COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Report No. 46

THE GEOLOGY OF THE BADGERADDA AREA, WESTERN AUSTRALIA

BY

W. J. PERRY AND J. M. DICKINS

Issued under the Authority of Senator the Hon. W. H. Spooner,
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Minister : SENATOR THE HON. W. H. SPOONER, M.M.
Secretary : H. G. RAGGATT, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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ILLUSTRATIONS

SUMMARY

The Badgeradda area is 120 air miles north-north-east of Geraldton; it occupies 1,500 square miles between 26°45' and 27°17' south latitude, and 115°18' and 116°00' east longitude.

Precambrian schist, gneiss, and gneissic granite are overlain unconformably by the Nilling beds, an arenaceous sequence of unknown thickness, which is followed, probably unconformably, by the Badgeradda Group, a sandstone-siltstone succession more than 10,000 feet thick. The Group is divided into four formations, which were deposited on an unstable shelf or intracratonic basin, probably in Upper Proterozoic time.

The Badgeradda Group rocks are folded into an asymmetrical syncline plunging gently north-north-east, with a steep west limb produced by high-angle reverse faulting, and a gently dipping east limb. The sediments of the Group are intruded by basic igneous dykes and sills.

INTRODUCTION

In 1956 the rocks of the Woodrarrung and Badgeradda Ranges and Errabiddy Hills were examined as part of the Bureau's field programme in the south-eastern part of the Carnarvon Basin, Western Australia (see map, Plate 1).

The authors mapped the area during the period 3rd August to 4th October, 1956, using vertical aerial photographs with a scale of 1:50,000, on which the geology was plotted directly. Sections were measured by Abney traverses or, where dips were too steep, by pace and compass method. As no megafossils were seen, random samples were taken throughout the section for examination for microfossils.

Location

The area investigated lies between latitude 26°45' and 27°17'S. and between longitude 115°18' and 116°00'E.; relevant 1-mile Military Maps are Meeberrie 240, Mt.Vinden 250, and the eastern parts of Yaringa 239 and Woodrarrung 249.

Access

The main road from Mullewa to Gascoyne Junction lies a few miles east of the Errabiddy Hills, and the area itself is served by mail roads between station homesteads and by tracks to bores and wells within station boundaries. There is a weekly mail service by truck from Mullewa to Yallalong and New Forest homesteads, south of the Woodrarrung Range. Butcher's Track, the old wool road from Meeberrie to Hamelin Pool, passes through the northern part of the area; it is little used now, but was trafficable at the time of field work.

Homesteads are in touch with Mullewa by telephone; the party used a Traeger transceiver for telegraphic communication through the Royal Flying Doctor base at Meekatharra.

Climate

The average annual rainfall is less than ten inches, mostly falling during the winter months though sometimes irregularly distributed throughout the year, and unreliable in total amount in any one year. Temperatures range from over 100°F in summer to below 32°F in June and July, but the winter climate is generally pleasant with warm days and cool nights.

Vegetation

The area lies within the Mulga Bush division of Gardner (1942), and stunted acacias are the dominant vegetation; they grow most densely on sand, and such areas are impenetrable to vehicles.

Rock outcrops are sparsely covered and areas of alluvium moderately thickly covered. Ghost gums are found on the banks of the larger watercourses and clay-pans.

Development

Pastoral properties occupy the whole of the area investigated and consequently it is divided up into paddocks each serviced with one or more wells or bores. Bore and well logs were not available.

PREVIOUS WORK

The rocks of the Woodrarrung and Badgeradda Ranges were first referred to by Gibb Maitland (1898, p.16), and recorded on an unpublished map as equivalent to the Nullagine "Series" of the Pilbara district (Johnson, 1950, p.60).

Hobson and Johnson (1948) and Johnson (1949-1950) described cross-stratified horizontal or flatly dipping quartzites from the Woodrarrung Range, and, following Maitland, assigned to them a Nullagine age.

A Bureau field party, as a result of a brief reconnaissance in 1955 (Konecki, Dickins ,and Quinlan, 1958), proposed the name Badgeradda Beds for the rocks of the Badgeradda and Woodrarrung Ranges and Errabiddy Hills, and recognised the major structure, an asymmetrical syncline plunging gently north-north-east.

PHYSIOGRAPHY

Physiographically, the region contains three divisions: the high-level plain, the low-level plain, and the ranges. Spot heights were determined barometrically at geophysical observation stations spaced at about 5-mile intervals along widely separated tracks through the area.

Remnants of the high-level plain are found all round the area; they are usually formed of red-brown sand over the probable equivalents of the Pindilya Formation and are gently undulating, with a heavy cover of vegetation. West of the Badgeradda Range, on Butcher's Track, the high-level plain is 970 feet above sea level, and it slopes gradually down towards the west. On the sand plain between the Badgeradda Range and the Errabiddy Hills, altitudes range from 955 to 1050 feet, and north of the map area, between Muggon and Narryer homesteads, from 890 to 950 feet.

The low-level plain has been formed from the high-level plain by erosion which has removed the cover of ?Mesozoic/Tertiary sediments.

TABLE I

TABLE OF STRATIGRAPHICAL SUCCESSION

Era	Rock Units	Approx. Thickness
Cainozoic	Sand, alluvium, wash, travertine, laterite.	
Mesozoic/ Tertiary	Probable equivalents of Pindilya Formation	60 feet
	UNCONFORMITY	
Palaeozoic	Lyons Group	?
	UNCONFORMITY	

Era	Badgeradda Range/ Woodrarrung Range Area: Rock Units		Thickness	Errabiddy Hills Area: Rock Units	Thickness
Upper Proterozoic to Lower Palaeozoic	Basic igneous dykes and sills			Basic igneous rocks	
	Badgeradda Group	(Yarrawolya (Formation	1400'	Errabiddy Sandstone	480'
		(Coomberarie (Formation	6900'	Unnamed quartz greywacke and siltstone	130'
		(Woodrarrung (Formation	1600'		
		(Bililly (Formation	1200'		
		?UNCONFORMITY			
	Unnamed sandstones equivalent either to the Nilling Beds or to part of the Badgeradda Group				
	Nilling Beds			Probable fault contact	
		UNCONFORMITY			
Precambrian	Schist, gneiss, gneissic granite.				

The difference in elevation between the two divisions can be clearly seen in the scarps 8 miles west of Wail outcamp, where it is 55 feet. A similar difference in elevation exists between the high-level sand plain and the exposed surface of the older Precambrian rocks about 4 miles south-west of Blue Mountain Well. The low-level plain, like its high-level ancestor, is undulating, and its general altitude in the Woodrarrung-Badgeradda area ranges from about 800 feet to 860 feet.

The Woodrarrung Range stands 300 feet above the low-level plain (about 1,100 feet above sea level), forming a prominent scarp that trends roughly east and faces south. At its western extremity the range turns north and its height gradually diminishes; it reaches plain level 8 miles to the north at Wail outcamp, where there is a gap two-thirds of a mile wide through which a creek flows from the north. The Range continues north as a low straight ridge about 50 feet above plain level, and terminates 16 miles north of Wail. One mile north-north-east of Deep Bore, the eastern boundary of the Woodrarrung Range proper seems to be structurally controlled, possibly by a fault trending 20 degrees east of north. East of this the range degenerates into discontinuous low hills.

About a mile east of the northern extremity of the Woodrarrung Range are the low meridional ridges of the Badgeradda Range, about half a mile wide; these continue north to Muggon woolshed and south to the west of Newgulda Well, where they turn east and form a low range 11 miles long. Extending 8 miles south of the woolshed, and 2½ miles wide at its widest part, is rough red sandstone country rising to 1,000 feet above sea level. Although this is unnamed on the Byro 4-Mile Military Map it is included in the Badgeradda Range in this report. Characteristic of this sandstone are the many small irregularly shaped claypans that no doubt owe their existence to its impermeable surface; their distribution is best seen in the aerial photographs.

The Errabiddy Hills form a prominent landmark 10 miles north-west of Meeberrie homestead. They are composed of bedded sandstones dipping gently to the south, with a steep north-facing scarp 300 feet high; the highest point is nearly 400 feet above the high-level plain, which in this locality is approximately 1,050 feet above sea level.

STRATIGRAPHY

PRECAMBRIAN

No attempt was made to map the metamorphosed Precambrian rocks, and observations were confined to areas close to the unmetamorphosed sedimentary sequence; the following account is therefore brief.

Metamorphosed Precambrian rocks are found to the east, south, and west of the outcrop area of the Badgeradda Group. Rock types in the west include cleaved "siltstone", mica phyllite and mica schist, intruded in places by fresh-looking dolerite dykes trending north. Fresh mica schist was observed only at one place, 4½ miles east of Bompas Hill, but farther north, to the west of the Woodrarrung and Badgeradda Ranges, the metamorphosed material, including the "siltstone", is so weathered that the original nature of the rock is difficult to determine. The "siltstone" is highly cleaved, and differs in this respect from siltstone of the Badgeradda Group, which, though in places standing vertically or even overturned, shows little or no development of cleavage. In general, the metamorphic grade of the rocks west of the Badgeradda Range appears to be lower than that of the gneiss and schist to the south and east, but whether this is due to an original difference in composition or to other factors is not known. The cleaved "siltstone", phyllite, and mica schist may be part of the Badgeradda sedimentary sequence dynamically metamorphosed by tectonic movements associated with the Woodrarrung Fault, but to the authors this seems unlikely, on the evidence of the cleavage. Near Mt.Aubrey and south of the main area of sediments both gneiss and schist are found, and in places gneissic granodiorite is associated with them. Its relationship to the gneiss was not observed, but probably it is intrusive, the gneissosity being due to movement during consolidation of the magma. Quartz reefs and veins intruding schist and gneiss are common.

Johnson (1950, p.58) reports injection gneiss near Mt.Aubrey, formed by intrusion of granitic solutions along the foliation planes of a schist. He classified all the Precambrian rocks to the south and east of the Woodrarrung Range as gneiss, and assigns it to the lower of his two divisions of Precambrian time.

To the east of Melia Well schist and gneiss crop out, and in places are associated with and probably intruded by gneissic granodiorite. East of the Errabiddy Hills schist is present, and one small outcrop has been observed 60 feet east of brecciated sandstone about 2½ miles north-west of the Meeberie outcamp. Bedding is discernible in the schists in places, for example 3 miles south-west of Yarrawolya Pool, but it is obscured at most observation points by recrystallization.

UPPER PROTEROZOIC/LOWER PALAEOZOIC

General Statement

Overlying the older Precambrian with angular unconformity is an unmetamorphosed dominantly arenaceous sequence more than 10,000 feet thick; the lowest unit, the Nilling Beds, has been separated from the overlying Badgeradda Group because of an intervening probable unconformity, but lithologically the two sequences are very similar. Sandstones at Mt.Aubrey have been classified as undifferentiated because it is not certain whether they should be correlated with the Nilling Beds or with the Badgeradda Group.

The Group is divided into four formations, only the uppermost of which, the Yarrawolya Formation, differs markedly from the other three. The upper part of Yarrawolya Formation is characterized by reddish hematitic sandstone, whereas the lower units are white to grey sandstone-siltstone associations.

The Group contains minor basic igneous sills and is intruded in places by basic dykes.

No sign of organic life has been observed in the whole sedimentary section, most of which at least was laid down in shallow water. The age of the sediments is not known. Previously they have been regarded as equivalent to the Nullagine "system" (Clarke, Prider & Teichert, 1955,p.217). Indirect evidence of age is as follows: in the Ajana Precambrian inlier, an age determination of galena, which occurs in both quartz dolerite dykes and the surrounding gneissic garnet granulite, was 500 million years (Prider, 1954, p.73). The dykes trend north-east in a well-defined swarm. Seventy miles to the north-east, basic dykes trending north of east intrude the Badgeradda Group sediments, and these dykes are possibly of the same general age as the dykes near Ajana. If this is so, it suggests that the sediments probably are not younger than Lower Palaeozoic or older than Upper Proterozoic.

Nilling Beds

The name Nilling Beds is proposed for the poorly outcropping sequence predominantly of sandstone and quartz greywacke that rests with a marked angular unconformity on the older Precambrian, and is overlain by the Bililly Formation. The Nilling Beds form the basal part of the unmetamorphosed sedimentary sequence which overlies the older schistose and gneissic rocks; they are separated from the higher part of the sequence because of the probability that their top is marked by an unconformity. The Nilling Beds are exposed in small areas south of the Woodrarrung Range. Folding and faulting affects the sediments in varying degree and in some places dips are close to vertical; because of the folding and the isolated outcrops it was not possible to measure any thickness (not more than a few tens of feet are exposed at one place).

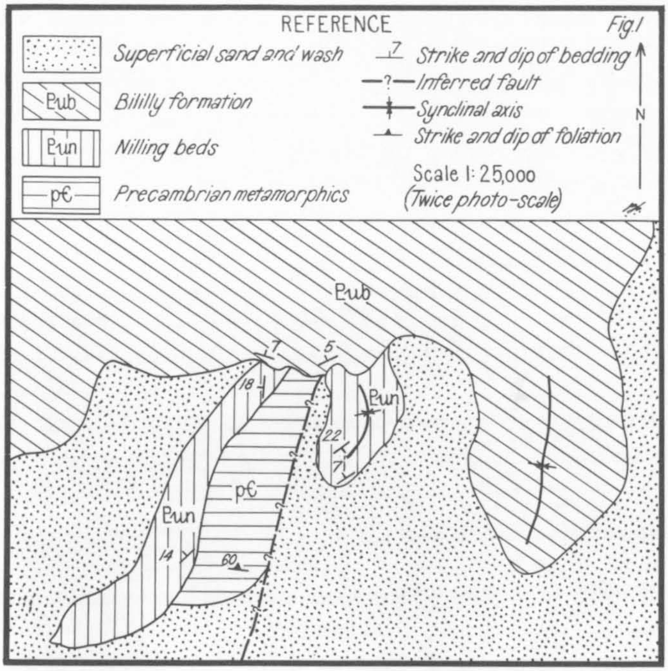
The name is taken from Nilling Well (Lat. $27^{o}29\frac{1}{2}$'S, Long.115^{o} $38\frac{1}{2}$'E).

The unconformity between the Nilling Beds and the older Precambrian can be seen at many places. At most of these, angular quartz fragments (up to 6 inches across) are present, which in places form a quartz breccia (sharp-stone conglomerate (Shrock, 1948, p.667). About one mile south of Deep Bore more than 20 feet of thin-bedded predominantly medium to coarse-grained sandstone overlies the older Precambrian, which here is composed of very ferruginized and weathered steeply dipping schist. Near the base of the sequence the sandstone is very coarse and contains pieces of feldspar and many angular fragments of schist and gneiss; the rock is grey and very micaceous, and is in places almost a conglomerate. On the east side of the outcrop the dip is 25° at 298°, but 40 yards to the west the dip is reversed to 40° at 112° and a small syncline is apparently present.

A similar relationship is shown $2\frac{1}{4}$ miles west of Nilling Well, where thin-bedded fine to coarse very silty sandstone (quartz greywacke) with many feldspar grains overlies steeply dipping quartz-feldspar gneiss. At the base, the rock is composed of a very coarse sandstone with quartz pebbles up to half an inch across. Here again a small syncline trending 050° is associated with the contact. A small vein of quartz penetrates the sediments; this was the only quartz reef observed in rocks younger than the older Precambrian.

Two small isolated synclines of thin-bedded micaceous, kaolinic cross-stratified sandstone, lying on the Precambrian $2\frac{1}{2}$ miles south-west and 4 miles south-west of Nilling Well, were mapped as Nilling Beds. A small outcrop of similar cross-stratified sandstone was seen $4\frac{3}{4}$ miles south-south-west of Nilling Well; $1\frac{1}{2}$ miles to the north-east is a small outcrop that has been interpreted as sandstone from the air photographs. It is evident that the trend of the synclines and two scattered outcrops to the north, namely 015°, is also that of the long embayment in the present outcrop of the older Precambrian, on the west side of which the synclines are found. These scattered sandstone outcrops may therefore be the remnants of a much larger, probably synclinal, structure now almost wholly eroded.

The relationship of the Nilling Beds to the overlying Bililly Formation was seen at only one locality, $2\frac{3}{4}$ miles south-west of Deep Bore, where the Nilling Beds lie unconformably on the Precambrian. Several north-trending folds in the Nilling Beds, probably faulted in places, are not reflected in the overlying basal beds of the Bililly Formation, which have more gentle dips and less acute changes in strike. Also the basal sandstones of the Bililly Formation apparently transgress across the Nilling Beds on to the older Precambrian (see Text Figure 1). The basal sandstones of the Bililly Formation form a small breakaway about 15 feet high, and are composed of cross-stratified mainly coarse and very coarse sandstone; many fragments are up to half an inch across. In one place at the base of the breakaway many quartz pebbles up to an inch across are derived from the basal part of the Bililly Formation. The underlying Nilling Beds are composed of greenish fine-grained laminated and thin-bedded micaceous greywacke and grey thin-bedded coarse and very coarse-grained silicified sandstone, all much jointed.



Text Figure 1. Relationship between Nilling Beds and Bililly Formation.

The small-scale structures in the Nilling Beds lie in two well defined axial directions, one at about 320° and the other approximately at right angles at 60°. This regularity was considered to indicate that the structures were of tectonic origin. This is confirmed by the absence of criteria of slumping, such as irregularity in the trends or the presence of strata clearly out of place. The Nilling Beds, therefore, were probably subjected to compressional forces before the deposition of the Bililly Formation.

Undifferentiated Sandstones

A section on the east side of Mt. Aubrey indicated the presence of about 200 feet of thick-bedded medium to coarse-grained light grey feldspathic sandstone; below this is a few feet of poorly exposed thin-bedded micaceous silty sandstone and white siltstone. The contact with the older Precambrian could not be observed because of a cover of scree at this locality. On the north-west slope about 90 feet of thin-bedded fine light grey and greenish-grey sandstone interbedded in places with light grey siltstone was observed below light grey feldspathic sandstone equivalent to the sandstone on the east side.

One mile north-north-west and half a mile south-west of Mt.Aubrey, isolated outcrops of sandstone similar to that at Mt.Aubrey rest with angular unconformity on the older Precambrian gneiss. These outcrops were probably originally part of a syncline the axis of which trends and plunges east-south-east and passes through Mt.Aubrey.

The Mt.Aubrey rocks may perhaps be equivalent to part of the Woodrarrung Sandstone and part of the Bililly Formation, or they may belong with the Nilling Beds, but the isolation of outcrops and lack of fossil evidence make definite correlation inadvisable and hence they have been shown on the map as undifferentiated.

BADGERADDA GROUP

The name Badgeradda Group is here applied to the predomantly arenaceous sequence in the Badgeradda and Woodrarrung Ranges and Errabiddy Hills called Badgeradda Beds by Konecki et al.(1958). These workers do not record the Nilling Beds and did not observe the unconformity on the older Precambrian. The Group comprises four formations: in ascending stratigraphic order, these are the Bililly Formation, Woodrarrung Sandstone, Coomberarie Formation and Yarrawolya Formation; the total thickness of the Group is more than 10,000 feet.

Bililly Formation

The name Bililly Formation is proposed for the sequence of thin to thick-bedded medium to coarse-grained cross-stratified quartz sandstone below, and thin-bedded fine-grained silty micaceous sandstone and interbedded micaceous siltstone above, unconformably overlying the Nilling Beds and probably conformably underlying the Woodrarrung Sandstone.

The name is taken from Bililly Well, $3\frac{3}{4}$ miles south-south-west of Wail Outcamp, which penetrates at least part of the Formation. The type locality is at Lat. $27^{\circ}12\frac{1}{2}$'S, Long. $115^{\circ}31\frac{1}{2}$'E., $2\frac{1}{2}$ miles north-west of Pooten Well;[x] here the base is obscured by sand, but the unconformable contact with the Nilling Beds may be observed $6\frac{3}{4}$ miles to the east. No continuous section through the upper unit could be found, and its thickness was calculated from photo distance and dip readings at the top of the lower unit and near the base of the Woodrarrung Sandstone. Dips in both places are about 7° so the estimate

x For description of measured section see Appendix.

TABLE 2

Formations of Badgeradda Group

Southern and Western Limb of Badgeradda Syncline

Formation	Lithology	Other Characteristics	Thickness
Yarrawolya Formation	Brown to greyish purple thin-bedded micaceous silty sandstone, cross-stratified, and brown siltstone.	Current lineations, small-scale slumping, current crescents, minor ripple mark.	1,425 feet
Coomberarie Formation	Light grey to light brown and reddish-white thin-bedded siltstone and fine-grained sandstone, with cross-stratification, mostly small-scale, in places.	Sole markings, current lineations, minor ripple mark, basic sills.	6,900 feet (approx.)
Woodrarrung Sandstone	Light grey to white prominently cross-stratified thick-bedded medium to coarse quartz sandstone and thin-bedded fine to medium-grained kaolinic sandstone.	Massive-weathering, cliff-forming sandstone, forms Woodrarrung Range.	1,625 feet +
Bililly Formation	Light grey to light brown, and reddish-white thin to thick-bedded medium to coarse cross-stratified sandstone and inter-bedded thin-bedded micaceous siltstone and fine-grained silty sandstone.	No sole markings observed, rare ripple mark.	1,200 feet (approx.)

of thickness is probably of the right order. The total thickness of the Formation is 1,200 feet, made up of 490 feet of coarse sandstone and 710 feet of fine sandstone and interbedded siltstone.

The two lithologies form two units, the lower of which, the coarse sandstone, forms a discontinuous south-facing scarp up to 60 feet high, two miles south of the main scarp of the Woodrarrung Range. The probable contact between the two units can be seen five miles east-north-east of Munyi's Well. The upper unit can also be found in places at the base of the main scarp to the south and west of the Woodrarrung Range, but it cannot be followed north for more than three miles beyond Wail Outcamp.

Five miles north of Pooten Well, the junction between the two-inch-thick beds of brown fine-grained very micaceous silty sandstone and the overlying light-brown coarse micaceous sandstone with reddish siltstone pellets is regarded as the contact between the Bililly Formation and the Woodrarrung Sandstone. The contact is essentially conformable, though a minor break may be represented by the siltstone pellets at the base of the Woodrarrung Sandstone.

About two miles south-east of Bililly Well, the Bililly Formation near the contact with the Woodrarrung Sandstone is a thin-bedded white fine-grained micaceous silty sandstone; in general it dips more steeply and its attitude is more variable than the Woodrarrung Sandstone, and this difference is ascribed to its being relatively less competent than the more massive Woodrarrung. The contact itself appears to be conformable.

Probably a similar relationship between the two formations obtains four-fifths of a mile north of Wail Outcamp, where thin-bedded white fine-grained micaceous silty sandstone and sandy siltstone of the Bililly Formation dip 75° east, and 200 feet farther to the east the basal beds of the Woodrarrung Sandstone dip at about 60° east. The actual contact, however, is not exposed.

Woodrarrung Sandstone

Woodrarrung Sandstone is the name proposed for the cross-stratified sequence of thick-bedded medium to coarse-grained quartz sandstone, feldspathic in part, and thin-bedded fine to medium-grained kaolinic sandstone, probably conformably overlying the Bililly Formation and probably conformably beneath the Coomberarie Formation.

The lower thick-bedded medium to coarse-grained quartz sandstone forms the locally prominent Woodrarrung Range, the southern part of which is a scarp 12 miles long and 300 feet high (1,100 feet above sea level), trending east by north; 4 miles south-east of Bililly Well the Range turns north, and this trend continues for 25 miles. The formation takes its name from the Woodrarrung Range.

In the axial region of the Badgeradda syncline, the outcrop of upper fine to medium-grained kaolinic sandstone is separated from the sandstone of the Woodrarrung Range by an area of sand about $1\frac{1}{2}$ miles wide. This gap in outcrop possibly represents a few hundred feet of less resistant rock. The type locality of the lower unit is at Lat.27°10'S, Long.115°33$\frac{3}{4}$'E, about 5 miles north of Pooten Well (Appendix 1). Here the thickness is 425 feet; one mile north-west of Deep Bore the unit is 525 feet thick (Appendix 1); the contact with the Bililly Formation is regarded as conformable, though the coarse Sandstone near the base contains siltstone pellets probably derived from below. However, the pellets may represent only an intra-formational break in sedimentation.

The type locality of the upper part of the Woodrarrung Sandstone is at Lat.27°06$\frac{1}{2}$'S, Long.115°37'E, five miles south-west of Diamond Well (Appendix 1), where the unit is 1,100 feet thick, and composed of fine to medium-grained white to light brown friable kaolinic sandstone, in places silty and micaceous. The contact with the overlying Coomberarie Formation in this area is concealed by sand.

North-east of the type locality of the upper part of the Woodrarrung Sandstone, discontinuous exposures of fine and medium-grained sandstone with bedding about a foot thick can be traced by similarity of lithology and photo pattern to a locality at which the sandstone overlies mainly medium and coarse-grained quartz sandstone regarded as equivalent to the lower unit. This lower unit equivalent is 700 feet thick (Appendix 1) and is folded into a west-plunging anticline nine miles east of Mt.Vinden; on the south-west flank of this anticline, coarse-grained cross-stratified sandstone in beds two to three feet thick forms the lower unit; immediately to the south-west is a small creek, on the other side of which is fine-grained thin bedded silty sandstone; the latter sandstone is thought to be the base of the upper part of the Woodrarrung Sandstone, which is not represented in the type locality. The other flank of the anticline is not well exposed.

West of the axial region of the Badgeradda Syncline, the upper unit cannot be traced in outcrop farther north than $1\frac{1}{2}$ miles south-east of Wail Outcamp, but it is very probably present in the Woodrarrung Range near its northern end, since a section measured three miles north-west of Newgulda Well is 2,000 feet thick (Appendix 1). The lower unit could not be separated from the upper unit in this section.

The Woodrarrung Sandstone in outcrop is characterized by the medium scale of its cross-stratification, that is, the cross strata are more than twelve inches and less than 20 feet long (McKee & Weir, 1953, p.388); by the predominantly coarse grain-size of the lower unit and the medium to fine grain-size of the upper unit; and by the generally good sorting. Individual cross-strata range in thickness from one-quarter of an inch to three inches.

Little silt is present, but in the lower coarse sandstone some beds contain numerous weathered feldspar grains, and in the upper unit the kaolinic grains present probably derive from feldspar. Beds composed almost entirely of quartz sandstone are commonly silicified at the surface.

Errabiddy Sandstone

A section measured on the northern scarp of the Errabiddy Hills showed 480 feet of medium and coarse-grained feldspathic sandstone overlying 130 feet of quartz greywacke and siltstone (Appendix 1). The sandstone is similar lithologically to the lower part of the Woodrarrung Sandstone and probably it is equivalent in part to the sandstone of the truncated anticline nine miles east of Mt.Vinden, which, as suggested above, may be equivalent to the lower part of the Woodrarrung Sandstone.

As the Errabiddy Hills form so prominent a landmark and are isolated, it is proposed that the name Errabiddy Sandstone be applied to the medium and coarse-grained feldspathic sandstone that forms the Errabiddy Hills.

The type locality is in the northern scarp of the hills ten miles north-west of Meeberrie Homestead, where the medium and coarse-grained feldspathic sandstone overlies, without marked discordance, grey-brown quartz greywacke and greenish-grey siltstone. The quartz greywacke and siltstone here are lithologically different from the siltstone of the Bililly Formation, so that although they may occupy the same general stratigraphical position there is some doubt that they are equivalent. The difference in lithology may reflect only a difference in environment of deposition; inferred current direction during deposition of the Woodrarrung Sandstone was from the north of east, and if this were true of the Bililly Formation also, then the quartz greywacke and siltstone of the Errabiddy Hills would probably have been nearer the source of sediment during deposition of the Bililly Formation.

Coomberarie Formation

The Coomberarie Formation is the name proposed for approximately 6,900 feet of siltstone and fine-grained sandstone that lies between the Woodrarrung Sandstone below and the micaceous laminated siltstone and fine-grained silty sandstone of the Yarrawolya Formation above. The name is taken from Coomberarie Well (Lat.$26^{o}56\frac{3}{4}$'S, Long.$115^{o}36$'E) on Muggon Station. The most complete section was measured between Lat.$26^{o}52$'S, Long.$115^{o}30$'E, and Lat.$26^{o}52$'S, Long.$115^{o}31\frac{1}{2}$'E (Appendix 1), slightly west of the south end of the Badgeradda Range, and the vicinity of this line is adopted as the type locality.

The contact of the Coomberarie Formation with the overlying Yarrawolya Formation was not seen in this section, and its position is obtained from another section two miles to the north. The top of the formation is placed above the blocky-weathering white fine-grained quartz sandstone which forms a prominent north-striking ridge; the quartz sandstone was probably originally thin-bedded, and has only a small amount of mica. Above this is found the laminated and thin-bedded predominantly brown micaceous siltstone and silty fine sandstone (quartz greywacke) with ripple marks, current marks and small slump structures, which is considered to be the basal part of the Yarrawolya Formation. As shown in the section the actual contact is covered by scree.

The base of the formation is placed below the laminated and thin-bedded very fine-grained sandstone overlying the thick-bedded fine to medium-grained quartz sandstone of the Woodrarrung Sandstone; outcrops near the junction are poor, however, and the actual contact is not exposed. No evidence was found to suggest an angular unconformity either at the base or at the top of the Coomberarie Formation. Dips in the formation are in most places not less than 10 degrees, whereas the general dip of the Yarrawolya Formation is 8 degrees or less, except where the beds are affected by minor local faulting and folding. The direction of cross-stratification in the Yarrawolya Formation is also distinctly different from that of the Coomberarie Formation and the lower formations.

The Coomberarie Formation is known to occur around both flanks and in the axial region of the Badgeradda syncline. On the west flank it forms a broad zone of steeply dipping beds; south-west of Newgulda Well there is a break in outcrop, and in the axial region of the Badgeradda Syncline and south of Coomberarie Well many isolated outcrops are referred to the formation. Five miles north-west of the Errabiddy Hills a low strike ridge of the Coomberarie Formation forms part of the east limb of the Badgeradda Syncline.

Compared with the Woodrarrung Sandstone the outcrop is poor, reflecting the softer nature of the sediments; some of the sandier beds however, especially near the top of the formation, form distinct but low strike ridges. The sedimentation is rather uniform throughout, and the variations consist in most places of relatively small differences in grain-size and composition. The bedding is mostly laminated to thin-bedded, with a few thick beds. Cross-stratification is present in places throughout the formation, though it is not so distinctive a feature as it is of the Woodrarrung Sandstone; most sets are small, although tabular sets up to two feet thick were observed. Many of the siltstones and silty fine sandstones are micaceous, but most of the fine quartz sandstones have little mica; the latter are frequently silicified and form more prominent outcrops.

At Mt.Vinden a section 475 feet thick was measured (Appendix 1). Its contact with the upper part of the Woodrarrung Sandstone is concealed by wash and sand. From the base of the section upwards the first 200 feet consists of fine-grained silty sandstone and subordinate interbedded siltstone; above this, 220 feet of section is concealed by a scree of silicified sandstone, and then comes 55 feet of fine silty sandstone. These sediments are considered to belong more logically with the fine sandstone and siltstone of the Coomberarie Formation than with the fine and medium-grained sandstone of the upper part of the Woodrarrung Sandstone.

Other partial sections of the Coomberarie Formation have been measured in two places; the first of these is half a mile south-west of Yarrawolya Pool (Appendix 1), where there is 2,190 feet of white siltstone and fine sandstone, and near the base of the section at least 40 feet of mottled ferruginous material parallel to the bedding, probably originally a basic sill. Most of the sediments dip vertically or are overturned; the truncation of cross-stratified sets in certain beds indicates that the sequence faces east.

The second partial section was measured 1½ miles south-west of Comeback Well; it is 1,675 feet thick and comprises poorly outcropping laminated to thin-bedded fine-grained quartz sandstone and fine-grained kaolinic micaceous sandstone. A vertical basic dyke about 80 feet wide and 6 miles long intrudes the sediments; the igneous rock is very leached but was probably originally dolerite.

Yarrawolya Formation

The name Yarrawolya Formation is proposed for the poorly outcropping siltstone and fine-grained greyish-purple silty sandstone conformably overlying the Coomberarie Formation and unconformably overlain by Mesozoic/Tertiary beds probably equivalent to the Pindilya Formation. Boulders of quartz, quartzite, and chert on the surface near Muggon Woolshed probably derive from the Lyons Group, but they are regarded as having been reworked, and the Lyons Group has not been observed in contact with the Yarrawolya Formation.

The formation takes its name from Yarrawolya Pool (Lat.$26^{O}47\frac{3}{4}$'S, Long.$115^{O}33$'E) near the Yallalong-Muggon road, $3\frac{1}{2}$ miles south of the Muggon woolshed.

The contact of the Coomberarie with the Yarrawolya Formation may be observed about three miles west of south of Yarrawolya Pool immediately to the east of the prominent north-striking ridge of fine-grained quartz sandstone. Here the lithology changes from fine-grained light-grey quartz sandstone to fine brown silty micaceous sandstone and interbedded brown micaceous siltstone. The top of the Yarrawolya Formation is concealed under sand and Mesozoic/Tertiary rocks.

The Formation can be divided into two units, the lower of which is mainly siltstone and the upper fine-grained hematitic sandstone The lower unit is poorly exposed, but it is probably mainly siltstone, because siltstone is interbedded with the fine sandstone three miles west of south of Yarrawolya Pool, and is also present half a mile west of south of Yarrawolya Pool.

No single type section could be found, so five reference sections were measured where the rocks were best exposed, and a composite type section compiled.

Two sections were measured through the lower unit; the first of these is three miles west of south of Yarrawolya Pool at Lat.$26^{O}50\frac{1}{4}$'S, Long.$115^{O}32$'E (Appendix 1). Overlying the Coomberarie Formation is fine-grained brown micaceous sandstone and siltstone 140 feet thick. Stratigraphically above this is an estimated 100 feet of siltstone concealed by alluvium.

The second of the two sections through the lower unit is between two and three miles north of Newgulda Well (between Lat.$26^{O}52\frac{1}{2}$'S, Long.$115^{O}32\frac{1}{2}$'E. and Lat.$26^{O}51\frac{1}{2}$'S, Long.$115^{O}32\frac{1}{2}$'E), where 236 feet of brown fine-grained silty sandstone with, in places, interlaminated brown siltstone, was measured. Stratigraphically above this there is a striking change in the colour of the sandstone, which shows as a marked contrast in tone on the air photographs. The bed at which the change occurs can be followed for miles along the strike and this bed was taken as the base of the upper unit; the following sections were run through the upper unit.

Six and a half miles north-west of Comeback Well (Lat.26^{O} $49\frac{1}{2}$'S, Long.$115^{O}32\frac{3}{4}$'E), greyish purple to purplish brown fine-grained micaceous silty sandstone 226 feet thick was measured. The weathered sandstone is red brown and flaggy, and shows very well developed current lineations. This section was continued six miles north-west of Comeback Well (Lat.$26^{O}50$'S, Long.$115^{O}33$'S), where a thickness of 645 feet of grey to greyish purple fine-grained silty micaceous sandstone was recorded. Medium-scale cross-stratification is common.

Eighty feet of sandstone of similar lithology was measured a mile and a half south of east of Yarrawolya Pool (Lat.26°48'S, Long. 115°34'S), and this is stratigraphically the highest sequence of the formation; the top of this section is concealed by sand. The upper unit is 950 feet thick and the total thickness of the formation is 1,435 feet.

The Yarrawolya Formation forms the Badgeradda Range, a tract of rough country rising to about 1,000 feet above sea level in the northern part of the area investigated. The main part of the range extends from three miles south of Muggon Woolshed to about ten miles south, but scattered outcrops of the formation are found as far north as the woolshed itself. Two to three miles north-north-east of Comeback Well the Yarrawolya Formation forms the eastern limb of a north-plunging anticline subsidiary to the main syncline, and six miles north-north-west of the Errabiddy Hills are further outcrops of the Yarrawolya Formation dipping gently west.

The sediments of the Yarrawolya Formation are brown to purplish grey, in contrast to the underlying Coomberarie Formation, which is generally light grey to whitish. Much mica is present and the beds are in most places less than a foot thick; they tend to be flaggy and break away in large slabs. Current lineation is particularly well developed.

Sedimentary Structures in the Badgeradda Group

Cross-stratification: The terminology adopted is that suggested by McKee and Weir (1953). Cross-stratification, chiefly of the planar type, may be observed in the sandstones of the Nilling Beds and throughout the Badgeradda Group. Medium-scale cross-stratified sets up to two feet thick are present in the lower sandstone unit of the Bililly Formation; individual cross-strata are from half an inch to three inches thick. Cross-stratification is rarely seen in the upper part of the Bililly Formation, possibly because of the lack of good outcrops.

The Woodrarrung Sandstone is commonly cross-stratified and, where observed, the sets were planar, tabular, of medium scale, and from 1 to 4 feet thick. Individual cross-strata range in thickness from one-quarter to 3 inches and commonly are one-half to 2 inches thick.

Cross-stratification in the Coomberarie Formation is generally small-scale and of the planar type, that serves most usefully to indicate sequence in the steeply-dipping beds north-west of Newgulda Well. Medium-scale sets up to a foot thick are found in places both in the upper part of the Formation and in the section at Mt.Vinden. In the latter area there is probably some trough-type cross-stratification, but exposures are too poor to be sure.

Cross-stratification is common in the Yarrawolya Formation, predominantly of medium scale with sets up to a foot thick, and individual beds of one-half to one inch thick.

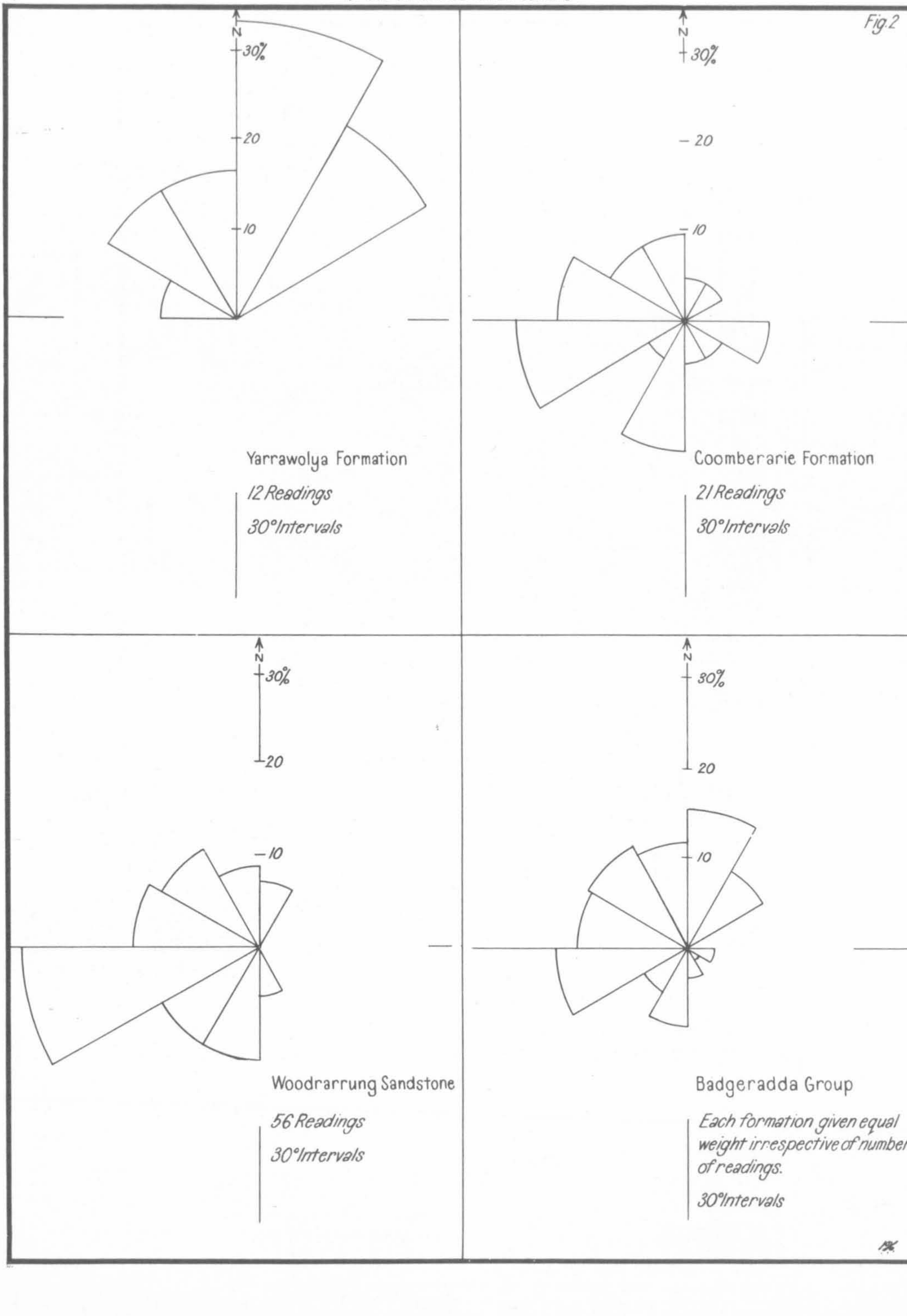
To evaluate the dip directions of the cross strata before the containing beds were folded, it was assumed that deformation had taken place only about horizontal axes. By plotting the poles of a cross-stratum and its containing dipping bed on a stereographic net and then, in effect, rotating the dipping bed back to the horizontal, the original direction and magnitude of the dip of the cross-stratum was found. M.A. Condon has suggested the term "foreset angle" for the magnitude of the dip of a cross-stratum relative to its containing bed.

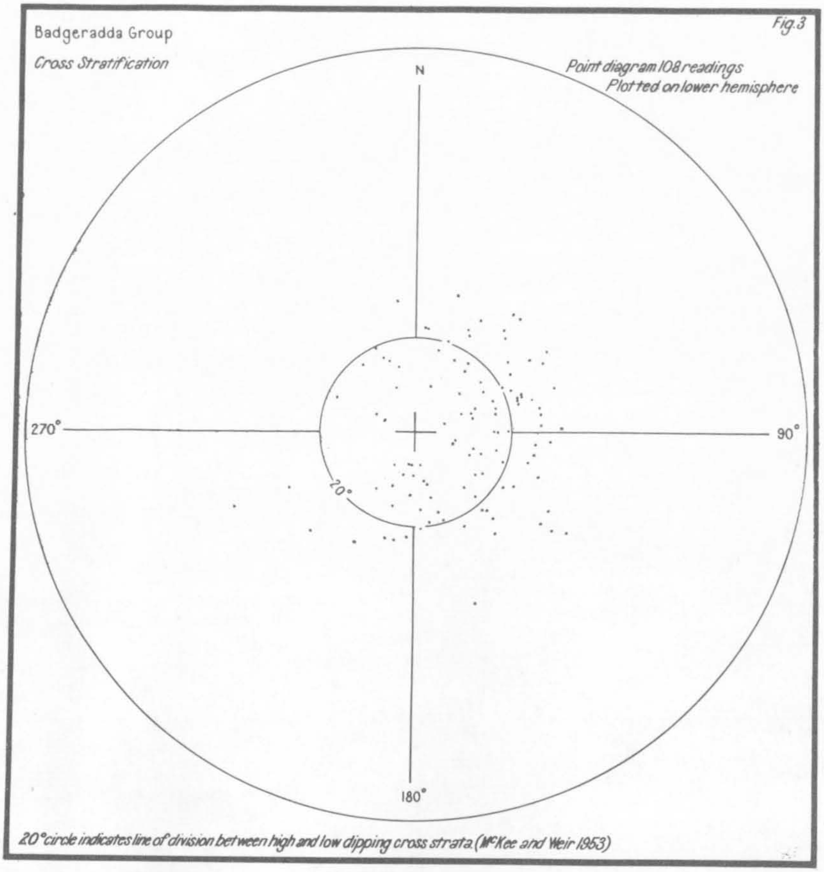
Circular histograms have been prepared for the Woodrarrung Sandstone, Coomberarie Formation, Yarrawolya Formation, and the Badgeradda Group as a whole (Text Figure 2). It may be concluded from these that, for the levels sampled, the currents responsible for the cross-stratification in the Woodrarrung Sandstone came mainly from the east; in the Coomberarie Formation they were more variable, though easterly components still predominate. During the deposition of the Yarrawolya Formation, however, currents from slightly west of south are dominant, and the distinctive lithology may be a reflection of this change of direction.

Of the 108 readings taken, slightly more than half had foreset angles less than 20 degrees; the distribution of readings is shown in the point diagram (Text Figure 3, page 18).

An effort was made to determine whether the differences in current direction inferred from cross-stratification could be related to position in the Badgeradda structure. Thus if the Precambrian rocks east and south-east of Deep Bore were exposed or at a shallow depth during deposition of the Woodrarrung Sandstone, it might be expected that current directions on either side of such a ridge would be significantly different. This possibility was tested, but no significant variation was found; at the time of deposition of the Woodrarrung sandstone relief in the basin floor was probably insufficient to cause changes in direction of the depositing currents. However, this conclusion must remain tentative, because of the small number of observations of cross-stratification in the area.

Cross Stratification Directions





Text Figure 3: Badgeradda Group: cross-stratification. 108 observations, plotted on lower hemisphere.

Ripple Mark: Ripple mark is not common in the Badgeradda Group but it is present in places in each of the formations of the Group.

Interference ripple marks have been noted in the lower sandstone unit of the Bililly Formation, but only on loose blocks of coarse sandstone. This type of ripple mark has also been recorded in the upper part of the Coomberarie Formation in fine sandstone, in fine slightly calcareous sandstone from the lower part of the Yarrawolya Formation, and in medium to coarse sandstone from the Errabiddy Sandstone.

Current ripple marks were observed at three localities in the upper part of the Coomberarie Formation. What is possibly very small scale oscillation ripple mark modified by rounding of original sharp crests was found at one place in the Coomberarie Formation south of Mt. Vinden (Plate 2, figure ii).

Kuenen and Sanders (1956) have pointed out that in shallow water both current ripples and wave (oscillation) ripples may form, but that wave ripple mark appears to be restricted to shallow depths, though current ripple mark may be produced by bottom currents in deep water. Interference ripple mark also may probably be formed in deep water by cross currents as well as in shallow water by wave and current action. On the other hand, Menard (1952) has described and figured approximately symmetrical ripple marks, thought to be caused by oscillation, from Sylvania Seamount in the northern Marshall Islands at a depth of 4,500 feet. Though Evans (1952, p.156) is of the opinion that "these must be extremely rare in indurated sediments", nevertheless it appears that for the present, type of ripple mark cannot alone be used as a reliable guide to depth of deposition.

Current Lineation: A structure that is here interpreted as current lineation (Stokes, 1947) is found in places in the upper Coomberarie Formation and in the lower part of the Yarrawolya Formation, where it is particularly well developed on the flat bedding-surfaces of fine-grained flaggy sandstone. It has the form of small ridges and troughs, each one in the main parallel to its neighbour; the distances between adjacent ridges from crest to crest range from 3 mm. to 5 mm., their height from trough to crest is approximately ½ mm., and the ridges range in length from about 7 cm. to 10 cm. Any particular ridge followed along its length may be seen to diminish in height and give place gradually to a trough. Some ridges and troughs have such minute relief that they may perhaps be better described as striations. The lineations are formed parallel to the current (see Stokes). Plate 3, Figure 1 shows current lineation on laminated fine-grained sandstone of the Yarrawolya Formation: on the earlier of the two visible laminae the marks have a trend differing by 15 degrees from that of the lineations on the overlying lamina, the thickness of which is 1 to 1½ mm., indicating a swing in direction of the depositing current during the time of formation of this layer.

An alternative interpretation of these lineations that was considered is that they are rill marks or back-wash marks (Thompson, 1937); however, as Shrock (op. cit.) has pointed out, the zone of rill marks on modern beaches is only a few feet wide, whereas about 1½ miles south of Junction Well the lineations can be followed along their strike for over 250 feet.

Stokes regards lineations as having originated in shallow water flowing smoothly at moderate velocity. Flaggy bedding is common in sandstones in which current lineation is developed.

Current Crescents: Current lineation is common in the gently dipping fine-grained sandstone of the Yarrawolya Formation about $4\frac{3}{4}$ miles south-east of Marloo Bore, but in addition crescentic or U-shaped grooves are associated with the lineation on certain bedding planes (Plate 4, Figure 1). The arms of each U are parallel to the lineation and are usually from 1 to 3 cm. apart and up to $\frac{1}{2}$ cm. deep.

The structures form under the same conditions as current lineation, and are thought to be due to obstruction of the smooth flow of water by clay or silt pellets now eroded. The laminar flow is locally checked and made turbulent, and sand is scoured from the front and sides of such pellets, the sand behind being protected and remaining as a ridge slightly above the bedding surface. The pellets tend to incline gently up-current since the sand supporting them at the front is removed.

Excellent casts of the crescents have been found on the undersurface of some beds in the same locality (Plate 4, Figure 2), and a rubber impression of one of these shows well the attitude of the base of the pellet (Plate 3, Figure 2).

For the lineations and crescents to have been preserved, the flow of water must have ceased after their formation, exposing the surface to the air, and allowing the fine sand to dry sufficiently to become firm before the next layer of sand was deposited.

The term "current crescents" has been used by Peabody (1947) for virtually identical structures found on mudflat surfaces in the Triassic rocks of Arizona. Shrock (1948, p.129) figures similar structures under the heading of rill marks.

Sole Markings: In places in the upper Coomberarie Formation and the lower Yarrawolya Formation there are small smooth protuberances on the lower surfaces of some beds; they are from two to four inches long and extend as much as two inches below the general bedding surface. Only very small areas of the marks were observed and in these there appeared to be no definite orientation. Some of the marks have contour-like ridges round them. These marks are interpreted as infillings of modified interference ripple marks probably exposed at low tide, at which time the contour-like grooves on the original surface were produced by erosion of the sides of the hollows between ripple ridges (Plate 5, Figure 1). The smooth protuberances may possibly be load casts (Kuenen and Prentice, 1957).

Flute casts (see Prentice, 1956, p.394) were observed in the Coomberarie Formation, but none was seen in position and no detailed study was made of their occurrence (Plate 6).

"<u>Slump Rolls</u>": Another sedimentary structure present in the upper Coomberarie and lower Yarrawolya Formations has roughly the form of a long gently tapering cone flat on one side, with its long axis parallel to the strike of the bedding (Plate 6). The flat side faces the top of the sequence. A cross-section of one such structure is shown in Plate 5, Figure ii. Dimensions at the larger end are 14 cm. across and 7.5 m. deep; overall length is about 76 cm. The silt layers between the two dark fine-grained sandstone beds are slumped, and the whole structure is overlain by a horizontal thin layer of grey silt and clay. Details of bedding in subjacent strata could not be observed.

The structure is interpreted as the infilling of an eroded channel in the underlying sediment before its consolidation. Soon after the channel was formed it was filled with fine sand and silt, and being somewhat hydroplastic the sides of the channel yielded and steepened, causing the roll-like form of the contained beds.

Probably there followed erosion and subsequent deposition of the overlying layer of grey silt.

From the evidence of cross-stratification and current lineations in associated beds, it was noted that one "slump roll" paralleled the current and tapered in the current direction, but it is not known if all do so. It was found also that in all slump rolls observed, the flat surface faced the top of the sequence, suggesting its formation by contemporaneous erosion.

<u>Environment of Deposition</u>

The metamorphosed Precambrian rocks formed the basement on which the younger sediments were laid down. The style of cross-stratification, that is, the absence of the usual criteria for the recognition of aeolian sandstones (Thompson, 1937, p.750), and the low index (height/amplitude) of ripple marks point to deposition under water. The presence of cross-stratification throughout the sequence and the absence of graded bedding indicates that deposition by traction currents was dominant, and the medium scale of cross-stratified sets and the occurrence of current lineation and current crescents suggests that water was shallow. Parts of the sequence, however, especially in the Coomberarie Formation, may have been deposited in deeper water.

As the sequence is 10,000 feet thick, the basement floor must have sagged as deposition went on, probably maintaining an epineritic or shallow infraneritic environment on the unstable shelf or intracratonic basin where deposition occurred. The change from coarse sandstone to siltstone in the Bililly Formation and again from sandstone in the Woodrarrung Sandstone to fine sandstone and siltstone in the Coomberarie Formation indicates that sinking was intermittent, or that there was some change in the relative elevations of deposition and sediment source areas. The dominant current directions from the east throughout Woodrarrung and Coomberarie time suggest that the location of the source remained essentially the same during this period, but the hematitic fine sandstone of the Yarrawolya Formation, with currents mainly from the south, is probable evidence of a source different in location and type at this time. Insufficient petrological work has been done to provide additional data that might help in indicating the provenance of the sediments.

Relationship of Badgeradda Group to Tumblagooda Sandstone and Yandanooka Group.

Both the Tumblagooda Sandstone and the Yandanooka Group were examined to see if they were related to the Badgeradda Group. The Badgeradda and Yandanooka Groups lack fossils and only tracks are known from the Tumblagooda Sandstone.

The Tumblagooda Sandstone is found in outcrop 60 miles south-west of the Badgeradda Group;it continues a considerable distance to the north under younger cover (McWhae, Playford, Lindner, Glenister and Balme, 1958, p.17), but how far it extends eastward under cover is unknown. The Tumblagooda Sandstone shows little resemblance to the Badgeradda Group, in part or as a whole; it is persistently more sandy and contains many conglomeratic bands which are absent from the Badgeradda sequence. The common reddish colour of the weathered Tumblagooda Sandstone is matched only in the Yarrawolya Formation. As the Tumblagooda has neither been intruded by dolerites nor affected by compression in the same way as the Badgeradda Group as a whole, it may be younger.

The Yandanooka Group (see McWhae et al, 1958, p.14), 160 miles to the south, also has little similarity to the Badgeradda Group;only in colour does the Yarrawolya Formation resemble some of the subdivisions of the Yandanooka Group. The Yandanooka Group contains andesitic volcanic detritus, which is absent in the Badgeradda area; it is similar to the Tumblagooda Sandstone in lacking dolerite intrusives and evidence of strong compression.

IGNEOUS ROCKS

The sediments of the Badgeradda Group are intruded by basic dykes and sills. A very leached sill more than 100 feet thick intrudes the Coomberarie Formation; it can be observed in places north of New-gulda Well as far as Butcher's Track, where it apparently terminates against a small north-west-trending reverse fault. About half a mile to the north-west is another sill about 100 feet wide and quarter of a mile long; it lies to the north of the fault, but it is unlikely to be a faulted continuation of the southern sill because movement on the fault is of the order of only ten feet in this vicinity. The intrusive nature of the sill may be observed three miles north-north-west of Newgulda Well, where there are minor transgressions of the igneous material across the bedding of the sandstone. Half a mile to the north, part of the sedimentary sequence is incorporated in the top of the sill. Though the igneous rock is very leached, the ophitic texture typical of dolerites is still recognisable in many places, and this, together with the general absence of quartz, serves to indicate the probable nature of the original rock.

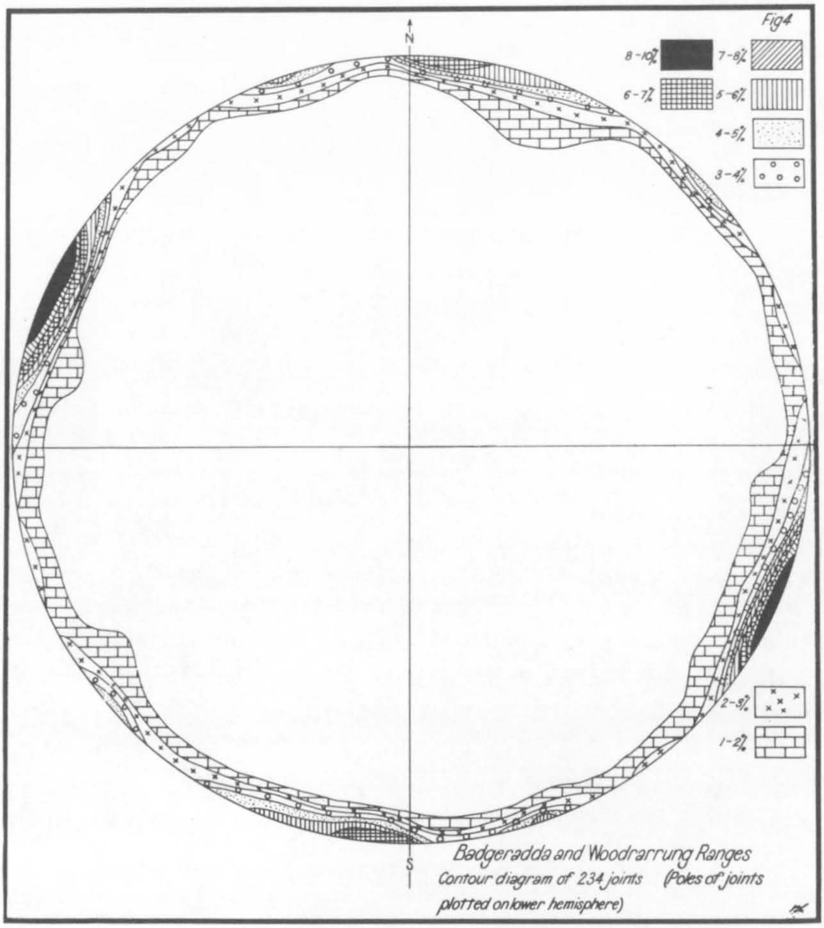
The sills were probably emplaced at the same time but along different bedding surfaces; it is not clear whether they preceded or post-dated the faulting, but possibly the latter, with the igneous material transgressing the bedding along the existing fault. The fault itself is younger than the main folding.

About one mile north of Coomberarie Well the Coomberarie Formation is also intruded by a vertical dyke trending 085 degrees and six miles long; it is about 100 feet wide and almost completely leached. A similar dyke of comparable size and the same trend intrudes the upper part of the Woodrarrung Sandstone; weathering of the dyke has produced a narrow straight trough across the southern end of the Woodrarrung Range. Five miles west of Deep Bore a fine-grained layer about two inches thick, representing a chilled margin, was seen on either side of the dyke. About 1,000 feet south of the eastern end of this dyke is a second parallel dyke about 100 feet wide; only a length of one-quarter mile has been mapped. As the dykes cut across the main structures, it is evident that they are younger than the major folding.

There is a suggestion in the air photos of a third dyke in the Woodrarrung Sandstone parallel to the first and about a mile to the north, but as the locality was not visited this has not been confirmed.

The dykes, which are assumed to be filled tension-joints, trend at 085 degrees. This is close to one of the main directions of jointing, 275° (Text Figure 4), which may therefore be a tension-joint direction. But in that case one of the compressional joint directions is poorly represented. If, on the other hand, the 275° joints and the 025° joints are both compressional it is not clear how the dykes are related to them, for the inferred theoretical maximum stress-direction would be the bisector of the acute angle between them, i.e. 60°. Tension joints would be expected to lie in this direction if they were related to the primary stress condition, or normal to it if they were the result of stress release.

It seems probable, however, that the maximum stress must have been normal to the Woodrarrung Fault (and to the fold axis of the Badgeradda Syncline) and thus a direction of about 280° is indicated for this stress. The observed joint pattern is difficult to relate to this direction.



Text-Figure 4: Badgeradda area: contour diagram of 234 joints; poles of joints plotted on lower hemisphere.

Two and a half miles north-north-west of Melia Well a possible dyke of leached basic igneous rock crops out, but neither its form nor its relationship to nearby sandstones is clear. A similar outcrop was seen one and a half miles west of the Errabiddy Hills.

Low hills about a mile north-east of Mt.Vinden have a striking red capping of pisolitic laterite 25 feet thick over quartz dolerite at least 75 feet thick; this rock is quite fresh-looking and is possibly a sill. Remnants of it are found in isolated outcrops to the north-west of Mt.Vinden. Neither the top nor the bottom of the dolerite has been seen, but its disposition in the field suggests that it has a dip to the north similar to that of the sandstones at Mt.Vinden.

PERMIAN

Lyons Group

The presence of Lyons Group sediments in the area is in most places inferred from the presence of boulders of heterogeneous rocks, including gneisses and granites. At only one outcrop, about 3½ miles east by north from Bompas Hill, was it possible to be sure that the sediments belonged to the Lyons Group. Here many pebbles and fewer cobbles and boulders are found in a fine to very coarse, very kaolinic sandstone, the whole being poorly sorted, roughly bedded, and massive when weathered; rounded quartz, silicified sandstone (quartzite), schist (similar to that found in the nearby Precambrian outcrop), and granitic and other igneous rock fragments of pebble to boulder size were observed. In addition, one silicified stromatolitic boulder was seen at this locality (Plate 2).

The tillitic nature of the sediments and the presence of the stromatolitic boulder and of a dropped boulder of quartzite are taken as evidence that these rocks belong to the Lyons Group. The stromatolitic boulder is of a type similar to that described by Clarke, Prendergast, Teichert and Fairbridge (1951, p.44) as erratics from the Irwin River area and from outcrop of the "Yandanooka Group"* near Gunyidi, 75 miles south of the Irwin River area. The dropped boulder has its long axis approximately vertical and the beds below it were broken by its impact.

About 1½ miles south-east of this outcrop, beds of horizontal and low dipping sandstone with angular pebbles, cobbles, and boulders of schist and silicified sandstones overlie Precambrian schists and igneous rocks (dolerites?) with an angular unconformity. The schist fragments are similar to those of the underlying Precambrian, and the silicified sandstones are similar to those outcropping in the Woodrarrung Range nine miles to the north-east. These beds probably belong to the Pindilya Formation or equivalents rather than to the Lyons Group.

In the discontinuous line of scarps (breakaways) extending northward from Bompas Hill to west of Wail Outcamp and Muggon Woolshed, no rocks were found that could be definitely assigned to the Lyons Group.

* Moora Group of Logan & Chase in McWhae et al.,(1958, p.12).

Boulders, comprising only quartz and silicified sandstones of the type found in the Woodrarrung Range, could be traced to the base of the younger formation which in this report is tentatively assigned to the Pindilya Formation. P.E. Playford (personal communication) has suggested that the siltstone and fine-grained sandstone near the base of these breakaways (see Table 3) may be assigned to the Holmwood Shale. We regard this as likely.

Pebbles and cobbles of many rock types are present in the spoil of Junction Well, near Muggon Woolshed. These include gneissic and granite rocks, and suggest that though they do not crop out rocks of the Lyons Group are at a shallow depth.

South-east from Junction Well to about 4 miles north-east of Coomberarie Well, and within the limbs of the Badgeradda Syncline, is a line of low breakaways up to ten feet high. These scarps are made up of flat-bedded coarse to very coarse-grained sandstone, in places very silty, with scattered cobbles and boulders of quartz and silicified sandstone. The beds unconformably overlie the Badgeradda Group, and no evidence was found to indicate that they represent the Lyons Group rather than the younger sediments referable to the Pindilya Formation. Remnants of similar sandstone are found on the east side of the main syncline and north of the Errabiddy Hills about 12 miles north-west of Meeberrie Homestead; here the younger formation appears to rest on a "billy" formed on the surface of beds of the Badgeradda Group.

MESOZOIC/TERTIARY

In the line of breakways trending north from near Bompas Hill, and in the low breakaways within the limbs of the Badgeradda Syncline, as well as in other scattered outcrops, flat-bedded siltstone and sandstone overlie the Badgeradda Group, and at least partly overlie the Lyons Group about 3½ miles east by north of Bompas Hill. These rocks have been referred to in the previous section. West of the Woodrarrung and Badgeradda Ranges they underlie the surface of the high-level plain. Two measured sections are shown in Table 3.

In its lithology and stratigraphical position, the sandstone unit found at the top of both these sections resembles the Pindilya Formation of the Callytharra Springs area and is provisionally referred to the Pindilya Formation (Konecki et al., 1958 p.55). Some reservation is held about this correlation because of the discontinuity of outcrop between the Badgeradda area and the Byro Plains/Callytharra Springs region.

TABLE 3

9½ miles	west-south-west of Muggon Woolshed; in descending order.	15 miles	south-west of Muggon Woolshed; in descending order.
	Top of scarp.		Top of scarp.
15 feet	silty SANDSTONE, unsorted, fine-grained with some coarse and very coarse grains; 3" bed at base with pebbles, cobbles and a few boulders of quartz and quartzite, also fragments of siltstone.	8 feet	white SANDSTONE, unsorted, medium to very coarse-grained, pebbly, kaolinic; beds 6 inches to 2 feet thick; pebbles are quartz, quartzite, vein quartz, and near base, pieces of underlying fine sandstone up to 5 inches across.
46 feet	micaceous SILTSTONE, purple, brown and grey at base becoming white towards top, beds 1" and thinner, flat-bedded, no pebbles observed.	26 feet	white SANDSTONE, fine-grained, micaceous, very kaolinic; laminated in places but mostly massive; hardened in top 2 to 3 inches.
5 feet	rubble and wash		
	Base of scarp		Base of scarp.

It is not certain what stratigraphical units are represented by the lower siltstones and sandstones in the above sections. Konecki et al. (1958, p.53) suggest that the Thirindine Formation and Permian or Lower Cretaceous rocks may be present; they collected, from a few localities along the Murchison River between Bompas Hill and Yandi Homestead, specimens of siltstone and claystone that contained small sub-spherical siliceous bodies thought to be radiolaria. If these sediments are radiolarites they may represent the Thirindine Formation; one specimen was considered to be a reconstituted radiolarite, and Konecki et al. conclude that whether the sediments have been reworked or not "the indications are that some Cretaceous sediments were deposited on the eastern side of the Ajana Precambrian inlier".

The presence of the fine-grained sandstone in the section 15 miles south-west of Muggon Woolshed suggests that there at least the Thirindine Formation, which contains no sand, is not present. The presence of a break below the top coarser sandstone unit in the breakaways west of the Woodrarrung and Badgeradda Ranges is evidence against including the whole sequence in the Pindilya Formation. We regard the suggestion made by Playford (mentioned previously), that the lower siltstones and sandstones may represent the Holmwood Shale, as the most likely.

TERTIARY/QUATERNARY

Sand

Red-brown sand covers a large part of the area investigated. The high-level plain is covered by sand possibly derived in place from weathering of the Mesozoic/Tertiary beds. In places, for example within the northern part of the main syncline, the sand has formed dunes, now fixed, trending generally north-west; but in most places the sand plain lacks dunes and has a gently rolling surface. South and south-west of Mt.Vinden, the Woodrarrung Sandstone is covered in places with dune sand. A creek draining west toward Wail Outcamp has eroded dunes north of Limestone Well, leaving hummocks of sand on the alluvial surface. Similar sand hummocks are found south-west of Yarrawolya Pool.

The sand dunes were probably formed during a climatic cycle more arid than the present one.

Alluvium

Alluvium is found along all the drainage channels and in extensive tracts of the low level plain, where it merges in places with areas of sand.

Wash

The term is used for gravel and scree that seems not to have have been transported very far from its source. Large areas of ferruginous pebble gravel are found in places, apparently deriving from the laterite that formed on the finer beds in the Bililly and Coomberarie Formations; similar gravel derives from the laterite on the quartz dolerite north of Mt.Vinden.

Old Alluvial Deposits

Scree fans are found in places along the scarp of the Woodrarrung Range and the east side of the Errabiddy Hills; these are being eroded by streams of the present cycle, and are thus pre-Recent. A ferruginous pisolitic horizon up to six inches thick was observed on one fan 3½ miles west-south-west of Newgulda Well.

In some places, for example about a mile south-east of Bililly Claypan, there are outcrops of what has been termed in the field "older alluvium". It consists of poorly bedded mottled red-brown and light brown firm to friable unsorted fine to coarse sandstone with a ferruginous pisolitic layer six inches thick at the top, which is probably an immature laterite. The same sort of material is common along the Murchison River east of the Ajana Precambrian inlier, where it is being eroded at present. Very similar formations elsewhere in the Carnarvon Basin have been equated with the Joolabroo Formation (Condon, 1954, p.122).

Travertine

Travertine is found in a long narrow zone between Wail outcamp and Brand's Well, and also south-west of Newgulda Well, and in isolated patches south of Deep Bore. At Wail outcamp it has probably been deposited from springs along the east side of the ridge of Woodrarrung Sandstone; numerous crystals of gypsum are associated with the travertine in this locality. The source of the calcium carbonate is not known, but possibly it derives from basic igneous rocks at depth. Five and a half miles north-west of Wail outcamp, low-grade metamorphic rocks adjacent to the dolerite are travertinized. The travertine south-west of Newgulda Well may be derived from the basic sill in the Coomberarie Formation.

Saline Deposits

The springs referred to above give rise to a white deposit on the sandstones along the creek immediately north of Wail outcamp, and nearby soil contains crystals of gypsum. A qualitative analysis of the white material * showed that major elements are sodium, potassium, and calcium, and major acid radicles chloride and sulphate; the salts are probably derived from within the sandstone itself by the action of the spring water.

SILICIFICATION

All the sediments are affected in some degree by surface silicification, apparently associated with weathering, though in most places examined a little searching revealed unaltered rocks. An exception to this was noted in the Woodrarrung Sandstone at the north end of the Woodrarrung Range, where the intense silicification, apparently related to the steepness of dip and proximity to the Woodrarrung Fault, completely obscures the bedding. The reason for differential silicification is not clear; perhaps it is related to minor compositional differences and related porosity variations; thus the presence of less kaolin in certain parts of a bed may render it more porous and so more susceptible to silicification. A good example of differential silicification was observed in the Coomberarie Formation just north of Butcher's Track where it crosses the formation on the west limb of the syncline; here there are pieces of sub-rounded silicified fine sandstone ranging from a few inches to more than a foot across, within a friable fine quartz sandstone, all apparently part of the same bed.

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* Salt Sample MB.45, near Wail Outcamp.

Major acid radicals: Cl^-, SO_4^{--}. Major elements: Na, K, Ca. Minor elements: Fe, Mg. Trace elements: Ba, Al, Pb, Bi. Acid radicals determined on portion of sample soluble in boiling water. Metals determined spectrographically.

LATERITE

Laterite in the area is best developed on the igneous and metamorphic rocks, especially on the fresh-looking quartz dolerite north of Mt.Vinden, and the dolerite north-west of Wail outcamp. A complete profile was observed on the dolerites and on gneiss to the south-west of Blue Mountain Well, but on the sediments in most places only a thin ferruginous pisolitic zone is present. This zone is found particularly on the fine-grained rocks, namely the siltstone and fine sandstone of the Coomberarie Formation, though it occurs also on the coarser sandstones. The ferruginous pisolites are being eroded at present, leaving large areas of ferruginous gravel, notably south and south-west of Coomberarie Well. As mentioned above, a pisolitic layer up to six inches thick was observed on the surface of an alluvial fan deriving from the Woodrarrung Sandstone west-south-west of Newgulda Well.

STRUCTURE

The major structure of the Badgeradda Group is the asymmetrical Badgeradda Syncline, 33 miles long, plunging north-north-east at about 3°. Flank dips on the east nowhere exceed 15° and in most places are of the order of 5° to 7°; the dip of the west flank, on the other hand, as shown in the Woodrarrung Sandstone, steepens progressively towards the north, and south-west of Yarrawolya Pool, for example, beds are vertical and in some places overturned. The west flank is remarkably straight, maintaining a northerly trend for 21 miles; 3 miles north-west of Newgulda Well the north trend changes gradually to north-north-east, and 3 miles south of Muggon Woolshed it gradually reverts to north. At the south end the dip is 4°, east of Bililly Claypan it is 15°, at Wail outcamp 30°, west of Malumbrara Well 60° and at the most northerly outcrop of the Woodrarrung Sandstone the beds are probably overturned. Immediately to the east in the Coomberarie Formation is a zone 2,000 feet wide in which beds are vertical or slightly overturned toward the east; this zone can be followed northward for about 6 miles, and the structure is thought to be due to a high-angle reverse fault, the Woodrarrung Fault, in which the west block has moved upward relative to the east block. Successively younger beds are involved in the faulting towards the north; for example, at Muggon Woolshed tank there is a zone 150 feet wide in the Yarrawolya Formation in which dips range from 70° to vertical.

The inferred position of the Woodrarrung Fault in the north of the area is to the west of, but close to, the outcrop of the Woodrarrung Sandstone and Yarrawolya Formation. Farther south, the fault is farther west of the Woodrarrung Range, as shown by the gradual decrease in dip of the competent part of the Woodrarrung Sandstone. Even south of Bililly Well, however, the fault has affected the soft siltstone and fine sandstone of the Bililly Formation.

The area contains other smaller structures in addition to the main syncline. North of Comeback Well there is a minor anticline in the Yarrawolya Formation and probably also in the underlying Coomberarie Formation; it dies out to the south. The small folds in the Woodrarrung Sandstone north-east of Deep Bore cannot be followed farther north. Fine whitish sandstone, four miles north-north-west of Melia Well, dips consistently to the east at 10° to 30°; it may be the equivalent of the upper part of the Woodrarrung Sandstone, but its thickness estimated by dip and distance measurement on the air photographs is too great for direct equivalent. Possibly there is a cross-fold in this locality and the fine whitish sandstone is equivalent to part of the Coomberarie Formation in the core of a syncline plunging to the south-east.

Along the eastern margin of the sediments, particularly near the Errabiddy Hills, there are several truncated anticlines; these trend and plunge generally west. In places along the contact of the sediments with the older Precambrian the sandstone is brecciated; nine and a quarter miles north-west of Meeberrie Homestead there is a zone of breccia about 400 feet wide, and 60 feet to the east is older Precambrian schist. In thin section the breccia can be seen to be made up of angular fragments of sandstone in which individual grains are cemented in part by authigenic silica; fragments are broken across the grains of the original rock. The anticlinal structures and associated breccia are thought to result from a normal fault; the mechanism of formation of the anticlines is not clear, but it may be related to drag of the downthrown block along a sinuous fault surface (Wheeler, 1939).

North-west of the Errabiddy Hills is a low ridge with Woodrarrung-type sandstone on the east; to the west there is no outcrop in the immediate vicinity, but half a mile to the north-west and also to the south-west are scattered outcrops of fine and medium-grained sandstone. These may belong to the Coomberarie Formation or to the Woodrarrung Sandstone; they are shown as the latter on the cross-section (Plate 1), but as few dips could be found it is not possible to be sure. In either case part of the sequence is missing and this is thought to be due to a normal fault, which is marked by the ridge.

Three and a half miles south of Yarrawolya Pool a small reverse fault trends north-west; it shows up prominently on the air photographs. It disrupts the lowest beds of the Yarrawolya Formation;

the maximum throw is about ten feet with the north-east block up relative to the south-west block. The trend of the fault can be traced in the air photographs to an anticlinal fold two miles north-east of Comeback Well.

Small-scale faulting has been observed in several places in the Coomberarie Formation, particularly one and a half miles east-north-east of Malumbrara Well, where it is associated with probable disharmonic folding referred to below.

The jointing observed in the area is considered to be later than or related to the folding; few joints are curved, as they would be if they were older than the folding. Distribution of joints is shown in the contour diagram (Figure 4). Most of the joints recorded have relatively plane surfaces that cut across well developed cross-stratification without deviation, and are considered to be shear joints, but others are somewhat irregular in trend and have rough surfaces and are probably tension joints. A few joints show slickensided surfaces. All joints dip steeply, and the most prominent maximum (8% to 10% of all joints) lies between 020° and 030°, with a secondary maximum at 275°. Minor folding within the Badgeradda Syncline is gentle in the competent beds, but the incompetent layers are affected quite strongly in places, and this difference is attributed to disharmonic folding produced by compression.

The upper part of the Bililly Formation in places shows small-scale, probably disharmonic, folding, particularly five miles north of Pooten Well; white fine-grained micaceous sandstone is folded into small anticlines and synclines with axes about ten feet apart, and limbs dipping at 25 to 40 degrees; the more competent Woodrarrung Sandstone is little affected.

Associated with the base of the Woodrarrung Sandstone along the west side of the Woodrarrung Range are a small number of small folds; 5½ miles north of Wail Outcamp small overturned anticlinal folds are formed in the topmost beds of the Bililly Formation. The basal beds of the Woodrarrung are involved in the folding but dip less steeply. A mile and a quarter south-east of Bililly Well there is a small asymmetrical anticline at the base of the Woodrarrung Sandstone; exposures of the Bililly Formation are poor, but the beds appear to be dipping more steeply than the Woodrarrung Sandstone a short distance away.

Several small folds occur in the Coomberarie Formation about one and a half miles east-north-east of Malumbrara Well; their axes trend generally north and are of the order of ten feet apart; minor faulting has disrupted them in places.

Small-scale folding and faulting in the Coomberarie Formation was observed three-quarters of a mile north of Yallawoondiara Well. The measured directions of fold axes ranged from 330° to 030°; the rocks are disrupted by minor faults, including reverse faults, and intruded by a dolerite dyke.

As the sediments were laid down in shallow water it is evident that the basin floor must have sunk as sedimentation progressed. At the end of deposition of the Yarrawolya Formation the basin may have filled up. Either in the final stages of deposition or later, strong compression from the west folded the sediments, causing asymmetry of the west limb of the main syncline and finally high-angle thrusting oblique to the west limb, with resultant truncation of the western edges of the Woodrarrung Sandstone and the Coomberarie and Yarrawolya Formations. Probably complementary to this east-west compression was the formation of east-trending joints along which quartz dolerite dykes were intruded into the Badgeradda Group rocks.

Epeirogenic uplift probably followed, with subsequent normal faulting, giving rise along the present eastern margin of the sediments to the truncated anticlines with sandstone breccia along the contact with the older Precambrian. At about the same time another normal fault developed just west of the present Errabiddy Hills, dropping the west side down, and causing omission of about 500 feet of the sequence, probably mainly of the Bililly Formation.

The regional gravity (Bouguer anomaly) map of the area (south-east Carnarvon Basin, G98.37) poses a number of problems. In the axial region of the Badgeradda Syncline, east of Wail outcamp, where at least 2,000 feet of sediments and a corresponding negative anomaly might be expected, there is a positive anomaly of 17 milligals. Moreover about twelve miles to the west of the Syncline in an area of sand plain there is a negative anomaly of 45 milligals.

Between 5½ and 12 miles west of Wail outcamp a steep gravity gradient forms a linear zone trending north, indicating a large change in density over a short distance, probably the expression of a fault. This zone of steep gradient is on the line of the Darling Fault zone, and the anomaly is of the same character as on that structure.

The Precambrian rocks to the west of the Badgeradda Syncline do not produce a recognisable anomaly; they have been described as sericite schists and are regarded as metamorphosed sediments of relatively low density. M.A. Condon (personal communication) has suggested that these rocks may be part of the Badgeradda sequence affected by dynamic metamorphism brought about by compression.

‿rarrung Fault does not show on the regional gravity map, perhaps because only a few widely spaced readings were taken across the line of the fault.

ECONOMIC GEOLOGY

Oil Possibilities

No evidence of organic remains has been observed in the Badgeradda Group and it cannot therefore be favourably regarded as a potential source of oil. The age of the Group is not known, but it is tentatively put at Upper Proterozoic to Lower Palaeozoic. It seems unlikely, from present knowledge of the stratigraphy of adjoining areas, that oil could have migrated into the Badgeradda Group for two reasons: earlier rocks are not likely to have been oil-bearing; and later rocks would have to be downfaulted into a suitable structural position before oil could migrate, a condition of which there is as yet no evidence. In any case no structural traps have been found, although stratigraphic traps may be present.

Water

Ground-water and sub-artesian water, mostly of stock quality, are available from shallow wells and bores in the sediments of the Badgeradda Group and in the older Precambrian rocks. Little can be said about water-bearing horizons, as no bore or well logs are available, but from the evidence of existing wells it seems that ground-water can be obtained at a shallow depth almost anywhere in the sedimentary rocks, and that though suitable for sheep, it is likely in most wells to be too saline for human consumption.

Building Stone

Flaggy fine-grained sandstone from the Yarrawolya Formation has been used at Yallalong and Muggon Stations as a building stone; it is particularly well suited for paving, as large quantities of the stone are available in flags one and a half to two inches thick, up to eighteen inches wide and two to three feet long, though more blocky sandstone is also available. Material used to date came from a locality approximately half a mile south of Yarrawolya Pool.

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APPENDIX

BILILLY FORMATION

Thickness above base (feet)	Thickness (feet)	Type section, lower part (Bub) 2½ miles north-west of Pooten Well; Lat. 27°12½'S., Long. 115°31½'E.
		Concealed;
388	11	light grey, fine to medium-grained, feldspathic SANDSTONE; coarse quartz grains and pellet impressions in places;
377	48	concealed;
329	6	light grey, coarse, kaolinic SANDSTONE; friable;
328	53	white to light grey, fine to medium-grained kaolinic SANDSTONE; friable, with mica flakes and feldspar grains;
270	20	concealed;
250	24	white to light grey, medium-grained, kaolinic SANDSTONE; coarse quartz grains and a few quartz pebbles in places, mica flakes on bedding surfaces, cross-stratified;
226	38	white to light grey, fine to medium-grained, kaolinic SANDSTONE; beds 4 to 12 inches thick, few coarse grains and mica flakes in places;
188	66	white to light grey, medium to coarse-grained, kaolinic SANDSTONE; friable, few feldspar grains, cross-stratified;
122	20	concealed;
102	10	white to light grey, coarse-grained SANDSTONE; lenses of fine quartz conglomerate in places, with scattered feldspar grains;
92	11	concealed;
81	6	white to light grey, coarse-grained SANDSTONE; beds 6 to 12 inches thick;
75	27	concealed;
48	32	light brown, medium to coarse-grained silty SANDSTONE; beds 6 to 18 inches thick, with few very coarse quartz grains well-rounded, firm friable;
	16	concealed.
	388 feet	

WOODRARRUNG SANDSTONE

Thickness above base (feet)	Thickness (feet)	Type section, lower part (Buw), 5 miles north of Pooten Well, Lat. 27°10'S, Long. 115°33¾'E., in descending order.
424	23	light grey, coarse to very coarse-grained SANDSTONE; small quartz pebbles in places, surface of sandstone silicified;
401	134	light grey, mainly coarse-grained feldspathic SANDSTONE; beds 2 to 4 feet thick, cross-stratified, poorly outcropping;
267	113	light grey, coarse-grained feldspathic SANDSTONE; beds 2 to 4 feet thick, very coarse quartz granules in places, cross-stratified;
154	114	light grey, medium to coarse-grained SANDSTONE; beds 1 to 2 feet thick, with feldspar grains, in places cross-stratified;
40	10	light brown, medium to coarse-grained micaceous SANDSTONE; beds 2 to 3 inches thick;
30	16	concealed;
	14	light brown, coarse-grained micaceous SANDSTONE; friable with reddish pellets of SILTSTONE overlying brown, fine-grained, very micaceous, silty SANDSTONE of the Bililly Formation.
	424 feet	

Thickness above base (feet)	Thickness (feet)	Type section, upper part (Buw 2), 5 miles south-west of Diamond Well, Lat. 27°06½'S., Long. 115°37'E., in descending order.
		Concealed;
1100	35	white, medium-grained, kaolinic SANDSTONE; beds 9 to 12 inches thick, friable, cross-stratified;
1065	65	light brown, fine to medium-grained, kaolinic, silty SANDSTONE; beds up to 12 inches thick;
1000	545	light brown, fine to medium-grained, kaolinic, silty SANDSTONE;
455	285	light brown, fine to medium-grained, kaolinic, silty SANDSTONE; beds up to 2 feet thick, friable, with mica flakes in places, cross-stratified;
170	45	light brown, fine to medium-grained, kaolinic, silty, SANDSTONE; beds up to 3 feet thick, friable, cross-stratified, with mica flakes in places;
125	95	white to light brown, fine-grained, kaolinic SANDSTONE; cross-stratified, fresh material friable, weathered surfaces silicified;
30	15	white, fine-grained, silty SANDSTONE; beds up to 12 inches thick, friable, few weathered feldspar grains;
	15	white, fine-grained, SANDSTONE; beds one-half to 2 inches, with weathered feldspar grains, and mica flakes on bedding surfaces;
		concealed.
	1100 feet	

WOODRARRUNG SANDSTONE

Section of lower unit one mile north-west of Deep Bore, Lat.27°09¾'S, Long.115°38¾'E.

Thickness above base (feet)	Thickness (feet)	
525	86	light grey, coarse-grained SANDSTONE, poorly outcropping, mainly rubble;
439	49	light grey, coarse-grained, feldspathic SANDSTONE; with small quartz pebbles;
390	223	light grey to light brown, coarse-grained, feldspathic SANDSTONE; beds 4 to 6 feet thick, with very coarse quartz granules in places and mica flakes on bedding surfaces, cross-stratified;
167	27	light grey, medium to coarse-grained, feldspathic SANDSTONE; well jointed;
140	26	light grey, coarse-grained SANDSTONE, with interbedded medium-grained, feldspathic SANDSTONE; beds up to 3 feet thick, mica flakes abundant on bedding surfaces;
114	42	light grey, coarse-grained SANDSTONE; cross-stratified;
72	6	white to light grey, medium to coarse-grained SANDSTONE;
66	55	concealed;
11	4	light grey, medium-grained, micaceous SANDSTONE;
	7	light grey, fine to medium-grained micaceous SANDSTONE; ferruginous in places and containing pellets of siltstone from underlying Bililly Formation.
	525 feet	

Section of lower unit equivalent, 9 miles east of Mt.Vinden, Lat.27°00'S, Long. 115°48'E, in descending order.

704	20	scattered outcrop, fine-grained SANDSTONE with some coarse and very coarse-grained SANDSTONE;
684	50	scattered outcrop, fine-grained SANDSTONE with some medium-grained SANDSTONE;
634	54	scattered outcrop, fine-grained SANDSTONE; beds 2 to 6 inches thick with few weathered feldspar grains;
580	64	light grey, fine to medium-grained SANDSTONE with weathered feldspar grains, cross-stratified;
516	22	concealed;
494	101	white to grey, medium to coarse-grained SANDSTONE;
393	10	white to grey, coarse-grained SANDSTONE
383	319	white to grey, coarse to very coarse-grained SANDSTONE below, grading into medium to coarse-grained SANDSTONE above; beds up to 10 feet thick;
	64	concealed, scree slope.
	704 feet	

WOODRARRUNG SANDSTONE

Thickness above base (feet)	Thickness (feet)	Section 3 miles north-west of Newgulda Well, Lat. 26°52½S, Long. 115°30'E, in descending order.
		Concealed;
1989	3	white to grey, fine to medium-grained SANDSTONE;
1986	36	concealed;
1950	307	white to grey, fine to medium-grained SANDSTONE; little feldspar;
1643	209	scattered outcrop, fine to medium-grained feldspathic SANDSTONE;
1434	199	scattered outcrop, fine to medium-grained with minor coarse-grained SANDSTONE; beds up to 20 feet thick;
1235	91	white to grey fine to medium-grained SANDSTONE; with a few quartz pebbles up to ¾ inch across;
1144	10	white to grey fine to medium-grained SANDSTONE;
1134	336	white to grey, medium to coarse-grained SANDSTONE with many weathered feldspar grains;
798	204	white to grey, fine to medium-grained SANDSTONE, with some coarse and very coarse quartz grains;
594	449	scattered outcrop, mainly fine-grained SANDSTONE;
145	5	fine-grained silicified SANDSTONE;
140	61	concealed;
	79	white to reddish white, fine-grained SANDSTONE; beds up to 10 feet thick, friable, with feldspar grains;
		lower contact concealed.
	1989 feet	

ERRABIDDY SANDSTONE

Type section, 10 miles north-west of Meeberrie Homestead, Lat. 26°52½'S, Long. 115°50½E., in descending order.

479	209	light grey medium to coarse-grained feldspathic SANDSTONE; white mica flakes in places, cross-stratified, silicified on the surface in places;
270	86	light grey coarse-grained feldspathic SANDSTONE; quartz granules up to 4 mm. in places, cross-stratified;
184	67	light grey, medium to coarse-grained feldspathic SANDSTONE; beds mostly 3 to 4 feet thick, some beds 1 to 4 inches thick, cross-stratified in places;
117	59	light grey-brown medium to coarse-grained feldspathic SANDSTONE; bedding poorly developed, firm-friable to friable;
58	24	light brown, medium-grained with many coarse grains, silty feldspathic SANDSTONE; beds 6 to 18 inches thick;
	34	concealed;
		base of ERRABIDDY SANDSTONE overlying light grey-brown medium to coarse-grained QUARTZ GREYWACKE.
	479 feet	

COOMBERARIE FORMATION

Thickness above base (feet)	Thickness (feet)	Composite type section, 3 miles north-north-west of Newgulda Well, between Lat. 26°52'S, Long.115°30'E., and Lat.26°52'S, Long.115°31½'E., in descending order.
		Light brown micaceous SILTSTONE and brown fine-grained micaceous silty SANDSTONE of the YARRAWOLYA Formation above;
6925	35	concealed;
6890	27	light grey, fine-grained SANDSTONE; beds 4 to 6 inches thick, silicified;
6865	115	concealed at line of section, dolerite sill along strike to south;
6750	130	pale brown fine-grained micaceous silty SANDSTONE; beds half to 2 inches;
6620	390	concealed;
6230	330	light grey fine-grained SANDSTONE; beds up to 2 feet thick in places, poorly exposed;
5900	180	white, fine to medium-grained SANDSTONE; firm-friable;
5720	45	light grey, fine-grained micaceous SANDSTONE; beds up to 2 inches thick;
5675	295	light grey fine-grained SANDSTONE; beds up to 4 inches thick;
5380	135	concealed;
5245	590	light grey fine-grained micaceous kaolinic SANDSTONE;
4655	525	concealed;
4130	170	white, fine-grained micaceous kaolinic SANDSTONE, beds 1 to 5 inches thick; and subordinate interbedded white micaceous SILTSTONE;
3960	115	concealed;
3845	665	white, fine-grained micaceous silty SANDSTONE and interbedded white micaceous sandy SILTSTONE poorly exposed;
3180	120	concealed;
3060	30	cream micaceous SILTSTONE; beds 1 to 4 inches thick;
3030	1090	concealed;
1940	50	white fine-grained kaolinic SANDSTONE; beds up to 6 inches thick;
1890	120	concealed;
1770	30	white fine-grained, micaceous, kaolinic SANDSTONE; cross-stratified;
1740	380	concealed;
1360	50	white fine-grained micaceous SANDSTONE; beds 1 to 2 inches thick, with SILTSTONE in places;
1310	290	concealed;
1020	60	light grey fine-grained SANDSTONE; beds 2 to 3 inches thick;
960	890	concealed;
	70	white kaolinic SANDSTONE; beds up to ½ inch thick; base concealed, WOODRARRUNG SANDSTONE below.
	6925 feet	

COOMBERARIE FORMATION

Thickness above base (feet)	Thickness (feet)	Partial section, Mt.Vinden, Lat.27°01'S., Long.115°40'E., in descending order.
		Concealed;
475	55	grey to light brown, fine-grained, micaceous, silty SANDSTONE, beds up to 6 inches thick, and interbedded grey to light brown fine-grained micaceous SANDSTONE, beds up to 18 inches thick, with weathered feldspar grains;
420	222	concealed, sandstone scree;
198	56	grey, fine-grained, micaceous, silty SANDSTONE; beds 2 to 4 inches thick, probably with partings of SILTSTONE;
142	35	grey with purple tinge, fine-grained SANDSTONE and interbedded grey SILTSTONE;
107	37	grey, fine-grained, silty, micaceous SANDSTONE, cross-stratified, and interbedded micaceous SILTSTONE;
	70	brown, fine-grained, silty SANDSTONE; beds 2 to 12 inches thick, friable, cross-stratified in places;
		base concealed;
	475 feet	

Thickness above base (feet)	Thickness (feet)	Partial section, half mile south-west of Yarrawolya Pool, Lat.26°48'S, Long. 115°32'E, in descending order.
2189	56	White fine-grained SANDSTONE; beds half to 2 inches thick, cross-stratified, little mica and silt matrix;
2133	238	white, grey and brown SILTSTONE; beds up to 2 feet thick, with subordinate fine-grained SANDSTONE increasing towards top;
1895	68	mainly white fine-grained SANDSTONE, with minor SILTSTONE;
1827	41	mainly white fine-grained SANDSTONE, silicified
1786	969	white to greenish-white SILTSTONE; and very fine to fine-grained silty micaceous SANDSTONE; beds half to 2 inches thick;
817	168	concealed
649	171	white and grey micaceous SILTSTONE and silty SANDSTONE; interbedded, beds half to 2 inches thick;
478	40	mainly concealed, but some leached igneous material, probably dolerite sill;
438	300	white micaceous silty SANDSTONE; beds half to 2 inches thick, friable, with minor SILTSTONE;
	138	white fine-grained quartz SANDSTONE interbedded with micaceous sandy SILTSTONE and silty SANDSTONE; beds up to 2 feet thick, silicified in places;
		base concealed;
	2189 feet	

YARRAWOLYA FORMATION

Thickness above base (feet)	Thickness (feet)	Composite type section, 1½ miles south of east of Yarrawolya Pool, Lat.26°48'S, Long.115°34'E, in descending order.
		Concealed by sand;
1435	80	greyish purple fine-grained silty micaceous SANDSTONE; beds up to 18 inches thick, with current lineations.
		6 miles north-west of Comeback Well, Lat.26°50'S, Long.115°33'S.
1355	5	Light grey, fine-grained, silicified SANDSTONE;
1350	15	light grey, fine-grained, micaceous, kaolinic SANDSTONE; beds up to 4 inches thick;
1335	171	grey to greyish purple, fine-grained micaceous silty SANDSTONE; beds 4 to 18 inches thick;
1164	280	greyish purple, fine-grained micaceous silty SANDSTONE; beds 2 to 4 inches thick, firm-friable, cross-stratified;
884	93	greyish purple, fine-grained, micaceous silty SANDSTONE; beds up to 18 inches thick;
791	59	greyish purple fine-grained, micaceous silty SANDSTONE; beds 2 to 4 inches thick, friable, cross-stratified;
732	22	greyish purple fine-grained micaceous silty SANDSTONE; beds 1 to 3 feet thick, friable.
		6½ miles north-west of Comeback Well, Lat.26°49½'S, Long.115°32¾'E.
710	33	Greyish purple fine-grained micaceous silty SANDSTONE; beds 6 to 12 inches thick;
677	21	concealed;
656	134	pale brown to purple brown, fine-grained micaceous silty SANDSTONE; beds up to 12 inches thick, current lineations in places;
522	15	concealed;
507	23	grey to brown fine-grained micaceous silty SANDSTONE; beds up to 2 inches thick, grades in places into SILTSTONE (base of upper unit).
		Between 2 and 3 miles north of Newgulda Well, between Lat.26°52½'S, Long.115°32½'E, and Lat.26°51½'S, Long.115°32½'E.
		(top of lower unit)
484	138	Brown, fine to very fine-grained, micaceous, silty SANDSTONE; beds 2 to 3 inches thick, interference ripple mark, and small slump structures in places;

Thickness above base (feet)	Thick-ness (feet)	
346	21	brown fine-grained, micaceous, silty SANDSTONE, beds up to 6 inches thick; and interbedded brown SILTSTONE, beds 1/16 to 1/8 inch thick;
325	77	brown fine-grained, micaceous silty SANDSTONE; beds one-quarter to 4 inches thick, some beds slightly calcareous, small slump structures in places.

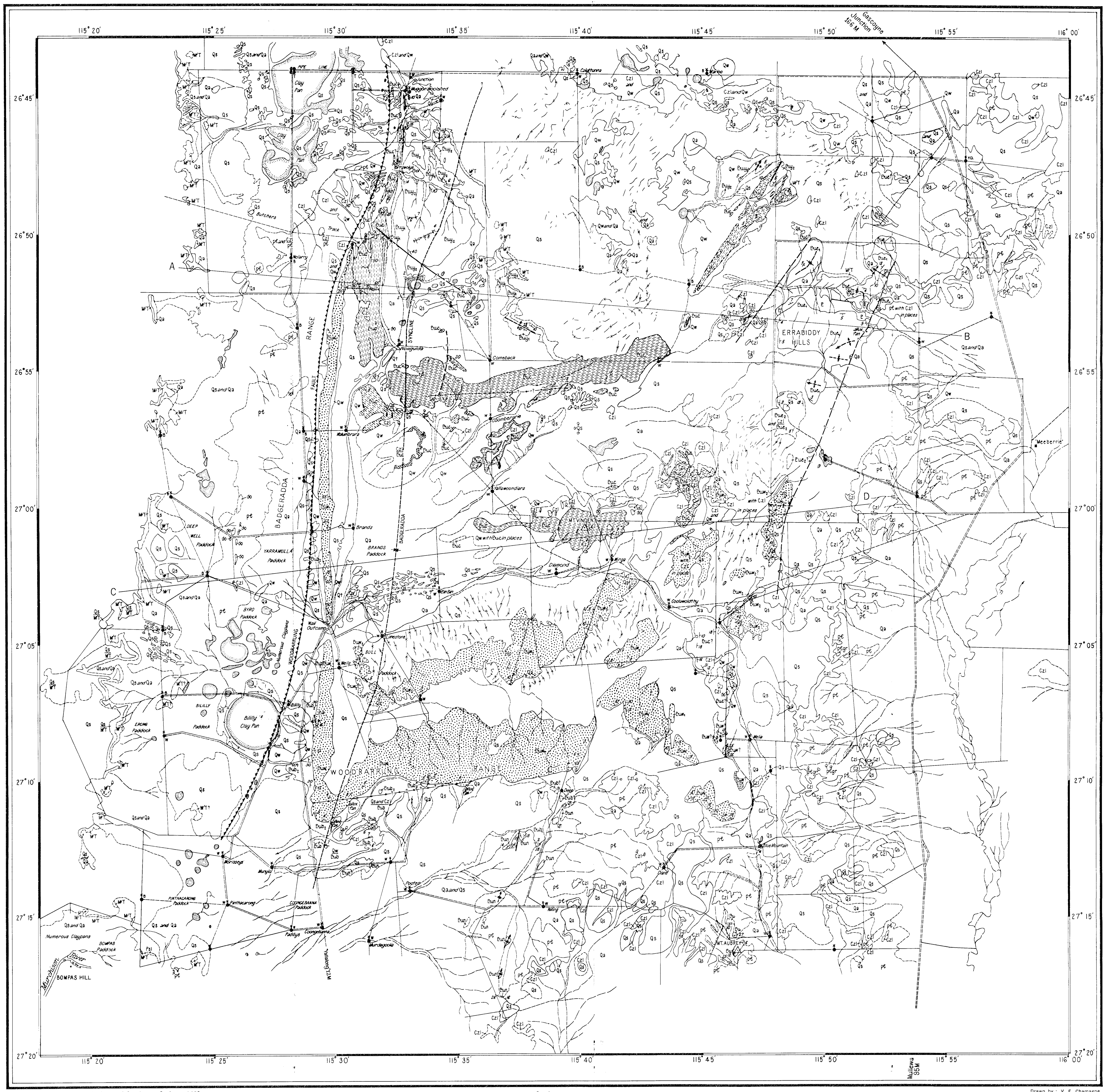
3 miles west of south of Yarragwolya Pool, Lat.26°50¼'S., Long.115°32'E., in descending order.

248	100 (Approx.)	Concealed, probably siltstone;
148	68	light brown, fine-grained, micaceous, silty SANDSTONE; beds up to 3 inches thick;
80	39	concealed;
	41	light brown, micaceous SILTSTONE; beds 1 inch thick, and brown, fine-grained, micaceous, silty SANDSTONE; beds 2 inches thick. Base concealed, light grey fine-grained SANDSTONE of the COOMBERARIE FORMATION below.

1435 feet

GEOLOGICAL MAP OF BADGERADDA AREA

WESTERN AUSTRALIA



Bureau of Mineral Resources, Geology and Geophysics, Canberra, 1959

Scale

2 Miles to 1 inch

Drawn by : V. F. Charnagne

Reference

CAINOZOIC		Qs	Sand
		Qa	Alluvium
		Qw	Wash
		Qt	Travertine
	Disconformity		
		Czl	Laterite
MESOZOIC / TERTIARY		M/T	Probable equivalents of Pindilya Formation
	Unconformity		
PALAEOZOIC	Lyons Group	Psl	Siltstone and sandstone, with tillitic texture
	Unconformity		
UPPER PROTEROZOIC / LOWER PALAEOZOIC		do	Basic igneous dykes, sills, flows?
	Badgeradda Group: Yarrawolya Formation	Ɛuy₂ / Ɛuy₁	Upper silty sandstone / Lower siltstone and sandstone
	Coomberarie Formation	Ɛuc	Silty sandstone, siltstone
	Woodrarrung Sandstone	Ɛuw₂ / Ɛuw₁	Upper kaolinic sandstone, thin bedded / Lower quartz sandstone, thick bedded
	Errabiddy Sandstone	Ɛue₂ / Ɛue₁	Kaolinic sandstone / Feldspathic quartz sandstone
	Bililly Formation	Ɛub₂ / Ɛub₁	Upper silty sandstone, siltstone / Lower quartz sandstone
	Disconformity		
		Ɛ	Quartz greywacke, siltstone
	Probable Unconformity		
	Nilling Beds	Ɛun	Sandstone, quartz greywacke
		Ɛu	Undivided sandstones equivalent either to the Nilling Beds or part of the Badgeradda Group
	Unconformity		
PRECAMBRIAN		p€gr	Gneissic granite
		p€	Mainly schist and gneiss, some phyllite

Geological boundaries
- Established boundary, position accurate
- Established boundary, position approximate

Strike and dip of strata
- 12 Inclined
- Vertical
- 80 Overturned
- Horizontal

Folds
- Established anticlinal crest - position approximate
- Established synclinal trough - position approximate

(Showing direction of plunge)

Faults
- Established fault - position accurate
- Established fault - position approximate
- Established fault - concealed
- Inferred, probable or indefinite fault
- Reverse fault - concealed
- Type section
- Sand dune
- Dolerite dyke
- Tank
- Bore
- Well

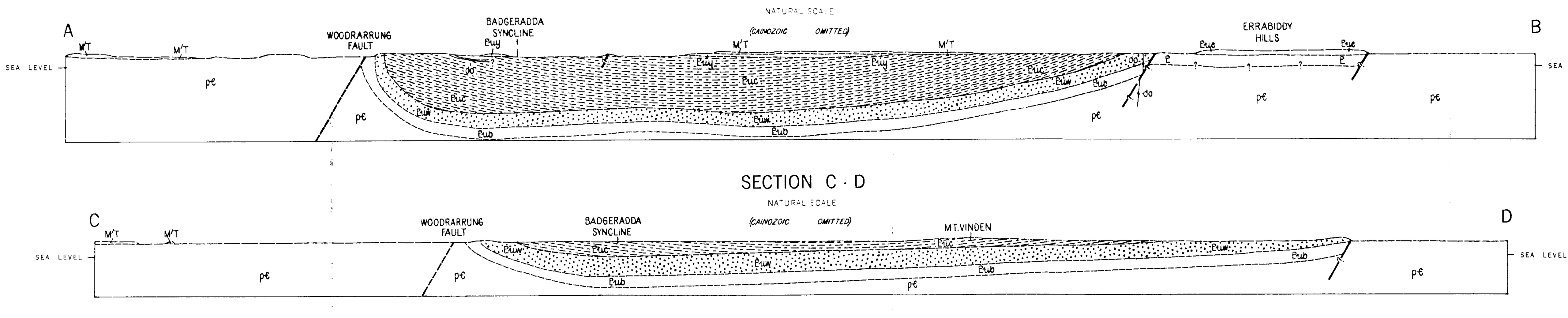
with wind pump
- Road
- Vehicle track
- Fence
- Homestead

SECTION A - B

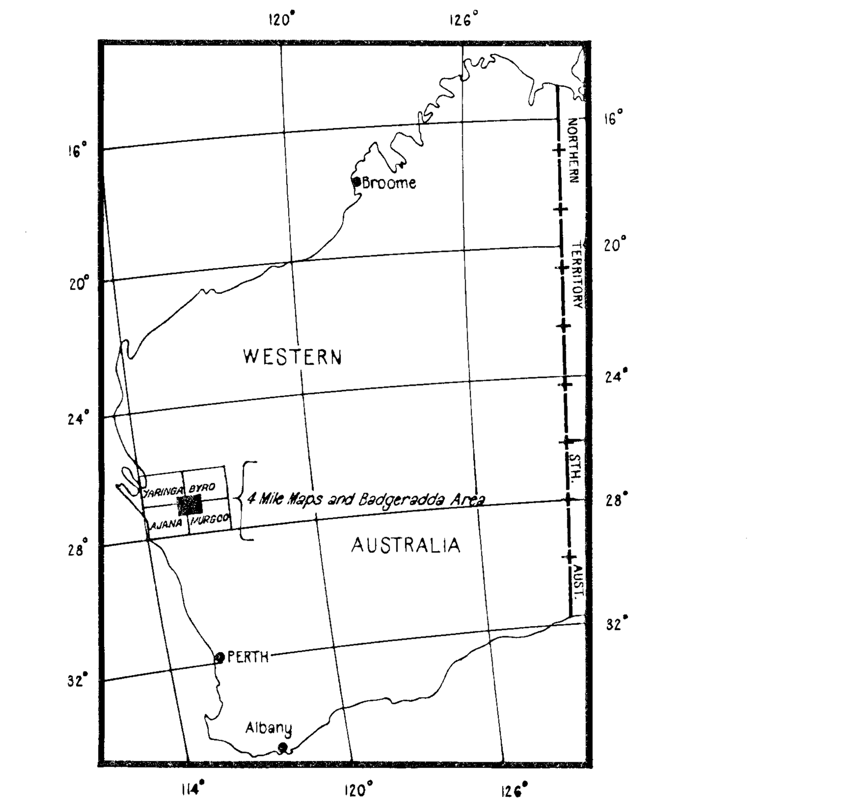
NATURAL SCALE

SECTION C - D

NATURAL SCALE



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



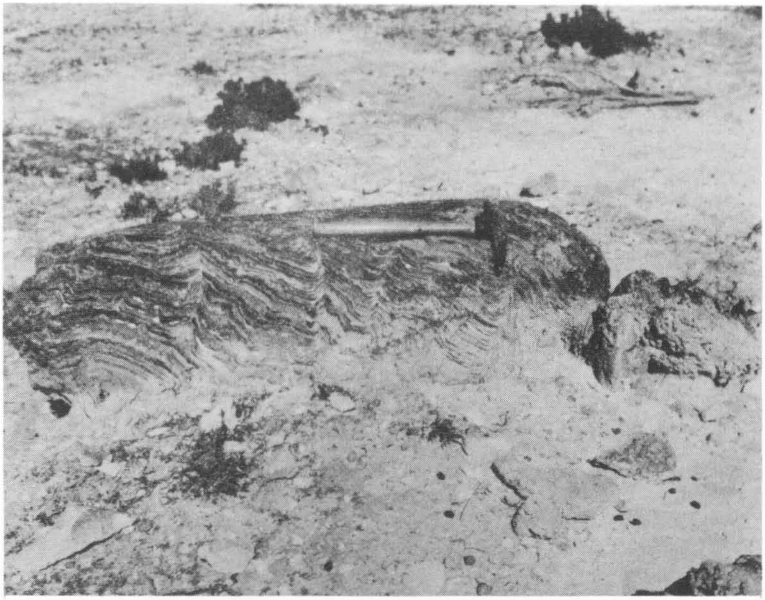


Fig. 1.—Stromatolitic boulder, Lyons Group.

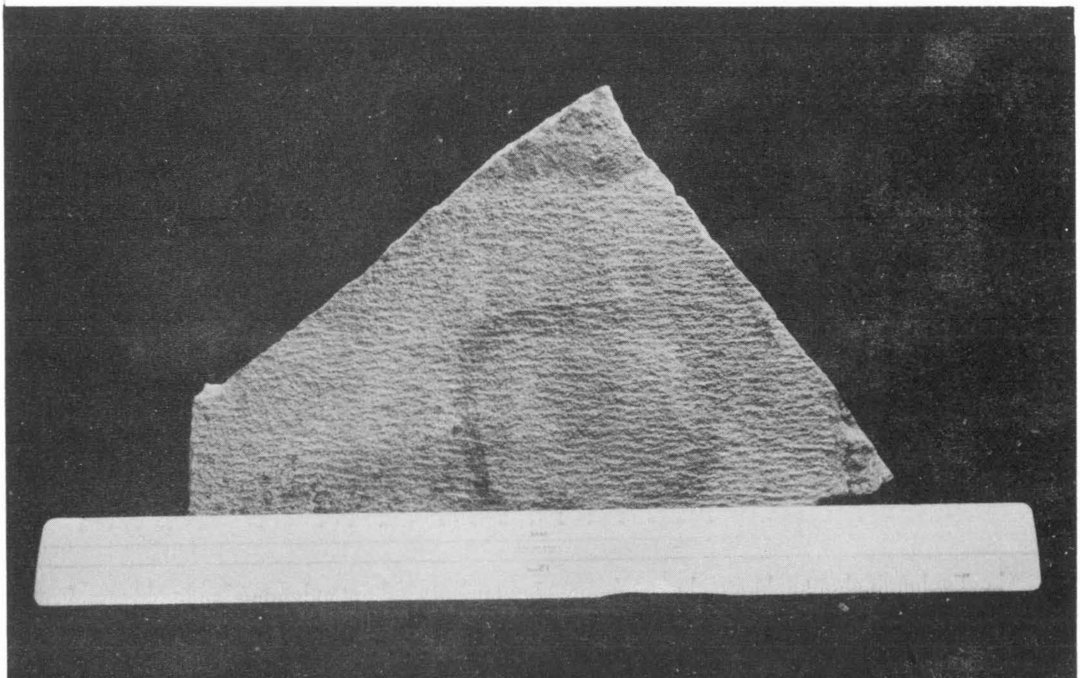


Fig 2.—Small-scale ripple marks, Coomberarie Formation.

Fig. 1.—Current lineation, Yarrawolya Formation. (Maximum width of block, 30 cm.).

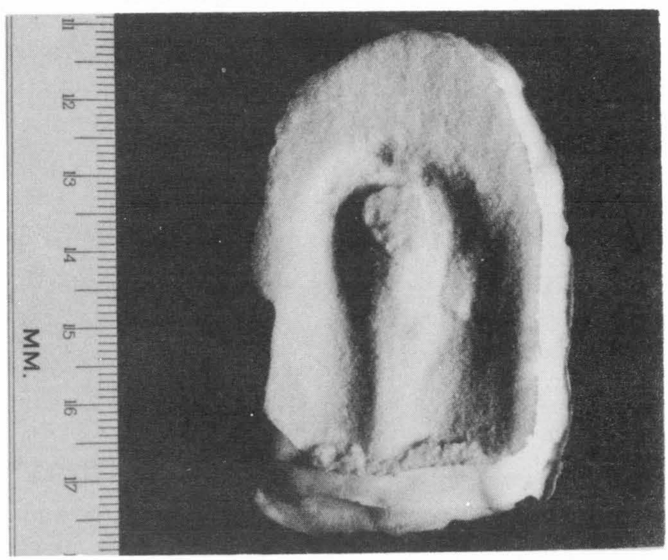


Fig. 2.—Rubber impression of cast of current crescent.

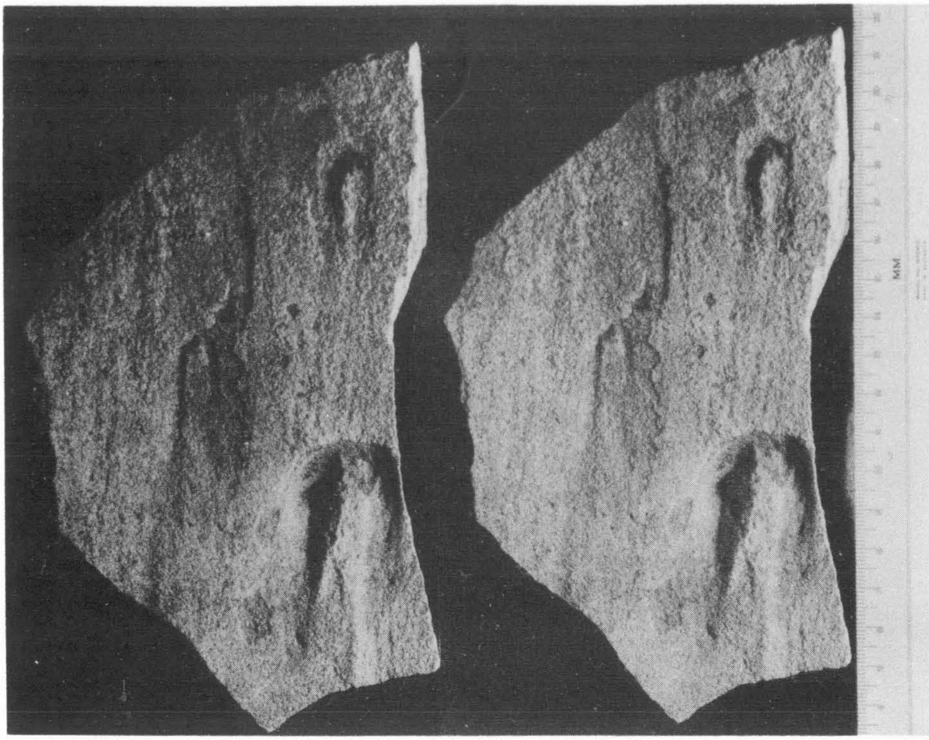


Fig. 1.—Current crescents, half natural size.

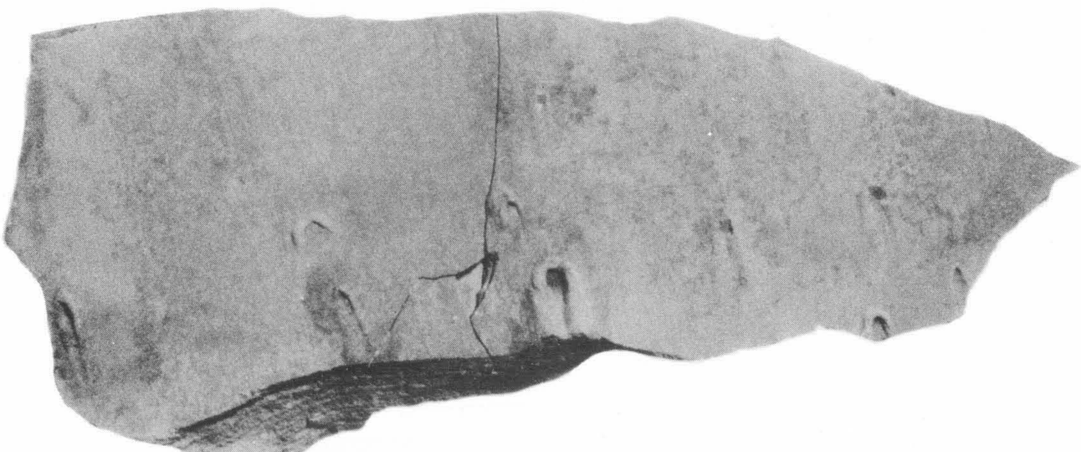


Fig. 2.—Casts of current crescents.
(Length of slab 55 cm.).

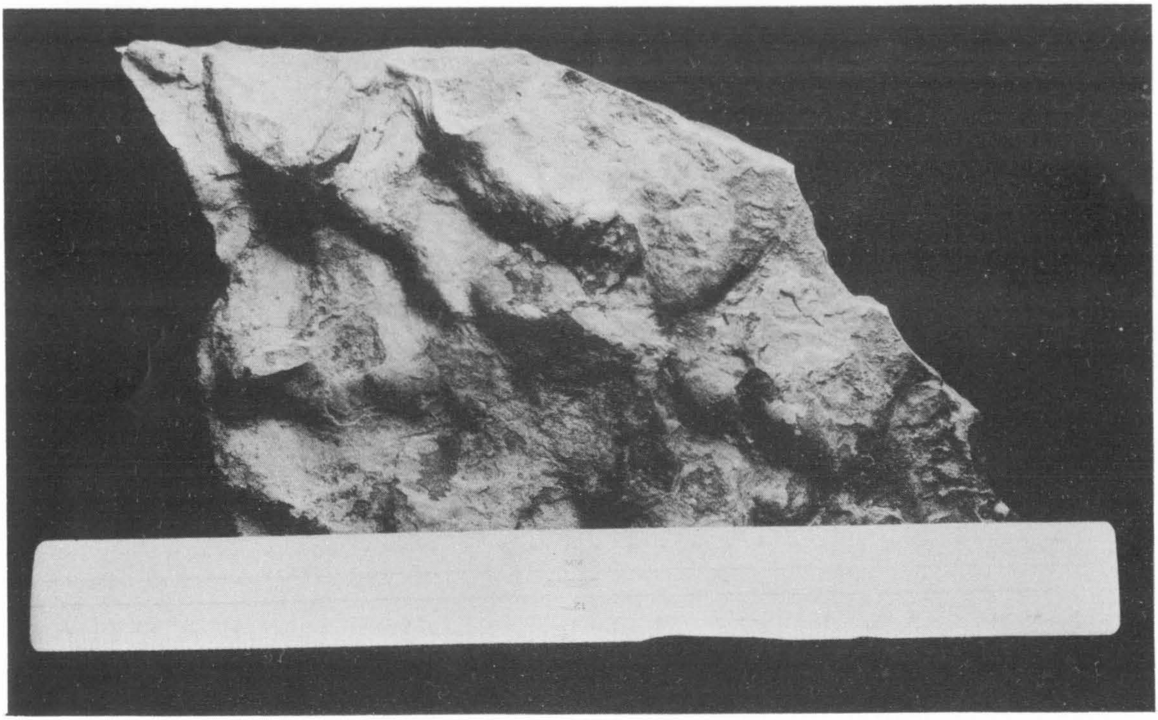


Fig. 1.—Sole markings, Yarrawolya Formation.

Fig. 2.—Cross-section of " slump-roll ", Coomberarie Formation. Approx. natural size.

Fig 1.—" Slump-roll ", Coomberarie Formation.
(Length of scale, 6 inches).

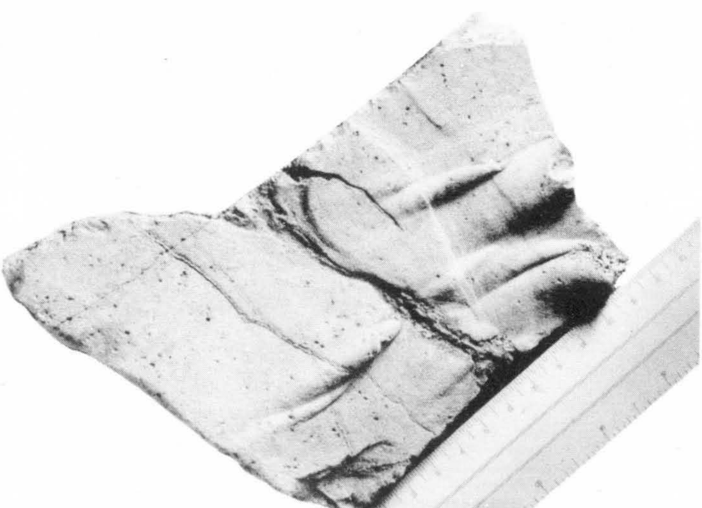


Fig. 2.—Flute casts, Coomberarie Formation.

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