lubbock Range small flat-topped mesas and benches are developed along the flanks of a tributary valley of the Margaret River, where they overlie steeply dipping Tean Formation. The flat top of the deposits is roughly 80 to 100 feet above the present level of the Margaret River. The beds are now altered to chalcedony; "horses" of conglomerate occur within the chalcedony, indicating that there has been some replacement of the underlying strata. Away from the tributary valley, the small outliers of Lawford Beds and thin pebble and granule conglomerates overlie the Lubbock Formation. The Lawford Beds show minor slump structures. These deposits probably mark the edge of the basin in which the original limestones were laid down.

Extensive exposures of the Lawford Beds also occur to the south of Louisa Downs Homestead and along Christmas Creek. In these areas the Beds appear to be in shallow basins flanking the courses of major present-day streams. This is particularly evident in the Christmas Creek area where about 50 feet of chalcedony and/or limestone occurs in mesas close to the present drainage channels (e.g. at Trigonometrical Station C31a), less than a mile or so away from the channels the strata are either very thin or absent.

The Lawford Beds are commonly associated with major watercourses and they could have been deposited in lakes along the ancestral drainage system. An alternative hypothesis isthat the Lawford Beds formed at or near the existing water table, in the same way as a laterite or kunkar deposit. This would also explain their association with the drainage pattern.

CAINOZOIC UNDIFFERENTIATED

Czl - (Lateritic Soils)

Lateritic soils generally occur over areas of laterite, or as small aprons shed from laterite mesas. They are usually dark, red brown ferruginous, friable soils, often intermixed with small, ($\frac{1}{8}$"), smooth, rounded granules of limonitre material. Like the laterites, these soils have a dark photo-pattern, but can usually be distinguished by the lack of "breakaway" features at the edge of the outcrop. Lateritic soils are particularly extensive west of Moola Bulla.

Czb - (Black Soil)

Black soils and cracking clays occur throughout the Sheet area. They are typically black or grey, often with whitish top, and they develop deep, open, polygonal cracks, giving a very uneven surface. Black soils can usually be recognised on air photos by their typical smooth pattern or else by the characteristic "gilgai" pattern. Four main types of occurrences are known, as follows:

a) In small basins associated with minor streams and drainage channels. Such areas are probably formed by deposition of silt due to ponding of the streams.

b) Overlying areas of basalt or other basic rocks. These are generally small areas of poor drainage e.g. on broad interfluves.

c) Overlying alluvium, particularly on flood plains.

d) Overlying limestone and calcareous shales. This is by far the most important mode of occurrence, for black soils are developed extensively on the Devonian limestones of the western part of the Sheet area. They are also commonly developed over calcrete and kunkar, where these deposits occur in stream courses.

Czg-(Gravels)

Loosely cemented gravels are present throughout the Sheet area, particularly in the south-west and south central portion, and in the Margaret-O'Donnell Depression. They include material of all grades from sand to boulders, and are composed dominantly of quartzite and quartz sandstone, but boulders of shale, greywacke and Archaean basic rocks occur in some localities. Individual elements are generally subangular to subrounded, and sorting is poor, but stratification and cross bedding are locally well developed e.g. west of Me No Savvy Yard.

The gravels generally form broad flats which are higher than the present stream level. In the larger outcrops, dissection is well marked at the edges, where a close system of short, steep gullies is developed, but in smaller areas a close dendritic drainage pattern is produced, particularly where an overlying laterite has been eroded.

Gravel deposits also occur on and along the margins of the Devonian-Permian conglomerate outcrops. These deposits are identical with the weathering products of the conglomerate itself, so mapping is necessarily imprecise in these deposits.

The age of the gravels is not precisely known, but it is believed that the sheet gravels are contemporaneous. Palynological determinations made on samples from Mount Dent, from the O'Donnell River, and from near the Mary River-Laura Creek Junction suggested a Pliocene age (Edgell, 1964). No marine plankton were present in these samples, so it is presumed that the gravels are of fresh water origin. In the southern part of the Sheet the gravels are commonly capped by laterite or Lawford Beds, which dip gently southwards towards Christmas Creek. In the O'Donnell basin the top of the gravels is either flat or else dipping gently towards the main river channels. The gravels are deeply dissected and on Mount Dent they lie at least sixty feet above the present river level.

Czs - (Sand, soil and alluvium)

This division includes the various residual sands and soils developed in the region, as well as deposits of alluvium too small to be shown on the accompanying map. Although some of the material mapped as Czs has certainly undergone transport, the major part is believed to have developed more or less in situ and its varying composition directly reflects the variable nature of the underlying bed-rock. A full account of the deposits is given by Rutherford (1964).

QUATERNARY(?)

Qs - (Aeolian Sand)

Sand covers wide areas in the south-east and south-west corners of the Sheet. In the area north of Bohemia Downs, the sand forms a thin, flat cover over a laterite developed on Permian Grant Formation. This is also the case south of Christmas Creek, though fixed dunes with an east-west trend are developed in the sands south-east of Bohemia Downs Homestead.

Dunes are more common on the adjacent Mount Bannerman Sheet area and further south in the Great Sandy Desert (Wells, 1960). A thorough discussion of the development of these dunes is given by Veevers and Wells (1961), pp. 191-211) who conclude that they "were formed during an arid phase of the Pleistocene, and that since then the climate has ameliorated and vegetation has spread over the desert and fixed the dunes". The sands of the Mount Ramsay Sheet are probably of similar origin and age; they are certainly of aeolian origin.

Qa - (Alluvium)

Alluvium occurs in creek beds throughout the area, and particularly over the extensive flood plains of the Margaret River. Creek alluvium is generally sandy or silty, though stony stream sections are common in the King Leopold and Mueller Ranges. The flood plains show development of levees and braided streams, and billabongs occur in the more silty and clayey parts of the flood plains. West of Macdonald Gorge, these flood plains are deeply incised; up to 30 feet of grey and yellow sandy alluvium can be seen in the banks of the Margaret River near Black Rock.

TABLE 14 : SUMMARY OF STRATIGRAPHY - CAINOZOIC

	ROCK UNIT	MAP SYMBOL	LITHOLOGY	THICKNESS IN FEET	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION OF EXPOSURES	STRATIGRAPHIC RELATIONSHIPS	REMARKS
QUATERNARY		Qa	Alluvium - mud, silt, sand, gravel.	30	Flood plains.	Widespread, particularly along Margaret River.	Overlies other Cainozoic deposits.	Provides high quality groundwater at shallow depth.
		Qs	Red sand	30?	Broad flats; dune-fields.	Mainly in south-west and south-east.	Probably post-dates much of Czs.	Includes only aeolian sand.
UNDIFFERENTIATED		Czs	Soil, sand, alluvium	10?	Flats, gentle slopes.	Widespread.	Probably post-dates Tp and Tl.	Mostly residual deposits.
		Czg	Unconsolidated or poorly consolidated gravels, talus.	80	Bare rounded hills and rises.	Widespread, but mainly in south and south-west.	Overlies, underlies and also "interbedded" in Tp.	Much of material derived from Devonian and Permian conglomerate.
		Czb	Black soil, cracking clay.	10?	Flats.	Widespread, but mainly in west.	Probably post-dates Tp and Tl.	Supports grass, but trees rare.
		Czl	Red-brown ferruginous soil containing limonitic pisolites and granules.	10?	Broad plains.	Widespread, but mainly in north-east.	Overlies Tp.	Developed on or from laterite.
TERTIARY (?)	LAWFORD BEDS	Tl	Light grey weathering, white limestone, silicified limestone, chalcedony.	70	Mesas or plateaux.	Mainly along major drainage basins.	Unconformably overlies Tp in places, but in others is overlain by Tp. Post-dates Czg in places.	Probably "freshwater" lacustrine deposit.
		Tp	Tubular laterite, ferruginous, pisolitic laterite.	40	Broad, flat plains, mesas and plateaux.	Widespread, but mainly in north-east, and central-south.	Unconformably overlain by Tl in places, but in others rests on Tl.	Includes rocks of "mottled" zone.

STRUCTURAL GEOLOGY

The structure of the Mount Ramsay Sheet area involves rocks which range from probable Archaean to Permian in age, aside from the undisturbed Cainozoic superficial deposits which overlie the older strata. Throughout this period, the structure has been dominated by two long, narrow, tectonically active areas, known as the Halls Creek Mobile Zone and the King Leopold Mobile Zone (Traves, 1955), which converge in the southern part of the Sheet area. These zones have been active throughout their existence and this has resulted in the complicated structure, the wide variety of lithology, and the numerous unconformities in the sedimentary succession of the Sheet area.

Between the Mobile Zones lies the more stable Kimberley Block (Traves, 1955) ; in the present area, this includes the Mount Cummings Division, characterised by broad, gentle folds and associated faulting, and the Western Faulted Margin, characterised by severe faulting. To the south-east of the Halls Creek Mobile Zone lies the stable Sturt Block (Traves, 1955), while the Lennard Shelf and Fitzroy Trough were developed south and west of the King Leopold Mobile Zone. Figure 25 shows the limits of these structural divisions.

<u>The Halls Creek Mobile Zone</u> is roughly defined by a broad, faulted belt of deformed Archaean sediments, including low grade and high grade metamorphic rocks which have been intruded by acid and basic plutons of Proterozoic age. It extends with a general north-easterly trend from Mount Fairbairn and One Tree Hill, in the west and south of the Sheet area, to One Tree Palm Gorge and Moola Bulla Station. From here, the zone extends through the East Kimberley District with the same general trend, to beyond Wyndham and into the Northern Territory. In the Mount Ramsay Sheet area the zone also affects later sediments which range in age from Middle Proterozoic to Permian.

The oldest rocks of the Mobile Zone are the probable Archaean rocks of the Halls Creek Group, which occur in the Willy-Willy - Mount Dockrell - Mount Angelo district, in the south-west of the Sheet area. A thick sequence of shale, siltstone and greywacke, with minor interbedded dolomite and basic volcanic bands makes up the Olympio and Biscay Formations, which are tightly folded along north-west

Fig. 25 Structural Sketch Map - Mount Ramsay 1:250,000 Sheet Area.

Reference

Major Fault, showing direction of movement	King Leopold Mobile Zone
Fault, position approximate	Western Faulted Margin
Anticline	Mount Cummings Division
Syncline	Halls Creek Mobile Zone
Overturned syncline	Lennard Shelf
Geological boundary	Fitzroy Trough
Trend line	① McKinnon Syncline
Homestead	② Talbot Syncline
	③ O'Donnell Syncline

Qs Quaternary Sand	Ꝑd Glidden Group
Pz Palaeozoic Undifferentiated	Ꝑk Kimberley Group
Ꝑi Louisa Downs Group and Cambrian	Ꝑb Lamboo Complex
Ꝑn Kuniandi Group	Ꝑh Halls Creek Group

trending axes. A strong axial plane cleavage is developed, and while the central portion of the outcrop is virtually unaltered sediment, the fringing areas to the east and west are metamorphosed to biotite grade. In the more highly deformed metasedimentary area, e.g. in the Mount Dockrell and Willy-Willy Creek areas, a strong strain-slip cleavage is developed, indicating a second period of folding in this region.

Large granite batholiths, together with smaller basic plutons, are intruded into these rocks, and occupy most of the area of the Mobile Zone. The granites occur as large, elongate masses, roughly parallel to the edges of the zone, and often include small roof pendants of Halls Creek Group sediments, which may be highly metamorphosed. Shearing in the granites is generally restricted to narrow zones on the margins, or close to major faults. Gabbro and ultrabasic rocks occur as small elongate bodies, which parallel the trend of the zone, or as small plugs.

Two areas of unaltered Proterozoic sediments overlie older rocks of the Halls Creek Mobile Zone. In the first, the Upper Proterozoic Glidden Group is seen as two perched synclines with north-east or north-north-east axes, and a smaller faulted outlier, north of the Glidden River between Mount Amherst Homestead and Mount George. The folds are open structures, with dips ranging from 20° to 40° on the limbs, and show no signs of a second folding.

The second area is much larger, and includes the Kuniandi and Louisa Downs Groups, which are of Upper Proterozoic age, and the Lally Conglomerate and Antrim Plateau Basalt, which are probably Cambrian. These rocks are folded into broad, gentle, anticlines and synclines, which trend north-north-west, and plunge slightly in the same direction. The Kuniandi Group occurs on the western edge of the basin, and is bounded to the north and south by faults; it was probably eroded in the east prior to the deposition of the Louisa Downs Group.

Two periods of folding are known over much of this area. The first folding gave the main north-north-west trending structures, and the second, which also affects the Cambrian rocks of the area, formed gentle cross folds on east-north-east axes. The sinuous outcrop of the Tean Formation east of Mount Tean, and the horseshoe-shaped outcrop of the Cambrian strata near Mount Ramsay, are caused by this cross folding. Domes in the Tean and Lubbock Formations north-north-east of Margaret River Homestead might be due to the interaction of the post-Cambrian folds on the major structure, but it seems more likely that these were contemporaneous with the main folding. No trace of this second folding is known in the Kuniandi Group.

The Kuniandi Group to the north of Mount Bertram, however, is affected by a second folding, which has a north-west trend. This has produced several parallel, narrow folds in the shales and sandstones which show a strong axial plane cleavage. Dips on the limbs are of the order of 20° to 30°. This folding is restricted to the Mount Bertram area where it affects the Louisa Downs Group, but is on strike with folding and faulting in the Middle Proterozoic rocks north and east of Mount Huxley.

<u>The King Leopold Mobile Zone</u> occupies the low ground between the King Leopold Range and the Palaeozoic rocks of the western part of the Sheet area. It is similar to the Halls Creek Mobile Zone in many respects, and consists of strongly cleaved and faulted Archaean sub-greywacke, sericitic schist, shale and siltstone, rare amphibolite and metadolerite of the Halls Creek Group, which have been intruded by large granite plutons. The zone as a whole has a northerly trend, and the granite bodies are oriented parallel with this trend.

Folding is not well displayed within the Halls Creek Group, and no detailed structural pattern has been resolved. The strong north-trending foliation is probably an axial plane cleavage.

Overlying the Halls Creek Group/and the granitic intrusives on the eastern side, are the Middle Proterozoic sediments of the Speewah and Kimberley Groups, while the western side is covered by Devonian and younger sediments.

Faulting is important in the King Leopold Mobile Zone. Major faults in the northern part of the Sheet trend north or north-west, (e.g. the Mount Elma and Mount Winifred Faults), while in the south-west, the Pinnacle Fault, which is believed to be associated with the Mobile Zone, has a north-westerly trend. Subsequent faulting in the overlying strata tends to parallel these directions.

<u>The Mount Cummings Division</u> occupies a large triangular area in the northern part of the Sheet area and is bounded on the western side by the King Leopold Range. It includes rocks of both Middle and Upper Proterozoic age which unconformably overlie the Halls Creek Group and the Whitewater Volcanics in the extreme north-west of the division. The division is characterised by broad simple folds, with dips of the order of $20^{\circ} - 30^{\circ}$, which trend west-south-west and plunge gently in this direction. At its western margin, however, this trend changes abruptly to north-south, the dips become steeper, and some of the fold axes are bent, but generally the change in direction occurs over a fault. This is thought to be due to a later folding associated with activity in the King Leopold Mobile Zone.

Faulting is very common; most of the faults are associated with folding, and are simple, normal cross faults of small throw, trending roughly east-north-east or north-south. Transcurrent faults in the central and western parts trend slightly east of north, and displace the major fold axes by as much as five miles. One of these is the southern extension of the Greenvale fault on the East Kimberley district. A reverse fault of very large throw cuts out most of the Speewah Group just west of the McKinnon Syncline. This fault trends north-east on the Mount Ramsay Sheet area, but swings to the north on the adjacent Lansdowne Sheet area.

Upper Proterozoic sediments are preserved in two areas in the Mount Cummings Division. These are:-

(i) The <u>O'Donnell Syncline</u>, which trends north-east, is twenty-four miles long and five miles wide; it surrounds the confluence of the Margaret and O'Donnel Rivers. The elongation and shape of this syncline has been governed by the structural trends in the underlying rocks. The development of this structure probably began in the Middle Proterozoic and extended into the Upper Proterozoic.

The margins of the syncline are modified by faulting and folding. Small east-west and north-south trending faults are the most common, but the eastern margin of the basin is defined by a large transcurrent fault, the southerly extension of the Greenvale Fault of the East Kimberley area. The latest movements on these faults post-date the deposition of the Upper Proterozoic rocks; however, some of these faults are rejuvenated Middle Proterozoic dislocations. Shallow northerly or southerly plunging drag folds are associated with the faulting.

(ii) The McKinnon Syncline is an elongate east-north-easterly trending feature sixteen miles long and three miles wide, near the northern edge of the Mount Cummings Plateau. The axial trend of the syncline follows that of the underlying Middle Proterozoic strata. The southern limb of the fold has been modified by a fault, and the post-Kuniandi Group dislocation on this fault was probably a recurrent movement along a pre-existing reverse fault in the underlying Kimberley Group. Other smaller north-south trending faults post-date this sedimentation, and these are rejuvenated Middle Proterozoic transcurrent faults.

The Western Faulted Margin trends north-south, and extends from Mount Huxley and Palm Spring in the south, through Macdonald Gorge to beyond Mount Winifred in the north. It is about ten miles wide throughout. Within this zone, rocks of the Speewah and Kimberley Groups form the gently dipping western limb of a syncline, which has been greatly modified by faulting. In the relatively undisturbed areas, dips range from 15° - 45°, and axial plane cleavage and minor folding are developed, but in strongly faulted localities large drag folds are commonly seen (Fig. 26).

Faulting has taken place along three main trends. The larger faults strike north, or west of north; e.g. eight miles east of Mount Philip, where Pentecost Sandstone is thrown against the base of the Warton Sandstone, a movement of at least 3000 feet, and eight miles east of Chaney's Yard, where the Mount Winifred Fault cuts out most of the Speewah Group, a throw of at least 2000 feet. Other major faults have an east-west trend, e.g. eight miles east of Mount Winifred, where King Leopold Sandstone is thrown against the Tunganary Formation, and west of Macdonald Gorge, in the Margaret River valley, where faulting shifts the base of the Warton Sandstone over two miles. No transcurrent movement is known on this fault, but there is extensive dragging of the Teronis Member in the fault zone. Further to the south, east-west folding marks the southern limit of the zone, but there is no way of estimating movements on the fault. Minor faulting with a north-easterly trend is present north of the Margaret River.

Figure 26: King Leopold Sandstone, showing steep folding. King Leopold Range, 2 miles north of Mount Phillip.

Some of the faulting in the King Leopold Range took place in the interval between the deposition of the Speewah and Kimberley Groups. Four miles south of Macdonald Gorge, on the western side of the fault, the King Leopold Sandstone rests on the O'Donnell Formation, while on the eastern side it overlies the Luman Siltstone. It seems likely that almost the whole of the Speewah Group has been eroded from the upthrown area west of the fault prior to deposition of the King Leopold Sandstone. Similarly, five miles north of Macdonald Gorge, there is a rapid thinning of the Speewah Group from north to south beneath the King Leopold Sandstone. Nowhere is the entire Speewah section present to the west of the Mount Winifred Fault, which bounds this block, but east of the fault the complete Speewah succession can be seen. Pre-Kimberley Group faulting, with possible tilting to the north, was followed by erosion of the Speewah Group strata.

Lennard Shelf and Fitzroy Trough. The region covered by Palaeozoic sediments in the western part of the Sheet area can be divided into two tectonic units - the Lennard Shelf, to the north of the Pinnacle Fault and the Fitzroy Trough, to its south (Playford and Johnstone, 1959).

The Fitzroy Trough contains a thick sequence of Carboniferous and Permian sediments which are thought to have been laid down in a rapidly subsiding basin, whose subsidence was related to movement on the Pinnacle and other faults (McWhae et al, 1958).

The Lennard Shelf of the Old Bohemia-Laidlaw Range area has remained virtually undisturbed since its inception, though local unconformities and conglomerates within the reef complexes are ascribed to movements on major faults in Devonian times. Apart from these regional effects and local faults and their associated drag folds, most structures in the reef complexes are depositional and include steeply dipping fore-reef beds, and in the area immediately bordering the reef, gently dipping back-reef beds. In both cases the direction of dip is away from the associated reef, so an impression of steeply plunging folds may be given. In most cases, the rocks of the inter-reef facies are horizontal, though weak folding in these beds is known from the southern Bugle Gap-Old Bohemia area. Tectonic folding is known in the Horseshoe Range where the Pillara Limestone and Fairfield Formation have been folded into a gentle west-north-west trending syncline. This is probably due to late movements in the adjacent Halls Creek Mobile Zone.

The eastern margin of the Lennard Shelf is marked by thick, but locally restricted boulder conglomerates, which make up the Burramundi Range, Mount Elma, and the Sparke Range. These conglomerates are of Devonian and possible Permian age, and are probably fanglomerate deposits associated with faults. It seems likely from their position that their formation is due to fault movements within the two mobile zones.

The southern part of the area has a thin cover of Grant Formation, which is of Lower Permian age. This unit is very gently folded or tilted, and lies with angular unconformity on the Devonian rocks.

In summary, the western part of the Sheet has been subject to series of tectonic events, which were probably controlled by movement within the Halls Creek and King Leopold Mobile Zones. The recurrent major faulting, together with folding and tilting, repeats the pattern seen further to the east in the Proterozoic basins of the Lubbock Range and Matheson Hills, and in the East Kimberley Division, while the large Mount Elma, Mount Winifred and Pinnacle Faults are analogous with the Springvale, Woodward and Halls Creek Faults of the eastern area.

The structural history of the Mount Ramsay Sheet area can thus be summarized as follows:-

1. Formation of a narrow geosynclinal trough in Archaean time, in which greywacke, dolomite and basic volcanics of the Halls Creek Group were accumulated. This was subsequently folded on a north-easterly trend, and cut by the large faults of the Halls Creek Mobile Zone.

2. Intrusion of large acid and basic plutons into these rocks in the Lower Proterozoic.

3. Following peneplanation, the Kimberley Basin began to subside in the Middle Proterozoic and the feldspathic sediments of the Speewah Group were deposited. Some faulting and uplift took place in the southern and western margins of the basin, but sedimentation continued throughout Kimberley Group and Crowhurst Group time.

4. Folding of these sediments on an east-north-easterly trend, into simple open folds, accompanied by faulting.

5. The Colombo Sandstone was probably deposited after a short period of erosion in a basin developed along the trend of the O'Donnell Syncline. Faulting on a northerly trend was established in the King Leopold Mobile Zone at some stage following the formation of the east-

north-east structures of the Kimberley Basin. East-west faulting also took place prior to the deposition of the Colombo Sandstone.

6. In the Upper Proterozoic, a small basin was developed within the Halls Creek Mobile Zone, where the sediments of the Glidden Group were deposited and subsequently gently folded on north-east and north-north-east axes.

7. Following a period of erosion, the basin of deposition of the Kuniandi and Yurabi Groups was developed over the central part of the Sheet in Upper Proterozoic time. The westerly extent of the basin is not known, but it covered a very large area to the north and east and was probably very deep during the deposition of the McAlly Shale and Lubbock Formations. Folding on a north-north-westerly trend was then developed; it is possible that an earlier folding on the same trend, followed by erosion, took place between the deposition of the Kuniandi and Yurabi Groups. A later folding on a north-west trend affected the Kuniandi Group in the northern part of its outcrop. This folding is on strike with the faulting of the Western Faulted Margin, and is presumably due to rejuvenation of these faults.

8. In Cambrian(?) time, further subsidence took place within the Halls Creek Mobile Zone, and the Lally Conglomerate and Antrim Plateau Basalts were formed. This was followed by folding on east-north-east axes, which also affected the Upper Proterozoic of the Lubbock and Ramsay Ranges.

9. Subsidence in the southern part of the Sheet occurred during the Palaeozoic, and the Lennard Shelf and Fitzroy Trough were established. The subsidence of the Fitzroy Trough was probably related to movements on the Pinnacle Fault and other faults, but the Lennard Shelf remained stable throughout its existence. In the Horseshoe Range, however, some post-Fairfield folding took place, and Permian rocks of the Fitzroy Trough are folded into the gentle Talbot Syncline.

<u>The Goat Paddock</u>. An almost circular topographic depression, over three miles wide, and known as the Goat Paddock, occurs to the east of the junction of the Margaret and O'Donnell Rivers. The depression is cut into the gently dipping strata of the Kimberley and Crowhurst Groups (fig. 27).

Figure 27: The Goat Paddock, viewed from the north-west.

In the north-eastern quadrant, the softer sediments of the Crowhurst and Louisa Downs Groups have been breached in two places, and the creeks draining the depression flow through the more easterly gap. In the southern area, the walls are breached by narrow, steepsided gorges cut by these streams; in most cases they are controlled by jointing or faulting.

Exposures in the walls show gently dipping, largely unaltered Proterozoic sediments, except near faults where local flexuring occurs and fine quartzite fault breccia is commonly developed. Around much of the south-western quadrant thick, poorly cemented scree deposits cover the lower slopes of the walls, but in places these can be seen to rest unconformably on older rocks, which are tentatively regarded as being of Palaeozoic age (see Stratigraphy).

The (?)Palaeozoic rocks crop out intermittantly around two-thirds of the circumference of the depression; they are not exposed in the north-eastern sector. In most localities only the uppermost beds are exposed, but in at least one locality (in the eastern part of the depression) what appears to be the full succession can be examined. The lowermost beds are up to 50 feet thick and consist of very poorly sorted sand-cemented sandstone-breccia and rest unconformably on the Proterozoic rocks (figs. 28 and 29).

Figure 28: (?)Palaeozoic sandstone-breccia (right) resting unconformably on Pentecost Sandstone: Eastern part of Goat Paddock.

Figure 29: Close-up view of (?)Palaeozoic sandstone-breccia shown in Fig.28.

The lowermost beds grade upwards into cobble and pebble conglomerate (with well-rounded megaclasts), and this in turn grades into medium-grained, well sorted, yellow-weathering, silty, quartz sandstone. The conglomerate is up to about 50 feet thick, and the sandstone is roughly the same thickness. The thickness of the lower two units appears to decrease rapidly towards the centre of the depression.

The features which need to be explained are (i) The circular shape of the structure and its high steep walls. (ii) The tangential and radial faults and joints in the immediate area of the depression. (iii) The origin of the younger sandstone and conglomerate deposit. Two hypotheses have been put forward; the first suggests that the circular shape is due purely to erosion, which has been aided by the strong rectangular jointing and faulting which is tangential to the rim of the depression. The younger sediments represent later flood deposits and may be equivalent to the Pliocene gravels of the O'Donnell Basin. The sandstones of the upper part of the sequence, however, resemble parts of the Candren Sandstone Member of the Liveringa Formation, and so the whole sequence has been tentatively placed in the Palaeozoic. The joint pattern and folding is probably due to the overall east-north-east trending folds of the Mount Cummings Division, but could be influenced by the large, transcurrent Greenvale Fault to the west.

The second hypothesis suggests that the initial depression was due to the impact of a large meteorite, and that subsequent erosion and deposit has produced the present structure. The fault and joint pattern are considered to be due to the initial impact, and the younger conglomerates to be derived from the shattered upturned rim which is commonly associated with meteorite craters. This rim has been entirely eroded at the present day.

There seems to be no way of settling the question without resort to geophysical methods. None of the diagnostic features of meteorite craters, e.g. nickel-iron fragments, upthrown rim, high-pressure minerals, have been discovered, and because of the extensive soil cover within the depression, are unlikely to be found. A magnetometer survey might detect a nickel-iron body if it exists beneath the soil cover, and gravity work might clarify the structure within the rim.

<u>Meteorite(?) Craters</u>. Four elliptical depressions up to 100 feet across occur in an area about 12 miles to the south-east of Mount Dockrell, and are thought to be due to meteorite impacts. (Dow, in prep.).

GEOLOGICAL HISTORY

The geological history of the Mount Ramsay Sheet area is long and complex. The area contains the most complete record of Middle and Upper Proterozoic sedimentation in the Kimberley region, and may well provide - despite long breaks in the record - the most complete representation of this time span to be found in northern Australia. More importantly, the elucidation of the stratigraphic sequence in the map area has led to a much better understanding of the overall stratigraphy of the Kimberley region. We propose the correlations set out in Table 15: most of the Middle and Upper Proterozoic formations named so far in the Kimberley region are included in the table, although the Carr Boyd Group of Dow et al (1964) (which is thought to be broadly equivalent to the Speewah Group) and some other units of doubtful stratigraphic position have been excluded.

A summary of the geological history of the Mount Ramsay Sheet area is given in Table 16. The table is necessarily generalised and, in part, interpretative, but should provide a starting point for more elaborate investigations.

TABLE 15. CORRELATION CHART - MIDDLE AND UPPER PROTEROZOIC ROCK UNITS. - KIMBERLEY REGION.

	KIMBERLEY PLATEAU (Gellatly, Derrick and Plumb, in prep.)		MOUNT RAMSAY SHEET AREA		EAST KIMBERLEY REGION (Dow and Gemuts, in prep)	
CAMBRIAN	UNCONFORMITY		Antrim Plateau Volcanics Lally Conglomerate		Antrim Plateau Volcanics	
UPPER PROTEROZOIC			UNCONFORMITY		UNCONFORMITY	
			Louisa Downs Group	Lubbock Formation Tean Formation McNally Shale --- Yurabi Formation --- Egan Formation	Albert Edward Group	Flat Rock Formation Nyuless Sandstone Timperley Shale --- Boonall Dolomite Mount Forster Sandstone
			UNCONFORMITY		UNCONFORMITY	
	Mount House Group	Estaughs Formation Throssell Shale Traine Formation --- Walsh Tillite	Kuniandi Group	Mount Bertram Sandstone Wirara Formation Stein Formation --- Landrigan Tillite	Ord Group	Ranford Formation --- Moonlight Valley Tillite Fargoo Tillite
	UNCONFORMITY		UNCONFORMITY		UNCONFORMITY	
			Glidden Group	Maddox Formation --- Forman Sandstone Matheson Formation Harms Sandstone		Helicopter Siltstone --- Wade Creek Sandstone
			UNCONFORMITY		UNCONFORMITY	
MIDDLE PROTEROZOIC				Colombo Sandstone		Bungle Bungle Dolomite Mount Parker Sandstone
			UNCONFORMITY			
	Bastian Group	Cockburn Sandstone Wyndham Shale Mendena Formation	Crowhurst Group	Hibberson Dolomite Collett Sandstone Liga Shale Hilfordy Formation		
	Kimberley Group	Pentecost Sandstone Elgee Siltstone Warton Sandstone Carson Volcanics King Leopold Sandstone	LOCAL UNCONFORMITY			
	Speewah Group	Luman Siltstone Lansdowne Arkose Valentine Siltstone Tunganary Formation O'Donnell Formation				
	UNCONFORMITY					
		Whitewater volcanics				

TABLE 16. SUMMARY OF GEOLOGICAL HISTORY - MOUNT RAMSAY SHEET AREA.

AGE	MAGMATIC EVENTS	OTHER EVENTS						AGENCY OF DEPOSITION						MAIN MATERIAL DEPOSITED					POSSIBLE ENVIRONMENT OF DEPOSITION.					ROCK UNIT AND MAXIMUM THICKNESS IN FEET.		GROUPS AND GROSS THICKNESS
		Epeirogenic uplift	Epeirogenic subsidence	Folding	Faulting	Marine transgression	Marine regression	Traction currents	Suspension	Chemical	Biogenic	Turbidity current	Glacial	Boulders, cobbles etc.	Quartz-feldspar-sand	Quartz sand	Silt	Clay	Bathyal	Neritic	Littoral	Lacustrine	Terrestial			
		x			x																					
			x			x		x	x							x	x?	x?		x?				Hardman Member L I Fm.		
			x				x	x								x						x?		Pr3 Condren I N		
PERMIAN			x			x		x	x							x	x	x		x?				Pr2 Sandstone V G	550	
			x				x	x								x						x?		Pr1 Member E A		
			x					x	x							x	x	x		x				Lightjack Member R		
			x					x	x		x?					x	x	x		x				Noonkambah Formation	200+	
			x																					?	?	
			x			x		x					x	x		x					x			Grant Formation	500+	
CARBONIFEROUS		x≠	x≠		x?		x																			
DEVONIAN			x x					x	x	x	x			x	x	x	x	x		x	x			See Playford & Lowrie (in prep).	?	
		x		x	x		x																			
CAMBRIAN	Basic vulcanism		x																				x?	Antrim Plateau Volcanics	5000+	
			x			x		x						x	x						x			Lally Conglomerate	420	
		x					x																			
			x						x			x												Lubbock Formation	6000+	
			x					x	x			x							x	x	x			Tean Formation	400	Louisa Downs Group (13,000+)
			x						x										x					McAlly Shale	5000	
			x					x	x							x	x	x		x						
			x					x	x	x?							x			x	x			Yurabi Formation	100	
			x					x	x							x	x	x		x	x					
UPPER			x			x				SEE TABLE ELEVEN														Egan Formation	650	
		x		x?	x?		x																			
			x					x							x					x	x			Mt. Bertram Sandstone	600	
			x						x								x	x	x					Wirara Formation	1600	
PROTEROZOIC			x				x	x?							x		x				x?			Stein Formation	700	Kuniandi Group (4,000'+)
													x	x				x					x?	Landrigan Tillite	1100	
		x					x																			
									x								x	x				x?		Maddox Formation	300+	
								x							x					x				Forman Sandstone	220	Glidden Group (1,850'+
									x						x		x	x	x					Matheson Formation	1120	
			x			x		x	x							x	x	x		x				Harms Sandstone	200	
		x					x																			
			x			x		x								x				x	x			Colombo Sandstone	300+	
		x		x	x		x																			
	Intrusion of Hart Dolerite		x								x										x			Hibberson Dolomite	85+	
			x						x								x	x	x					Collett Siltstone	200	Crowhurst Group (500'+)
MIDDLE			x						x								x	x	x					Liga Shale	150	
			x					x	x							x	x	x		x	x			Hilfordy Formation	100	
			x					x								x				x	x			Pentecost Sandstone	2900	
			x						x	x?							x	x	x?					Elgee Siltstone	1160	
PROTEROZOIC			x						x		x						x	x	x?		x			Teronis Member	460	Kimberley Group (9,500')
			x					x								x				x				Warton Sandstone	1200	
	Basic Vulanism		x												x						x?		x?	Carson Volcanics	2000	
			x		x			x								x				x	x			King Leopold Sst.	2100	
			x						x								x	x		x?				Luman Siltstone	200	Speewah Group (5,600')
			x					x							x					x				Lansdowne Arkose	1100	
			x						x								x	x	x					Valentine Siltstone	100	
			x					x							x					x				Tunganary Formation	3540	
			x						x								x	x	x	x				O'Donnell		
			x			x		x								x				x	x			Formation	650	
	Acid Intrusions (Watery R.Porphyry)																									
	Acid Vulcanism																						x?	Whitewater Volcanics	?	
LOWER PROTEROZOIC		x*																								
	Granitic, basic and ultrabasic intrusions	x																								
	(Lamboo Complex)	x		x	x		x																			
			x						x			x			x		x			x?				Olympio Formation	10,000+	Halls Creek Group (11,000'++)
ARCHAEAN ?	Basic Vulcanism		x																	x?				Biscay Formation	500+	
			x					x								x				x	x			Saunders Creek Fm.	650	
	Basic Vulcanism		x																	x?				Ding Dong Downs Volcanics	?	
			x			x					?					?					?			?		

≠ Uplift on Lennard Shelf, subsidence in Fitzroy Trough.

* Where circled orogenic movements as opposed to epeirogenic.

ECONOMIC GEOLOGY

A description of the mining activity in the Kimberley and East Kimberley Districts is given in Harms (1959) and Dow et al (1964). Most of the mining within the Mount Ramsay Sheet area is confined to rocks of Archaean age. Gold, lead and tin have been produced at various times, while small shows of copper, chromite and chrysotile asbestos are also known.

Asbestos. Small deposits of a rather silicified asbestos (?chrysotile), of the cross-fibre variety are associated with blebs of magnetite, and occur in an ultra-basic body 6 miles north of Lamboo Homestead. The maximum length of fibre seen was about one inch.

Copper. Copper mineralization has been recorded from the Halls Creek Group and Carson Volcanics but a deposit of economic importance has yet to be discovered. Near Mount Angelo, 20 miles south-west of Halls Creek, a ferruginous and silicified gossan with malachite and cuprite occurs in limestone gossan with malachite and cuprite occurs in limestone lenses which are interbedded with schists, shale and greywacke of the Olympio Formation. The largest area of mineralization is at Prospect "A", and is about 150 feet long and 50 feet wide. Following geophysical investigation, the Mount Angelo deposits were drilled in 1962 by Peko Mining, but there has been no production from these deposits. Several other copper deposits occur in the Olympio Formation near Lamboo Homestead.

Chalcopyrite has been recorded from vughs and amygdales within the Carson Volcanics. The lowermost flows of this formation also contain disseminated crystals of chalcopyrite.

Chromium. Several bands of chromite, associated with magnetite bands occur near the base of an ultrabasic body six miles north of Lamboo Homestead. These gravity differentiated layers are exposed over a strike length of 150 feet, in a zone about ten feet wide, and are up to six inches in width. Chemical analyses are not available to date, but it seems unlikely that the body would be economic. However, similar bodies in the East Kimberley District, e.g. Panton Lopolith, carry traces of platinum, so further work is warranted.

<u>Gold</u>. Gold was discovered in the Kimberley Region by Hardman (1885) during his geological reconnaissance of the area, and during the ensuing rush, much alluvial gold was won. The deposits were small, however, and were soon worked out. Reef mining was also carried out at the Mount Dockrell and Mary River mining centres. Smith (1898, p.19) lists returns for the whole of the Kimberley District up to 1897. Finucane and Jones (1939) described several of the mines, and suggested that only two mines, the Western Lead and the Irish Lass, showed any promise at that time.

The Mount Dockrell and Mary River deposits occur in quartz reefs in a sequence of sandstone, shale, slate and intrusive metadolerites of the Olympio Formation. The richest ore came from veins associated with the metadolerites.

Lead and silver also occur in associated with gold in the Mount Dockrell reefs (Finucane, 1938(b), Woodward, 1891), and the presence of sulphide in the ore led to extraction problems in these ores. In addition, such ores are generally up-graded in the zone of oxidation, due to leaching of the sulphides, and this could be one of the reasons for the general fall in grade with depth in these deposits.

The following Table which has been compiled by the Statistics Branch of the West Australian Mines Department, gives details of the production of the Mount Dockrell centre up to the end of 1963.

TABLE 17: PRODUCTION - MOUNT DOCKRELL CENTRE TO 1963.

Number of Lease	Registered Lease	Production Period	Ore Treated	Gold (fine oz.)	Silver (fine oz.)
107	Erin-go-bragh	1939-1941	61.00	53.32	
47	Lady Hopetoun	Prior to 1897	40.00	322.77	
81	Mt. Miniard	1935-1936	184.00	169.71	
112	Old Golden Dream	1941-1942	92.00	29.19	
103	Old Mac	1938-1940	235.70	179.66	
7(M.A. 7)	Victoria	Prior to 1897	4.00	113.16	
85	Western Lead	1935-1942	216.00	75.53	93.00
45	Irish Lass	1937-1943	314.00	266.75	
	McNeill's	Prior to 1891	40.00	123.6	
		Totals	1186.70	1333.68	93.00

The Table shows that some of the early mines showed a good return, but later mining has not been very profitable. At the present time, there is virtually no active gold mining in progress in the Mount Ramsay Sheet area.

Gold was also worked in the Mount Amherst region (Jones, 1938). The gold occurs in quartz reefs in Proterozoic granite, and in one case the productive reef is also associated with a dolerite dyke. The deposits are not economic.

Lead-Silver. A small lead mine was in operation about six miles north-north-west of Mount Amherst Station. A Report by Jones (1938) states that granite country rock was cut by "a number of quartz-carbonate veins containing galena and cerussite". The strike length of the productive vein is stated to be 350 feet, and the maximum width is 12 feet; two samples cut across it assayed 15.69% lead, +2.34 fine oz. silver per ton over 52 inches and 7.27 lead +1.45 fine oz. silver over 144 inches. Dolomite and quartz are the principle gangue minerals.

The deposit was worked in 1948 and 1952, when the price of lead was high; the following table of production figures was compiled by the Western Australian Mines Department Statistician.

TABLE 18: PRODUCTION - MOUNT AMHERST LEAD MINE.

Year	Ore + Concentrates (tons)	Lead (tons)	Value (A£)	Silver (fine oz.)	Value (A£)	Total Value (A£)
1948	6.53	4.51	356.12	18.54	1.2	357.82
1952	2.73	1.73	290.99	19.08	3.64	294.63
TOTALS	9.26	6.24	647.61	33.62	4.84	652.45

From the present state of the workings it seems that the vein does not persist in depth, nor was it economic over its entire length of 350 feet.

Jones (op. cit.) also reports similar veins south of Mount Amherst Homestead and carbonate veins are known from east of the homestead and from Me No Savvy Yard. Lead and silver also occur in association with gold in the Mount Dockrell reefs. (Finucane, 1938(b), Woodward, 1891).

A new, minor occurrence of galena in an isolated outcrop of sheared dolomitic siltstone and sandstone of the Lubbock Formation was found by geologists of Pickands Mather & Co., in the course of their prospecting near Louisa Downs in 1964. This is the only occurrence of economic minerals recorded in these rocks.

Tin, Tantalum, Columbium. Tantalite, mangano-columbite and cassiterite occur in pegmatites in the Mount Dockrell region, together with albite, muscovite, tourmaline and minor spessartite. Where the pegmatites cut calcareous country rock, small amounts of fluorite and apatite are also developed in the pegmatite. The pegmatites are of several types; irregular, tabular or thin reeflike bodies are known, and some include masses of country rock. Strike lengths of up to 500 feet are not uncommon, and they range in width from 10 to 200 feet.

Alluvial concentrates shed from these pegmatites have been worked from time to time. Production figures, compiled by the West Australian Mines Department Statistician are given below:

TABLE 19 : TIN PRODUCTION - MOUNT RAMSAY 1:250,000 SHEET

Mining Centre	Period	Tin concentrates Quantity (Tons)	Tin concentrates Metal Content(units)	Value (A€)
Mt. Dockrell	1943	0.40	40.00	143.00
Mt. Dockrell	1962	0.46	30.31	295.95
Willy Willy (Columbium Ck)	1951	0.17	12.00	166.87
"	1952	0.06	4.00	42.56

Sampling of the Columbium Creek deposits by Finucane (1938c) showed the following results.

TABLE 20 : ALLUVIAL CONCENTRATES, COLUMBIUM CREEK

		SAMPLE NUMBERS 1	2	3	4
Amount of concentrate in oz.		2.07	0.47	0.18	0.23
Calculated concentrate (lb per cu.yd.)		0.93	0.32	0.10	0.17
Assay of concentrates					
SnO_2	%	74.3	69.3	7.3	60.6
$(TaNb)_2O_5$	%	20.0	22.3	72.4	29.9
present as Cassiterite	%	75.8	70.7	7.4	61.8
Columbite	%	24.1	26.9	87.2	33.6

Finucane's survey found no tantalite on this survey, but Simpson (1952) describes ferro-tantalite from the headwaters of Willy Willy Creek, and from a pegmatite near Mount Dockrell.

Water. (Description provided by A.D. Allen, Geological Survey of Western Australia). The area covered by the Mount Ramsay Sheet has an average annual rainfall of about 15 inches per annum, most of which is received in the wet season between November and April. It has an average potential evaporation of 100-110 inches and consequently most surface water is lost, and there is a scarcity of water during the dry season.

The area is drained by several large rivers or creeks the majority of which are tributaries of the Fitzroy River. The rivers flow only during the wet season and for the rest of the year they are dry, except for isolated water holes, which may be sustained by springs or are merely ponds of river water. Where the rivers have wide sandy beds soakage water (underflow) may be obtained from the alluvium.

Groundwater is obtained from 45 bores and wells in the area and occurs in a variety of rock types and structures. Eight abandoned bores are known.

For ease of description the region is divided into hydrological provinces, the Kimberley, Halls Creek, and Canning Basin Provinces.

1. Kimberley Province. The Kimberley Province is underlain by sedimentary and basic igneous rocks which range from Lower to Upper Proterozoic in age. The sedimentary rocks are dominantly feldspathic and quartzose sandstone with minor siltstones. They are hard and silicified in outcrop and in general appear to have a low primary porosity and permeability, although this may not be so at depth. The basic igneous rocks, comprising dolerites and volcanics are well jointed and less resistant to weathering, and commonly have residual black soil plains developed over them.

Perennial and intermittent springs frequently occur where rivers have formed gorges in strata dipping at 30° or more and may sustain water holes. Other springs (rock-holes) occur along fault lines, particularly in the flat-lying King Leopold and Pentecost Sandstones, where the groundwater salinity is exceptionally low with values of up to 100 p.p.m. total dissolved solids.

Bores within the Kimberley Province on the adjacent Lansdowne 1:250,000 Sheet area are generally 40 to 60 feet deep with static water levels 20 to 30 feet below the surface, but little information on these features is available in the Mount Ramsay Sheet area. The groundwater is usually non-pressure water but occasionally pressure water may be obtained from within confined joints or bedding planes; salinity is on average about 250 p.p.m. total dissolved solids. Supplies vary from a few gallons to 2000 gallons per hour, with average yields of about 750 gallons per hour.

The main aquifers utilized are the Hart Dolerite and Carson Volcanics mainly because where weathered they are easier to drill by percussion cable-tool plants and because they have a greater number of potential water-bearing fractures than do the sandstones.

Groundwater levels usually decline during the dry season due to water lost by evapo-transpiration and pumping. Occasionally after several years of low rainfall, bores or wells may dry up. However, water levels recover during the wet season (if there is sufficient rainfall) and indicate effective direct recharge by rainfall or indirectly from run-off.

2. Halls Creek Province. This Province is underlain by the Archaean Halls Creek Group which includes greywacke and siltstone with subordinate dolomite. It has been isoclinally folded, faulted and later intruded by the granites and basic igneous rocks of the Lamboo Complex. The rocks have little or no primary porosity and groundwater is obtained from joints within the rock or from alluvium derived from them. Consequently, this province (mainly underlain by granitic rocks) which contains some of the most valuable pastoral country, has a very low groundwater potential.

Rare springs of low salinity water issue from joints within granite and from bedding planes and fracture cleavage within rocks of the Halls Creek Group. However, most are probably intermittent and flow only after the wet season.

There are 34 bores and wells in the province most of which yield non-pressure water. They range in depth from 30 to 50 feet and the groundwater occurs at a depth between

20 and 30 feet below the surface, except in alluvium along creeks, where groundwater (underflow) may occur at very shallow depth. Groundwater salinity varies between 150 and 4500 p.p.m. total dissolved solids, but the average salinity is about 450 p.p.m. Supplies of up to 2000 gallons per hour have been obtained from the fractured rocks but 250 to 500 gallons per hour is more usual. Bores or wells in alluvium may give higher yields.

The most important aquifer is probably alluvium deposited along drainage lines, which are commonly aligned along master joints. If there is a depth of about 30 feet of alluvium and weathered granite, groundwater is usually encountered. However, hard rock is usually encountered at shallow depth and even if hard rock drilling plants are used it is a matter of chance whether water bearing exfoliation joints or cross joints are intersected. In areas underlain by the Halls Creek Group, the basic volcanics are commonly water bearing, and dolomites and greywackes are also potential sources of supply.

Similar comments apply to groundwater levels and recharge as to the Kimberley Province.

3. Canning Basin Province. On the Mount Ramsay Sheet the Province is underlain by siltstone, sandstone, limestone conglomerate and shale which range from Devonian to Permian in age. With the exception of the limestones, the rocks have primary porosity and permeability, and all can be readily drilled by percussion cable-tool rigs, with the exception of the conglomerate.

Perennial springs are known in the Burramundi Range, Horseshoe Range, Guppy Hills and Hull Range. They are usually associated with limestone or conglomerate and may discharge large supplies of low salinity groundwater e.g. Cave Spring in Bugle Gap.

Little information is available about the 11 bores or wells in the area. Bores range in depth from about 50 to 250 feet and obtain both pressure and non-pressure water. Static water levels are between 30 to 60 feet below the surface. Groundwater salinity depends on the aquifer and the proximity of intake areas and is reported to be low in the limestones but variable. In the Grant Formation supplies are also dependent on the aquifer. In the limestones and the Grant Formation supplies of 5000 gallons per hour and more may be obtained but in other formations the supply is generally much smaller.

The most important aquifers are Devonian limestones in the north-western part of the Province and sandstones within the widespread Grant Formation. Coarse conglomerates like those of the Burramundi Range are also potential aquifers but would present drilling problems. The other formations have a poor groundwater potential.

Miscellaneous. Although of no immediate economic value, deposits of limestone, presumed to be of fairly high quality, are plentiful in the Devonian reef complex in the western part of the Sheet area, and in the Egan Formation in the O'Donnell Syncline.

Gossans have been noted along a west-trending line stretching from a point 4 miles west of Bullock Paddock Yard for 3 miles to the west. They overlie rocks mapped as Biscay Formation. Strong iron and manganese staining and the incipient development of gossanous material is evident about 1 mile to the east of the Ell section locality and limonite-boxworks have been observed along a fault 5 miles north-east of Junction Yard (near the junction of the Margaret and O'Donnel Rivers) and at several other points in the O'Donnel Syncline, all within the carbonate-bearing strata of the Yurabi Formation.

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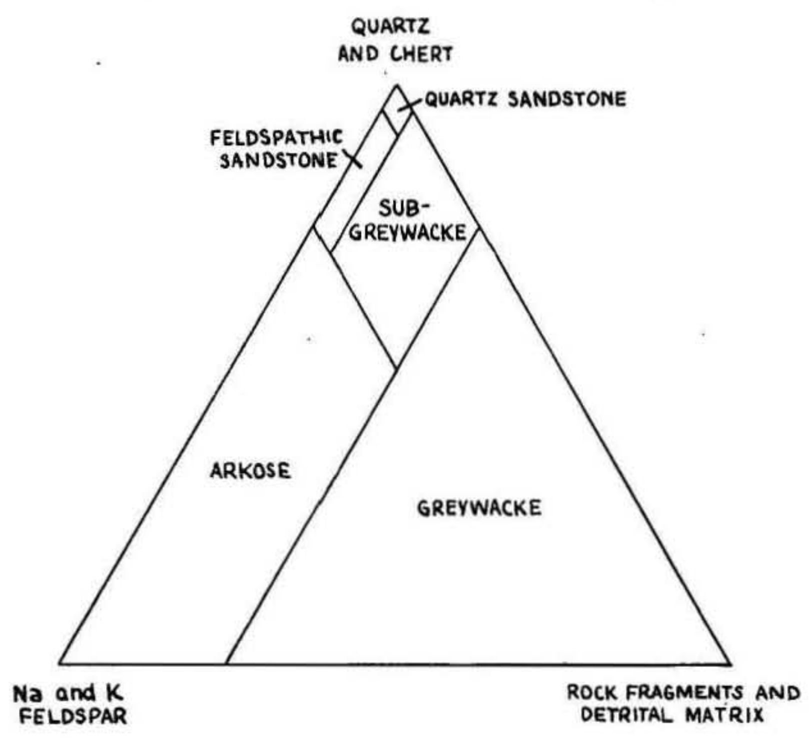
APPENDIX I

Classification of Sandstones

The sandstone classification used in this report is adapted from the classification proposed by Dapples, Krumbein and Sloss (1953). The essential features of this classification are shown in figure 1.

FIGURE 1: CLASSIFICATION OF SANDSTONES

(After Dapples, E.C., Krumbein, W.C., and Sloss, L.L., 1953 – Petrographic and lithological attributes of sandstones ..... J. Geol. V. 61 pp 291-317.)



Key to Lithological Symbols.

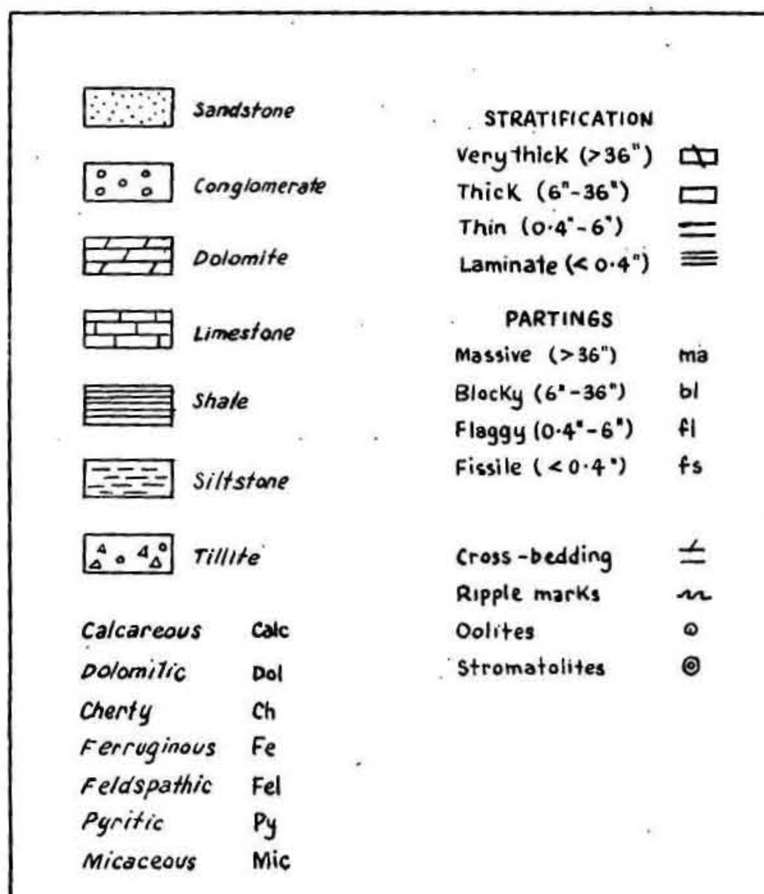


FIGURE 2 : Symbols used in columnar sections

Classification of Stratification and Parting Units.

In an effort to standardize the terminology used in describing parting intervals and stratification intervals, we have adopted, for use in this report, the nomenclature shown in Table 1.

TABLE 1 : PARTING AND STRATIFICATION NOMENCLATURE

Terms to describe stratification	Thickness cm.	Thickness ins.	Terms to describe parting units
Very thick bedded	100	36	Massive
Thick bedded	15 - 100	6 - 36	Blocky
Thin bedded	1 - 15	0.4- 6	Flaggy
Laminated	1	0.4	Fissile

Measured Sections

Descriptions of sections measured through the Elgee Siltstone, Egan Formation and Yurabi Formation are set out below: all have been measured with tape and Abney level and most have a reasonable order of accuracy (say $\pm$ 10%). Photo-reference numbers refer to air photographs of Mount Ramsay 1:250,000 Sheet

ELGEE SILTSTONE:

Location: Measured along east bank of Margaret River 3 to 4 miles north of Me No Savvy Yard.

Photo-Reference:

Measured by: R. Halligan.

OVERLAIN BY PENTECOST SANDSTONE

190'	Purple, finely laminated shale and silty shale, with occasional minor flaggy laminated medium to fine-grained quartz sandstone near base, and occasional green bands in shale near top.
5'	Pinkish-orange weathering, cream, medium to fine-grained, micaceous friable quartz sandstone. Forms hard ridge.
30'	Purple, finely laminated shale.
1'	Purple, silty shale, finely laminated, forms a hard ridge.
5'	Purple, finely laminated purple shale with occasional flaggy laminated pink and green fine-grained silicified quartz sandstone and silty shale bands.
2'	Massive, thick bedded, purple siltstone, forming a hard, outstanding ridge.
30'	Purple, massive finely laminated shale.

70' Maroon, thinly flaggy to fissile, laminated siltstone with thin green bands. Flaggy to blocky, laminated, cream fine-grained quartz sandstone beds near base, becoming less frequent upwards.

473' Maroon, thinly flaggy to fissile, laminated siltstone, Interbedded with thinly flaggy laminated pale green shale and silty shale horizons. The maroon rock is the dominant type. Bedding planes are not very regular in the siltstone. Greenish bands become less common near top.

26' Purplish and green fissile, finely laminated, siltstone with thin (6") yellow ocherous dolomite bands.

26' Maroon, fissile, laminated, maroon siltstone, interbedded with occasional blocky to massive yellow weathering grey dolomite and fine-grained orange weathering silicified quartz sandstone.

45' Purplish fine-grained massive dolomitic siltstone.

58' Poor exposures. Thinly flaggy to flaggy, thinly bedded dolomitic siltstone.

20' Poor exposures. Purplish thinly flaggy laminated dolomitic siltstone, siltstone and shale; sometimes micaceous.

5' Fine-grained off white or grey micaceous quartz sandstone with ripple marks; occasional interbeds of grey or fawn weathering, fawn ferruginized sandy dolomite.

30' No exposures. Rubble of brown weathering off white or grey fine-grained micaceous quartz sandstone.

25' Coarsely crystalline fawn weathering grey dolomite with occasional flaggy thin bedded medium to fine-grained grey silicified quartz sandstone parts. The dolomite becomes sandy near the top, and current bedding is also present, and ferruginisation along joints and bedding planes is frequently seen, which weathers to give a rough surface to these beds. Stromatoliths are present in beds about 12" thick, and in one core this bed is followed immediately by a current bedded quartz sandstone.

5' Grey flaggy thin bedded fawn weathering medium-grained micaceous quartz sandstone.

2' Dark brown weathering grey fine-grained dolomite with tubular stromatoliths.

5' Grey flaggy thin bedded fawn weathering medium-grained micaceous quartz sandstone.

10' Olive weathering, cream, blocky fine-grained crystalline dolomite, with closely parallel separate tubular stromatoliths. Rather rubbly and with a granular sandy appearance on weathered surface. Some manganese dendrites. The stromatoliths are frequently ferruginised.

2' Cream, silicified, fine-grained dolomite with occasional dendritic manganese patches.

20' Poor exposures. Off white to fawn blocky to thinly flaggy current bedded sandstone, with occasional finely laminated porous, ferruginous medium-grained silicified quartz sandstone, possibly representing dolomite sandstone. E/C.

10' Grey weathering silty and sandy laminated, thinly flaggy, micaceous shales, with ?compaction depressions, interbedded with thin bedded, medium-grained quartz sandstones.

40' Maroon laminated silty shales with occasional green bands, becoming more massive towards the top, inter bedded with flaggy, thin bedded fine-grained fawn or pinkish fawn, well sorted quartz sandstone. Some of the sandstones are finely laminated. The sandstones occur at irregular intervals throughout the section, but are closer together near base. E/A, E/B.

1158' UNDERLAIN BY WARTON SANDSTONE

EGAN FORMATION : SECTION E1

Location: 3¼ miles south 20° east of Hibberson Bluff.

Photo-Reference: Not available.

Measured by: D.B. Dow

OVERLAIN BY YURABI FORMATION

55'	Cream and grey, thinly flaggy dolomite. Crops out as resistant beds and comprises 30 to 40% of the succession. The remainder does not crop out (probably mainly dolomitic siltstone).
11'	Grey, massive limestone. Grades laterally into pink to cream flaggy medium-grained, slightly sandy dolomite to west.
50'	Grey to pink laminated fine sandy limestone.
33'	Pink thinly flaggy calcareous siltstone interbedded with pink thinly flaggy calcareous quartz sandstone.
8'	Brown weathering, pink, massive, medium-grained calcareous sandstone. Quartz grains well rounded. Ripple marks and cross beds present.
11'	No outcrop.
70'	Reddish-brown, massive, medium-grained calcareous quartz sandstone. Angular pebbley beds common near base.
6'	Conglomerate consisting of mostly well rounded pebbles of dolomite and other rock types, set in a medium-grained calcareous sandstone matrix.
33'	No outcrop. Scree suggests presence of clay containing pebbles (tillite).

UNCONFORMABLY UNDERLAIN BY KIMBERLEY GROUP

EGAN FORMATION : SECTION E2

Locality: 2 miles south of Hibberson Bluff, Margaret River.

Photo-Reference: 5A/75/A-B.

Measured by: R. Halligan.

OVERLAIN BY YURABI FORMATION (SECTION Y1)

10' Yellow weathering, yellow thick-bedded dolomite, some flaggy bands.

25' Grey weathering grey thin bedded flaggy dolomite, with some softer shaley bands.

12' Yellow weathering yellow and grey dolomite and dolomitic shales.

15' Light and dark grey laminated flaggy limestone.

33' Dark grey fine-grained sandy limestone, with interbedded thin pale grey and fawn weathering pale grey limestone.

65' Dark grey flaggy laminated limestone.

22' Rubble, with occasional bands of limestone.

52' Massive, thick bedded grey weathering, slightly ferruginised medium-grained angular quartz sandstone. The rock is porous, probably derived from calcareous sandstone.

23' No exposure.

25'
25' Massive, thick bedded grey weathering, slightly ferruginised medium-grained angular quartz sandstone. The rock is porous, probably derived from calcareous sandstone.

24' Grey weathering, massive, thick bedded slightly ferruginised medium-grained sandstone, possibly derived from calcareous sandstone. Occasional pebble beds, and includes thin, calcareous current bedded sandstones.

10' Grey, thin bedded dolomite, with interbedded soft pink occasionally laminated shaley dolomite. Some thin dolomitic sandstone beds.

2' Pebble conglomerate. Angular and rounded pebbles of quartz sandstone and dolomite, up to ¾ inch, in a coarse quartz sand matrix.

UNCONFORMABLY OVERLIES HIBBERSON DOLOMITE

EGAN FORMATION : SECTION E3

Locality: O'Donnell Syncline, 2 miles north of Mount Dent.

Photo-Reference: M.R.5/85/A-B-C.

Measured by: R. Halligan

OVERLAIN CONFORMABLY BY YURABI FORMATION

30' Cream weathering, and white and fawn weathering, thin bedded flaggy pinkish-grey, fine-grained dolomite.

4' Pale grey and fawn weathering, laminated dolomite.

20' Pale grey and medium-grey weathering, dark grey to medium-grey, thick bedded limestone.

4' Pale grey weathering, blue grey, massive, thick bedded limestone.

5' Striped dark and pale grey weathering, dark grey and pale grey, flaggy to blocky laminated limestone.

36' Dark and medium-grey weathering, grey, massive to blocky, thick bedded limestone. Brown, ramifying ferruginised stringers throughout the rock.

53' Grey weathering, pinkish, flaggy, finely laminated granular limestone. Some interbeds of secondary calcite.

10' Grey weathering, grey, flaggy, thinly bedded limestone.

30' No exposure.

10' Cream, maroon and ocherous, flaggy, thin bedded limestone with occasional sandy bands.

16' Pebble and granule conglomerate. Rounded pebbles of abundant quartz sandstone, less frequently quartz, in brown or mauve-weathering medium to fine-grained quartz sandstone matrix.

18' Rubble, with occasional brown and grey weathering, maroon and cream, flaggy, thinly bedded dolomite; may be calcareous.

OVERLIES PENTECOST SANDSTONE WITH ANGULAR UNCONFORMITY

EGAN FORMATION : SECTION E4

Location: O'Donnell Syncline, 2 miles north-east of Mount Dent.

Photo-Reference: M.R.5/83/C-D.

Measured by: R. Halligan

OVERLAIN CONFORMABLY BY YURABI FORMATION

30' Cream weathering, grey and slightly pink, flaggy, thin bedded dolomite.

20' Cream weathering, maroon, flaggy, thin bedded dolomite.

32' Brown grey weathering, grey and pale grey, laminated limestone. Sometimes ferruginised.

6' Buff-weathering pale cream and brown limestone; speckled appearance on fresh surface.

5' Dark grey and white weathering, dark grey, irregularly laminated limestone.

62' Pale grey and dark grey weathering, pale grey and dark grey, flaggy, laminated limestone. Contains irregular cavities with calcite infillings.

30' Pink and cream weathering, pink and cream, flaggy, thin bedded limestone.

50' Pebble conglomerate. Rounded pebbles of abundant quartzite, less frequently quartz, in a siliceous medium to coarse-grained quartz sandstone matrix.

UNCONFORMABLY OVERLIES KIMBERLEY GROUP

EGAN FORMATION : SECTION E5

Location: 1½ miles north-west of Junction Yard.

Photo-Reference: Mount Ramsay Run 5, Photo 79, Point 1.

Measured by: H.G. Roberts

OVERLAIN BY YURABI FORMATION

30' Yellow and light grey weathering, yellow and light grey, flaggy, thin bedded dolomite interbedded with pink and yellow dolomitic siltstone. Light grey dolomite near base.

30' Black and light grey, massive, finely laminated to thick bedded limestone. May be oolitic in places. Stromatolites occur in the uppermost 10 feet.

30' Black and brown weathering, dark grey thinly flaggy, finely laminated, fine-grained sandy limestone.

20' No outcrop.

10' Red, brown and yellow weathering, flaggy, laminated fine and medium grained calcareous sandstone. Pitted surfaces common. Calcite(?) cement forms up to 30% of the rock.

2' Cobble conglomerate consisting of ovoid, polished, boulders, cobbles, pebbles and granules of white and purple quartz sandstone, set in a dolomite matrix.

30' Yellow, flaggy and blocky, laminated dolomite, interbedded with sandy and silty dolomite.

10' Orange weathering, massive, medium-grained quartz sandstone with a minor clayey cement. Some clay grains. Ripple marked near top.

3' Brown weathering, white, flaggy, fine-grained quartz sandstone with a minor silica cement. Current ripple marks common.

5' Cobble conglomerate consisting of ovoid cobbles and boulders (up to 3 feet across) of purple quartz sandstone, set in a minor sandy matrix.

UNDERLAIN BY COLLETT SILTSTONE

EGAN FORMATION : SECTION E6

Location: 10 miles east 30° north of Junction Yard.

Photo-Reference: Mount Ramsay Run 4, Photo 38, Point 2.

Measured by: I. Gemuts.

OVERLAIN BY YURABI FORMATION (SECTION Y2)

22' Pink, thinly flaggy, finely laminated, fine-grained, dolomite and silty dolomite interbedded with fissile, thinly laminated dolomitic shales. Unit is shaley towards the top. Dolomitic shales are current bedded.

27' Yellow to pink, flaggy to thinly flaggy, finely laminated fine-grained siliceous dolomite. Unit has thin breccia horizons.

15' Grey to black, blocky to flaggy, thin bedded interbeds of dark black fine, and grey medium-grained limestone. Some of the limestone bands are porous and have a gossan like appearance. No oolites or stromatolites were noted.

20' Pink to yellow to grey, flaggy to thinly flaggy, finely laminated, fine to coarse-grained sandy and silty dolomite and silty dolomitic limestone. Towards the base a 3 ft. brecciated dolomite with minor slumping and a 6 ft. grey coarse sandy dolomitic limestone with poorly sorted quartz grains and possible detrital mica.

10' Poorly outcropping, dominantly pink, thinly flaggy laminated limestone.

15' Grey to pink, flaggy, finely laminated, medium-grained feldspathic calcareous sandstone. Cross bedded.

1' Yellow, thinly flaggy, non-laminated, fine-grained dolomite.

32' Conglomerate - pebbles (50% and cobbles (50%) (quartz sandstone dominant and dolomite subordinate) set in a fine-grained dolomitic matrix. Cream thick bedded fine-grained dolomite band close to base.

34' Yellow to buff - flaggy, thin bedded, poorly sorted, coarse-grained pebbly feldspathic sandstone. Matrix is siliceous and slightly ferruginous. Towards the top pebbles form poorly sorted bands. Right at the top a poorly sorted cobble band occurs - pebbles and cobbles are set in a feldspathic sandstone with a dolomitic calcareous matrix.

BASE NOT EXPOSED

EGAN FORMATION : SECTION E7

Location: 3 miles south-west of Junction Yard.

Photo-Reference: Mount Ramsay Run 5A, Photo 77, Point 1.

Measured by: H.G. Roberts

30' (Approx.) Yellow, buff and pink surfaced, pink to yellow flaggy, laminated silty dolomite and dolomitic siltstone. A thin bed of poorly sorted sandy dolomite is present near the base. (Q)

40' (Approx.) Massive limestone, laminated and predominantly light grey near base (PO, P1), becoming thick bedded and black (P3) with sporadic 2"-6" light grey bands in upper half. Light grey bands (P3) contain some fine-grained quartz sand and are cross bedded. Bands of black oolitic limestone (P4) occur in the upper part of the unit; algal stromatolites overlie the oolitic strata (P5). (P) Pyritic in upper half.

5' Dark grey, massive, medium bedded dolomite breccia with lenticular 2"-3" bands of pink to white dolomite (O).

64' Grey and yellow weathering, grey to brown, flaggy and thinly flaggy, finely laminated, very fine and fine-grained sandy limestone with micro cross beds and thin penecontemporaneously brecciated beds. Becomes dark grey and less sandy near top. (MN).

8' Light grey surfaced, pink, laminated, flaggy and thinly flaggy, fine sandy limestone. Small scale cross beds present. (L).

15' Brown weathering, buff, flaggy, thinly laminated, fine to medium-grained calcareous sandstone (70% sand 30% calcite). Grains are well rounded, poorly sorted. Laminae due to varying calcite content. A thin bed containing pebbles of white silicified quartz sandstone up to 2" in diameter occurs near the base. Cross beds and slump structures occur at the base. Rare thin cherty limestone interbeds occur near the top (K).

15' Pink surface, pink, flaggy laminated silty dolomite and medium-grained sandy dolomite with rare thin dolomite or silty dolomite laminae; calcareous in part. The sand consists mainly of clear quartz, chert and yellow dolomite, and is well rounded, but poorly sorted.

The sand content of the strata varies vertically in a mega-alternation as well as a micro-alternation (J).

3' Buff, massive, laminated, fine and medium-grained sandy dolomite, with thin bands of coarse-grained sandy dolomite containing scattered pebbles of quartz (I).

4' Yellow surfaced buff, massive, thick bedded, pebbly coarse-grained calcareous sandstone. Coarse-grained quartz sand comprises 35% of rock, calcite 35% and pebbles 30%. The pebbles are concentrated in two 9" zones, one at the base the other 9" above; they range from well rounded to angular and are up to 3" in diameter, but are mainly from $\frac{1}{8}$"-$\frac{1}{4}$"; they consist of quartz sandstone (60%), dolomite (30%) and quartz (10%). Some cross beds (G).

1'6" Black surfaced, white to light pink, medium-grained thin bedded calcareous sandstone. Washouts and other evidence of diastems at base (F).

2" Poorly sorted pebble conglomerate, consisting of well rounded to angular pebbles of quartz sandstone (50%) quartz (40%) and dolomite (10%) set in a quartz sand-calcite matrix (F).

2' Light pink, laminated silty dolomite verging on dolomitic siltstone. Contains abundant scattered fine and medium-grained quartz sand. Somewhat leached. Some white stringy shale partings present (E).

4' Pink, massive, sandy dolomite, mainly medium-grained sand but some 2" bands are very coarse-grained and some 2"-6" bands contain fine-grained sand. Ripple marked at the top (D).

2' Pink sandy dolomite with scattered pebbles up to $\frac{1}{8}$" in diameter. Coarse (3"-4") ripple marks at top (C).

4' Thinly flaggy, "wispy" very poorly sorted medium-grained quartz sandstone with minor dolomite or calcite in the matrix; contains thin dolomitic or calcareous siltstone partings; in middle of unit 9" bed of pink finely laminated very fine-grained sandy dolomite with scattered grains of medium-grained quartz sand (C).

6' Massive alternating calcareous sandstone and pebbly calcareous sandstone. Thepebbly rocks are more important low in the sequence; the matrix ranges in grainsize from fine to very coarse sand and includes a variable amount of calcite - the pebbles are mainly well rounded and consist of quartz (90%) red and black jasper and other rock types (10%). The pebble free calcareous sandstone is usually fine to medium-grained and contains calcite in the matrix (B).

2' Massive pebble-breccia consisting of angular elongate preferentially oriented pebbles of purple siltstone and purple very fine-grained sandstone of Crowhurst Group (70%) and vein quartz (30%) set in a matrix of coarse-grained quartz sand and calcite. Sand 30%, calcite 20%, pebbles 50%. The pebbles average $\frac{1}{2}$-$\frac{3}{4}$" in size.

UNCONFORMABLY OVERLIES COLLETT SILTSTONE

EGAN FORMATION : SECTION 8

Locality: 1 mile east of Hells Gate

Photo-Reference: 6.33.28

Measured by: I. Gemuts

OVERLAIN BY YURABI FORMATION

35' Grey weathering, grey, massive, coarse-grained limestone, in part cherty and oolite rich.

25' Cobble/boulder conglomerate; red, sandy matrix.

15' Yellow weathering pink, thick bedded, blocky coarse-grained dolomite.

5' Grit tillite; red clay/silt matrix.

20' Cream weathering pink, thin bedded, flaggy fine-grained dolomite.

UNCONFORMABLY OVERLIES CARSON VOLCANICS

EGAN FORMATION : SECTION E9

Location: $2\frac{1}{2}$ miles east of Lily Hole Bore.

Photo-Reference: E.9.

Measured by: R. Halligan.

22' Pale brown and yellowish brown weathering, yellow, fissile finely laminated dolomite with occasional blocky, laminated, yellowish dolomite interbeds.

20' Dark grey to grey, flaggy, thin bedded, cross bedded, oolitic limestone.(T.1).

20' Dark and pale grey, striped, flaggy, finely laminated dolomite and cream weathering dolomite with thin brown laminae.(T.2).

26' Grey weathering, dark grey, blocky, thin to medium bedded, fragmental dolomitic limestone.(T.3).

82' Dark grey and pale brown weathering finely laminated fissile silty limestone, with occasional 2" beds of finely laminated limestone towards top of section.

1'6" Dark blue-grey blocky irregularly laminated, thinly laminated dolomite, with alternate laminae of dark grey and fawn dolomite. This is a very fine-grained rock, almost cherty in appearance.

9" Conglomerate. Elements vary from granule to boulder size, but are mainly pebble to cobble grade. They consist largely of medium to coarse-grained silicified white or fawn quartz sandstones, generally subrounded or rounded, though some angular types are present, together with frequent angular pebbles of dark dolomite. These elements are set in a dolomite sandy matrix.

1' Dark grey weathering, dark grey blocky finely laminated dolomite.(T.6).

25' Grey, cream and pinkish cream weathering blocky, thin bedded dolomite. Some beds are thinly laminated. (T.7)

EGAN FORMATION : SECTION E10

Location: 4 miles west of Louisa Downs Homestead.

Photo-Reference: Mount Ramsay Run 10, Photo 57, Point 13.

Measured by: I. Gemuts

OVERLAIN BY YURABI FORMATION (SECTION Y3)

100'	Purple, (carbonaceous in part), fissile, finely laminated shale. Micaceous and alternate laminae are limonite enriched. At base a friable feldspathic sandstone; leached and has a spongy texture.
25'	Grey and yellow, blocky thin bedded oolitic limestone - the oolitic bands vary from 1"-1' in width. Oolites are up to ⅛" in diameter and lighter bands consist of dolomite or a fissile dolomitic shale.
20'	Purple to yellow, fissile, finely laminated dolomitic shale and silt.
15'	Pink, flaggy thin bedded dolomite.
10'	Boulder tillite; very poorly exposed.

BASE NOT EXPOSED

EGAN FORMATION : SECTION E11

Location: 9 miles south 10° east of Louisa Downs Homestead.

Photo-Reference: Mount Ramsay Run 12 Photo 01, Point

Measured by: H.G. Roberts

OVERLAIN BY YURABI FORMATION (SECTION Y4)

120' Tillite represented by scattered boulders in soil - boulders and cobbles mainly purple quartz sandstone and white and purple quartzite. No matrix seen, but silty, leached rubble is associated with boulders. Manganese staining common.

120' Orange surfaced buff to yellow, massive to flaggy, thick bedded to laminated cherty siltstone (b); rare thin (2" to 3") interbeds of coarse-grained arkose occur in the lowermost few feet. Rock is strongly cleaved. Lenticular medium-grained clay-silica cemented poorly sorted quartz sandstone (C) interbeds up to 2' thick occur near the top where siltstone more massive (D) and may be slightly dolomitic (E).

310' Orange weathering, friable, white to pale green, massive, thick bedded, very coarse-grained arkose (A) consisting of sub-rounded to angular grains of quartz (40%) and pink feldspar (40%) set in a matrix of chlorite and/or epidote-stained clay. Rare cobbles and pebbles of quartzite occur in the uppermost few feet.

UNDERLAIN BY LAMBOO COMPLEX

EGAN FORMATION : SECTION E12

Location: 6.4 miles east 30° south of the point where the Great Northern Highway crosses the Mary River.

Photo-Reference: Mount Ramsay Run 11 Photo 45, Point 7.

Measured by: H.G. Roberts.

OVERLAIN BY YURABI FORMATION (SECTION Y5)

40' Mainly rubble - appears to be derived from purple and cream thinly flaggy, laminated siltstone. May contain sandy interbeds. (7F).

30' Yellow massive cherty siltstone containing scattered boulders of white quartzite and silicified fine to medium-grained white quartz sandstone up to 2 feet in diameter. (7D).

40' Yellow, massive, laminated, slightly silicified (cherty) siltstone containing scattered angular sand sized grains of quartz and pink feldspar. The laminations are produced by the alternation of very thin iron oxide stained lamellae with yellow bands which are up to ⅛" thick. (7C).

25' Yellow to orange surfaced, buff, massive, coarse and very coarse-grained arkose consisting of angular grains of quartz and fresh feldspar set in a secondary cherty matrix. (7A, 7B).

UNDERLAIN BY LAMBOO COMPLEX

EGAN FORMATION : SECTION 13 (Reference Area)

Location: To north of Great Northern Highway where it crossed the Egan Range.

Photo-Reference: Mount Ramsay Run 9, Photo 75, Point 4-7.

Measured by: H.G. Roberts

OVERLAIN BY YURABI FORMATION (SECTION Y6)

6' Yellow, flaggy to fissile, leached dolomitic siltstone. Poorly exposed.

6' Yellow surfaced light pink, blocky, laminated, to thin bedded silty dolomite (D).

18' Pink and occasionally yellow surfaced, pink, blocky to flaggy dolomite (C) interbedded with thinly flaggy to fissile pink and purple dolomitic siltstone and dolomitic shale. Silty dolomite contains scattered medium and coarse grains of quartz and feldspar sand near base.

70' Tillite; massive unstratified purple claystone(B) forms the matrix and makes up 99% of the total volume. Granules, of claystone (similar in composition to their host), cherty siltstone and grey, black and purple quartzite form much of the remaining 1% of the volume. They are scattered randomly throughout the rock. Rare cobbles of quartzite up to 3" in diameter occur in the uppermost three feet.

10' Yellow surfaced, pink and occasionally yellow poorly bedded dolomite and dolomite breccia (A). Coarse irregular shaped clusters of crystals of siderite(?) and calcite or dolomite are present throughout the bed.

15' No outcrop - along strike to north-east can be seen to be pink-green, very coarse-grained, poorly sorted arkose consisting of quartz (50%) and pink feldspar (40%) set in a matrix of chlorite 5% and white clay (5%).

UNDERLAIN BY LAMBOO COMPLEX

EGAN FORMATION : SECTION 14

Location: 6 miles east 10° north of Margaret River Homestead.

Photo-Reference: Mount Ramsay Run 9 Photo 71 Point 7.

Measured by: H.G. Roberts.

OVERLAIN BY YURABI FORMATION

10'	Buff surfaced, buff, silicified limestone. Crops out as rounded tors.
5'	Dark grey massive limestone.
60'	Massive tillite. Matrix consists dominantly of pink clay-sized material. Erratics of quartzite and chert up to 2 feet in diameter are scattered throughout the rock.
10'	Brown, flaggy to blocky, medium-grained, leached, dolomitic sandstone or sandy dolomite.
15'	Pink surfaced, pink, flaggy, weakly laminated dolomite, interbedded with pink dolomitic siltstone and dolomitic shale.
45'	Light grey surfaced, light grey, flaggy to blocky, laminated dolomite. Dark grey limestone occurs as lenses towards the base.
5'	Dark grey, thinly flaggy, laminated sandy limestone.

UNDERLAIN BY LAMBOO COMPLEX

EGAN FORMATION : SECTION E15

Location: 2 miles south-east of Mount Amherst Homestead

Photo-Reference: Mount Ramsay Run 6, Photo 29, Point 10.

Measured by: H.G. Roberts.

OVERLAIN BY YURABI FORMATION (SECTION Y7)

2'	Yellow weathering, yellow to pink, blocky, laminated dolomite (N).
10'	Yellow and pink, thinly flaggy, laminated dolomitic siltstone interbedded with fine-grained dolomitic sandstone.
2'	Brown to yellow weathering, light grey dolomitic sandstone. Contains occasional pebbles and granules of yellow dolomite, quartz and jasper.
8'	Yellow and pink, thinly flaggy to fissile, dolomitic siltstone verging on silty dolomite in places (M).
70'	No outcrop - probably tillite with clay matrix. Erratics consist entirely of quartz sandstone pebbles, cobbles and boulders.
3'	Light grey dolomite and dolomite breccia; the latter consists of fragments of porous sponge-textured dolomite set in a dolomite matrix. Lenticular (L).
5'	Tillite - as above.
2'	Yellow weathering, pink, medium-grained dolomitic sandstone (K).
20'	Tillite - no matrix preserved as outcrop; erratics are mainly of pebble size, but occasional 2 ft. boulders are present; they are composed of quartz sandstone.
5'	Yellow surfaced, pink, massive dolomite breccia.
12'	Pink and light grey, blocky, thick bedded dolomite. Vague stromatolites (?) near base. Pink or yellow weathering near base, light grey in middle, and pink at top (G, H.J.)
3'	Yellow weathering, light grey flaggy laminated dolomite.
12'	Flaggy and thinly flaggy fine to medium grained friable, leached ex-calcareous sandstone.

1' Yellow surface, yellow to buff and sometimes purple, laminated dolomite (D).

4' Pale green, thinly flaggy very fine-grained slightly micaceous dolomitic calcareous sandstone interbedded with siltstone (C).

1' Flaggy thin bedded pink silty calcareous dolomite containing siderite lenses (B).

2" Faint grey laminated sandy limestone. Sand includes quartz and feldspar grains (A).

UNDERLAIN BY LAMBOO COMPLEX

EGAN FORMATION : SECTION E16

Location: 9 miles south-west of Moola Bulla Homestead.

Photo-Reference: Mount Ramsay Run 5, Photo 65, Point 18.

Measured by: D.B. Dow

OVERLAIN BY YURABI FORMATION (SECTION Y8)

33' Red laminated dolomitic shale and dolomite. Rare thin beds of pebble conglomerate with a dolomitic sandstone matrix. Towards the top beds of fine-grained quartz sandstone up to 6 inches thick are interbedded. Some of the strata are slightly micaceous.

22' Thinly flaggy, laminated, fine-grained sandstone and some siltstone, leached and probably originally dolomitic. Beds of coarse-grained quartz sandstone up to 6 inches thick are interbedded; some are ripple marked.

1' Pebble conglomerate consisting of pebbles of quartz and a great variety of other rock types set in a dolomitic sandstone matrix. Ripple marked.

27' Cream thinly flaggy fine to medium-grained quartz sandstone. Poorly-exposed.

17' Tillite. Matrix is grey to green in colour and consists of clay to sand sized grains. The erratics which are up to 3 feet in diameter include a great variety of igneous rock types as well as quartzite, dolomite and other rock types.

6' Very coarse-grained quartz sandstone. Grains are well rounded. Possibly originally dolomitic. Contains rare pebbles and rounded boulders up to 4 feet across.

22' Tillite. Matrix consists of red clay, arkose and sand. Pebbles and boulders up to 8 feet across scattered throughout the matrix. They consist of various igneous and sedimentary rock types.

UNDERLAIN BY LAMBOO COMPLEX

YURABI FORMATION : SECTION Y1

Location: 2 miles south of Hibberson Bluff

Photo-Reference: 5A/75/A-B.

Measured by: R. Halligan.

OVERLAIN BY McALLY FORMATION

30'	Red-brown weathering, red, thin bedded medium-grained quartz sandstone with ripple marks.
10'	Yellow weathering, cream and grey, laminated, flaggy dolcarenite.
8'	No exposure.
65'	Brown weathering, pinkish to pale fawn, thin bedded, ferruginised, quartz sandstone. Occasional ripple marks.
25'	White weathering, white, thin to thick bedded, blocky medium-grained siliceous quartz sandstone. Minor ferruginous patches; joints ferruginised.
35'	Red weathering, white or grey, medium to fine-grained siliceous quartz sandstone.

UNDERLAIN BY EGAN FORMATION (SECTION E2)

YURABI FORMATION : SECTION Y2

Location: 10 miles east 30° north of Junction Yard.

Photo-Reference: Mount Ramsay Run 4, Photo 38, Point 2.

Measured by: I. Gemuts

OVERLAIN BY McALLY SHALE

22' Pink to yellow thick bedded, thinly laminated fine-grained dolomite. Yellow laminae slightly siliceous and in some areas brecciated.

43' Pink to yellow, or grey, flaggy, thinly laminated interbands of dolomitic fine-grained sandstone, siltstone and shale. Towards the top, pink flaggy, thin bedded and laminated intercalations of dolomite. The sandstone occurs towards the base and is very friable. Round quartz grains are set in a dolomitic matrix.

2' Grey to black bed of a non-laminated, medium-grained well sorted dolomitic sandstone. Contains round quartz grains, leached feldspars and dark dolomitic pebbles. Cement is a ferruginous dolomite.

60' Grey to brown, flaggy, thin bedded, well sorted, medium-grained, friable, quartz sandstone. Feldspar is less than 5%. Quartz grains are well rounded and well sorted and are set in slightly ferruginous siliceous cement. Rock may be ex-dolomitic.
40 feet feet from base, broad ripple marks and clay pellet impressions.
22 feet from base, numerous clay pellet impressions. Cement is ferruginous.

UNDERLAIN BY EGAN FORMATION (SECTION E6)

YURABI FORMATION : SECTION Y3

Location: 4 miles west of Louisa Downs Homestead

Photo-Reference: Mount Ramsay Run 10, Photo 57,
Point 13.

Measured by: I. Gemuts.

OVERLAIN BY McALLY SHALE

10' Buff to grey, thinly flaggy, well sorted ex-dolomitic, fine-grained sandstone; matrix clay.

260' Grey to brown, thinly flaggy to fissile, laminated, siltstone and shale with thin clay bands - slightly micaceous and possibly ex-dolomitic. Waffle pattern structures.

195' Red flaggy to thinly flaggy, thin bedded well sorted sparsely laminated, fine-grained, feldspathic sandstone with a ferruginous matrix. Laminae lack ferruginous matrix and consist of quartz and feldspar. Ripple marked and current bedded; towards base numerous clay pellets. Cut by shallowly dipping crenulation cleavage in some areas.

100' Yellow, blocky, medium bedded, well sorted ex-dolomitic, medium-grained, friable feldspathic sandstone. Matrix calcareous. Leached and stained with manganese and iron oxides. Rocks in outcrop may have dark black manganese coating.

(Specimen 11.53.1.)

150' White to brown (buff), well sorted with poorly rounded grains, blocky to flaggy, laminated, friable in part, medium-grained feldspathic sandstone with a calcareous matrix. Current beds and coarse ripple marks present. Towards the base numerous clay pellet cavities.

UNDERLAIN BY EGAN FORMATION (SECTION E10)

YURABI FORMATION : SECTION Y4

Location: 9 miles south 10° east of Louisa Downs Homestead.

Photo-Reference: Mount Ramsay Run 12, Photo 01, Point

Measured by: H.G. Roberts

OVERLAIN BY McALLY SHALE

5' Brown-black and white surfaced, manganese and iron stained, white, blocky, fine-grained quartz sandstone with a silica matrix. Resistant.

30' Leached, grey, white, yellow, and purple, thinly flaggy and fissile siltstone and shale. Poorly outcropping.

70' Purple surfaced, purple, blocky, medium bedded, medium-grained, quartz greywacke (H) or feldspathic sandstone. Cement largely clay - appears to be 20% feldspar in detrital fraction. Small quartz veins common, cleavage strong.

250' Poorly bedded orange-yellow surfaced, fine-grained yellow and (F) pink (G), clay-cemented, or clay-silica cemented, quartz sandstone. Yellow porous beds may be ex-dolomitic. Interbedded with leached thinly flaggy, pastel grey-yellow and purple siltstone. Bedding "rolls" and load casts are common near the base. Siltstone bed near top may be dolomitic. Clay pebbles common in sandstone.

UNDERLAIN BY EGAN FORMATION (SECTION E11)

YURABI FORMATION : SECTION Y5

Location: 6.4 miles east 30° south of the point where the Great Northern Highway crosses the Mary River.

Photo-Reference: Mount Ramsay Run 11, Photo 45, Point 7.

Measured by: H.G. Roberts.

OVERLAIN BY McALLY SHALE

10' Grey surfaced, grey, flaggy, laminated to thin-bedded, fine-grained quartz sandstone. Manganese oxide stains occur along the bedding and as joint coatings. Pyrite crystals common.

100' Interbedded light grey, fissile, shale and siltstone, and thinly flaggy fine-grained quartz sandstone.

30' Pink to purple, flaggy to blocky, fine to medium-grained slightly ferruginous quartz sandstone - consists of quartz grains (80% of rock) set in a matrix (20% of rock) of iron oxide, clay and silica. Purple silt pellets and clay pellets are common. Near top pseudomorphed cubic minerals (probably pyrite) are common.

10' Interbedded purple-brown, thinly flaggy, ferruginous siltstone and purple-brown, very fine-grained, slightly ferruginous sandstone.

20' Yellow surfaced, yellow, blocky thin bedded fine to medium-grained clay cemented quartz sandstone. Possibly ex-dolomitic: some coarse-grained zones present. Ripple marks common.

30' Yellow weathering, white to pink, leached flaggy and thinly flaggy, laminated, fine-grained, clay-cemented quartz sandstone. Probably ex-dolomitic. Ripple marks common.

60' Purple-brown, flaggy, thin bedded, medium-grained, slightly feldspathic quartz sandstone. May be interbedded with softer rocks. Ripple marks and clay pellet impressions fairly common.

80' Red-brown surfaced, white to brown, flaggy, thin bedded, medium-grained quartz sandstone. Matrix mainly silica but clay (after feldspar?) and iron oxide sometimes present. Ripple marks with 6" wave length at top, and smaller wave-lengths throughout. Clay pellet impressions and mud cracks abundant.

UNDERLAIN BY EGAN FORMATION (SECTION E12)

YURABI FORMATION : SECTION Y6

Location: To north of Great Northern Highway where it crosses the Egan Range.

Photo-Reference: Mount Ramsay Run 9, Photo 75, Points 4-7.

Measured by: H.G. Roberts.

OVERLAIN BY McALLY SHALE

10' Brown weathering, grey-brown, flaggy and thinly flaggy, laminated, fine-grained quartz sandstone. Manganese staining common. Limonite filled cavities (after pyrite?) common (J).

145' Interbedded grey fissile shale and grey thinly flaggy to flaggy very fine-grained slightly micaceous sandstone and siltstone. Sandstone may possibly contain dolomite in matrix. (H).

5' Grey blocky, thin bedded leached, ex-dolomitic sandstone.

40' Grey, fissile, dolomitic siltstone with interbeds of thinly flaggy, fine to medium-grained, slightly micaceous, dolomitic sandstone. Mud cracks and ripple marks common. (6).

40' Purple, fissile to thinly flaggy, laminated, leached, ex-dolomitic, siltstone with 1 foot to 2 feet thick interbeds of pink and yellow silty, and occasionally sandy, dolomite.

30' No outcrop.

85' Interbedded grey, flaggy to blocky, thin bedded quartz sandstone and grey fissile silty sandstone, and, near top, olive green fissile shale. In general the succession becomes more fine-grained upwards. The uppermost few feet consist of yellow weathering, clay cemented (probably ex-dolomitic) quartz sandstone. Ripple marks and clay pellets are abundant throughout the beds.

UNDERLAIN BY EGAN FORMATION (SECTION E13).

YURABI FORMATION : SECTION Y7

Location: 2 miles south-east of Mount Amherst Homestead.

Photo-Reference: Mount Ramsay Run 6, Photo 29, Point 10.

Measured by: R. Halligan, H.G. Roberts

OVERLAIN BY McALLY SHALE

30' Pale fawn, thin bedded, flaggy, fine-grained quartz sandstone. Poor exposure.

120' Poor exposure. Rubble of pale brown to blocky, medium-grained siliceous quartz sandstone. A few ferruginous grains (possibly representing original feldspathic material). Some porous flaggy, laminated types are also present.

60' Pale yellow or slightly purple, fissile to flaggy laminated dolomitic shale, with occasional harder two inch bands of pale cream laminated sandy dolomite which have alternate dolomite and feldspathic sandy laminae.

45' No exposure.

1' Pale fawn weathering, grey, medium-grained, flaggy, thin bedded feldspathic sandstone.

10' No exposure.

5' Pale brown or fawn, blocky to flaggy, thin bedded feldspathic sandstone. Ripple marks and clay pellet impressions common. Poor exposures.

40' White flaggy, laminated and thin bedded fine and medium-grained quartz-sandstone. Ripple marks abundant - have 6" wavelength at top, where rocks fine-grained and have a strong silica matrix, giving rise to "tors".

12' White to buff thinly flaggy, laminated fine to medium-grained ex-dolomitic(?) quartz sandstone.

UNDERLAIN BY EGAN FORMATION (SECTION E15)

YURABI FORMATION : SECTION Y8

Location: 9 miles south-west of Moola Bulla Homestead.

Photo-Reference: Mount Ramsay Run 5, Photo 65, Point 18.

Measured by: D.B. Dow

OVERLAIN BY McALLY SHALE

5' Cream, thinly flaggy sandstone. Abundant clay pellet casts.

30' Flaggy, laminated fine-grained quartz sandstone interbedded with dolomite. Lower half mainly sandstone with rare six inch thick beds of cream dolomite increasing in abundance upwards; upper half consists of thinly flaggy pink dolomite with subordinate sandstone interbeds.

55' Creak to light brown thinly flaggy, thin bedded to laminated, fine to medium-grained quartz sandstone. Clay pellet casts and ripple marks present.

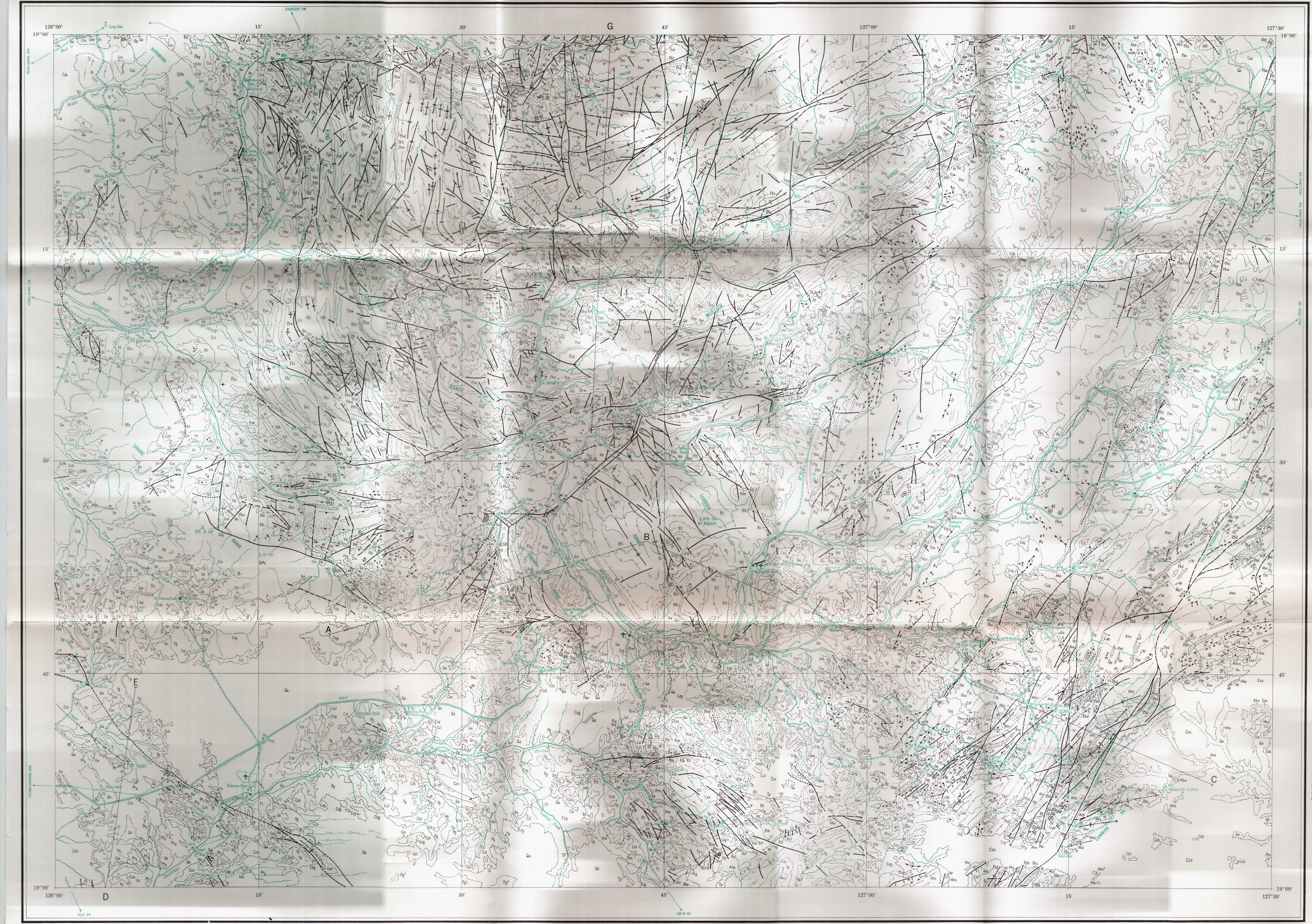
UNDERLAIN BY EGAN FORMATION (SECTION E16)

AUSTRALIA 1:250,000

MOUNT RAMSAY

WESTERN AUSTRALIA

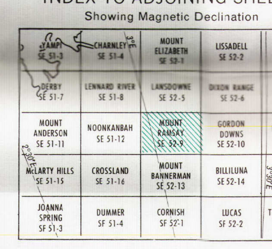
1:250,000 GEOLOGICAL SERIES SHEET SE 52-9



Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Geological Survey of Western Australia. Topographic base compiled by the Mapping Branch, Department of Lands and Surveys, Perth, Western Australia. Aerial photography by the Royal Australian Air Force; complete vertical coverage at 1:50,000 scale.
Transverse Mercator Projection.

INDEX TO ADJOINING SHEETS

Showing Magnetic Declination



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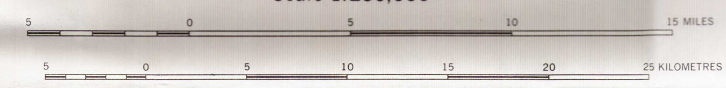
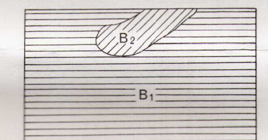


GEOLOGICAL RELIABILITY DIAGRAM

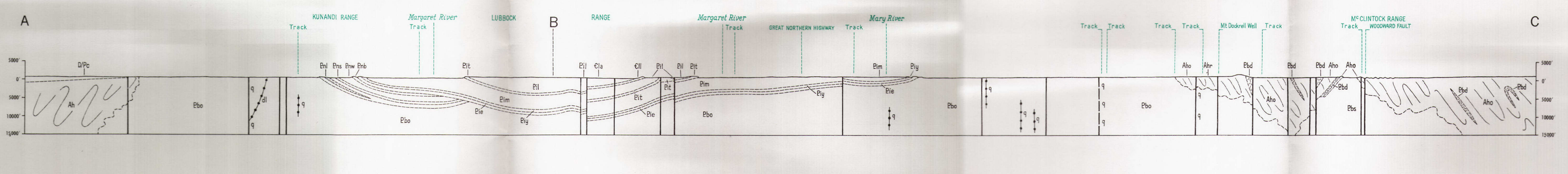


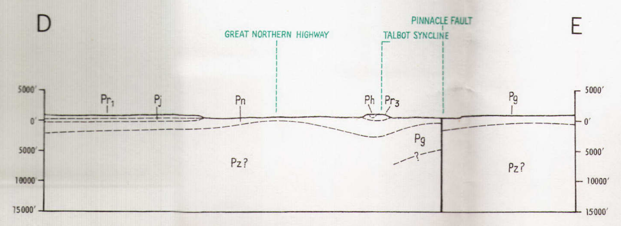
Geology, 1964, by: I. Gemuts, R. Halligan, P.E. Playford, D.C. Lowry (G.S.W.A.)
H.G. Roberts, D.B. Dow (B.M.R.)
Compiled, 1965, by: H.G. Roberts, A.S. Mikclajczak
Drawn by: A.S. Mikolajczak

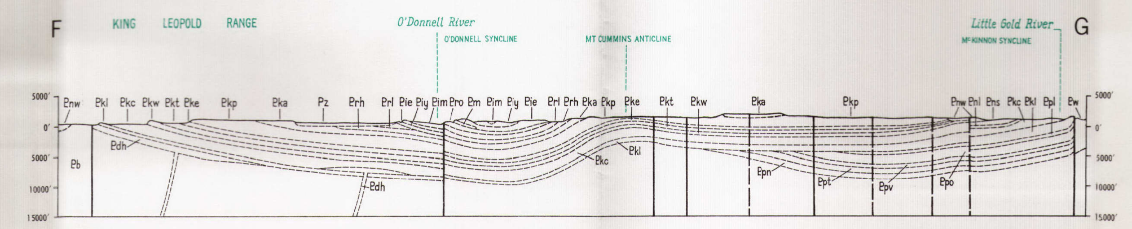
Sections

Cainozoic sediments omitted from sections

Attitude of faults not known







PRELIMINARY EDITION, 1965

SUBJECT TO AMENDMENT

Reference

CAINOZOIC	QUATERNARY(?)		Qa	Alluvium
			Qs	Sand
	UNDIFFERENTIATED		Czs	Soil, sand, alluvium
			Czg	Unconsolidated gravel, pebbly sandstone
			Czb	Black soil
			Czl	Ferruginous pisolitic soil
	TERTIARY(?)	Lawford Beds	Tl	Limestone, calcareous siltstone, silicified limestone, chalcedony
			Tp	Laterite
PALAEOZOIC	UNDIFFERENTIATED		Pz	Sandstone breccia conglomerate silty quartz sandstone, flaggy limestone calcareous sandstone and siltstone
	PERMIAN	Liveringa Formation: Hardman Member	Ph	Medium-grained ferruginous sandstone
		Condren Sandstone Member	Pr_3	Medium-grained quartz sandstone
			Pr_2	Ferruginous siltstone and sandstone
			Pr_1	Medium-grained quartz sandstone, silty quartz sandstone
		Lightjack Member	Pj	Fine-grained sub greywacke, ferruginous siltstone and sandstone
		Noonkanbah Formation	Pn	Fine-grained calcareous sandstone, ferruginous sandstone
		Grant Formation	Pg	Massive coarse to very coarse-grained quartz sandstone, boulder conglomerate
	DEVONIAN OR PERMIAN		D/Pc	Boulder, cobble and pebble conglomerate
	UPPER DEVONIAN TO (?) LOWER CARBONIFEROUS	Fairfield Formation	D-Cf	Grey to yellow-brown coquinoid limestone, calcareous sandstone, siltstone and shale
	DEVONIAN: FAMENNIAN (?) GIVETIAN	Windjana Limestone	Dw	REEF FACIES: Yellow to white massive limestone dolomitized in part
		Pillara Limestone	Dp	BACK-REEF FACIES: Yellow to light grey, thin to thick-bedded, algal, stromatoporoid and coral limestones, calcarenite, calcilutite
	DEVONIAN: FAMENNIAN	Napier Formation	Dn	INTER-REEF FACIES: Red to light grey silty limestone, siltstone, shale, sandstone
		Piker Hills Formation	Di	INTER-REEF AND FORE-REEF FACIES: White to pink, medium to thick bedded calcarenite and calcirudite
		Bugle Gap Limestone	Du	FORE-REEF FACIES: White to pink, medium to thick bedded calcarenite grading to calcirudite
	DEVONIAN: FAMENNIAN TO FRASNIAN	Virgin Hills Formation	Dr	INTER-REEF AND FORE-REEF FACIES: Calcareous siltstone, shale, and very fine-grained sandstone, silty calcarenite and calcilutite; calcarenite, calcirudite
	DEVONIAN: FRASNIAN TO (?) GIVETIAN	Sadler Limestone	Dd	FORE-REEF FACIES: Yellow to light grey calcarenite grading into calcirudite, calcareous siltstone
		Gogo Formation	Dg	INTER-REEF FACIES: Dark grey to yellow calcareous shale, siltstone with characteristic limestone concretions
	DEVONIAN: FAMENNIAN TO FRASNIAN	Bobs Bore Conglomerate	Do	Boulder, cobble and pebble conglomerate
	LOWER CAMBRIAN(?)	Antrim Plateau Volcanics	Ꞓla	Basalt, amygdaloidal basalt
		Lally Conglomerate	Ꞓll	Sub-greywacke, cobble conglomerate, quartz sandstone, feldspathic sandstone
PRECAMBRIAN	UPPER PROTEROZOIC	Louisa Downs Group: Lubbock Formation	Ꝑil	Grey, green or purple siltstone and shale, alternating with fine and medium-grained sub-greywacke
		Tean Formation	Ꝑit	Feldspathic sandstone, sub-greywacke, pebble conglomerate, quartz sandstone, shale, siltstone, minor dolomite
		McAlly Shale	Ꝑim	Black, grey and green shale; minor siltstone, and fine and very fine-grained sandstone
		Yurabi Formation	Ꝑiy	Flaggy to blocky quartz sandstone and feldspathic sandstone; grey and purple siltstone, shale, dolomitic siltstone, sandy dolomite
		Egan Formation	Ꝑie	Tillite, arkose, dolomitic sandstone, sandy dolomite, silty dolomite, dolomite, dolomitic siltstone and shale; siltstone, shale
		Kuniandi Group: Undifferentiated	Ꝑn	
		Mount Bertram Sandstone	Ꝑnb	Purple to grey, fine-grained micaceous and ferruginous sandstone, purple fissile shale and siltstone
		Wirara Formation	Ꝑnw	Green to grey laminated shale, green, brown and purple siltstone, green and purple sandstone
		Stein Formation	Ꝑns	Purple, coarse-grained greywacke
		Landrigan Tillite	Ꝑnl	Tillite, purple or cream laminated dolomite; sandstone and siltstone (stippled)
		Glidden Group: Maddox Formation	Ꝑdx	Black shale, black micaceous siltstone, purple-grey feldspathic sandstone, purple siltstone
		Forman Sandstone	Ꝑdf	White, massive to blocky, fine-grained quartz sandstone
		Matheson Formation	Ꝑdm	Laminated claystone, dark shale and siltstone, sub-greywacke ferruginous feldspathic sandstone, quartz sandstone
		Harms Sandstone	Ꝑda	Medium and coarse-grained quartz, sandstone, purple shale and siltstone
	UNDIFFERENTIATED	Hart Dolerite	Ꝑdh	Green-black, medium to coarse-grained dolerite
PRECAMBRIAN	MIDDLE PROTEROZOIC	Colombo Sandstone	Ꝑm	Massive, medium-grained quartz sandstone, sandy chert-pebble breccia, silicified dolomite
		Crowhurst Group: Hibberson Dolomite	Ꝑrb	Massive dolomite, minor sandy oolitic dolomite breccia, dolomitic sandstone
		Collett Siltstone	Ꝑro	Purple and green siltstone, minor white, silty dolomite, pyritic cherty siltstone
		Liga Shale	Ꝑrl	Green shale, minor micaceous siltstone, silty sandstone
		Hilfordy Formation	Ꝑrh	Quartz sandstone, ferruginous siltstone, shale
		Kimberley Group: Pentecost Sandstone	Ꝑkp	White, fine to coarse-grained quartz sandstone, purple fine-grained sandstone, purple siltstone and shale
		Mount Amherst Member	Ꝑka	Medium to coarse-grained quartz sandstone, pebbly quartz sandstone
		Elgee Siltstone	Ꝑke	Maroon siltstone and silty shale, minor quartz sandstone
		Teronis Member	Ꝑkt	Grey algal dolomite, sandy dolomite, oolitic dolomite; shale, micaceous siltstone, fine-grained sandstone
		Warton Sandstone	Ꝑkw	White to purple, massive to blocky, medium-grained quartz sandstone, minor feldspathic sandstone
		Carson Volcanics	Ꝑkc	Green-black basalt, amygdaloidal basalt, feldspathic sandstone; minor micaceous siltstone
		King Leopold Sandstone	Ꝑkl	White, medium to coarse-grained quartz sandstone, pebbly quartz sandstone
		Speewah Group: Undifferentiated	Ꝑp	
		Luman Siltstone	Ꝑpl	Purple-grey shale, grey micaceous siltstone, silty shale and fine-grained sandstone
		Lansdowne Arkose	Ꝑpo	Buff to pale pink, medium to coarse-grained, arkose and feldspathic sandstone, granule and pebble conglomerate silty shale interbeds
		Valentine Siltstone	Ꝑpv	Purple, grey and brown fissile, finely laminated shale and siltstone
		Tunganary Formation	Ꝑpt	Buff to pale grey feldspathic sandstone, siltstone, shale, quartz sandstone
		O'Donnell Formation	Ꝑpn	Olive-green to fawn micaceous silty-shale, coarse-grained quartz sandstone at base
		Watery River Porphyry	Ꝑww	Dark-grey othopyroxene-feldspar porphyry with sporadic quartz phenocrysts
		Whitewater Volcanics	Ꝑw	Quartz-feldspar porphyry, feldspar-pyroxene porphyry, lapilli tuff. Locally sheared
	UNDIFFERENTIATED PROTEROZOIC	Lamboo Complex: Undifferentiated	Ꝑb	Intimate mixture of granite and uralitised gabbro; minor metamorphics
		Mulkerrins Granite	Ꝑbu	White, coarse and even-grained leucocratic granite, tourmaline-muscovite aplite, quartz feldspar pegmatite
		Lerida Granite	Ꝑbl	Porphyritic to even-grained biotite granite
		Chaneys Granite	Ꝑby	Coarse, even-grained biotite granite, foliated and locally sheared
		Long Hole Granite	Ꝑbg	Grey coarse-grained porphyritic biotite granite, biotite gneiss, augen gneiss
		Violet Valley Granite	Ꝑbv	Equigranular, medium to coarse-grained tonalite
		Bow River Granite	Ꝑbo	Porphyritic granite, coarse-grained granite, granodiorite, aplite
		Sophie Downs Granite	Ꝑbs	Coarse, even-grained granite, granodiorite
		McIntosh Gabbro	Ꝑbi	Uralitised gabbro, troctolite, dolerite, amphibolite
			Ꝑbd	Uralitised dolerite and ultrabasic sills
		Alice Downs Ultrabasics	Ꝑba	Serpentinite with fibrous asbestos veins, garnierite and chromite
		Tickalara Metamorphics	Abt	Paragneiss and calc-silicate rocks, amphibolite
ARCHAEAN (?)		Halls Creek Group: Undifferentiated	Ah	Quartz greywacke, sericite schist, amphibolite, uralitised dolerite
		Olympio Formation	Aho	Quartz greywacke, feldspathic greywacke, siltstone, shale carbonaceous siltstone subordinate conglomerate
		Biscay Formation	Ahr	Uralitised basic volcanic rocks and basic volcanic agglomerate, greywacke, siltstone, carbonaceous shale, dolomite, marble, calc-silicate rocks, chert, quartzite, epidozite, jaspilite
		Saunders Creek Formation	Ahs	Quartz sandstone, feldspathic sandstone, quartz pebble conglomerate
		Ding Dong Downs Volcanics	Ahd	Uralitised and epidotised basic volcanic rocks

Geological boundary
Anticline, showing plunge
Syncline, showing plunge
Overturned anticline
Plunge of minor anticline
Plunge of minor syncline
Plunge of drag-fold
Plunge of fold axes
Fault, showing relative horizontal movement
Shear zone

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

Strike and dip of strata
Prevailing strike and dip of strata
Vertical strata
Horizontal strata
Overturned strata
Dip < 15° — air-photo interpretation
Dip 15°-45° — air-photo interpretation
Dip > 45° — air-photo interpretation
Horizontal strata — air-photo interpretation
Trend lines — air-photo interpretation
Joint pattern — air-photo interpretation
Top of bed

Strike and dip of cleavage
Vertical cleavage
Strike and dip of foliation
Prevailing strike and dip of foliation
Vertical foliation
Strike and dip of bedding, with lineation
Strike and dip of joints
Glacial striae
Glacial striae, showing direction of movement

Macrofossil locality
Plant fossil locality
Type section locality
Measured section
Sample locality for age determination
Dyke or vein; amph-amphibolite, dl-dolerite, p-pegmatite, q-quartz
Pb — Prospect: little or no production
Sn — Alluvial workings
Cu — Minor mineral occurrence

Ac	Asbestos-chrysotile	Pb	Lead
Cr	Chromium	Mn	Manganese
Nb	Columbium (niobium)	Ag	Silver
Cu	Copper	Ta	Tantalum
Au	Gold	Sn	Tin

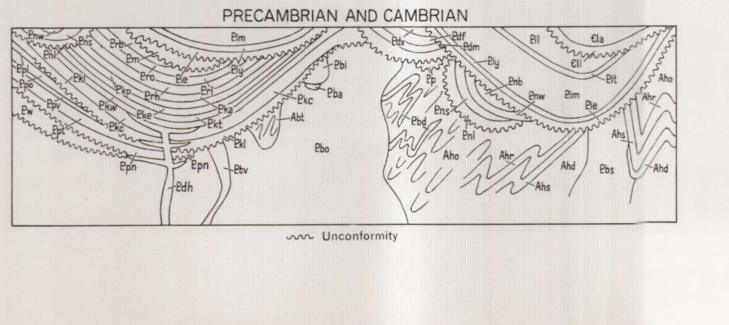
Battery, smelter not operating

Bore
Abandoned bore (dry)
Well
Windpump
Equipped with pump engine
Tank
Earth tank
Spring
Waterhole
Sand dunes

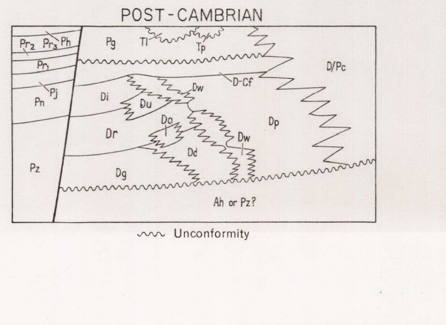
Road
Vehicle track
Telephone line
Fence
"Lamboo" Homestead
Landing ground
Yard
Trigonometrical station
.375' Height in feet; datum: mean sea level

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

PRECAMBRIAN AND CAMBRIAN



POST-CAMBRIAN



MOUNT RAMSAY

SHEET SE 52-9