COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

1953/60

GEOLOGY OF WILLIAMBURY AND MOOGOOREE. ONE MILE MAP AREAS.

by

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SUMMARY

The stratigraphy and structure of an area in the Carnarvon sedimentary basin covered by the Williambury and Moogooree one mile sheets, is described. Resting unconformably on a Pre-Cambrian basement of schists gneisses and granites, are Devonian marine sediments 4750 feet thick, followed conformably by Carboniferous approximately 2150 feet thick; these are separated from the overlying Permian more than 8000 feet thick, by a possible hiatus. The Cretaceous System is represented by about 40 feet of siltstones lying unconformably on the Palaeozoic rocks. Marine Tertiary arenaceous deposits are widespread and have a maximum thickness of 80 feet; they are not seen in contact with the Cretaceous rocks.

The whole area has been subjected, in Tertiary time, to lateritisation, the most prominent feature of which is the presence of a silicified cap ranging in thickness from a few feet to 30 feet. In one place a post-laterite deposit of 12 feet of probably fresh-water limestone has been observed.

An account is given of the structural geology, geological history, and physiography of the region.

INTRODUCTION

The Williambury and Moogooree One Mile military map areas cover the eastern edge of the North-West Basin in the vicinity of the Minilya River. The boundaries of the two sheets combined are latitudes 23°45'00" and 24°15'00" South and longitudes 115°00'00" and 115°30'00" East. The area is covered by pastoral holdings. The major part of Williambury and lesser parts of Moogooree, Merlinleigh, Mangaroon, Minnie Creek and Lyndon Stations are included. The area covered by the sheets is about 1070 square miles. Palaeozoic and younger sedimentary rocks occupy more than half this area and have been mapped in moderate detail. The Pre-Cambrian rocks which occupy the eastern part have not been studied in the field.

Williambury homestead is about 120 miles north-east of Carnarvon, the nearest town and port. The distance via the mail road is about 120 miles. Moogooree homestead is 18 miles south of Williambury. Both stations are connected with Carnarvon by party telephone line.

The aerial photographs from which the maps were prepared, were taken by the R.A.A.F. in 1948. A belt of country which extended from the coast easterly and covered the Minilya River, was photographed. The area described here, formed part of the belt.

METHODS OF SURVEY.

The base maps were compiled from the aerial photographs by Bureau personnel at National Mapping Branch of the Department of the Interior in Melbourne, by the use of the slotted template method. Topographic detail was plotted by students under supervision of the geologists. Ground control was somewhat limited. Lands Department Trig. points, where recognisable in the photographs and the surveyed angles of the Vermin-Proof fence were used. The scale of the photographs and field sheets is approximately 1 in 30,000. Preliminary photo-geological interpretation was made and recorded on the field maps before the field season began.

In the field, all significant outcrops were visited and examined. Sections were measured by chain and compass or by clinometer. Some sections were measured more approximately by compass and pacing. Boundaries were plotted from the photographs with frequent field verification. Rock and fossil specimens were collected from the measured sections and from isolated outcrops for verification of the formation.

Photo-interpretation gave a good guide to outcrop location but many important features were not revealed in the photographs.

The field party comprised two geologists and two assistants for the full season from early May to early October. The geologists were G.A. Thomas and C.E. Prichard and the field assistants were J. Dale and K. Moloney. Dr. C. Teichert, consultant to the Bureau spent seven weeks with the party in May and September and M.A. Condon, Senior Geologist, who supervised the operations generally, made two shorter visits.

A civilian type Willys Jeep was the main field vehicle, supplemented to some extent by a Chevrolet 10 cwt. Utility. A 3 ton Chevrolet truck was used for transporting camp gear.

TOPOGRAPHY

The area described extends from 120 to 50 miles east of the coast and lies south of the range of the north-west-monsoonal rains. The climate is hot and dry and the greater part of the annual rainfall of approximately 9 inches falls between January and July. Most of the country is covered with low mulga scrub and in the sandier areas with spinifex (Triodia). The rivers are fringed by eucalypts.

The topography is mature and has developed from an uplifted Tertiary low land level. The following physiographic units

can be distinguished : Kennedy Range, Black Range and the flood plains.

The Kennedy Range extends north from the Gascoyne River for over fifty miles. The north-east portion of the range comes into the area described. The range is a flat-topped mass of Permian rock, rising from 100 to 600 feet above the surrounding plains. The apparent height i.e. above plain level is greater, south and west of the area here described. The boundary scarps of the range are generally steep. A thin cap of younger rocks covers much of the range. Both cap and older rock are often lateritised. Numerous outlying mesas throughout the area are similarly capped.

It is evident that the present topography has developed from the dissection of the uplifted lateritised Miocene peneplain. The range is often capped with sand, now fixed with vegetation, but patterned with dunes. The dunes often extend to the boundary scarps, which is suggestive of their formation before the scarps were eroded to their present position.

In the east, the area is bounded by the hills known as the Black Range. These hills are of Pre-Cambrian rock and rise to about 1200 feet above sea level. They form the divide between the headwaters of the westerly flowing Minilya River and the south flowing Lyons River. The hills have the rounded topography of early maturity and there is rarely more than 100 feet of relief from creek bed to hill top. Much of the Pre-Cambrian rock in the eastern part of the area has developed the rounded topography. Some small mesas have been formed, notably where a laterite cap is well developed and in special areas of outlying younger sedimentary rocks.

Sedimentary rocks underlie the remainder of the area which is generally levelled to a plain about 700 feet above sea level. The Callytharra Limestone and adjacent Wooramel Sandstone form strike ridges above the plains and isolated mesas capped with laterite indicate the previous extension of the Miocene land surface over the area. In the Devonian-Carboniferous areas, the Moogooree Limestone and Longreach Sandstone form similar resistant strike ridges.

The plain does not merge into the higher country but is everywhere separated from it by scarps. The short, high intensity rainfalls induce sheet floods and the plain is scored by shallow anastomosing channels. Sand areas, either flat or with sand dunes, cover parts of the plains. Water courses are typically lacking in the sandy areas but clay pans are often well developed.

The three physiographic units, rise in altitude towards the east, maintaining a general parallelism. The drainage, therefore flows to the west. The only river within the area is the Minilya which has two major and some minor tributaries, the major are Minilya South Branch and Nortons Creek. The latter originates in the Kennedy Range and flows north to the Minilya River. The streams normally have dry sandy beds and braided channels. Semi-permanent pools are found at several locations on the Minilya River. The minor tributaries have a sub-rectangular pattern in the Pre-Cambrian Black Range Hills; no regular pattern is discernible on the plains. Distinct channels are lacking in the sand covered areas and on the top of the Kennedy Range.

The topography of the area faithfully reflects the geology. The three main geomorphological factors have been the hard crystalline Pre-Cambrian rocks, the relatively soft Palaeozoic sediments and the thin resistant cap on the uplifted Miocene land surface.

PREVIOUS WORK.

The first geologist to visit this area was A. Gibb Maitland in 1907., in the course of a very extensive geological survey of the North-West. He travelled down the Minilya River from its upper reaches in the Pre-Cambrian. He thus traversed the Devonian and

Pre-Cambrian contact which he may have seen; however it is not well exposed near the valley. He observed the notable ridge of Carboniferous limestone, several miles East of Williambury homestead, where the ridge is cut by the Minilya. Gibb Maitland also noted some of the Permian formations further downstream and recorded the prominent boulder bed, exposed along the Minilya South Branch. He correlated this with the "Lyons Conglomerate", 100 miles south.

In 1925, F.G. Clapp briefly visited the area in the course of a regional oil reconnaissance. He recorded the presence of easterly dips in the "Permo-Carboniferous" west of Moogooree homestead. He mentioned a dome structure with Lyons rocks exposed in the axis some 14 miles west of Moogooree, field work has not verified this structure.

H.G. Raggatt made the main contribution to regional mapping and stratigraphy while investigating the area for Oil Search Ltd. in 1934 and 1935. He established the broad stratigraphic divisions of the Permian and observed the faulted repetitions of the Callytharra Limestone in the west of the area. He noted the fault zone near Moogooree homestead. The Carboniferous Moogooree Limestone was correlated with the Permian Callytharra Limestone. The Lyons Series was thought to be the oldest sedimentary formation.

The earlier workers were not aware of the presence of the Devonian and Carboniferous formations below the Lyons glacial beds. Gibb Maitland in his Minilya River traverse collected some fossils from the Moogooree Limestone. He listed fossils from this locality. These were determined by Etheridge as Carboniferous. From the names listed, it seems most likely, that the specimens were confused with collections from higher formations, now known to be Permian.

STRATIGRAPHIC NOMENCLATURE.

An attempt has been made to apply the principles of the draft Australian Stratigraphic Code (Glaessner, Raggatt, Teichert and Thomas, 1948). Existing names have been retained but the status of the units has been changed to conform to the code and new units have been defined and named as required.

The provisional names for formations given in Teichert (1949, 1950) have been retained in some cases and modified in others in the light of fuller field work.

The results of petrological studies by A.B. Edwards are now available, C.S.I.R.O. Mineragraphic investigations Report No. 498. Dr. Edward's determinations in most cases confirm the field determinations and have been very helpful in indicating the identity of some isolated outcrops. The rock name Greywacke where used in the report follows the Bureau usage as in the chart "Descriptive Nomenclature of sedimentary rocks", Condon Nov. 1951 and covers the rocks named subgreywacke by Edwards.

SUMMARY OF STRATIGRAPHY.

SYSTEM.	FORMATION.	THICKNESS Feet.	DESCRIPTION.
Recent	River Alluvium Sands		
Quaternary (Pleistocene to Recent)	Hill wash (Sheet alluvium)		
	Sand dunes		
	Post-laterite deposits		
Tertiary		12	Chert and fine crystalline limestone occurring in a single mesa above laterite.
	Laterite	10-40	Ferruginous and silicified zones above either Tertiary or older rocks.
	Merlinleigh Sandstone (Miocene)	10-80	Cross-bedded medium to coarse sandstones and fine conglomerate. Some siltstone beds.
Cretaceous	Winning Group	40	White siltstone, sparsely present.
-	Unconformity -		
Permian	"Kennedy Sandstone"	basal beds only	Greywacke sandstone, cross-bedded ripple marked only basal part present in area. Over 600 feet present in Kennedy Range to West. The name is now superseded.
	"Kimber's Group"	3000 very approx.	Greywackes and grey to blue siltstones, sometimes carbonaceous and gypseous. Calcareous beds occur. Red concretionary horizons in the siltstones. Fossiliferous. This name is now unnecessary as the formations can be separated and correlated with the Wandagee area.
	"Mallens Greywacke"	1000	Fine-medium micaceous greywackes Interbedded siltstones in upper part. Fossiliferous.
	Coyrie Formation	500	Grey to blue siltstones and fine greywackes with calcareous beds. Fossiliferous.
	Wooramel Sandstone	350	Medium grained sandstone, cross-bedded partly micaceous. A few coarse sandstone to fine conglomerate beds. Cross-bedded.
	Callytharra Formation	500	Flaggy Limestones, Calcareous greywackes siltstones and thin limestone beds. Fossiliferous.
	Lyons Group	2,500 +	Sandstones, siltstones, conglomerate boulder beds (glacia thin limestones, fossiliferous.

SYSTEM	FORMATION	THICKNESS	DESCRIPTION.
	- Possible Hiatus -		
Carboniferous	Harris Sandstone	100-200 est.	Medium to coarse pebbly sandstones. Some plant fossils.
	Yindagindy Formation	150-300	Limestone, fine, blue-grey and interbedded calcareous greywacke. Ostracods and other fossils present.
	Williambury Formation	500-950	Greywacke, siltstone and pebbly to conglomeratic beds. Cross-bedded.
	Moogooree Limestone	690-880	Limestone, occasionally sandy. Partly silicified Fossiliferous, yellow to blue in colour. Fossiliferous
Devonian	Longreach Group comprising :		
	Wedlaraddy Formation	1000	Mostly greywacke with alternating siltstone and conflomerates, cross bedded.
	Mundabia Sandstone	1800	Quartz sandstones with some mica and 140 feet of siltstone and thin limestone near the top. Cross bedded.
	Gneudna Formation	1200-1750	Alternating limestone, calcareous siltstone, some greywacke. Biostromal in part. Fossiliferous.
	Nannyarra Greywacke	200	Medium to fine greywacke, basal gritty arkosic sandstone and felspathic sandstone.
-	Unconformity	-	
Pre-Cambrian	Mosquito Creek Series ?		Schists, gneisses and granite. Dolerite dykes and quartz reefs.

THICKNESS VARIATION OF THE DEVONIAN AND CARBONIFEROUS FORMATIONS.

Formation	Harris Block - about 2 miles N.W. of Williambury Homestead.	Type Sections in Gneudna paddock, Williambury	Moogooree Area - south of Moogooree Homestead.	Outlying Eastern fault blocks	
				Northern block near Mimabulya bore	Southern blo
	Feet	Feet	Feet	Feet	Feet
Yindagindy	150'	312	Not present	Not present	Not present
Williambury	480' approx.	950	Not present	Not present	Not present
Moogooree	690 approx.	880	Becomes thinner and also faulted out in the south.	Not present	Not present
Longreach Group Wedlaraddy Formation Munabia sandstone	2000' approx. 590 1400 approx.	2810 1000 1800	Often reduced by faulting. Thickest section about 2600.	Base only exposed.	Base only exposed.
Gneudna	1200	1750 - North of Gneudna Mill 1700 - South of Gneudna Mill	1000 approx. Est.	1900 Est.	1500 Est.
Nannyarra	Poorly exposed	190	200 approx. Est.	Poorly exposed	Poorly exposed.

SUMMARY OF THE STRATIGRAPHY.

The table attached outlines the stratigraphical succession. The oldest rocks of the area, the Pre-Cambrian complex of schists, gneisses and granites is overlain unconformably by a thick marine sequence of Devonian, Carboniferous and Permian sediments. The Pre-Cambrian rocks occupy the Eastern part of the area. The contact of the Pre-Cambrian and the Palaeozoic rocks trends North in the Williambury sector and north-westerly in the Moogooree. The contact is parallel to the strike of the Palaeozoic rocks. In the Williambury area, the contact is apparently simple and depositional but in the south part of the Moogooree area it is complicated by faulting. The contact is not equivalent to the edge of the basin because faulted outliers of the Devonian rocks - Gneudna beds and Munabia Group sandstones - are found six miles east of the main sedimentary outcrops in the Moogooree area.

A conformable west dipping sequence of Devonian and Carboniferous rocks lies west of the main contact. The sequence is interrupted by a major fault zone, extending north and south of Moogooree homestead. The zone, here designated the Moogooree Fault Zone, continues into the Williambury region and takes on an arcuate trend north-east of Williambury homestead. The name Williambury Fault is proposed for the northern structure, the throw of which is much greater than that of the southern fault.

Immediately east of Williambury homestead is a complex area of Palaeozoic sediments, partly incorporated in the Williambury Fault zone. The rocks are mainly sandstones, probably belonging to the Lyons Group and are apparently conformable with the Carboniferous beds.

West of the Moogooree Fault Zone is a conformable sequence of Permian rocks with the Lyons Group at the base. The lower part of "Kennedy" Sandstone outcrops in the south-west corner of the Moogooree area. The "Kennedy Sandstone" is the youngest Permian known in outcrop in the North-West Basin. Strike faulting causes repetition in the Permian sequence.

On the western side of the Williambury Fault zone, the upthrow of which is at least 7,000 feet, is a belt of Pre-Cambrian schists and gneisses. The Pre-Cambrian is overlain further west by a sequence of the Devonian and Carboniferous Systems, followed by a bed of the Lyons Group of Permian age. Another great fault, named the Harris Fault terminates this sequence. The belt of Palaeozoic rock between the Williambury and Harris Faults continues south to the Minilya River where its contact with the Lyons Group is intricately faulted. The block between these two faults will be referred to subsequently as the Harris Block. It is worthy of note here that the Devonian and Carboniferous formations in the Harris Block are considerably thinner than in the main eastern line of outcrop.

West of the Harris Fault the Palaeozoic sequence and underlying Pre-Cambrian recurs. Outcrops are generally obscured by sand cover, however. The Gneudna formation is not exposed at all, apparently mantled by the alluvium and sand near the Yindagindy Creek.

Another considerable fault, the Mundary Fault, west of the Harris Fault, was mapped. The block between the Harris and Mundary Faults will thus be the Mundary Block. The amount of throw apparently varies along this fault. On the western side are prominent boulder beds of the Lyons Group.

Further south, in the Williambury map area, oblique and strike faulting causes repetition in the Lyons-Callytharra-Wooramel sequences.

The regional dip is west to south-west. Within each block the dip decreases to the west.

A small outlier of Cretaceous rocks was noted about eight miles north-north-west of Williambury homestead. Approximately horizontal siltstones about 30' thick unconformably overlie Devonian Sandstones. The outlier is a remnant of the more extensive Cretaceous rocks of the Winning Group which outcrop in the Lyndon area further north.

The Tertiary System is represented by cross-bedded sandstones conglomeratic at the base, the Merlinleigh Sandstone, which unconformably overlies the Palaeozoic rocks. The thickness is variable, reaching 80 feet in places. These beds often form part of the mesa caps. More extensive areas are known beyond this area on the Kennedy Range and elsewhere. Shelly fossils have been found near Merlinleigh homestead; these suggest a Miocene age.

Laterite is widely developed. It is preserved on the Kennedy plateau and outlying mesas. The complete theoretical profile has not been observed but about 30 feet of lateritized rock is often seen. A silicified zone, called "billy" in the field is often present. The billy is best developed where the Tertiary sandstone has been lateritised.

Minor faulting of the order of 50 feet to 100 feet throw affects both the Tertiary and lateritic capping rocks which are also sometimes tilted.

An interesting outcrop of limestone and chert about 12' feet thick caps a mesa in the Pre-Cambrian area, 7 miles north-east of Williambury homestead. This is probably of freshwater origin and overlies lateritized sandstone which is rather poorly exposed. Talbot (1920) recorded similar outcrops in the Brumby Creek area further north.

PRE-CAMBRIAN ROCKS.

The Pre-Cambrian rocks of the area have not been examined in any detail. They form the bed rock of the sedimentary sequence. Earlier authors have correlated them with the Mosquito Creek Series. Trend lines revealing complex structures are visible in the aerial photographs. Steeply dipping Schistose and gneissic rocks appear to form the trend lines, at least where the lineation has been inspected near the Palaeozoic contact.

Granitic rocks often closely associated with gneissic outcrops are present, particularly in the Williambury area. Quartz reefs were observed in both the granitic and schistose areas. Dolerite dykes occur in the Williambury-Lyndon areas. Wide dykes sometimes traceable for many miles are numerous in the eastern part of the Pre-Cambrian country. These have often resistant upstanding walls; they were not visited in the field. The trend of the dykes is north to north-north-east and more rarely north-north-west. They frequently intersect the schistose lineation. Oblique faulting, has displaced some of the dykes.

Distinct sedimentary rocks apparently do not outcrop within this area of Pre-Cambrian. However, 20 miles north of Lyndon Station, there is a steeply dipping thick folded sequence of partly silicified limestone and sandstone with which is associated iron ore. A Nullagine age has been suggested for this sequence.

Lead mineralization is known on Williambury Station where prospectors have worked a small claim which is now abandoned.

DEVONIAN SYSTEM.

Rocks of Devonian age appear to be the oldest beds of the sedimentary sequence. The Devonian beds which unconformably overlie the Pre-Cambrian are followed conformably by the Carboniferous. Four main formations can be recognised ; The Nannyarra Greywacke at the base, followed by the Gneudna Formation and above are Munabia Sandstones followed by the Willaraddie Formation. The top two formations were grouped in mapping as the Longreach Group. The main outcrop of Devonian and also Carboniferous rocks forms a belt, trending north in the Williambury area. The belt which is approximately three miles wide is situated about a mile and a half east of Williambury homestead. The Devonian forms the eastern side of the belt which is readily followed within the two map areas. The strike changes to south-east near Moogooree homestead. The Devonian strike is parallel to the Pre-Cambrian contact, both show minor sinuosities in the Williambury area. The three main formations persist in outcrop throughout the main belt.

Faulting on a large scale in the Williambury region has repeated the outcrops of the Devonian-Carboniferous beds. In the Harris and Mundary Fault Blocks the exposures are poorer than in the main belt. A marked thinning of the Devonian formations is observable in the Harris Block. Outcrops are not sufficient to give a satisfactory estimate of thickness in the Mundary Block.

East of Moogooree homestead, there is a faulted outlier of Devonian rocks, some five miles long and about seven miles east of the main line of Devonian outcrop. Further south is another outlier, approximately four miles east of the main sedimentary area. These outliers consist of Gneudna limestone and of the lower part of the Munabia Group. The southern outlier continues south of the map area for some miles.

NANNYARRA GREYWACKE.

DEFINITION.

The lowest formation in the sedimentary sequence is the Nannyarra Greywacke. The name is that of a paddock on Moogooree Station. The formation consists of coarse to fine greywacke and some sandstone underlying, apparently conformably, the Gneudna Formation and overlying unconformably the Pre-Cambrian complex. The dips in the Gneudna are sometimes greater, however the strikes are parallel and the contact seems to be transitional. A disconformable contact with the Gneudna is possible in part.

DISTRIBUTION AND TYPE OF OUTCROP.

Outcrops generally are poor because of the friable character of the rock and also they are obscured along the base by wash from the Pre-Cambrian hills. The Nannyarra and succeeding formations form a plain on the eastern part of the main belt of the older Palaeozoic rocks. Occasionally harder beds only are exposed. For about a mile north, from the Williambury-Moogooree Station boundary the lower part of the Nannyarra is fairly well exposed. The type section was measured in this locality. The dip is from 30° - 35° west. Minor oblique faulting has offset the contact with the Pre-Cambrian in the type locality but elsewhere on the Williambury map the contact is obscured.

North-west and south of Nannyarra well on Moogooree Station, part of the Greywacke is well exposed.

At the southern end of the main Devonian-Carboniferous belt to the west and south of Howells bore, the formation is nearer sandstone in composition. Strike faulting is indicated at both the upper and lower contacts of this outcrop which is

indurated with silica and forms a strike ridge. Oblique faulting considerably offsets the lower contact in this region. The formation was not observed in the Harris and Mundary fault blocks where it is probably present but masked by alluvium. Similarly the Nannyarra appears to be obscured in the easterly Palaeozoic outliers on Moogooree Station.

LITHOLOGY AND THICKNESS.

The type section of the Nannyarra Greywacke was measured in Gneudna paddock, Williambury, 5,500 yards south of Gneudna Well. Here 190 feet of greywackes are exposed. Towards the base is a coarse grained to gritty friable arkosic rock, with sub-angular grains of quartz, pink felspar and mica in a finer matrix of rounded quartz, felspar, 15 per cent biotite, 5 per cent. muscovite, rare tourmaline and sericite and kaolin. This mineral assemblage resembles the underlying Pre-Cambrian rock and in hand specimens, the rocks are similar. Higher, the rocks are finer grained and have a greywacke composition. The colour is generally a speckled pale brown. They are well bedded throughout. The higher sediments are finer, less well sorted with more angular fragments and a fair percentage of unstable minerals.

The matrix of the gritty basal rocks Spec. (152, 154) and the quartz felspar sandstone (Spec. 152a) which corresponds to the gritty rock minus the fragments is moderately well sorted. The higher finer rocks (Specs. 155, 156, 157) are less well sorted. The composition is predominantly quartz with 10 per cent of felspar, 10 per cent of rock fragments (cherts, quartzite and phyllite), 5 per cent mica in a finer matrix (20 per cent). The composition and texture is that of "sub-greywacke" (A.B. Edwards).

The thickness of the formation is distinctly variable over comparatively short distances and may well be a reflection of the relief of the Pre-Cambrian surface. There is a general trend to greater thickness in the south. South of Howell's bore the thickness appears to be over 400 feet. However, strike faulting is present. The lithology also varies along the strike; the greywacke outcropping near Nannyarra well, Moogooree station, has quartz, felspar, and chert fragments in a clayey matrix, at the base, higher (Spec. 219) the rock has many shale fragments (50%). The basement is here Pre-Cambrian mica-schists. Near Howells bore, (Spec. 304) the composition is similar to that of the type area. Quartz felspar sandstone bands were noted in the type section, near the base. The composition of these sediments evidently reflects to some degree the composition of the base particularly at the base. Some of the faulted beds in the south of the area, herein referred to the Nannyarra, are thought by M.A. Condon to be overthrust Pre-Cambrian Sandstone.

GEOLOGICAL AGE. No fossils are known from this formation. As these beds are followed by Upper Middle Devonian rocks and no great break is evident, a Lower Middle Devonian age seems likely.

GNEUDNA FORMATION.

DEFINITION.

Conformably situated between the Nannyarra Greywacke and the Munabia Group above, is the Gneudna Formation - a sequence of alternating fossiliferous limestones, calcarenite, calcareous siltstones and minor greywacke. The name is derived from Gneudna paddock on Williambury station. Gneudna well, in the centre of the paddock is five miles south-east of Williambury homestead.

DISTRIBUTION AND TYPE OF OUTCROP.

The Gneudna Formation is readilytraced along the main belt of the older Palaeozoic outcrop in the two sheets. Its outcrop is about 3,000 feet wide. Though the softer beds are rarely exposed, the harder limestones are easily followed and appear as well defined strike lines in the aerial photographs.

The Gneudna areas are usually flat but a low hill three-quarters of a mile north of the Williambury-Moogooree boundary gives reasonably good exposures of the softer beds and of part of the underlying Nannyarra Greywacke. The type section was measured in this area.

The formation also outcrops in the eastern fault outliers and in the Harris Fault block. Small irregular outcrops occur along the western side of the Williambury fault zone.

The dip of the Gneudna Formation is 40° to 45° along the eastern edge of the main outcrops. The strike is meridional in the Williambury area, and veers to north-west in the Moogooree region. The dip decreases to about 30° on the western side of the outcrop belt. Accurate dip measurements are often hard to obtain from the limestone outcrops. No indication of disconformity within the Gneudna sequence was observed.

Minor anomalies, where dips do not seem to be decreasing steadily from east to west, are probably weathering effects. Dips were generally obtainable only from the thin resistant harder limestones which alternate with the softer beds.

LITHOLOGY AND THICKNESS.

The type section measured 1700 feet in thickness. This section occurs above the Nannyarra type section, in Gneudna paddock three quarters of a mile north of the Williambury-Moogooree boundary fence Diagram No. 4. The rock types present include tough fine-grained crystalline limestone, grey, bluish-grey and less often pale yellow in colour. This limestone is usually less than one foot thick and is often but not invariably fossiliferous. Interbedded with these resistant beds are 6 to 10 feet sequences of soft rocks, rarely exposed. These comprise medium grained calcareous greywackes, friable, yellow-brown chalky calcarenite, thin laminated fine-grained crystalline limestone and grey calcareous siltstones. Towards the top of the formation several beds of fine-grained pale brown, sparkling sandstones were noted.

Another measured section, north of Gneudna Well provided a similar record, not as well exposed and totalling 1750 feet. This section about 4¾ miles north of the other showed a similar lithology in the limestones but neither the top nor botton of the section was as well exposed. The width of outcrop is approximately the same in both sections.

The section, north of Gneudna Mill was sampled as in list below:

	Collection No.		Collection No.
1700 feet	26	905 feet	15
1580 "	25	850 "	14
1470 "	24	824 "	13
1300 "	22	623 "	12
1230 "	21	420 "	11
1225 "	23	402 "	10
1155 "	20	385 "	9
1055 "	19	365 "	8
1015 "	18	360 "	7
985 "	17	340 "	6
960 "	16	158 "	5

The formation is richly fossiliferous and in many beds small brachiopods form a significant part of the rock-forming material. The fossils occur in both the hard limestones and in the softer beds. They are often weathered out of the softer rock in excellent condition and abundance. The prevalence of dwarfed forms at certain horizons is of interest. There appears to be a very distinct correlation with lithological changes.

Towards the top of the section biostromal conditions are evidenced by several thicker massive limestone beds of considerable extent along the strike, traceable for several miles at least. The beds comprise large stromatoporoid masses, probably in positions of

growth and less abundant corals; elsewhere in the same beds the fossils show signs of transportation and are set in a limestone matrix. No evidence of biohermal conditions was observed throughout the area.

LONGREACH GROUP.

DEFINITION.

The name is after that of a paddock south east of Moogooree homestead. A type section was measured 4 miles south-east of Williambury homestead in Munabia paddock. Diagrams 5 and 6. There two formations are clearly distinguished. The name Munabia Sandstone is proposed for the lower 1800 feet of the section. The Munabia beds are chiefly cross-bedded sandstones but include 140 feet of siltstones towards the top. This formation extends from the type area south into Longreach paddock, Moogooree. The upper 1000 feet of the Longreach Group consisting of cross-bedded conglomerates, greywackes and siltstones is named the Willaraddy Formation. Willaraddy Creek is a small tributary of the Minilya, the junction is close to outcrops of the formation. The whole group was mapped as a unit. Detailed field work will readily enable a separation to be made throughout the area.

The Munabia Sandstone is conformable with the Gneudna formation; the contact is transitional. The Willaraddy follows the Longreach in conformity and shows conformable relationships with the overlying Moogooree Limestone.

DISTRIBUTION AND TYPE OF OUTCROP.

The distribution of the Longreach Group is broadly that of the Gneudna Formation. In the main older Palaeozoic belt the Group characteristically forms a bold outcrop up to 6,000 feet wide on the western edge of the Gneudna areas. Similar but less prominent outcrops occur in the Harris and Mundary Fault blocks. In the latter block the Longreach Sandstone is the oldest Palaeozoic rock exposed, the Gneudna Formation at present is completely obscured by sand. Low flat-topped hills are formed from the lower few hundred feet of the Longreach Sandstone occurring on the eastern side of the eastern Palaeozoic outliers, on Moogooree station. The rocks of the Munabia Sandstone commonly form long flat-topped steep-sided hills arising about 200 feet above the surrounding plain. The Munabia is distinctly more resistantthan the Willaraddy member hence the "ranges" are more prominent on the eastern side of the Munabia outcrop areas. The cap is usually silicified and less commonly covered by thin sandstones and conglomerates, relics of the Tertiary transgression. The hills are best developed, south of the Minilya River where both members are exposed as far south as the Williambury-Moogooree boundary. Further south the Willaraddy greywacke has apparently thinned out and the Munabia sandstone increased in thickness. The siltstone sequence at the top of the Munabia type section was not observed in the Moogooree area. At the southern end of the outcrops, the Group is considerably affected by strike and oblique faulting. The reduction of the Willaraddy Formation is probably partly due to faulting in addition to the effect of stratigraphic thinning.

In the Mundary and Harris Fault Blocks, outcrops are poor. A marked thinning of the Group is indicated by a section measured in the Harris block totalling 1900 feet, compared with 2800 feet in the type area.

The dips in the type section range from about 35° to 25°, generally declining from east to west. A steepening of dip was noted in the Willaraddy member. The steepening which is limited to under a hundred feet of section can be traced laterally for several miles along the strike and may be more extensive. A similar but less prominent steepening was observed in portion of the Munabia section. Cross-bedding is present throughout. The local steepening which amounts to about 5° probably does not imply a disconformity. Possibly the sagging which accompanied deposition did not proceed evenly

THICKNESS AND LITHOLOGY.

The type section is four miles south-east of Williambury homestead. Another section measured about a mile and a half south of the type indicates a similar succession and thickness. These sections show that the Group comprises 1400 feet of medium-grained sparkling sandstone, 140 feet of siltstone and 270 feet of medium-grained sandstone, constituting the Munabia Sandstone and 1000 feet of greywacke, siltstone and conglomerate forming the Willaraddy Formation.

The Group was mapped as a unit because it was not possible in the time available to trace the two divisions throughout the outcrop area. This is partly due to poor outcrops and at present it is proposed to divide the Group into two member formations, the Munabia Sandstone for the lower 1800 feet and the Willaraddy Formation for the upper 1000. Further work has enabled these formations to be separated through out the area.

In the type area the Munabia Sandstone is chiefly cross-bedded medium-grained, sparkling quartz sandstone. It contains several beds of fine grained slightly micaceous flaggy quartz sandstone near the base, occasional coarse sandstone beds, some thin siltstones and a few beds with well rounded quartz pebbles, less than ½ inch in diameter. The sequence is uniformly cross bedded. The quartz grains appear angular due to overgrowth of quartz but were originally rounded to sub rounded. The overgrowths help to bond the rock. Some of the sandstones are very porous. Weathered outcrops are usually a dark red-brown colour but the fresh rock is almost white. Small rectangular clay galls (1-2 inches) occur sporadically. Several hundred feet below the top of the member, 140 feet of finer grained rocks outcrop. These are chiefly siltstones but subordinate fine-grained greywackes, (Spec. 32) thin beds (less than 3") of hard yellow fine grained crystalline limestone and minor fine grained sparkling quartz sandstone also occur. These beds are not current-bedded. They have not been separated as a member of the group as they have been observed only in the main older Palaeozoic belt between the Minilya River and the Williambury-Moogooree boundary. The Munabia samples analysed by Dr. Edwards are spec. Nos. 26, 27, 28, 30, 32, 34 with the exception of 32 these are all quartz sandstones with valuable but low amounts of minerals other than quartz. A few rock fragments may be present. The minerals grains comprise quartz, felspar 2-5 per cent, glauconite 0-1% muscovite 0-1 per cent. tourmaline and a little zircon and leucoxene. These are set in a small amount of mostly fine matrix. The sandstones are generally well sorted and of medium grain size.

The intercalation of finer and partly calcareous rock is represented by Spec. 32. This is a greywacke, poorly sorted and greenish grey in colour. It contains angular quartz grains, cloudy felspars (2-3) per cent. muscovite chloritised biotite partly converted to glauconite and numerous fragments of mica schist and granite in an abundant matrix of sericite, chlorite, fine quartz and clay. The grains are largely angular, some rounded but with quartz overgrowths. The muscovite flakes lie parallel to the bedding. The rock has a "dirty" appearance in thin section. This sample has ten times as many heavy minerals as Spec. 30 and in different proportions, and includes some garnets.

This sequence probably indicates the temporary onset of the unstable environment in which the later Willaraddy formation was deposited. The fine grained and calcareous rocks may have been deposited in deeper water which may have contributed also to the differential proportion of heavy minerals.

The Willaraddy Formation comprising the upper 1000 feet of the Group is of varying lithology. Rarely does the same rock type persist for more than 50 feet of strata. Though siltstone, quartz sandstone, greywacke conglomerate and soft fine-grained micaceous red sandstone are present, medium-grained greywacke is the principal rock type. Cross-bedding is present throughout and the arenites are typically pebbly. Only occasionally are the pebbles, composed of quartzite, dark and light chert (up to 3" diameter) and of quartz (up to 1" Diameter) also red jasper abundant enough to form a conglomerate. Rare pebbles of silicified limestones have also been noted. The medium grained greywacke contains grains of quartz, dark and pale chert and mica flakes in a fine white matrix. The Wallaraddy rocks are sometimes red, often dark-brown on weathering but are usually white or pale coloured even on the surface.

Specimens from the Willaraddy Formation include Nos. 35, 36, 144 and 318. These are variable in composition. No. 35 is a conglomerate with rounded to sub-angular pebbles of black chert, light grey chert, milky quartz quartzite and red jasper from 1-5 cm. in an illsorted sandy matrix comprising quartz grains, quartzite, quart schist, chert, phyllite interstitial clay but no felspar. There is some expanded muscovite, coarse rounded leucoxene and a little coarse and slightly rounded tourmaline.

Spec. 36 is a coarse loosely compacted sandstone of somewhat similar composition to the matrix of spec. 35.

Spec. 144 shows the close association of a fine grained greywacke or "mictite" with 50 per cent matrix and a more"cleaned up" rock with the composition of a quartz sandstone. The "mictite has its mineral grains separated by a paste of clay and fine quartz. The grains are angular and variable in size and consist of quartz, muscovite, bleached biotite, some coarse blue tourmaline and not very abundant chert, quartzite, and quartzmica schist. The elongated grains are parallel to the bedding. Felspar is rare. The associated quartz sandstone has coarser representatives of the grains of the greywacke in an apparently opaline brown cement. It is porous and well sorted and would be a coarse "cleaned up" equivalent of the mictite in which the grains had been winnowed from the matrix.

Spec. 318 comprises illsorted pink medium grained sandstones consisting of angular grains of quartz, felspar 5-10 per cent, coarse muscovite and numerous angular fragments of chert, quartzite, phyllite, some mica schist in 10 per cent of matrix.

In the Harris block, the Longreach Group is only moderately well exposed. The two members can be recognised; the upper indicated largely by an abundance of pebbles derived from the pebbly to conglomeratic beds. The siltstone sequence of the Munabia Sandstone was not seen, possibly because of the poverty of outcrop, however the limestone beds are both thicker and occur over a greater part of the section than in the type area. This section shows an overall reduction of thickness to about 2000 feet. There is thus a westerly thinning from 2800' in a distance of 11,000 yards. Diagram No. 7.

Strike faulting in the southern limits of the area, precluded accurate measurement. The Willaraddy formation seems not to be present and the Munabia Sandstone is rather more pebbly than in the type area, the quartz sandstones are also a little less predominant among the rock types. The calcareous and siltstone sequence was not observed.

In the Mundary block, most probably the section has been partly repeated by faulting as the Longreach Group appears to have a width of outcrop greater than elsewhere. Details of the faulting and of the section are obscured by sand cover.

The sandstones from the Munabia beds of the eastern outliers on Moogooree Station are medium grained quartzose sandstones.

CARBONIFEROUS SYSTEM.

The Carboniferous System comprises four distinct formations. These are in order of succession; Moogooree limestone, Williambury Formation, Yindagindy Formation and Harris Sandstone. The formations are in conformable sequence. The Moogooree Limestone conformably follows the uppermost Willaraddy beds. The evidence points to conformity between the Carboniferous and overlying Permian in this area.

In the Moogooree sector, the complex Moogooree fault zone separates the areas of Carboniferous and Permian rocks and at the southern limit of the area, the Carboniferous rocks have been entirely faulted out and Devonian and Permian beds are in faulted contact.

The distribution is broadly similar to that of the underlying Devonian formations.

MOOGOOREE LIMESTONE.

DEFINITION.

Moogooree Station has provided the name for this formation. Good outcrops of the formation extend across both Williambury and Moogooree stations. This moderately fossiliferous limestone sequence has conformable relationships with the Devonian Munabia Group below and the Williambury Formation above. The type section was measured in Gneudna paddock about 3½ miles south-west of Williambury homestead. This section totalled about 860 feet. Diagram No. 8

DISTRIBUTION AND TYPE OF OUTCROP.

The Moogooree Limestone has the same general distribution as the Munabia Group. It can be traced along the main pre-Permian Palaeozoic belt where its average width of outcrop is about 2100 feet, but decreasing markedly in the south. The limestone is relatively resistant and outcrops are often in the form of a rounded ridge, generally less than 150 feet above the plain level. The ridge is prominent where breached by the Minilya River and its South Branch. Elsewhere two parallel lower longitudinal ridges are often present, and in places the formation maybe eroded to plain level and largely obscured. The dip in the main belt is about 22° west. At the southern end of the belt, the Moogooree outcrop is evidently reduced in width by strike faulting and finally cut out by oblique faulting which brings Munabia Group sandstone and Lyons Group sandstones into contact.

The formation is well exposed in the Harris Fault block mainly as a strike ridge which flattens to the south. North of Yindagindy Creek, the outcrop displays a marked curve round to the west. This is interpreted as a drag effect along the Harris Fault. The structure is an asymmetric south-pitching syncline. At the southern end of the Harris Block, the Carboniferous rocks are in faulted contact with the Lyons Group. Near the Lyndon boundary fence, the dip on the eastern edge of the Moogooree Limestone is about 40°, suggesting a local strike fault near the contact. Further west, the beds have the regional dip. Two isolated triangular blocks of Moogooree Limestone occur on the eastern side of the Harris Fault near Yindagindy Creek. These are probably horses caught up in the Fault Zone which is probably more complex than it is shown on the map but the poverty of outcrop does not permit a more detailed interpretation.

The Moogooree Limestone is present in the Mundary Fault Block but is poorly exposed. There is evidence of strike faulting below the contact with the Williambury beds. The passage seems to be conformable. The formation can be traced as discontinuous partly silicified outcrops but is mostly covered by sand.

LITHOLOGY AND THICKNESS.

The type section Diagram No. 8 in Gneudna paddock is representative of the unfaulted outcrops. This section consists of 880 feet of continuous limestone, in beds two inches to two feet thick. The lower 20 feet comprised calcareous siltstone and yellow argillaceous limestone. The formation is mainly tough, fine to coarse grained, crystalline limestone. The colour is most often yellow, sometimes brownish or pinkish yellow and also blue-grey. The limestone shows considerable silicification in some beds. Some of the fossiliferous beds have selectively silicified fossils, other beds contain irregular small nodules of chert. Treatment with acid revealed small silicified shell fragments but an absence of quartz grains or other terrigenous material. Some beds contain vuggy cavities; some of the vughs are lined with small calcite crystals. Some oolitic limestones have been noted within the sequence. In the field, the impression was gained that some of the rock is dolomitic. No analyses are available.

The thickness in the Harris block is about 700 feet, displaying the reduction, already noted for the Devonian formations in this area. In the Harris block the basal few feet of limestone is sandy to pebbly with rounded pebbles of quartzite, cherts and limestone. The underlying Willaraddy formation is poorly exposed in this area, however the surface is abundantly strewn with similar pebbles which are also characteristic of the formation in areas of better outcrop. It would seem that the relationships of the two formations are transitional.

As noted, the formation when followed to its southern limit in the main belt is gradually reduced in width of outcrop and finally faulted out. It is thought that the apparent reduction in thickness is essentially due to faulting.

The formation is not abundantly fossiliferous throughout but certain beds are quite rich mainly in brachiopods. Locally towards the top of the section, a strong development of Syringopora sp. was noted. These were apparently in the position of growth. The spiriferids indicate an age low in the lower carboniferous.

WILLIAMBURY FORMATION.

DEFINITION.

The formation name is that of Williambury station where the formation is best developed. The formation consists of conglomeratic greywackes, some mictites (field observation) and interbedded siltstones, all with cross-bedding. It is conformable with the overlying Yindagindy Limestone and the underlying Moogooree Limestone, though in the type section the dip of the Williambury Formation is several degrees steeper. Local faulting near the lower contact was noted about 3¼ miles south-east of Williambury homestead. A wedge of Williambury beds has been downfaulted into the Moogooree Limestone. The type section is 2½ miles E.S.E. of Williambury Homestead.

DISTRIBUTION AND TYPE OF OUTCROP.

The formation is not generally well exposed because of its friability but it can be traced along the main older Palaeozoic belt in the Williambury area, both north and south of the Minilya River. In the north, the formation is cut off by the oblique Williambury fault. South from the Williambury-Moogooree boundary fence, the formation is incorporated in the complex Moogooree Fault Zone and is preserved only as small separated fault blocks. South of Moogooree homestead, the formation has been faulted out.

The Harris Fault Block has a continuous belt of Williambury beds parallel and adjacent to the Moogooree Limestone outcrops and displaying similar drag folding north of Yindagindy Creek. The Williambury outcrop is in places reduced to the form of the low ridge of cobbles and pebbles of chert and quartz derived from the conglomeratic members.

Small discontinuous patches of the Formation were noted in the Mundary Block. The sand cover has obscured outcrops.

THICKNESS AND LITHOLOGY.

A complete section Diagram No. 9 across the Williambury Formation was measured at the type locality only where the outcrops were protected by a cover of Tertiary rocks but elsewhere partial sections show the same general characters. The predominant rock type is a medium to coarse grained greywacke, generally pale brown in colour, sometimes yellowish brown. Though generally light in colour, dark brown bands also occur. Pebbles are common; the grains are often sub-angular and unequal. The minerals noted include quartz, kaolin, and chert particles in a friable kaolinitic silty matrix. Mica is present in some beds only and may reach 2 millimetres in diameter. The coarser rocks are on the whole ill sorted. Analyses indicate phyllite and shaly rock fragments in some samples. Ferro-magnesian minerals are rare. Also present are siltstones, generally red in colour and micaceous. Fine conglomerates in bands or lenses are also present. These may contain larger pebbles, generally less than three inches in diameter. Pebbles comprise dark and light chert, quartz and quartzite and are fairly well rounded. Cross-bedding is general and the conglomerates and siltstones which often grade into the greywacke tend to be lenticular. Pene-contemporaneous erosion is indicated by cut and fill structure. Clay "biscuits" about 1 inch diameter resembling fine siltstones from lower in the section were sometimes observed in the cross-bedded greywackes. A number of beds of siltstone, less than 10 feet thick are present. A bed 50 feet thick occurs near the middle of the type section and another about 30 feet thick near the top. These are generally soft, micaceous and red-brown in colour. In the type area, the section is about 950 feet thick.

The samples from the type area include specimens 135, 137 and 312 which were analysed by Dr. Edwards (see type section).

The specimens all show rather similar composition; characteristically there is an abundance of black chert fragments similar in size to the other granular constituents and abundant interstitial white to buff kaolin (up to 20 per cent.) Felspars are rare.

Specimen 135 is a light buff consisting of angular fragments of quartz, 10 per cent. of chert fragments, 10 per cent. of quartzite in a fine matrix of quartz and much clay. Some muscovite, a little blue tourmaline are present.

Specimen 137 is pebbly, has more interstitial clay, and a greater proportion of black chert and quartzite particles. The Sandstone matrix to the pebbles has a ratio 60:10:30 for the quartz, quartzite, chert grains. The fine matrix is about 25 per cent. of the rock. This rock is classified by Dr. Edwards as a conglomeratic cherty "sub-greywacke" (greywacke in the Bureau terminology).

Specimen 312 shows a close association of generally similar rocks of variable grain size. One sample resembles 135 in composition but finer, another is like 137 but slightly iron-stained. Fine grained rock similarly iron-stained is also present. The quantity of chert is relatively higher than in Specimen 135 constituting nearly half the rock.

The angular ill sorted character of these rocks suggests, according to Dr. Edwards, rapid deposition in waters "milky" in kaolin, the clay being deposited by flocculation. The source area must have been rich in dark cherts and quartzites and clay.

In the Harris block, the formation appears to be more uniform medium-coarse greywackes, though not well exposed. The thickness is estimated at about 500 feet in thickness.

YINDAGINDY FORMATION.

DEFINITION.

This formation is a sequence of fossiliferous limestones and interbedded greywacke which conformably overlies the Williambury Formation. The upper contact is a conformable one with the Harris sandstones. The name is derived from Yingagindy Creek, a tributary of the Minilya River. The type section is near the Yindagindy creek.

DISTRIBUTION AND TYPE OF OUTCROP.

The Yindagindy Formation crops out poorly because it consists of thin limestone beds alternating with greater thicknesses of soft friable rocks and usually only the limestone beds are visible. The outcrops can be traced in the main belt for several miles south of the Minilya River. They are not then visible for some miles further south to near the Williambury-Moogooree boundary fence. From that position and south to near Moogooree homestead, isolated outcrops of ostracod rich limestone of this formation occur in the fault blocks of the Moogooree Fault Zone. Several hundred yards north of Moogooree homestead, a small synclinal structure was noted in a fault block. On the limbs of the syncline, fossiliferous limestone beds were exposed. Overlying the limestone, apparently conformably is a small outcrop of medium grained sandstone. The limestones are of the Yindagindy type with ostracods, some small pelecypods, bryozoa and a sharks tooth. (Specimen 293). In another fault block about 3,000 yards north of Moogooree homestead, are outcrops of probably Yindagindy Limestone showing conformable relationships with an overlying pebbly sandstone. South of Moogooree homestead the formation has been faulted out altogether.

In the Harris block, the Yindagindy formation can be traced for several miles to the north from near the main Williambury-Middalya Road. Here it is succeeded apparently conformably by a sequence of pebbly medium grained sandstones less than 100 feet thick which form a low ridge. Dips are very difficult to measure in the limestone beds but appear to be about 25°. Erosion effects simulate steeper dips locally. Parallelism of strike of the Moogooree, Williambury, Yindagindy and Harris formations is clearly visible in this area.

LITHOLOGY AND THICKNESS.

Because of the obscured nature of the outcrops of this formation detailed description is not available. A section measured in the Harris fault block about 2½ miles north of the main road indicates a thickness of approximately 154 feet. Within this are eight beds of tough limestone, three inches to 6 inches thick. The interbedded friable arenite is not exposed for examination. The limestones are massive blue-grey, fine-grained crystalline limestone containing ostracods.

A section was also measured about 3 miles south-east of Williambury homestead. The beds are poorly exposed but again eight tough limestone beds are exposed. These range from 6 to 12 inches thick. This section total about 300 feet. The limestone beds are probably not directly correlable. The limestone beds are of similar character. The lower beds are somewhat gritty yellowish grey in colour and frequently contain scattered well rounded pebbles of Pre-Cambrian igneous and metamorphic.

rocks, mostly less than 1 inch in diameter. The limestones contain scattered brachiopods, crinoid stems, gastropods and ostracods.

In the basal part of this section some of the interbedded arenites were exposed. These comprised medium grained and fine grained yellow greywacke with chert fragments and quartz and felspar grains in a calcareous matrix. Thin ferruginized and concretionary layers were noted.

In the Moogooree fault zone region, the limestone beds are frequently rather thicker. The lithology is of the same type, including thin yellowish-grey limestone bands. Ostra-cod and other rather poorly preserved fossils occur. No complete sections were observed. Specimens, 139, 140, 141, 142, 319, 320, 321, 310, 313, 328 * were collected from this formation.

DEFINITION. HARRIS SANDSTONE.

This name is proposed for the sandstone beds overlying the Yindagindy Formation. The earlier suggested name Red Hill Sandstone (Teichert 1950) is unsuitable as Red Hill is in the pre-Cambrian and Red Hill Well is not close to outcrops of the formation. The stratigraphic relationships of the formation are less equivocal in the Harris Fault Block. The name is that of Harris Well, 4 miles west of Williambury homestead. The Harris Sandstone conformably overlies the Yindagindy Formation. Its relationship with the succeeding Lyons Group is less clear but they appear to be conformable

DISTRIBUTION AND TYPE OF OUTCROP.

The Harris Sandstone can best be seen in the Harris Fault block north east of Harris Well, Williambury. Here lying west of and parallel to the Yindagindy formation is a low ridge of pebbly sandstone which can be traced for about five miles, north from the Minilya river. Not more than about fifty feet of sandstone are well exposed and there is very little outcrop for about 400 years to the west where a prominent outcrop of one of the very characteristic Lyons boulder bed occurs. This has a strike parallel to the Harris sandstone. No fossils were obtained from the sandstones in this area.

In the main pre-Permian Palaeozoic belt east of Williambury Homestead, the formation is represented by a pebbly sequence. No outcrops are exposed but for several miles a low rise can be traced near the Minilya River. This rise is parallel to and overlies the Yindagindy Formation. The surface is richly covered by pebbles and small cobbles of quartz, quartzite, cherty rocks and Pre-Cambrian partly silicified limestone; some of the latter have a structure reminiscent of Collenia. The pebbles are mostly well rounded and though seemingly more abundant are similar to those in the Harris Block sandstone.

Within the blocks of the Moogooree Fault zone are a number of isolated outcrops which are probably correlable with the Harris outcrops. Conformably overlying probable Yindagindy limestones, are several outcrops of medium to coarse felspathic sandstones, some parts of which contain lycopod plant fossils. cf. Lepidendron sp.

No evidence of the upper relationship of the Harris sandstone was obtained in the Moogooree Fault zone. The western side of the Harris beds is in faulted contact with rocks of the Lyons Group. Close to the fault line Permian fossils have been found in the Lyons beds.

On the west of the Harris cobble ridge, east of Williambury homestead is a sequence of felspathic cross-bedded sandstones containing locally a few large igneous rock cobbles.

Dips are of the same order as in the Yindagindy beds and the strike is the meridional. The immediate contact is not exposed but conformable relationship seems probable. The sandstones are similar to sandstones of the Lyons Group outcropping near the southern limits of the Moogooree area.

LITHOLOGY AND THICKNESS.

No complete section was observed. The exposures on the Harris Block indicate about 50 feet of cross bedded, pebbly coarse to medium micaceous sandstones with kaolin in the matrix, possibly near greywacke in composition. These are pale brown in colour. The uppermost Yindagindy beds appear to contain similar rock interbedded with the limestone. The pebbles are sub-angular to rounded and consist of quartz, white quartzites, grey and black cherts; a few reach cobble dimensions.

The limestone pebbles common in the outcrops east of Williambury were not noted. These may well be of spasmodic distribution. Pebbles of similar Pre-Cambrian limestone have been noted as a rare constituent among the Weeleraddy pebbles and the limestones are fairly common among the Lyons boulders and cobbles. The sandstone is partly silicified and some faulting of minor dimensions is present.

In the Moogooree fault zone, some of the beds contain numerous moderately well preserved plant fossils - Specimen 210. The rock types are medium to coarse grained, brown sandstones and also pebbly beds approaching the greywacke classification. The maximum thickness exposed would not exceed 150 feet but as the outcrops show considerable faulting, a reliable thickness was not recorded. Petrological examination of Specimen 210 showed it to be an "ill sorted quartzose sandstone with some resemblance to the Williambury sandstones". The rock may be regarded as an "ill sorted quartzose sandstone or cleaned up greywacke" with fragments of chert, felspar and black slate and phyllite. There is little clay.

PERMIAN SYSTEM.

The Permian system as known in the North-West basin is well represented in the Williambury-Moogooree area. The Permian beds occupy most of the western side of the Moogooree map area. The regional dip is south-west and the formations outcrop successively to the west and the youngest beds outcrop in the south-west corner. Faulting is common and complex and causes repetition of outcrops.

The formations can be grouped in ascending order as Lyons Group, Callytharra Limestone, Wooramel Sandstone, Coyrie Siltstone, Mallens Greywacke, "Kimbers Group" and "Kennedy" Sandstone". The name Kimber's Group, published by Teichert 1951, was used to collectively describe a group of formations which have later been separated and correlated with the Bulgadoo Shale, Cundlego Sandstone, Quinnannie Shale, Wandagee Formation, (Coolkilya Sandstones and Nalbia Sandstones) of the Wandagee area. Hence the name as applied to this section should now be abandoned. It is used in this report as a record of the preliminary interpretation of the section which was held until field work in 1951. The earlier opinion was based on a brief study of the section.

The lowermost Permian beds - the Lyons Group overlie the Carboniferous and older beds, from which they are separated in the south by the Moogooree Fault Zone. Further north and east of Williambury homestead there is a sequence of sandstones overlying conformably the Carboniferous beds. These sandstones are probably of Lyons age. Conformable relationship appears to be present also in the Harris Fault Block between the Harris Sandstone of the Carboniferous System and the Lyons beds of the Permian System.

The Permian formations seem to be essentially conformable throughout; the dips decrease gradually to the west from about 15° in the Lyons to about 4° in the Kennedy Group. With the exception of the Callytharra and Wooramel contact there are no abrupt changes in lithology. Generally the formation boundaries are transitional. The beds grouped here as Permian were described as Permo-Carboniferous by Raggatt (1936) but have all been included in the Permian System by Teichert (1946) and Raggatt & Fletcher (1937).

Glacial evidence was observed only in the rocks of the Lyons Group.

LYONS GROUP

A Gibb Maitland 1911 first proposed the name Lyons Conglomerate for a boulder bed which he observed in the Wyndham, Arthur, Lyons, Minilya and Lyndon Rivers. The term Lyons series was defined by Raggatt (1936) to include all the "Permo-Carboniferous beds below the base of the Callytharra stage. He stated that "the series consists of more than 2000 feet of strata, most of which show evidence of having been deposited under glacial conditions". Extensive areas of beds showing signs of glacial activity are evident in the area being described. It proved impossible to obtain a satisfactory complete section because of the extensive faulting which has affected the Lyons outcrops of the area and because of the generally poor nature of the outcrops. The term Lyons Group is used here to designate the whole of the Permian sediments deposited below the Callytharra Limestone. Within this area beds of sandstone, thin limestone, siltstone, claystone, conglomerate and boulder conglomerate are present.

The Lyons Group here has strikes parallel to the overlying Callytharra Limestone and the dips near the contact are similar. Hence no marked disconformity is apparent. However, as pointed out by Raggatt, the uppermost Lyons beds elsewhere in the North-West Basin show considerable variation. Similar variation is evident in this area. No doubt the peculiar conditions of marine glaciation produced a variable lithology. The relationship with the underlying Carboniferous beds is still to be finally established. The Lyons Group and Harris Sandstones appear to be conformable. The only fossils so far found in the Harris beds are plants of a Carboniferous aspect but not yet critically determined. The Lyons fauna so far determined is quite Permian in character. The age is Sakmarian. The regional strike of the Lyons beds is similar to that of the Carboniferous formations. The contact of the Permian and Carboniferous systems is rarely exposed.

In the Moogooree area, the outcrops of Permian and Carboniferous rocks are separated by the complex Fault Zone. In the southern part of the area, the Carboniferous rocks have been faulted out and Longreach sandstones of the Munabia Group have been brought in contact with sandstones of the Lyons Group.

In the Williambury area near the Minilya River, there is a sequence of sandstones, some hundreds of feet thick, which seems to follow in conformable succession the Carboniferous beds. The outcrops of Yindagindy beds and of these sandstones are separated by the low ridge of pebbles and cobbles which has been referred to the Harris Sandstone. The sandstones, locally contain large cobbles of igneous rocks and are generally reminiscent of sandstones which occur in the Lyons belt about 10 miles south of Moogooree homestead. They have consequently been mapped as Permian rocks of the Lyons Group. These sandstones have strikes and dips apparently close to those of the Yindagindy Formation.

In the Harris Block also the outcrop patterns are consistent with conformable relations. Here the Harris sandstone is fairly well exposed. However the lower part of the Lyons Group is very poorly exposed. A well defined boulder bed was observed about 400 yards west of the Harris sandstone outcrop and

west of the old wool-shed. This boulder bed has a strike which curves to the west, comparable with the swing observed in the Moogooree Limestones north of the Yindagindy creek. The inference drawn is that the major faulting such as the Harris Fault is younger than the Permian and that the evidence for conformity of the Lyons Group and the Carboniferous beds is supported.

DISTRIBUTION AND TYPE OF OUTCROP.

The Lyons outcrops form a broad band, extending north-westerly across the area. The boundaries of the major Lyons band are of varied nature. The eastern boundary is formed by the Moogooree Fault Zone in the south, by the Mundary Fault in the north and between these areas by the complex faults at the south end of the Harris Fault Block. The western boundary is much simpler and is formed by the conformable contact with the Callytharra limestone. The width of the belt ranges from about one mile to a maximum of about eight miles. Lyons beds are present also in the Harris block and probable Lyons sandstones outcrop east of the Williambury Fault. In the north west corner of the Moogooree map area, faulting causes repetition of the Lyons outcrops.

Outcrops are generally poor and the Lyons areas are characterised by plains. Low ridges marking the strike of boulder beds are frequently present, notably on the western side of the Williambury area. Small areas of outcrop are protected by the laterite cap and form mesas. The sandstone members are occasionally exposed in this way but the softer and finer sediments are rarely exposed. The most notable feature of many areas of the Lyons Group, particularly near the South Branch of the Minilya, is the wide distribution of cobbles over the surface and very often a concentration in strike trend lines of boulders and larger erratics of plutonic and other Pre-Cambrian rocks. Elsewhere the Lyons is mantled by alluvium and is identified by occasional lines of boulders. Large erratics are fairly common and occur in the boulder concentrations. A prominent granitic erratic, observed west of the main road immediately north of the crossing over the South Branch of the Minilya, must have exceeded 12 feet in diameter originally. Others of the same order of size were noted elsewhere. Striation and facetting of the boulders are common. Locally in the fine sandstones and siltstones notably about 1¼ miles south of Dumbardo well, there is an alternation of light and dark bands about ⅛" thick, reminiscent of varves.

LITHOLOGY AND THICKNESS.

The lower most part of the Lyons Group is rarely exposed in the area. A sequence of at least 60 feet of cross-bedded sandstones, best outcropping about 2 miles north-east of Williambury homestead, is probably the basal member. The sandstones outcrop for several miles north of the Minilya river and south of the river form the eastern part of the great flat-topped block of sandstones, east of the homestead. This block is considerably faulted and the thickness cannot be accurately measured, south of the river. About half a mile north of the river, approximately 600 feet of sandstones were measured. A further 200 feet of faulted and jointed sandstones, lies west of these beds, adjacent to the Williambury Fault.

The sandstones are medium to coarse grained white to pale brown, uneven grained, moderately rounded and felspathic. The felspar is usually kaolinised and there is kaolin in the matrix. Little or no mica is evident. The sandstone weathers brown on the surface. Some hand specimens show reddish-brown laminae. Pebbly to conglomeratic sequences recur within the section. The pebbles consist of subangular to rounded pebbles and cobbles and rarely small boulders of quartz and quartzites and less commonly cherts. Igneous rocks were not noticed among the cobbles in the

measured section but south of the river some large cobbles of granitic rocks are present near the base of the sequence. Cross bedding is pronounced, the fore-sets dip westerly, or south-westerly at about 5°-10° to the bedding planes. The regional dip is from about 20° to 15° west. The dip is rather less on the south side of the river, i.e. about 10°.

SECTION OF BASAL LYONS GROUP, near Minilya River, 2 miles north-east of Williambury homestead, in descending order:-

Feet	
230	Sandstone, felspathic, in part uneven-grained, rounded to sub-angular grains. Alternating in coarse and medium grained sequences. Sometimes pebbly. Spec. 133 near top. Spec. 132 at botton.
	Specimen 133 is similar to the lower quartz sandstones though finer and with less kaolin. It is well sorted. Low in heavy minerals, no garnet.
	Specimen 132 is significant in being a white kaolinitic sandstone, ill sorted. It consists of angular quartz grains, 5 per cent of felspar, a little muscovite, bleached biotite and some chert fragments in about 5-10% clay and sericite matrix. Heavier minerals are more abundant.
35	Pebbly, coarse sandstone, as above
69	Sandstone, medium grained, felspathic
16	Sandstone, coarse pebbly and cobbly, cobbles mostly less than 6 inches diam.
35	Sandstone, coarse grained, a few pebbles.
8	Conglomeratic sandstone, with cobbles and pebbles Spec. 131 and quartzite boulders.
180	Sandstones, in alternate medium and coarse grained sequences, similar to Spec. 130. Rare apatite, not well sorted. Spec. 131.
2	Conglomeratic, coarse sandstone.
15	Sandstone, quartzose medium grained, with interstitial Kaolin, well sorted and rounded quartz grains, often rock fragments and some muscovite. No felspar. Rare Zircon and topaz. Spec. 130.
590	

These rocks are somewhat different from the other Lyons sandstones, analysed by Dr. Edwards with the exception of sample 132 which is similar to the kaolinitic sandstones collected further south. See later Spec. 220, 302, 303.

The above sequence is separated by an area without outcrop from the Moogooree Limestones. It is however quite identical with the beds overlying the Harris Sandstone - cobble ridges - south of the Minilya River. Possibly a thicker sequence is present, however the presence of numerous faults prevented an accurate estimate. White there is no direct evidence available for the age of these beds, their general resemblance to some of the sandstones of the Lyons group about 11 miles south-south-west of Moogooree homestead and the presence of cobbles and boulders possibly indicative of fluvio-glacial conditions has suggested a Lyons age. The general aspect is that of marine sediments. It must be admittedthat there is not the variety of rock types among the cobbles and boulders, which is evident in the boulder

beds in the higher sequences of the Lyons. It is possible that this sequence should be regarded as an upper part of the Harris Sandstones but the fossil evidence is lacking.

Fossils are lacking in the Harris Sandstones of the Harris block where less than 100 feet of sandstones are exposed and no further outcrops were noted for about 400 yards to the west where an undoubted Lyons boulder bed is present. The strikes of the Harris Sandstone and of the Lyons bed are parallel. Thus the basal Lyons sandstones if present are not exposed in the Harris Fault Block.

Satisfactory sections of the higher formations of the Lyons were not obtained in the area but several partial sections give a general idea of the order of succession. These are approximately only as faulting is very common, exposures are few and a regional dip has to be assumed. The thickness of the group probably exceeds 2,500 feet.

SECTION OF LYONS GROUP, about 4 miles South-east of Thambrong Pool, Williambury, descending order:-

Feet	
	Callytharra Formation.
45	Greywacke, fine to medium grained, brown friable, well bedded.
2	Pebbly and cobbly, coarse calcareous sandstones, with Calytharra type fossils.
344	No outcrop
10	Boulder bed
71	No outcrop
2	Sandstones, fine grained, ferruginised, with pebbly layer. Spec.114
120	No outcrop
10	Concentration of boulders and pebbly limestone band. Spec.115
40	No outcrop
2	Sandstone, medium grained, brown
315	No outcrop
70	Sandstone, fine grey, resembles till and contains scattered boulders, dips variable, suggestive of slumping. Spec.116
16	Sandstone, probably similar
5	Boulder concentration
30	No outcrop
5	Boulder concentration
38	No outcrop
55	Numerous boulders over surface
15	No outcrop
10	Boulder concentration
50	No outcrop
5	Boulder concentration
55	No outcrop

cont.

Feet	
5	Boulder concentration
75	No outcrop
5	Boulder concentration
26	Sandstone, till like, friable, brown fine to medium grained
10	Sandstone, calcareous, pebbly, Fontainebleu structure in part. Spec. 117
72	Sandstone, soft, friable, fine-medium grained.
10	Siltstone, similar with occasional thin grey limestone bands about 2 inches thick.
25	No outcrop
10	Boulder concentration. Granitic, schistose and gneissic types. Spec. 121
15	Siltstone, grey with thin limestone band.
35	No outcrop
10	Pebbly calcareous sandstone with a few boulders, coarse grained.
34	Siltstone, grey fine
10	Sandstone, coarse grained with scattered boulders
13	Siltstone, grey
5	Sandstone, coarse with scattered boulders
18	Siltstone, occasional fine sandstone bands
10	Sandstone, fine, till like with boulders, cross bedded. Spec. 120
105	No outcrop, probably siltstone
10	Boulder bed. Spec. 119
-	Outcrops obscured by river alluvium.
1838	

South of the Minilya River, about six miles downstream from Thambrong Pool are fairly good exposures of the upper part of the Lyons Group. These were not accurately measured as considerable evidence of faulting is present. Very approximately, the succession is:-

Callytharra Limestone

Feet	
100-200	No outcrop
200-300	Sandstone, fine grained in general, medium grained near the base, with some pebbles, thin bedded and with glistening quartz crystals. Spec.335
100	Sandstones, fine thin and cross bedded, pale brown.Spec.34
10	Limestone, grey, rich in bryozoa and other fragmental fossils. Spec.

cont.

Feet	
-	Boulder strewn area.
50	Sandstone, fine, pale grey brown, well bedded even grained. Contains worm casts and poorly preserved plant stem impressions.

An interesting rock type is exposed on the old road from Donnelly's Well to Moogooree Homestead. This is a coarse calcareous sandstone exhibiting Fontainebleu structure. The bed is 2 feet thick and is approximately 900 feet below the Callytharra Limestones. Marine fossils are present. SPEC.53. Other calcareous sandstones showing this structure, have been noted in various parts of the area and at different levels of the Lyons Group, e.g. Spec. 54 at 1300 feet below top and Spec. 117 at about 1400 feet below the top. Spec. 41.

Spec. 53 comprises calcareous sandstones with 37 per cent. calcite. The detrital grains of the rock are set in calcite crystals about 20 to 50 per cent. calcite crystal. The grains consist of quartz felspars - five per cent, bleached biotite - 1 per cent., little quartzite and chert. Heavy minerals are relatively abundant and include garnet, tourmaline, zircon, epidote, staurolite and probably glauconite. Associated coarser beds contain shell fragments. At the same locality thin grit bands contain fragments up to 5 mm. across, of quartzite, chert, graphic granite, granite, felspars, shale chalcedony, sandstone phyllite, and shells in a calcareous matrix. The fragments are mostly angular.

Spec. 54 is similar to 53 but the grains are less well sorted. Garnet forms ¼ of the heavy minerals. The garnet grains are often coarser than the quartz and felspar grains.

Exposures across the Lyons Group at the southern end of the Moogooree area, show a much greater development of sandstones and only a few lines of boulders. The width of outcrop is much narrower than near the Minilya. This is doubtless due to faulting having caused a greater amount of repetition in the north. Faulting occurs in the generalised approximate section below.

LYONS GROUP SECTION, about 1½ miles north of the Merlinleigh-Mt. Sandiman boundary fence, near Moogooree-Mt. Sandiman Road.

Callytharra Limestone, contact faulted, in part

Feet	
100	Outcrop poor, some fine to medium grained, glistening brown quartz sandstone
380	Sandstone, medium grained, white with kaolin in matrix. Occasional boulders in the sandstone.
20	Fault zone. With steep dips in the sandstone, 75° west.
180	Sandstone, white, medium grained, occasional pebble beds
-	Fault, probably small throw.
68	Sandstone, medium grained, kaolinitic matrix, occasional pebble and cobble bands of cherts, quartzites and decomposed igneous rocks.
320	Sandstone, slightly felspathic, medium to coarse grained. Near the base are white laminated siltstone beds. Large igneous boulders in lower part, mostly decomposed. Spec.249

Cont.

Feet	
-	Fault zone, with steep north-east hade, about 60°
10	Sandstone, similar to above. Spec. 250
1000	No outcrop. Indistinct boulder concentrations.
150	Sandstones, medium grained, white and felspathic and felspathic and siltstones, fine grey with very large boulders of decomposed igneous rock. Spec. 302.
300	No outcrop
400 east.	Outcrops mostly obscured. Arkosic sandstones in part with felspar and mica present, medium grained. Some fine siltstones and a few cobbles and boulders of decomposed igneous rock near the base. Near base - Spec. 220. Spec. 303.
-	Faulted contact with Munabia Group sandstones.

1928

At Loc. 220 a sample analysed is an arkosic sandstone with 15-20 per cent. of fresh or slightly cloudy felspars - including microchre, orthoclase and acid andesine with ragged overgrowths of clear albite. Muscovite forms 1 - 2 per cent. parallel to the bedding. Kaolin forms 15 to 20 per cent. and is interstitial and not derived from decomposition in situ of the felspars but was transported from the source areas. Heavy minerals include mica, tourmaline, zircon and minor amounts of garnet and hornblende.

From Loc. 303 a composite sample comprises arkosic grits and white sandstones. The grit has coarse altered felspars forming about 25 per cent. of the rock. Also present are fragments of chert - black, red, and grey, and white quartzite in a finer matrix of quartz and kaolin. Most of the fragments are rounded. Another specimen is nearer sandstone with less felspar and more quartz. A third specimen is a white pebbly sandstone. This comprises rounded and angular quartz grains, some felspar, about 20 per cent. of interstitial kaolin and a little muscovite. Set in this sandstone are a few fragments and pebbles of quartz shale chert and felspar.

Loc. 302 is higher in this section, separated from 303 by a belt of obscured outcrop. The samples comprise a friable white kaolinitic quartz sandstone and a coarser ironstained sandstone. The friable sandstone is similar to the sandstone of Loc. 303 but is finer. A little tourmaline is present. The coarser ironstained sandstones has rounded to sub-angular fragments of chert and quartzite up to 3 mm. across. One fragment is a sedimentary quartzite. Other isolated sandstones have been examined by Dr. Edwards. Locs. 245 and 299 are near Billidee well, Merlinleigh at horizons of approximately 200 and 400 feet respectively below the top of the Group. Spec. 245 comprises medium grained pale pink sandstone consisting essentially of quartz and abundant kaolin and also a fine grained thin bedded creamy white current bedded sandstone. The coarser rock contains quartz, fresh felspar, a little chert in about 20 per cent. kaolin. The grains are only moderately well sorted. The finer rock is similar but less well sorted, grains size ranging from 0.05 mm. to 0.25 mm. The chemical analysis indicates that the composition is intermediate between the arkose sandstones and the brown quartz sandstones of the base, e.g. 130-131.

Spec. 299 with two samples indicates the interbedding of fine pinkish white kaolinitic sandstone and a brown quartzose sandstone very similar to specimens 131 and 133.

The white kaolinitic sandstone is moderately well sorted and contains quartz, 10 per cent. fresh felspar, chert and shale fragments, some muscovite and rare zircon and tourmaline. Some of the quartz is angular but other grains are well rounded with quartz overgrowths. The brown sandstone is generally similar but with only local development of the interstitial kaolin. The grains are packed closer and are more rounded. They are cemented by films of limonite which coat the grains including those with quartz overgrowth.

Dr. Edwards points out that these Lyons Sandstones are derived from a variety of source rocks, the proportions supplied by any one type varying from place to place within the area of deposition. The arkosic and kaolinitic sandstones were derived from a variety of source rocks, the proportions supplied by any one type varying from place to place within the area of deposition. The arkosic and kaolinitic sandstones were derived from granitic source rocks. The coarser rocks may have formed fairly close to the source but it is most probably that much of the coarser material was carried by floating ice. In the latter case variation in grain, sige and degree of sorting would be fortuitous.

Some of the detritus is derived from earlier sediments as indicated by the presence of quartzose sandstone, chert and shale fragments and quartz grains with eroded overgrowths of quartz. The presence of a few pink garnets indicates some metamorphic source rocks.

Deposition took place under conditions of relatively rapid burial, in view of the fresh state of the felspar and the ill sorted character of the rocks.

The quartzose sandstones were chiefly derived from older sediments predominantly quartzose sandstones. Though their well sorted condition suggests stable deposition making for repeated reworking, the fact that they are interbedded with kaolinitic sandstones suggests that the two types are contemporaneous litho facies and that the good sorting was inherited from the source sediments. Thus they may have been deposited under relatively unstable conditions as were the kaolinitic sandstones.

The abundant kaolin suggests to Dr. Edwards that the waters in which the sediments were deposited were milky with kaolin. The kaolin is derived from the granitic rocks which provided the granitic boulders of the boulder beds and the fragments in the arkoses. The interdigitation of the sandstone types suggests migration of the shoreline exposing at times chiefly granites and at times older sedimentary areas. Dr. Edwards suggests that the kaolin may have been partly flocculated under marine conditions and deposited close to the source of supply together with large primary grains. On compaction the secondary clay particles would lose their identity and form the matrix to the sand grains. Some transport of clay to a distance could be expected and would account for the kaolin patches in the quartz sandstones.

The calcareous sandstones show the onset of the conditions under which the Callytharra Limestone was deposited. This took place at different times in different parts of the area. The abundant carbonate cement suggests that the calcite was precipitated from waters supersaturated with calcium carbonate. A possible cause of precipitation could be the passing away of glacial conditions.

The calcareous beds are rich in garnet, mica, epidote and iron ores and are low in tourmaline and zircon characteristic of the other sandstones indicates a metamorphic origin for the detritus. The finer grain size suggests deeper water which may have provided for differential concentration of the relatively fine-grained heavy minerals. These are mostly angular. The early sealing by the calcite cement probably assisted in their abundant preservation. To provide for fine-grained metamorphic minerals the metamorphic rocks would need to be fine-grained. Abundant fine schists occur among the Pre-Cambrian rocks east of the basin.

The fossiliferous beds so far recorded have been found in the upper half of the group. About 3 miles north-north-west of Moogooree homestead, as small outcrop of fossiliferous sandy limestone was noted. The outcrop lies west of Harris Sandstone which are in a fault block of the Moogooree Fault Zone. Boulders appear on the surface a short distance east. Although isolated, the limestone is most probably fairly low in the Lyons Group as the amount of throw of the faulted block does not appear to be very great. Spec. 216

CALLYTHARRA LIMESTONE.

The type locality for this formation is Callytharra Spring on the Wooramel River. The beds were described by Rudd and Dee (1932). They recorded 85 feet of highly fossiliferous marine limestone. Raggatt (1937) states that in the type area, the beds consist of "rather argillaceous limestone or highly calcareous mudstone, including foraminiferal, crinoidal and shelly types". Within the area described in this report the Lyons Group-Callytharra Limestone contact seems to be generally conformable. The Callytharra and Wooramel Sandstone contact which is generally moderately well exposed is conformable.

DISTRIBUTION AND TYPE OF OUTCROP.

As recorded by Raggatt, the Callytharra Limestone is not uniform in lithology. In this area the upper and lower parts are readily distinguished by their mode of weathering. The lower part consists of soft calcareous greywackes with frequent thin tough limestone bands and the upper of flaggy to massive tough fossiliferous limestones. The upper part of the Callytharra and the adjacent Wooramel Sandstone form very characteristic strike ridges which can be followed for many miles. The height may reach to about 200 to 250 feet above the plain level. In profile these ridges show steep easterly erosion scarps and gentle westerly dip slopes. In some places, notably near Thambrong Pool on the Minilya, the Wooramel Sandstone may be stripped off the ridge, exposing the Callytharra Limestone on the dip slope. The dip is usually less than 10 and is predominantly south-westerly. The lower part of the Callytharra erodes to the same level as the Lyons beds, the thin limestone beds often outcrop a few inches. Fossils are readily weathered out from the softer beds and often occur abundantly on the surface.

The main Callytharra outcrop forms a ridge which extends north-west across the Moogooree map area and which is terminated by faulting about four miles north-west of Thambrong Pool. Faulting has caused duplication of outcrop at the south end of the ridge. The complex fault system, west of Donnelly's Well, has affected the Callytharra and caused three-fold repetition of outcrop. In the small fault block, about one mile west of Donnelly's Well, a small faulted anticlinal structure was noted. Callytharra rocks only are exposed in the structure. The much faulted area west of Donnelly's Well marks the southern end of the Callytharra Wooramel ridge which further to the north west forms the K 52 Range and which is crossed by the main road from Williambury to Middalya.

The Callytharra is in places affected by the weathering process associated with the lateritization which developed on the old peneplain level. An interesting effect was observed

in a number of places along the Callytharra outcrops on Moogooree and Merlinleigh Stations, west of the road from Moogooree to Merlinleigh. The calcareous constituent of the rock has been largely removed and a fine brown sandy rock remains which preserves some of the bedding structure and often retains the impression of typical Callytharra fossils. In one mesa near Billidee Bore, Merlinleigh the junction between the zone of weathered and of unaltered rock is quite sharp. Traces of the bedding planes and fossil impressions can be followed up into the altered zone. In reconnaissance mapping, no recognition of the possibility of such alteration of the Callytharra could lead to errors of interpretation.

LITHOLOGY AND THICKNESS

The Callytharra retains a uniform thickness and lithology in the area described. A section measured about four miles south-east of Thambrong Pool on the Minilya is representative Diagram No.11. The contact with the Lyons Group is transitional and the base is here taken to be 45 feet above a fossiliferous pebbly bed which contains some large cobbles of igneous rocks and is similar to cobbly beds lower in the Lyons Group. The Callytharra therefore measures about 512 feet. The uppermost 234 feet of section is mainly tough flaggy, yellowish-green limestone and the lower 278 feet is mainly calcareous silty micaceous greywacke and frequent lenses and beds of limestone. The whole sequence is richly fossiliferous with shelly, crinoidal, bryozoal and coral fossils present. Brachiopods are particularly abundant in the lower part and the corals and bryozoa more common in the upper sequence. The upper tough limestones are sandy and pebbly in places and at least one thin sandstone bed occurs.

WOORAMEL SANDSTONE

DEFINITION

The Wooramel River is the type area for this formation. Rudd and Dee (1952) described and estimated 800 feet of sandstones overlying the Callytharra Limestone. Three lithological types are present; a very fine grained micaceous sandstone, laminated and resembling shale, fine grained micaceous sandstones with a subconchoidal fracture, a coarse grit and ferruginous fossiliferous zones in the higher levels. In the Moogooree-Williambury area there is a sequence of about 360 feet of fairly uniform medium to coarse sandstones conformably following the Callytharra Limestone. The Coyrie Siltstone which overlies the Wooramel has similar dips and strikes. The coyrie beds are not well exposed generally but the contact would appear to be conformable though the beds near the transition seem to be somewhat variable along the strike.

DISTRIBUTION AND TYPE OF OUTCROP

The Callytharra and Wooramel formations form a topographic unit generally in the form of a strike ridge. In consequence the distribution of the Wooramel Sandstone is similar to that of the Callytharra limestone and need not be described separately. The Wooramel is readily distinguished from the succeeding Coyrie in outcrop by the marked change in topography; the Coyrie beds are eroded to plain level and are exposed only in rare sections.

LITHOLOGY AND THICKNESS

Mapping the two sheets, indicated that the Wooramel is of almost constant thickness in this part of the basin. A section measured across the formation nea r the road from Moogooree homestead to Donnelly's Well gave a thickness of 350 feet of sandstone. Typically the formation outcrops in beds, one feet to four feet thick of dark red-brown medium to coarse grained sandstone. Mica and dark ferromagnesian minerals are present in very small amounts. Scattered well rounded quartz pebbles occur

at bedding interfaces and many of the thicker beds are cross-bedded. Where unferruginised, the rock is white, friable and porous. Within the sequence are several beds less than one foot thick of micaceous siltstone. Occasionally the grainsize increases and beds of fine conglomerate a few inches thick are formed. Towards the top occur two beds of fairly tough, grey, calcareous micaceous greywacke. The upper calcareous bed, partly coarse grained was taken to be the top of the formation. These calcareous beds are not always present notably in sections further to the south east. They are probably lenses but erosion prior to the deposition of the Coyrie would be a possible cause of their present discontinuous distribution. Raggatt (1936) has mentioned a possible disconformity at the top of the Wooramel "Stage" but there is apparently no evidence here of any marked break. Fossils were collected from the topmost beds. These were marine forms and included nautiloids. Spec. No.
With the exceptions of poorly preserved plant stem impressions no fossils have been collected from the lower beds.

COYRIE FORMATION

The name Coyrie Formation is proposed for the sequence of siltstones and fine sandstones which conformably overlies the Wooramel Sandstone. The name is that of a paddock on Williambury station. In this paddock fairly good sections outcrop about five miles south east of Donnelly's Well. In the type area there are about 500 feet of sediments which are followed by a conformable sequence of coarser greywackes, the Mallens Greywacke which sometimes forms low ridges, in distinct contrast to the flat Coyrie area in which outcrops are rare.

DISTRIBUTION AND TYPE OF OUTCROP

The Coyrie areas are generally obscured by alluvial wash from the neighbouring hills. The formation can be traced on the western side of the prominent Wooramel ridge in the Moogooree area. The Coyrie beds retain the same north-west strike and have a dip of about 8 degrees to the south-west. In the type area, fair exposures occur in the scarp of the north-easterly extension of the Kennedy Range which is in mesa form with a cap of Tertiary sandstone and laterite. The scarp is somewhat obscured by detritus. Generally exposures are limited to the harder and more calcareous bands. The belt in which the type section occurs can be traced north-west to where it is cut off by faulting about five miles north of Donnelly's Well. South east of the type area, the formation can be traced to the bottom of the Moogooree map. The Coyrie shows a distinct thinning to the south east. The calcareous coarse an d medium sandstones which characterize the transition beds near the Wooramel contact in the type area, were not found towards the south.

Other outcrops of Coyrie beds are found west of Donnelly's Well where faulting has caused multiple repetition of beds. The better exposures are in the scarps of mesas. The calcareous horizons are well developed in this area. A remnant of the basal Coyrie is preserved in outcrop, about four miles north-west of Thambrong Pool, where the soft beds overlying the Wooramel sandstones have been protected by a capping of Tertiary sandstones.

LITHOLOGY AND THICKNESS

In the type area, five miles south-east of Donnelly's Well a section about 500 feet thick was measured. This comprises siltstones and fine sandstones and a number of calcareous beds, none of which is thick. At the Wooramel contact a fairly coarse calcareous greywacke was noted.

SECTION OF COYRIE SILTSTONE, 5 MILES SOUTH-EAST OF DONNELLY'S WELL,

descending order:-

Feet	
Mallens Greywacke	
15	Siltstone, dark grey, micaceous, finely bedded
2'9"	Calcareous siltstone, yellowish to dark grey, micaceous
6	Siltstone, micaceous, pale brown to grey, partly sandy
3	Calcareous, micaceous, siltstone, pale brown
3	Siltstone
1'6"	Calcareous, micaceous, silty sandstone, grey brown
4'6"	Siltstone, grey
6"	Limestone, fine grained, thin bedded
8	No outcrop
6"	Calcareous, micaceous siltstone with "worm trails"
26	No outcrop
2	Limestone, micaceous, silty with "worm" trails
50	Siltstones, dark grey, micaceous with some brown bands
36	Siltstones, sandy, micaceous, pale brown and grey
10'6"	Siltstones, dark grey, micaceous
1	Calcareous, micaceous siltstone
25	Siltstones, sandy, micaceous grey
41	Siltstones, sandy, brown and dark grey in alternating beds about one foot thick. Micaceous and occasionally ferruginous.
37'6"	Siltstone, sandy grey and brown
165	Siltstone, grey and brown, occasionally dark grey
38	Poor outcrop, apparently mostly sandy siltstone and fine sandstone.
Wooramel	Coarse calcareous greywacke 2 feet.
485'9"	

Some of the fine sandstones particularly where micaceous probably are nearer greywacke in composition.

North and west of the type area calcareous beds are present near the base of the section, attaining a thickness of about 20 feet about 2 miles east of Donnelly's Well. These calcareous beds become thinner again in the most northerly outcrop of the formation indicated in partial section below:-

PARTIAL SECTION ABOUT 4 MILES NORTH-WEST OF THAMBRONG POOL

Feet	
16	Sandstone, very fine, white fissile micaceous with thin coarser bands. Spec. 347
33'6"	Sandstone, thin bedded, fine, micaceous pale grey. Spec. 346, 345.

cont.

Feet	
6"-1'	Calcareous grey sandstone forming a lens
51	Siltstone, dark grey, gypseous with reddish nodular bands Spec. 349
101'6"	

Wooramel. Medium grained quartz sandstone, brown and cross bedded some pebbles. Contact is conformable.

The above section has been preserved from erosion by a thin cap of Tertiary sandstone.

On tracing the formation south-east of the type area, the calcareous beds are seen to be much reduced and the sandier element appears to be stronger. The formation is apparently thinner.

Fossils are not abundant in the formation but occur sporadically particularly in the calcareous beds.

MALLENS GREYWACKE.

DEFINITION.

This formation is named after Mallens paddock, Williambury. Donnelly's well is situated at the south-west corner of the paddock. The best development of the formation occurs about one mile east of Donnelly's Well. The Coyrie Siltstone and Mallens Sandstone are conformable, the contact being transitional and in part characterised by calcareous lenses. The Mallens is followed conformably by finer sediments; the Bulgadoo Shales transition is gradual. The type section is about 1000 feet thick.

DISTRIBUTION AND TYPE OF OUTCROP.

The formation lies west of the Coyrie. Outcrops can be seen north and east of Donnelly's Well and can be traced south-east into Merlinleigh. The thickness is unknown in the south as the formation is partly covered by the thin Tertiary and laterite cover of the Kennedy Range. The strike is uniformly south-south-east and the beds dip south-west at 8° or less. It is possible that the formation becomes thicker in the south where the Coyrie siltstone appears to be thinner. In the type area the Mallens tends to form a low ridge in contrast to the preceding and succeeding formations which have been eroded to plain level. The main belt of Mallens, in which the type section was measured, continues in isolated hill outcrops to a position about a mile and a half north of Donnelly's Well. The sandstones are here in faulted contact with the Callytharra Limestone. Repetitions of part of the Mallens were noted in the faulted area west of Donnelly's Well.

LITHOLOGY AND THICKNESS.

The lower hundred feet of the Mallens Sandstone in the type area contains three or four calcareous horizons. These are either tabular or lens shaped sequences of the sandstone with a calcareous cement. Several of these beds can be traced for over a mile along the strike in the type area.

The basal 400 feet of the formation consists of medium hard, yellow, fine-grained micaceous clayey sandstone probably near to greywacke in composition. The formation is normally thin-bedded (less than ½ inch). Where the beds are thicker current-bedding is present. The rock is composed mainly of quartz grains, thinly coated by an argillaceous matrix. It is porous and friable except in the calcareous lenses.

The upper 600 feet become increasingly silty with calcareous lenses present. These are irregularly distributed and do not appear to favour special horizons in this part of the section.

Ferruginous concretions generally about one foot in diameter but occasionally up to three feet, are present throughout the formation, particularly between 200 and 400 feet above the base. Fossils, occurring as ferruginous moulds and casts, mostly of lamellibranches and also brachiopods may be found throughout the section.

Poor outcrop of part of the section prevented accurate measurement of the thickness. It was estimated at 1000 feet. The contact with the succeeding beds is transitional and the boundary was drawn where the siltstones become dominant.

The calcareous rocks near the base are sandy limestones with about 60 per cent calcite, 40 per cent quartz and mica grains. Biotite is common and muscovite is present.

"KIMBER'S GROUP"

The name was used in the field for the sequence of fine greywackes and siltstones which conformably follow the Mallens Sandstone and are overlain conformably by the Kennedy Group. Subsequent detailed fieldwork has shown that the formations known in the Wandagee area can be recognised in the Williambury area and the name Kimber's Group becomes unnecessary. They are described under this name in this report as a record of opinions previously held. The Group name was published tentatively by Teichert in 1952.

DISTRIBUTION AND TYPE OF OUTCROP.

The distribution of these beds in the mapped area is confined to the south-west corner of the Moogooree Sheet. Outcrops are for the most part only exposed in the Kennedy Range scarp and in creek beds. On the plains, the beds are obscured by alluvium and sand and on the Kennedy Plateau by laterite and sand. The regional dip is south west and ranges from about 8° at the base to about 4° at the top of the sequence. Within the sequence exposed along the Kennedy scarp is a section showing much steeper dips. This zone of steeper dips is about ¾ miles wide at the maximum and trends south-east from near Kimber's Well. It appears to die out at its northern extension. The steepening is best developed near the headwaters of Norton's Creek about 2 or 3 miles south-east of Kimbers well. Within the zone from east to west the dips rise from about 10° to 14° to 32° and then decrease to 10°. The beds in the zone appear to have the regional strike. In traversing the section, no observable break in the sequence was noted and the structure was interpreted as possibly a monoclinal fold. It was recognised that a major fault would be present if duplication of the section could be demonstrated. The medium grained sediments which occur in the upper part of the zone resemble the Mallens beds and carbonaceous siltstones west of the zone resemble the lower siltstones of the Group. Several faults, with north-south trend occur in the Kimber's sequence. The downthrow of each thought to be comparatively small. Recent field work has demonstrated the presence of a major fault in the steep zone and the presence of duplication of the section.

LITHOLOGY AND THICKNESS.

Throughout the sequence the conditions of deposition were very uniform. No sediments coarser than medium-grained sandstone occur and the main variation is alternation from siltstones to fine or medium grained greywacke. Calcareous sandstones recur in the sequence usually as lenses and dark carbonaceous siltstones are present particularly near the base of the section. The greywackes show marked cross-bedding and occasionally penecontemporaneous scouring. The coarser sediments appear to be near greywacke in composition, are somewhat micaceous and have a

silty matrix. The colour is mostly pale-brown, sometimes olive brown and grey. Fossils were found in moderately rich horizons in both siltstones and coarser sediments.

On the assumption that there was no major duplication of beds within the exposed sequence, a thickness of about 5,000 feet was calculated for the beds south of Kimbers Well. Duplication is present however. The lowermost beds are not exposed in that section but are present in the section about 2 miles south-east of Donnelly's Well. About 860 feet was estimated for the thickness of the lower part of the Kimber's beds exposed from the top of the Mallen's to the scarp south of Donnelly's well. The sections were calculated partly from field traverses and dip recordings; the regional strike and width of outcrop were measured on the aerial photographs. The thicknesses and lithology are generalised and no allowance is made for duplication or reduction of section as the result of faults.

SECTION OF LOWER PART OF KIMBER'S GROUP, COMMENCING ABOUT 2 MILES SOUTH OF DONNELLY'S WELL.

Feet.		
10-30	Greywackes, fine fissile, cyclic sandstones and siltstones towards the top.	
20-50	Siltstones, grey, gypseous, with thin carbonaceous bands	
2	Calcareous sandstone, thin, fissile	
	(Spec. 360-362 from here to top)	
160	Greywacke, fine fissile, some thin siltstone beds	
50	Sandy siltstones, fine dark, gypseous with some hard brown bands. Thin carbonaceous beds.	Spec. 361.
38	Siltstones, grey, with red fossiliferous nodules towards the top, gypseous. Fossils include Dita mopyge, conularia	Spec. 325.
2	Calcareous sandstone - fossiliferous -	Spec. 324
170	Siltstones, fine mostly pale grey	
5	Calcareous nodule bed fossiliferous	Spec. 358
220	Siltstone, fine	
3-5	Siltstones, fine carbonaceous, black.	Spec. 357
117	Fine greywackes and siltstones, grey.	

Mallens, contact transitional.

SECTION, ALONG KENNEDY SCARP, SOUTH OF KIMBER'S WELL. (a)

Kennedy Sandstone

Feet	
2	Calcareous sandstone, fossiliferous, Sample 272
500 approx.	Largely obscured. Probably fissile sandstones and some siltstones. Gypsum observed on surface of ground in places.
100 approx.	Sandstone, brown, mottled medium grained micaceous, well bedded, rich in lamellibranchs and worm casts. Resembles higher "Kennedy'sands tones' " and forming a prominent ridge.

Interesting conical impressions possibly organic occur in part of these beds. The bases of the cones are about 18" in diameter and are aligned with the bedding plane. The cones have helicol groovings suggestive of swirling movements of the agent which formed them. Sample 268, 269.

80 Siltstone, dark grey, carbonaceous and gypseous, some sandier beds

3 Calcareous sand lenses, fine grey.

150 Outcrop poor, probably mostly fine silty sandstone

2 Calcareous beds

370 Outcrop, probably mostly fine silty sandstone

220 Sandstones, fine micaceous, with some dark grey, silty beds Some clay galls at top Spec. 266

290 Siltstones, mostly dark with some pale, grey, very fine sandstones. Calcareous lenses at top

550 Outcrop poor, mostly fine sands, silty at top

160 Siltstones, grey with some fine fissile micaceous sandstones

100 Siltstones, grey with dark carbonaceous bands

250 Sandstone, very fine fissile, grey to brown, carbonaceous siltstone at base Spec. 59

- Approximate position of major fault -

2780 approx. This section repeats part of section lying to the east. The basal beds may be correlated with the Bulgadoo shale.

(b) Approximate position of major fault which may occur within upper part of greywacke sequence. The more massive beds may be Mallens in age.

560 Greywacke-sandstone, pale brown, fine and fissile, micaceous at base, becoming more massive and medium-grained in upper part. Generally show cross bedding and penecontemporaneous scouring

Fossiliferous: About 50 feet from top Spec. 371
150 feet from top Spec. 374

600 Greywacke-sandstones, soft fine, fissile pale brown to grey, with calcareous lenses and a few silty bands. Fossiliferous From upper 100 feet. Spec. 373, 372

250 Greywacke-sandstones, fine fissile, micaceous, grey-brown with some sandy siltstone beds and thin carbonaceous siltstones

140 Sandy siltstones, dark grey, partly carbonaceous and gypseous, red-brown nodules in the siltstones.

60 Sandy siltstones and fine sandstones, including cyclic types in thin alternations. Calcareous towards top.

6 Carbonaceous siltstone, dark grey

15 Greywacke-sandstone, fine fissile, micaceous

6 Carbonaceous siltstone, dark grey

270 Sandstone, fine pale grey-brown, micaceous, some thin dark grey siltstone bands, several inches thick.

300 Siltstones, grey and brown, fine and occasionally sandy. Gypseous towards top. Occasional red ochreous bands.

This section overlaps that near Donnelly's in part.

KENNEDY "Sandstone"

The Kennedy Stage was defined by H.G. Raggatt (1936) as the Sandstones which constitute the Kennedy Range and conformably overlie the more shaly strata of the Byro Stage. The Byro comprised the beds between the Wooramel Sandstone and the Kennedy Stage. The Kennedy Group has now been redefined as the result of field work in the 1951 season and will include some of the beds at the top of the section described in this report as occurring towards the top of the "Kimber's Group."

It will merely be recorded here that greywacke similar to that forming the Kennedy Range further west outcrops in the south-west corner of the Moogooree sheet. Only the basal part is present.

DISTRIBUTION.

The strike is north-west and the dip 4° to the south-west. The dip decreases further west beyond the Moogooree map area. The greywackes are more resistant than the underlying beds and form a scarp along their strike. Further west the lower beds of this formation form the scarp of the Kennedy Range. The greywacke formation near the top of the Kimber's Group often forms outlying hills away from the main plateau of the range.

LITHOLOGY AND THICKNESS.

Less than 200 feet are exposed within the mapped area. The beds are somewhat calcareous near the base. Spec. 272 is probably from this horizon. This contains Calceolispongia, Strophalosia and other brachipods. The beds above are medium, even-grained, cross-bedded sediments near greywacke in composition with some mica and kaolinised felspar. Ferruginised bands and nodules are present. The colour is brown, with dark brown bands, some purplish and yellow mottling particularly in the lower part of the section. A section of over 600 feet of this formation was recorded on Middalya Station, near Muderong Bore in 1948. The higher parts of the formation are particularly rich in thin beds of very coarse, often ferruginised greywacke which are strongly ripple-marked.

CRETACEOUS SYSTEM.

The Cretaceous System is represented by a small outcrop in the northern part of the Williambury area. The outcrop consists of about 40 feet of siltstones, unconformably overlying Munabia Group sandstones. The siltstones are micaceous, somewhat iron-stained and mostly grey in colour. They are rather sandy at the base which is poorly exposed. The locality is about 6 miles north-west of Williambury homestead and north of the Lyndon boundary fence.

The siltstone outcrop is a small outlier of the Winning Group of the Lower Cretaceous which overlaps the Palaeozoic sediments in the area to the north. The outcrop, in the form of a low hill demonstrates the major angular unconformity between the Winning Group and the Palaeozoic System. Evidence elsewhere indicates that the Cretaceous transgressed over a levelled surface, of Palaeozoic and Pre-Cambrian rocks.

TERTIARY SYSTEM.

Marine sedimentation was resumed in Tertiary time. Remnants of widespread arenaceous deposits, are preserved as part of the caps of mesas. The deposits reach a maximum thickness of about 80 feet but are generally less. The rock types are conglomerates, coarse and medium-grained sandstones and some sandy siltstones. Cross-bedding is usually well developed. The Tertiary bedsunconform-
ably

overlie the Permian formations in this area. The Cretaceous and Tertiary systems were not seen in contact within the area described. The surface on which the Tertiary sediments were deposits was one of slight relief; the thickness varies widely and the lithology is not constant. The eastern limit of Tertiary marine deposition probably lies within this area.

Subsequent to the marine deposition, the area was uplifted and subjected to lateritising processes. The laterite is developed above Tertiary deposits or above Palaeozoic rocks where the Tertiary was either eroded or not deposited. The complete theoretical profile has not been observed. About 30 feet seems to be the maximum depth of laterite. A leached zone can sometimes be recognised Ferruginised nodular concretions in bands and pockets are common. The most widespread and striking feature is the formation of a silicified zone which may reach 30 feet in thickness. The silicification seems to be best developed above the Tertiary sediments

About five miles north-east of Williambury homestead, overlying lateritised Tertiary sandstones is a sequence of about 12 feet of limestone and chert forming the top of a mesa cap. The outcrop area is small. The beds are probably lacustrine and analogous deposits have been recorded by Talbot from the Ashburton area.

MERLINLEIGH SANDSTONE

Definition

The widespread Tertiary arenites of the area have been named after Merlinleigh Station. Near Merlinleigh homestead, fossiliferous Tertiary beds occur in outlying hills of the Kennedy plateau. The beds are sandstones with basal conglomerates and they unconformably overlie the Permian deposits. Tertiary fossils including Aturia clarkei (Teichert 1944) have been collected from this formation about 1 mile south-east of Merlinleigh Station. Lamellibranchs and algae were collected by the Bureau party in 1948.

DISTRIBUTION AND TYPE OF OUTCROP

Widely distributed through the area are arenaceous deposits unconformably overlying the Palaeozoic rocks. These are regarded as being of the same age and character as the Merlinleigh beds. The outcrops are discontinuous and generally confined to the caps of mesas. The formation is not invariably present in the mesas. This is suggestive of incomplete submergence of the area, indicating a mild relief. In some places erosion of the Tertiary sediments before lateritisation may have occurred.

The best development of the formation is found in the country round Donnelly's Well. About a mile south-west of the well the thickest section, about 80 feet, was noted. North, south and east the deposits are thinner. The section is somewhat variable. There is generally a pebbly to conglomeratic base overlain by cross-bedded medium to coarse sandstones, generally less than 30 feet thick and overlain by thick-bedded uneven-grained sandsto-s. Finer sediments are present also. Sandstones of the same type can be traced round the Kennedy scarp on the south east side, near the road from Moogooree to Merlinleigh but are often only a few feet thick. East of the Kennedy's, the deposits are less well sorted implying terrestrial conditions. Scattered remnants only, occur above the Carboniferous and Devonian rocks in the Moogooree area. Further east, Tertiary beds were not present above the mesa of outlying Devonian rocks which outcrops about ten miles east of Moogooree homestead. Tertiary beds of the more terrestrial type can be traced north, overlying the main belt of Devonian and Carboniferous rocks and occur north of the Minilya River. There, they are mostly rather thin beds of subangular conglomerates, less than a few feet thick. The limits of predominantly marine deposition cannot be drawn with much precision.

Within a radius of several miles of Donnelly's Well, the hills generally have a capping of Tertiary rock of the marine type. Tertiary beds can be seen on the scarp between Donnelly's Well and Kimber's Well, some six miles to the south. The section has become markedly thinner and to the south and south-west of Kimber's Well, the Tertiary sediments appear to be absent. North of Donnelly's Well, isolated outcrops of the Merlinleigh beds can be found near the main Williambury-Middalya Road. For example, about 100 feet of conglomerate and cross-bedded sandstones overlie Wooramel Sandstone, about 4 miles north-west of Thambrong Pool.

Outside the area described, somewhat similar sandstones are known to the north-west and west. These beds overlie Cretaceous and older rocks.

LITHOLOGY AND THICKNESS

The maximum development was noted near Donnelly's Well where about 80 feet of section occurs in places, though even here the thickness is variable. From 30 feet to 60 feet appears to be most characteristic. The lithology varies somewhat but generally there is a pebbly to conglomeratic base from several inches to several feet in thickness. This is overlain by cross-bedded sandstones which are usually coarse grained, sometimes medium or finer grained. The cross bedded sandstones are generally less than 30 feet thick. Overlying these are thick-bedded and less well sorted sandstones.

The cross bedding sets are from about 6 inches to several feet thick and the dip of the foreset beds is generally to the north or north-west and more rarely north-north-east. Locally some very fine sandstone sequences, several feet thick occur among the cross bedded sandstones and in some section more than one pebbly horizon has been noted. In one section near Donnelly's Well, there is a thin conglomerate bed, 60 feet above the Tertiary base.

The colour is generally white or pale brown though occasionally the sandstones and conglomerates are strongly ferruginised. The rock is mostly a somewhat micaceous sandstone with a white matrix. The basal conglomerate contains well rounded pebbles of quartz, quartzite and grey and dark cherts and rarely igneous rocks such as porphyries and granitic types. The pebbles may often be derived from Palaeozoic conglomerates, but there are none of these in the immediate locality of the sections examined. Locally as in a section near the Coyrie siltstone type area, five miles south east of Donnelly's Well, angular pebbles of sandstone and siltstone appear in the conglomerate. This is possibly a remnant of the Cretaceous deposition. A sample Spec. 425 (1948) from this area was examined by Dr. Edwards. The rocks are quartzose sandstones with several per cent. of fresh felspar and occasional fragments of quartzite and chert. The rocks are derived from older quartzose sandstones and partly from granitic rocks.

An interesting feature noted in a number of localities in the presence in the basal conglomerate of large well-rounded and polished boulders of quartz and quartzites. These may be up to three feet in diameter. The boulders appear to be distributed along a band about 2 miles wide which runs from near Howell's bore Moogooree, north-westerly to near the locality where the boundaries of Merlinleigh, Moogooree and Williambury meet. The band then extends west to a position about 4 miles south-west of Donnelly's Well. Boulders of this type were not noted elsewhere in this area but they have been observed in 1948 near Merlinleigh Station in the type area of the formation. The distribution suggests deposition in a channel in which turbulent conditions prevailed. The channel would be very approximately parallel to the south Branch of the Minilya but this feature is probably fortuitous. Near Howell's Bore where Tertiary boulders are present, the Pre-Cambrian rocks contain large quartz reefs. See Diagram No. 1

The Tertiary sandstone and the laterite have been subjected to faulting. The maximum throw appears to be less than 100 feet. Tilting of the deposits is fairly common, dips so produced may be as much as 10 degrees but for the most part the beds are approximately horizontal.

FOSSIL EVIDENCE

No fossils were recorded in the Moogooree-Williambury area but the beds are undoubtedly of the same age as the Merlinleigh deposits which are regarded as Miocene (Teichert, 1944). Silicified wood fragments are occasionally found, notably at Merlinleigh and west of the Williambury area, at Paddy's Outcamp Middalya, where a silicified tree trunk, several feet long has been observed. Bureau geologists collected fossils at Merlinleigh in 1948 and 1952. Marine molluscs, algae, cephalopods occur.

LATERITE

Under this heading, is grouped a variety of rock types and weathering products which are thought to be part of a laterite profile developed on the uplifted late Tertiary peneplain. It is difficult to form a systematic picture of the processes involved as the character of the profile varies greatly with the underlying rock type. The most prominent feature is the widespread presence of a silicified cap, varying from a few feet to about thirty feet in thickness. This silicified zone which is usually horizontal but is sometimes tilted by faulting is best developed in Tertiary sections which may be completely silicified but preserve the outlines of pebbles and traces of bedding. The intensity of the silicification varies. Palaeozoic rocks including the limestones can also be affected. About four miles west of Donnelly's Well in a mesa formed in Callytharra limestone, the uppermost 15 feet of the outcrop has been completely silicified but fossil impressions have been preserved. No Tertiary sediments are present. Silicification is a common feature of fault zones; however this mode is generally not difficult to distinguish from the sub-horizontal silicified layers of the laterite profile. The silicific zone or "billy" is most often pale grey in colour. Quite often there are angular pieces of yellowish silicified sandstone incorporated in the grey "billy". Similar fragments of yellow quartzite may occur in other layers of the profile. It is suggested that these are relics of an older lateritising process, the angular fragments having been very little transported.

Generally, where the silicified zone is well developed, the ferruginised zone is absent, though small concentrations of ferruginous concretions, filling crevices in the "billy" surface often indicate the former presence of the ferruginised zone.

The surface of the "billy" is frequently polished and slightly dimpled. An occasional feature, of interest, is the presence of polished conical elevations, less than one foot high and about 6 to 9 inches in diameter at the base. These surface features are rather rare but occasional small areas show a crowded development of the cones. The silicified zone is not an invariable part of the profile.

Other manifestations of lateritisation include sections showing a gradual transition from unaltered rock into a pale reddish soil in which "pockets" and bands of dark brown concretions nodules become increasingly common towards the top. A section about four miles south-west of Kimber's Well, shows the fullest development of a profile that was observed in the area. The thickness is about 34 feet and the bed-rock is silty sandstone of Permian age.

SECTION OF LATERITE, FOUR MILES SOUTH-WEST OF KIMBER'S WELL.

Feet	Ins	
2		Yellow sandy soil with red incrustation
	3	Dark-red ferruginous concretions
4		Light coloured coarse sandy soil, with an irregular ferruginous concretionary layer of 6 inches, at the base.
7		Light coloured, medium-grained sandy soil, with rounded red mottlings scattered throughout.
2		Sandy soil with many small rounded red mottlings and some ferruginous concretions.
12		Fine-grained, partly indurated white "claystone" with some pink mottlings.
1		Slightly altered fissile silty sandstone.
		Unaltered Permian rock.

The lower level of the above profile is uneven. Such a profile suggests more than one period of lateritisation and consequent modification of the original profile.

Generally where the "billy" is present there is little sign of ferruginous layers. Apparently the silicified zones if formed occurred low in the profile and later the rather incoherent higher layers have been eroded off the hard impervious "billy" surface. The "billy" is sometimes found in situ at the present plain level but this would appear to be the result of faulting.

An interesting feature is the frequent presence of small non ferruginous white concretions in layers. These are apparently siliceous and sometimes are found close to ferruginous concretions.

The weathering effect seen in some parts of the Callytharra Limestone has already been described (p.30). "Billy" is often found above the altered limestone layer.

POST-LATERITE SEDIMENTARY DEPOSITS

An interesting small outcrop giving evidence of post-laterite deposition occurs in a mesa about 6 miles north-west of Williambury homestead. This mesa lies above Pre-Cambrian schistose rocks. The section reveals about 40 feet of partly ferruginous sandy soil with ferruginous concretions. The base has a layer of small rounded quartz pebbles which suggest that Tertiary sandstones have been lateritised.

Overlying the laterite is about 12 feet of horizontally bedded fine even grained limestone and pale grey chert. No fossils were observed. No other outcrops of this type have been observed in the area. The limited distribution and nature of the rock suggest freshwater deposition, probably lacustrine, perhaps soon after the period of lateritisation and possibly penecontemporaneous with a subsequent lateritisation. Deposits of this type and probably correlable have been described by Talbot (1920) from the Brumby Creek area.

STRUCTURAL GEOLOGY

As the investigation was primarily concerned with the sedimentary sequences, the areas of Pre-Cambrian outcrop were not closely examined in the field. However from traverses and study of air photographs, it is evident that the dominant fault pattern,

generally indicated by large basic dykes, is northerly in trend. The smaller dykes and quartz reefs are rather variable in trend but many favour an approximately north-west or north-east direction. No study was made of the folding in the Pre-Cambrian sector.

It is not possible to account satisfactorily for all the structural features observed in this area and probably it will be necessary for complete understanding to wait upon a final settling of the general structural problems of the basin. Diagram No. 3 shows the major faults.

Very little anticlinal folding was observed in the sediments. A small flat anticline occurs in the faulted area west of Donnelly's Well and is exposed only in Callytharra beds. Several small synclines were noted. These are invariably associated with large faults and are regarded as drag structures. Good examples can be seen in the faulted Devonian outlier, about 10 miles east of Moogooree homestead. Other comparable features occur east of the Williambury and Harris Faults in the northern part of the Williambury area. The syncline associated with the Harris Fault displays a southerly pitch.

The longest faults clearly traceable in the field have a northerly trend and are near to strike faults for much of their length. The Moogooree Fault zone which develops a north-north-west trend in the south can be followed for over twenty miles. The Williambury Fault zone develops a north-east trend in its northerly extension. The Harris Fault is more northerly in trend and it seems probable that it can be linked up in the south, by continuous north trending faults with the fault running just east of Donnelly's Well. It is admitted that faulting is difficult to trace in the beds of the Lyons Group which are rarely well exposed. Distinct faulting is clearly exposed along the projected line in the more competent Callytharra and Wooramel beds. If this projected Harris-Donnelly Fault is a continuous fault, the amount of throw is variable along the length, being at a maximum at the harris end, with a downthrow of at least 5,000 to the east. At the Donnelly end the downthrow is of the order of 1800 feet to the east. In the intermediate portion the throw does not exceed a few hundred feet. It may be noted that hinge effects can be seen in other faults, e.g. the smaller fault lying just west of Donnelly's Well.

A north-south fault may be projected south of the Mundary fault to link up clearly demonstrable, shorter faults. The order of throw for the whole of this fault is much less, not more than a few hundreds of feet to the east. Neither the Harris-Donnelly nor the southextension of the Mundary Fault, can be traced more than a few miles south of the latitude of Donnelly's Well. It seems very likely that they link up with the faults south-west of Kimber's Well.

The north-westerly trending faults do not generally attain the dimensions ofthe northerly and north-easterly trending faults. The former are frequently strike faults particularly in the southern part of the area. The fault extending south-east of Kimber's Well appears to be one of the greatest in magnitude. Another major fault, in this case indicated by the outcrop pattern, is the most northerly cross fault between the Harris and Mundary Faults.

The hade of the major faults can not be determined in outcrop but is thought to be generally steep. In placeswhere the minor non-meridional faults traverse sandstones, strong silicification occurs in the fault zones and quite often surprisingly dyke-like ridges with polished and slickensided walls are preserved by differential erosion. Particularly good features of this type occur in the great block of sandstones which lies east and south-east of Williambury Homestead. These faults may hade either east or west and thought generally over 70° may hade east atangles less that 20°.

It is suggested that the faulting is caused by stresses, transmitted through the Pre-Cambrian basement rocks. The stresses were relieved in the Pre-Cambrian rocks by movements along pre-exising lines of weakness in accordance with the pattern indicated.by

the dykes in the outcropping Pre-Cambrian areas. These faults continued up through the sediments probably with some change of direction and dip. The comparative rarity of jointing in the sedimentary rocks supports the view that the stresses were not carried by these rocks.

A number of areas present anomalous features which are difficult to unravel, partly because of lack of outcrop. For example, in the great belt of Lyons Group, south of Williambury Homestead, the section traversed by the Minilya South Branch must be very considerably faulted to account for the great width of west dipping outcrop. It is not clear whether the necessary fault of faults link up with the Williambury Fault Zone or with the faults near Dumbardo Bore at the south end of the Harris Fault block.

The Williambury Fault Zone in its major features seems to be a major steeply dipping fault with a downthrow of over 8,000 feet to the east. It is evidently a complex zone, since several small outcrops of Devonian limestone occur along the zone, no doubt as horses caught up in the movement. The small faults indicated in the block south of Williambury homestead must be regarded as a tentative suggestion to account for the distribution of the formations present. The rocks of the Gneudna Formation and Munabia Groups which outcrop on the eastern side of the fault zone about 2 miles south of Williambury homestead show evidence of low south-east dipping thrusts. These beds probably are a faulted continuation of the Devonian belt in the Harris Block.

The relationship of the Moogooree Fault Zone to the Williambury Fault is not clear. The Moogooree zone is marked towards the north by irregular blocks of the topmost Carboniferous formations. It is evident on tracing the zone southwards that there is a progressive faulting out of the Carboniferous formations namely the Harris, Yindagindy and Williambury Formations so that at the southern end of the zone the Munabia Sandstone and the Lyons Group are in faulted contact. Faulting has also affected the Munabia beds. South of the Minilya South Branch, part of the Willaraddy Formation is faulted out by a slightly oblique fault which lies to the east of the Moogooree Zone. Evidence of strike faults is common in the Munabia beds of this area.

In a very broad sense the combined Williambury and Moogooree Fault Zone act as a great hinge fault. In the north the downthrow is east and in the south the downthrow is west but to a considerably smaller degree. The west downthrow at the south end of the Moogooree Fault zone is perhaps as much as 3,000 feet though probably rather less. There is definite thinning of the Devonian and Carboniferous formations in this direction but it is difficult to assess the thickness of the faulted out formations. It is of some interest that the Moogooree Fault is almost the only major fault in the area which causes a reduction of section, the other faults result in a repetition of outcrops.

Another area difficult to interpret is the southern end of the Harris Fault block. At its southern end the belt of Pre-Cambrian and Palaeozoic rocks is faulted in a complicated fashion and brought into faulted contact with the Lyons Group. The outcrop pattern though incomplete because of alluvial cover is suggestive of thrust faulting. Hence it is suggested that this Palaeozoic-Pre-Cambrian belt is thrust over the Lyons Group rocks with the thrust movement operating in a southerly direction.

Both in this region and elsewhere in the mapped area, there are groups of faults occurring in a radial pattern. Osborne and Carey (1938) and Osborne (1950) cite radial fault patterns as contributory evidence for regional horizontal torsional movements in the Palaeozoic rocks of the Hunter Valley.

Faulting with a strong strike slip movement is a possible partial explanation of the complicated area near Howell's Bore, Moogooree where blocks of Gneudna and Munabia rocks have apparent

been moved horizontally. A radial pattern is evident for some of the faults in this locality. The block in which Howells bore is situated shows an apparently southern movement and the block lying west appears to have been moved north. Strike faulting is present in the Nannyarra beds.

Thus the regional picture suggests large scale steep angle faulting, with two exceptions resulting in downthrow to the east. Most of these faults have a northerly, north-west or less commonly north-east trend. These faults are thought to be transmitted up from the basement. Superimposed on this pattern are some thrust movements and strike slip faults which result from a regional torsional couple, operating in an approximately north-south direction

The age of all this major faulting is from epi-Permian to Pre-Lower Cretaceous time and sufficient time must have elapsed for the surface of high relief produced by the faults to have been levelled before the Lower Cretaceous transgression. Hence the age is probably close to the end of the Permian deposition period, the age of which is probably not younger than Kungurian.

Further faulting, this time on a small scale occurred in late Tertiary time. These movements often occurred along old fault lines. The Merlinleigh Sandstones and the laterites are affected. Vertical displacement is distinctly less than 100 feet. Near Billidee bore, Merlinleigh Station and elsewhere, faulted and tilted blocks, with tilting evident in the Tertiary rocks, can be seen. High angled faulting seems to be indicated. These movements are probably connected with the uplift which occurred in post Miocene time.

The outcrop pattern of the blocks north of the Minilya River is to some extent suggestive of great low angle overthrusts from the east. Thus a section might be drawn along a line of latitude north of Williambury homestead which would explain the great repetition of outcrops by low angle overthrusts several miles in throw and operating as the result of forces from the east. However, it is thought that such great overthrust would have provided more evidence of their movement in both overlying and underlying rocks. The synclinal patterns on the east of the faults are best accounted for by vertical movements. The outlying Devonian blocks, east of Moogooree show similar drag effects.

The Palaeozoic rocks have a regional dip to the west or south-west. This decreases from about 45° for the oldest and most easterly beds to about 4° for the youngest Permian beds. The steep dips in the east appear to be the result of sagging of the basin under load, the steepening is most marked near the edge of the basin. It must be noted that the lower Devonian beds in the eastern outliers of Moogooree Station have dips about 40°-45°. These outlier are about 5½ miles east of the main Devonian belt. The beds in the Harris and Mundary blocks show steep dips on their eastern side. Hence tilting which accompanied major faults may have been a factor in producing the steep dips.

GEOLOGICAL HISTORY

The known Palaeozoic sedimentary record in the Moogooree-Williambury area begins with the Nannyarra Greywacke of Lower - Middle Devonian age. North-east of Lyndon, steeply dipping sediments of Pre-Cambrian and possibly Nullagine age, are known but these do not outcrop in the area described.

Diagram No. 2, shows the environmental & tectonic history. The Nannyarra beds appear to be typical basal greywackes of a shallow marine transgression over a levelled shelf region and reflect, to some extent, in their composition the underlying Pre-Cambrian basement rocks. Fairly rapid burial occurred. Deposition continued throughout this period under relatively stable shelf conditions - quartz, felspar, sandstones occur in the lower part of the Nannyarra section. The development of finer sediments of somewhat different composition suggests a recession of the source area. Marine sedimentation continues during Middle to Lower Upper

Devonian time with prominent development of biostromal conditions in a mainly infra-neritic environment. During Gneudna time the shelf was moderately unstable indicated by the alternation of greywacke and limestone in part of the section. Some of the limestones were probably deposited as calcarenite but many were biostromal particularly towards the close of Gneudna deposition. The instability no doubt precluded the development of bioherms despite presence of stromatoporoids and corals among the fauna. During part of the time a dwarf fauna was developed, possibly as a result of rather sandy conditions.

Towards the close of Gneudna deposition stable shelf conditions returned and quartz sandstones were deposited probably under epi-neritic conditions. Gentle continuous sinking of the shelf then prevailed and the thick cross-bedded Munabia quartz sandstones were deposited. A short period of unstable conditions occurred towards the end of Munabia deposition within possibly deeper water. For the remainder of Devonian time and possibly extending into the Lower Carboniferous there was a very marked change of conditions. Marine sedimentation continued apparently uninterrupted. The repeated sequences of alternating cross-bedded greywackes, sandstones, conglomerates and siltstones of the Willaraddy Formation imply rapid advance and retreat of the strand line together with the exposure of different types of source rocks, Sagging probably did not proceed uniformly. The presence of quartz sandstones suggest occasional stabler periods. At the same time there was uplift in the source area in the east; this was not necessarily a period of marked tectonism as arkosic rocks do not appear to have developed in the sediments.

Deposition in the Lower Carboniferous then continued under quieter conditions to form the Moogooree Limestone. Moogooree time was one of quiet subsidence in a neritic environment. The limestone was possibly partly calcarenite but some fossiliferous beds occur. Occasional oolites indicate temporary shallower and more turbulent conditions. Towards the end of this period, small syringoporoid masses were able to form on the calcareous substratum. Then follows a return of conditions somewhat similar to those of Willaraddy time with strong development of conglomerates and rapid change of deposition. The source rocks must have been rich in dark cherts and quartzites and in kaolin and quartz of granitic origin. This period of Williambury deposition is probably Middle to Upper Carboniferous in age.

Deposition then became less violent and fossiliferous marine limestones and interbedded greywacke of the Yindagindy Formation were laid down. The conditions must have been fairly unstable and probably epineritic. A peculiar feature of the limestone beds is the presence of small rounded pebbles of igneous rocks. No large cobbles were present and probably glacial condition ice rafting - are not implied though somewhat similar beds occur in the Lyons Group. Shallow conditions followed and the cobbly, cross-bedded plant bearing Harris Sandstone was laid down. These may be fresh water in part.

This brings the history probably to the end of the Carboniferous and no marked unconformity heralds the inception of the glacial conditions of Lyons time. The lowermost beds do not always indicate intense glacial activity. The Lyons beds appear to be essentially marine and the variable lithology indicates an unstable shelf with both shallower and deeper conditions at different times. The larger erratics and boulder beds were no doubt deposited from ice rafts. The high relief necessary in the source area had been developed in Williambury time during the Carbon iferous epoch. Decomposed and fresh granitic rocks must have been abundantly exposed in the source areas. A feature of the Lyons Sandstones and of the Permian sandstones in general is the much greater content of garnets than in the Devonian and Carboniferous sandstones.

Glacial conditions ceased fairly abruptly and the Callytharra limestones were laid down. In early Callytharra time, the shelf was fairly unstable and the environment infra-neritic. Greater stability prevailed for the upper part though some sandy beds occur.

Then ensued a quick change of conditions and the mostly unfossiliferous cross-bedded quartz sandstone of Wooramel time followed the limestone. Possibly a diastem occurred between the two formations. Stable and epineritic conditions were present during Wooramel deposition. Subsequently for a long period, gentl but more or less cyclic changes prevailed. A fairly shallow environment was the rule for the remainder of Permian deposition. The shelf was somewhat unstable and alternating siltstones and fairly fine near-greywacke sandstones and thin calcareous bands were deposited. Somewhat restricted conditions recurred and for short periods a sapropelic environment was present. Gypseous beds also are found at more than one level. However, the Moogooree-Williambury area was probably marginal to areas showing a greater development of restricted conditions, further to the west. On Wandagee Station, the Bulgadoo shales contain both thick carbonaceous beds and fairly thick gypseous beds. The gypsum is regarded as primary by Sturmfels (1949). No recurrence of glacial conditions has been observed in this area, after the major development of Lyons time. Towards the end of the Permian deposition, shallower conditions prevailed, with probably steadier subsidence. Permian deposition younger than basal Kungurian is not known in the outcrop areas. A feature of the Permian sandstones is the greater content of garnet implying metamorphic rocks in the source areas.

Following the long period of marine loading in the basin major faulting then took place. This was accompanied by only minor folding. The age of the faulting is probably upper Permian or early Triassic as the major marine transgression of the Cretaceous epoch was over a mature erosion surface.

Marine Jurassic is known in the Wandagee area (Teichert as a small fault-bounded block but no beds of this age have been found in the Williambury-Moogooree area. The Lower Cretaceous sea may not have extended far into this area which was probably the eastern limit of the transgression. Upper Cretaceous beds are not known as far east as this area. There is no evidence of epi-Cretaceous faulting in this region; the Cretaceous outcrops are very small.

A long period of sub-aerial erosion then followed and the sedimentary record was not resumed until the shallow marine transgression of the Miocene took place. This transgression was over a gently relieved surface and the easterly limit of the marine invasion lies within this area.

The regression of the Miocene sea resulted in a nearly level land surface. Very little erosion ensued and the lateritic profile was developed. Uplift followed the lateritization. There is no evidence of the time of initiation of the uplift in this area but it is probably earlier than the Pleistocene. Minor faulting accompanied the uplift; the Tertiary beds and laterite are displaced to the order of tens of feet. The movement took place along old fault lines in many places. The uplift initiated the present cycle of erosion which has left the flat-topped Kennedy Range and the numerous small mesas as relics of the old land surface. More arid conditions existed prior to recent times.

PHYSIOGRAPHY

The area is drained by the west-flowing Minilya River system which has its source in the Black Range near the eastern border of the map sheets. The headwaters have reduced an area of Pre-Cambrian rocks to a stage of early maturity, characterised by rounded hills and a sub-rectangular drainage pattern. Where the

rivers flow across sedimentary rock, they are almost at grade and a peneplain is developing. The many mesas, with elevations from 100 to 200 feet above the plain are being rapidly eroded around their margins. The detrital material is transported to the braided river channels, chiefly by sheet flow during the rainfalls which though few are of high intensity. The drainage pattern on much of the flat sedimentary area is a maze of small enmeshed bifurcating channels, typical of sheet flow.

Areas of no surface drainage are characterised by sand. These may be plain or hummocky areas, covered by spinifex (Triodia) but typically sand ridges have been formed. These sand dunes, partially covered by spinifex and low scrub are now fixed.

The following physiographic units may be recognized:-

(1) The older peneplain

(2) The new peneplain

(3) The Black Range and foot hills

(4) Sand covered areas.

The old Peneplain was developed in rocks of Devonian to Tertiary age. In late Miocene or Pliocene time the relief and climate were suitable for the formation of a laterite profile, probably over most of the area. The "hard cap", thus produced has helped preserve the old surface and today it forms the flat tops of the Kennedy Range and the smaller mesas found throughout the area. The old Peneplain was well developed over the sedimentary areas but possibly less so in the Pre-Cambrian areas which though of low relief may not have been so mature. The laterite profile is not as well developed in the east of the area. Probably the eastern areas were slightly more elevated.

Uplift towards the end of the Tertiary initiated the present erosion cycle. Thus a peneplain is now developing about 150 to 250 feet below the level of the old peneplain. This New Peneplain is not yet very extensive in the area mapped but occupies much of the area to the west. Erosion of the Kennedy Range and of the many mesas is extending the plain area. The relatively harder formations of the Palaeozoic rock such as the Moogooree Limestone and Callytharra Limestone and Wooramel Sandstone, form strike ridges standing well above the plain level for much of their length. It is noteworthy that "billy" appears at the lower level in a few places. Faulting may be the explanation, otherwise lateritisation occurred also at a fairly recent period.

The eastern limit of this plain is approximately the edge of the Pre-Cambrian rocks. Foot Hills rise gradually to the east where the highest hills forming the divide between the Minilya River and the Lyons River are known as the Black Range. This is an area of mature topography with sub-rectangular drainage pattern. The creeks have wide valleys and commonly the relief from bed to adjacent divide is about 100 feet.

The sand covered areas are found on the Old and New Peneplains but not on the Black Range area. The Kennedy Range is partly covered by sand dunes. The sand ridges are longitudinal self dunes. Their trend is north-westerly within the area described The direction becomes more northerly, further west. Individual dunes may be 4 or 5miles in length. An interesting detail is the frequent repeated division of the crests, giving a beaded effect when seen from the air. The elevation of the dunes rarely exceeds 50 to 60 feet. On the Kennedy Range the dunes are often abruptly terminated at the scarp and appear to be transected by gullies. These dunes thus antedate the present erosion of the scarp. However in one or two places where the dunes are terminated at the scarp the sand has spilled down and retains a slight crest. All the dunes and sand areas are now fixed by vegetation. Some dunes have been formed on sand areas above the New Plain level. As far as this

area is concerned at least, these dunes are not as well developed as those on the Kennedy Plateau.

The other sand areas which occur are either relatively smooth or have irregular hummocks. Clay pans often with sandy rims are common, particularly in the hummocky areas. The diameters are variable and rarely exceed 300 yards. Elsewhere in the basin much larger ones are known.

The main stream, the Minilya River drains from east to west, its more important tributaries are the South Branch and Nortons Creek flowing north and Yindagindy Creek and Willaraddy Creek flowing south. The streams are at base grade. The Minilya is characterized by wide shallow valleys, attaining from 200 to 600 yards in width. The channel is generally much braided. The valley is narrower in water gaps where the river cuts through resistant ridges of limestone.

The north-eastern edge of the Kennedy Range lies within the area. The top is here about 200 feet above the surrounding plain. The northern end of the range extends for about 15 miles to the west. The scarp is generally fairly steep for the upper part with a lower more gentle talus slope. Alluvial fans are absent. The elevation is approximately 1000 feet above sea level.

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GEOLOGY OF WILLIAMBURY AND MOOGOOREE ONE MILE MAP AREAS - WESTERN AUSTRALIA.

GEOLOGY BY G.A.THOMAS, C.E.PRICHARD, M.A.CONDON, C.TEICHERT.

COMPILED BY G.A.THOMAS.

Reference

RECENT			River Alluvium	
			Sheet Alluvium	Qal
RECENT TO PLEISTOCENE			Sand	Qe
TERTIARY			Post-laterite lacustrine beds	Tl
			Laterite	Lat
	EOCENE		Merlinleigh Sandstone	Tem
CRETACEOUS	ALBIAN TO CENOMANIAN	Winning Group		Kw
PERMIAN	KUNGURIAN	Kennedy Group	Coolkilya Formation	Pkl
	ARTINSKIAN	Byro Group	Baker Siltstone	Pak
			Norton Greywacke	Pan
			Wandagee Formation	Pag
			Quinnanie Shale	Paq
			Cundlego Formation	Pau
			Bulgadoo Shale	Pab
			Mallens Greywacke	Pam
			Coyrie Formation	Par
			Wooramel Sandstone	Paw
	SAKMARIAN	Lyons Group	Callytharra Formation	Pac
				Pal

CARBONIFEROUS	MIDDLE TO UPPER	Harris Sandstone	Cmh
	MIDDLE ?	Yindagindy Formation	Cmy
	LOWER	Williambury Formation	Cew
		Moogooree Limestone	Cem
DEVONIAN	UPPER	Willaraddie Formation	Duw
		Munabia Sandstone	Dum
		Gneudna Formation	Dug
	MIDDLE ?	Nannyarra Greywacke	Dmn
PRÈ-CAMBRIAN	ARCHAEOZOIC	Schist, gneiss, basic dykes, granite, quartz reefs	A

Established Geological boundary — Dykes — q

Strike and dip of strata - inclined — Dykes, quartz

" " " - vertical — Trend lines

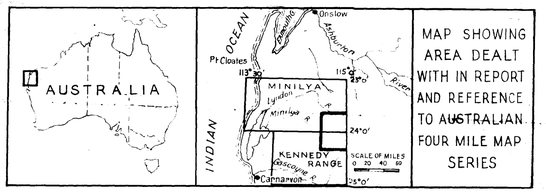
Fault, position accurate — Sand dunes

" probable or inferred — Tracks

Boulder beds — Fences

SCALE OF MILES

1 ½ 0 1 2 3 4



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

Bureau of Mineral Resources, Geology & Geophysics - March 1955

WA 53-3