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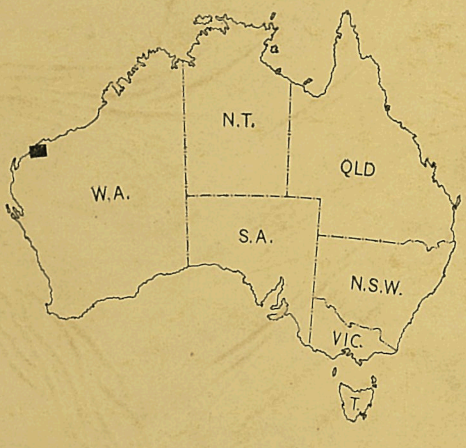
EXPLANATORY NOTES

YARRALOOLA
WESTERN AUSTRALIA



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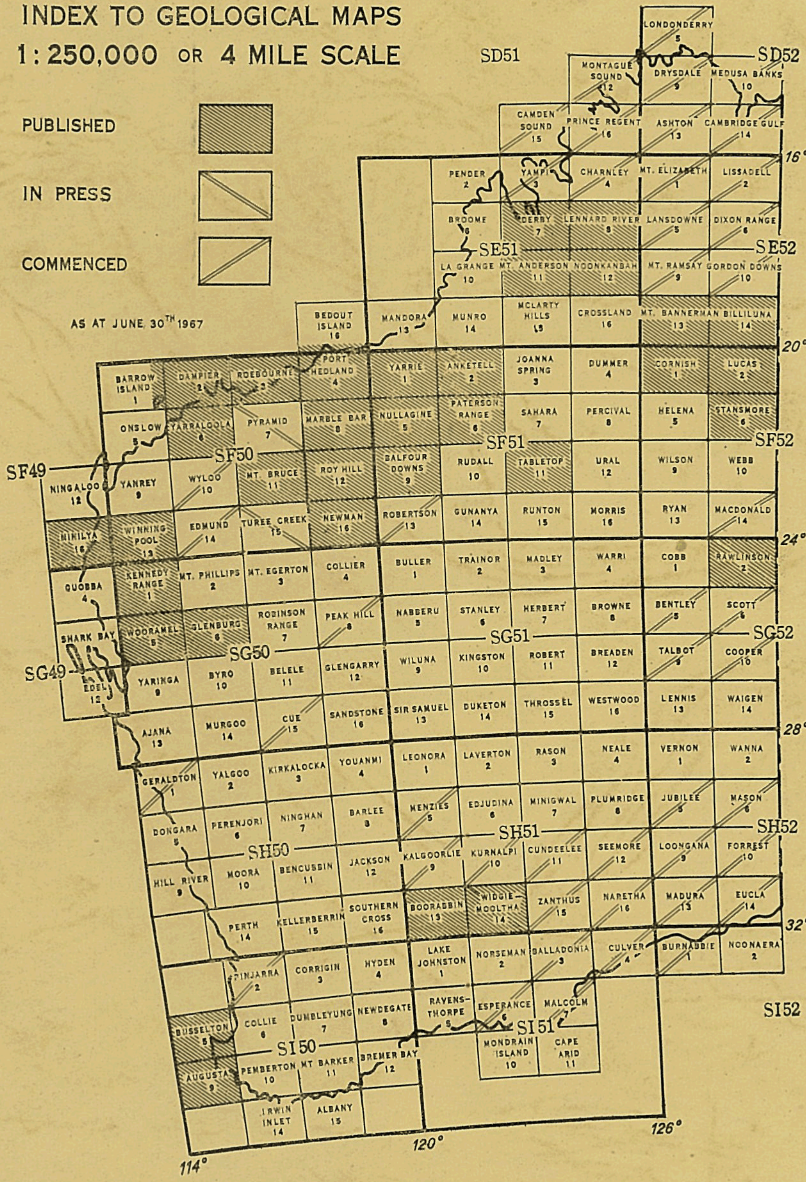

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

1:250,000 GEOLOGICAL SERIES

EXPLANATORY NOTES

YARRALOOLA
WESTERN AUSTRALIA

Sheet SF/50-6

Compiled by I. R. Williams

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Minister: THE HON. A. F. GRIFFITH, M.L.C.

Under Secretary: I. R. BERRY

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

Director: J. H. LORD

Explanatory Notes on the Yarraloola Geological Sheet

Compiled by I. R. Williams

The Yarraloola Sheet area, in the North-West Land Division of Western Australia, is bounded by parallels of latitude 21° S and 22° S and meridians of longitude 115° 30′ E and 117° E. There are no towns within the area. Onslow lies 35 miles northwest of the southwest corner, and Roebourne is 18 miles northeast of the northeastern corner. The North-West Coastal Highway traverses the area from near the southwestern corner to a point about midway along the northern boundary.

The eastern half is largely unoccupied, although portions of Chiratta, Karratha, Cooya Pooya, Daniels Well (unoccupied), and Millstream pastoral leases lie within the area. The pastoral leases of Balmoral, Mardie, Yarraloola, Peedamulla, Warramboo, Cane River, and Red Hill occupy the western part; and the Yalleen lease (Deepdale) lies in the south-central region. All the properties are sheep stations, with the exception of Yalleen which mainly runs cattle.

In 1964, the Broken Hill Proprietary Company maintained a small base camp for iron ore exploration 7 miles west of Deepdale homestead. It can be expected that towns will be established in the area as the iron ore exporting industry develops.

The climate is arid and the rainfall is erratic with the annual average a little over 9 inches. Most of this falls between December and June.

The principal vegetation is spinifex, and eucalypts are concentrated along water courses. The western plains are covered with plain grass, and small trees and shrubs such as *Cassia, Grevillea,* and *Acacia.* Samphire and mangrove fringe the coast.

The most important mineral deposits are the Robe River pisolite ores which are estimated to contain about 3,000 million tons of iron ore. Copper has been mined in small quantities from the Yannery district in the northeast, and from Yarraloola and Red Hill in the west.

PREVIOUS INVESTIGATIONS

Early geological investigations in the North-West Division at the turn of the century were stimulated primarily by the search for minerals. Little attention was given to the Yarraloola Sheet area, on which few mineral discoveries were made. The first geological inspection was that of Maitland (1909), followed by Woodward (1911), who traversed the Fortescue River from Balmoral to Gregory Gorge, and by Blatchford (1913). The copper deposits at Red Hill and Yarraloola were subsequently examined by Jones (1939), but apart from this, very little attention was paid to the area between 1914 and 1960.

Maitland (1909, p. 93) first noted the presence of 'ironstone' at Chalyarn Pool on the Robe River. It was not until 1960 that investigation into the iron potential of the area was begun by The Broken Hill Proprietary Co. Ltd (Harms and Morgan, 1964). In 1962 the Geological Survey of Western Australia began a regional survey of the Hamersley Iron Province (MacLeod and others, 1963) and as a part of this survey

R. Halligan mapped a portion of the Yarraloola Sheet area. Mapping was completed in 1964 by I. R. Williams and G. R. Ryan. An unpublished report on the photo-interpretation of the area was prepared in 1963 by B. de Lassus St Genies, of the Institut Français du Pétrole, for the Bureau of Mineral Resources. The adjoining sheet areas of Dampier, Roebourne, Pyramid, Mt Bruce, and Wyloo were mapped by the Geological Survey. In addition, publications by Ryan and Kriewaldt (1963), Low (1963), Halligan and Daniels (1964), Kriewaldt (1964a), Ryan (1965), and MacLeod (1966) are of interest for this area. Petrological and palaeontological determinations were carried out by A. F. Trendall and H. S. Edgell respectively, of the Geological Survey of Western Australia. The explanatory notes on the Yarraloola Sheet were compiled by I. R. Williams and include some brief notes by G. R. Ryan.

The Sheet area was covered during an airborne magnetic and radiometric survey of the Carnarvon Basin, carried out between 1956 and 1961 by the Commonwealth Bureau of Mineral Resources. The results were published in 1963, as map No. F50/B1-7, and are available from the Bureau.

PHYSIOGRAPHY

The physiography of the Yarraloola area is closely related to the geology of the underlying rocks. It is divided into three units: the upland, transition zone, and coastal plain. (Figure 1)

The upland is underlain by Proterozoic rocks and associated superficial deposits. It is subdivided by topography into the Hamersley Range and Nullagine Plateau (Jutson, 1950), also called 'the Tableland'.

The Hamersley Range is present in the southeastern corner of the Sheet area. It is rugged and strongly dissected with the more resistant rocks forming prominent cliffs and ridges. The highest part of the Sheet area lies in this region and reaches a height of 2,207 feet at Mt Elvire. The range is bounded to the north by a bold erosion scarp which can be traced eastwards for at least 200 miles.

The Hamersley Range is separated from the Nullagine Plateau by a wide alluvial valley which contains low rounded hills of the underlying rock and low mesas capped by Cainozoic rocks. Within the Sheet area the valley is drained mainly by the Robe River and its tributaries; it is continuous with the Fortescue Plain to the east.

The southern portion of the Nullagine Plateau consists of broad valleys separated by low cuestas, but to the north it is deeply dissected and forms a very rough, almost inaccessible area. The plateau lies between 500 and 1,000 feet above sea level and is bounded to the north by an erosion scarp.

The transition zone borders the upland to the west and north. Low hills of Archaean rocks are located north of the plateau scarp and they are separated by plains that are continuous with the coastal plain to the north.

A complex physiographic area is present in the west and northwest where Proterozoic rocks are capped by flat-lying Cretaceous and Cainozoic rocks. The latter, together with eroded outcrops of Proterozoic rocks, form the remnants of a plateau which is continuous with the Nullagine Plateau but slopes gently to the west. It is well preserved between Deepdale homestead and the Fortescue River. Widespread erosion in the Peedamulla and Red Hill districts has left only a few scattered remnants of the plateau.

The coastal plain lies to the west and northwest of the transition zone. It is a broad low-lying expanse of alluvium that slopes gently seawards. The coast is fringed by tidal and salt flats, mangrove swamps, sand shoals, and sand dunes.

The drainage over most of the area is west to northwest, and is part of the Robe and Fortescue River systems. A number of smaller rivers and creeks, of which the

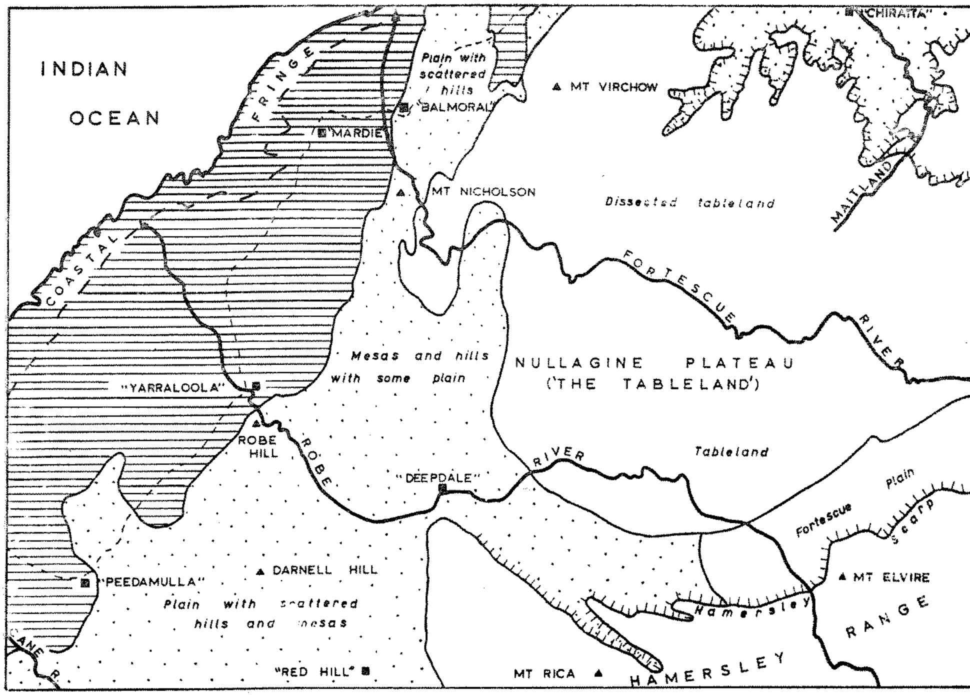

FIGURE 1

PHYSIOGRAPHIC SKETCH MAP
YARRALOOLA SHEET SF50 - 6

SCALE OF MILES
10 0 10 20 30

REFERENCE

Coastal Plain

Transition Zone

Uplands

most important is the Maitland River, drain northwards from the Nullagine Plateau. Some drainage is developed on the coastal plain and a small section of the Cane River lies in the extreme southwest corner of the Sheet area.

The rivers are deeply incised into the uplands, and are braided on the lower reaches. However some of the channels, such as Warramboo Creek, have cut into the coastal plain to a depth of about 20 feet. The rivers normally contain dry shingle and sand-filled channels along which permanent or nearly permanent water holes are located. They flow after heavy rain, and along the larger channels there is a subsurface flow which continues throughout the year. Most of the rivers flood out on the coastal plain or debouch on to tidal flats, but the Fortescue River maintains a well defined channel to the sea.

GEOLOGY

ARCHAEAN

Rocks of the Archaean succession, as established by Ryan (1965) for the North-West of Western Australia, are confined to the northern half of the Yarraloola Sheet area. They are exposed mainly in the northeast corner between Yanyare River and the eastern boundary of the Sheet, and along Eramurra Creek, northeast of Balmoral homestead. Three small inliers of Archaean rocks crop out along the Fortescue River, 30 miles northeast of Deepdale homestead.

The layered succession (part of the Roebourne Group) is made up of sedimentary and volcanic rocks (Table 1) and is intruded by sills and dykes of acid and basic rocks. The sequence has been folded and metamorphosed. Granite, which makes up the greater part of the Archaean rocks of the Sheet area, intrudes the sequence. The Archaean rocks are overlain unconformably by Proterozoic rocks.

Roebourne Group

The name Nickol River Formation is proposed for the bottom formation of the Roebourne Group in the Sheet area (see Appendix 1). It is recognised by the presence of prase and fuchsite. The formation consists mainly of amphibole schist; quartz-mica schist; banded chert, jaspilite, dolomite, and prase; and fuchsite-bearing rocks. Some blocky, green, basic lavas and pillow lavas, which underlie the formation south of the Whundo mine, have been included with the formation.

The Nickol River Formation is overlain by the Regal Formation which has volcanic and sedimentary facies. The volcanic rocks are altered basalts including pillow lavas, and massive and layered acid volcanic rocks. The sedimentary rocks are mainly greywacke, breccia, and shale, with some chert and iron formation.

Intrusive rocks

The Roebourne Group is intruded by acid and basic dykes and sills which predate the folding.

A large body of layered gabbro and associated rocks, the Munni Munni Complex, lies 8 miles south of Chiratta homestead on Munni Munni Creek. It appears to be gently folded and it is intruded by granite. Serpentinites with chrysotile are present along the northern edge of the body. The complex has a strong magnetic anomaly that extends for 10 miles underneath a cover of Proterozoic rocks, indicating a hidden extension of the complex.

Basic intrusive rocks that crop out in two small bodies near the Whundo mine are similar to the rocks of the Munni Munni Complex. In the extreme northeast corner of the Sheet area there are outcrops of porphyritic gabbro that has been epidotised and sheared but does not appear to be folded.

The Archaean granite is mostly leucocratic and equigranular with some porphyritic phases. It is unfoliated except along the margins where it is commonly gneissic. Migmatites have been seen in rocks near the margins of the granite.

Subordinate to the leucocratic granite are darker rocks that range from biotite granite to granodiorite; they commonly contained basic xenoliths. These rock types crop out in small stocks that have sheared contacts in some places and sharp contacts in others.

The Archaean rocks are cut by several dolerite dykes that trend between east and northeast; they are younger than the folding. These dykes do not cross an unconformity between the Archaean rocks and the overlying Proterozoic rocks. However, it is not

TABLE 1. PRECAMBRIAN STRATIGRAPHIC COLUMN

	Group	Map symbol	Thickness (feet)	Formation	Description	Relationship to underlying unit	Physiographic expression	Remarks
Proterozoic		Ptp	8,000 (est.)	Tanpool Beds	Massive and flaggy quartz and glauconite sandstone; siltstone and shale	Unknown	Mainly cuestas; low ridges separated by wide valleys	Intruded by dolerite, correlated with Mt Minnie Group
	Mt. Minnie	Pma	more than 2,000	Warramboo Sandstone	Massive and flaggy quartz sandstone; shale	Conformable	Low to moderate, rounded hills	
		Pmw	100 (est.)	Wabco Shale	Brown shale, thin interbedded sandstone	Conformable	Valleys, poor outcrop	
		Pmk	0–500	Katanga Conglomerate	Poorly sorted conglomerate, interbedded quartz sandstone	Unconformable	Bold hills	Correlated with Brodagee Sandstone
	Wyloo	Pwa	unknown	Ashburton Formation	Interbedded shale, fine-grained sandstone, greywacke, ferruginous and siliceous shale, thin dolomite, phyllite, quartz-mica schist, and mica schist	Locally disconformable	Scattered low hills and rises; strike ridges	Copper mineralisation
		Pwx	0-1,000 (est.)	Volcanic rocks	Predominantly acid lava and ?tuff with thin intercalated dolomite	Probably disconformable	Low hills, poor outcrop	Dolomite contains *Collenia*, minor intrusive bodies. Correlated with June Hill Volcanics
		Pwdc	irregular		Chert breccia	Contained in dolomite	Prominent outcrops	Some breccia related to faults
		Pwd	2,000 (est.)	Duck Creek Dolomite	Calcitic dolomite, minor shale	Conformable	Moderate to low hills	*Collenia* locally abundant (Edgell, 1964). Copper mineralisation at Red Hill
		Pw	3,000 (est.)	Undifferentiated Mt McGrath Formation, Beasley River Quartzite, Turee Creek Formation	Shale, mudstone, siltstone, quartz sandstone, greywacke, pebble conglomerate, altered lava, and tuff	Conformable except lowest contact which is faulted where visible	Low rounded hills poor outcrop	Units not differentiated on map
	Hamersley	Pho	unknown	Boolgeeda Iron Formation	Massive blue jaspilite, micaceous shale, siltstone	Conformable	Prominent but rounded ridges and hills	Faulted upper contact
		Phw	1,000 (est.)	Woongarra Volcanics	Aphanitic and porphyritic acid lava and tuff with intercalated jaspilite and shale	Conformable	Subdued rounded rough hills; tors in places	Age determinations (Leggo and others, 1965)
		Phj	unknown	Weeli Wolli Formation	Thinly bedded jaspilite, siltstone, shale	Conformable	Subdued ridges, cuestas	Intruded by dolerite sill (Pjd)
		Phb	2,000	Brockman Iron Formation	Massive laminated jaspilite with thin shale, chert, dolomite; acid tuff, breccia (Phba)	Conformable	High ranges, bold hills; cliff and scarp forming	Contains hematite and crocidolite
		Phr	125–300	Mt McRae Shale	White-weathering shale, chert; dolomitic shale, jaspilite in upper part	Conformable	Valleys and scarp slopes	
		Phs	?40–80	Mt Sylvia Formation	Interbedded jaspilite and shale with dolomitic shale	Conformable	Valleys, scarp slopes with benches, spurs	Contains Bruno's Band
		Phd	0–500	Wittenoom Dolomite	Grey to blue calcitic crystalline dolomite, chert, dolomitic shale towards top and bottom	Conformable	Poor outcrop, valleys, some low rough hills. Low hills, cuestas	Manganese staining in places
		Phm	0–700	Marra Mamba Iron Formation	Interbedded jaspilite, ferruginous pinch and swell chert, and shale	Conformable	Low hills, cuestas	Contains crocidolite, manganese staining
Lower Proterozoic	Fortescue	Pfjr	50–120	Roy Hill Shale Member	White-weathering shale, siliceous in places, shale	Conformable	Valleys, scarp	Carbonaceous and pyritic when fresh
		Pfjn	0–200	Nallanaring Volcanic Member	Fine-grained basic lava with pillows in places; acid volcanic rocks and volcanic pisoliths	Conformable	Poor outcrop, valleys	
		Pfjw	100–300	Warrie Member	Interbedded shale, chert, jaspilite, and dolomite	Conformable	Cuestas, low hills and intervening valleys	
		Pfjo	0–80	Woodiana Sandstone Member	Interbedded shale, impure sandstone, greywacke, silicified mudstone; basal grit in places	Locally disconformable	Low hills, cuestas	
		Pfm	2,000 (est.)	Maddina Volcanics	Basic, intermediate, acid, lavas, amygdaloidal and vesicular textures, thin intercalated tuffaceous sedimentary rocks	Conformable	Subdued to bold rough irregular hills, cuestas in places	Contains agates
		Pfp	500–1,000 (est.)	Pillingini Tuff	Bedded tuff, tuffaceous detrital rocks with thin jaspilite, dolomite, chert, and shale, and some lava; contains volcanic pisoliths	Conformable	Terraced rough hills; valleys in places	Contains *Collenia*
		Pfk	500-1,500 (est.)	Kylena Volcanics	Basic, intermediate, acid lavas, amygdaloidal and vesicular textures, thin intercalated pyroclastic rocks with sandstone and arkose	Conformable	Subdued to bold rough hills; terraced slopes	
		Pfcl	20–250	Lyre Creek Agglomerate Member	Tuff, fine-grained agglomerate, tuffaceous quartzite, calcareous beds with volcanic pisoliths and lava bombs	Conformable	Scarp slopes, low rough terrain	Upper part of Cliff Springs Formation
		Pfc	20–500	Cliff Springs Formation	Bedded tuff and tuffaceous detrital rocks, shale, siltstone, sandstone with volcanic pisoliths; arkose	Unconformable on Archaean, conformable or disconformable on Mt. Roe basalt	Scarp slopes, low rough terrain at foot of scarp, cuestas and mesas, valleys in places	
		Pfr	0–200 (est.)	Mt. Roe Basalt	Amygdaloidal, vesicular and columnar basic and intermediate lavas; thin intercalated tuffaceous sedimentary rocks, agglomerate in places	Unconformable	Bold rough hills	

clear whether the dykes have been truncated by erosion or stopped by the rocks above the unconformity.

Metamorphism

Most of the rocks of the Roebourne Group on the Sheet area have undergone low grade regional metamorphism belonging to the greenschist facies. Higher grade contact metamorphic rocks are restricted to aureoles surrounding the large granite instrusions.

PROTEROZOIC

The greater part of the Yarraloola Sheet area is covered by a lower Proterozoic succession of volcanic and sedimentary rocks which belong to the Mt Bruce Supergroup (Halligan and Daniels, 1964). This succession has been intruded by granite dated at 1,720 million years, and acid volcanic rocks from the middle part of the supergroup have been dated at 2,100 million years (Leggo and others, 1965).

The Mt Bruce Supergroup consists of three groups. The lowermost Fortescue Group is made up of volcanic rocks which contain coarse clastic material towards the base. Flood basalt formations alternate with pyroclastic units, and the lower formations are impersistent and variable in thickness. There is a transition to the more stable conditions in the Jeerinah Formation at the top of the group. This is followed by the thick accumulation of jaspilite shale, chert, and dolomite of the Hamersley Group. This group contains acid volcanic rocks towards the top. The Wyloo Group, which consists of quartzite, greywacke, shale, and dolomite with basic and acid volcanic rocks, conformably overlies the Hamersley Group.

The Mt Minnie Group, which is made up of sandstone, shale, and conglomerate, overlies unconformably the Mt Bruce Supergroup. It has been correlated with the Bresnahan Group and, on the Wyloo Sheet area, is overlain unconformably by the Bangemall Group which is possibly Middle Proterozoic (Halligan and Daniels, 1964). Similar rocks, the Tanpool Beds, which crop out north of Peedamulla homestead, are provisionally correlated with the Mt Minnie Group.

Descriptions of the Proterozoic stratigraphy are given in Table 1. The succession in the Mt Bruce Supergroup was originally established by MacLeod and others (1963), but it has since been modified in places by several authors.

Fortescue Group

The Fortescue Group covers a very large area in the North-West Land Division of Western Australia. Correlations between the different Sheet areas are postulated and given, with some notes on alterations to nomenclature, in Table 2.

The Mt Roe Basalt (Kriewaldt, 1964a) is restricted, except for a small outlier in the northeast corner of the Sheet area, to an area north of Yanyare Fault and west of Mt MacLeod. The Yanyare Fault has controlled the deposition of the formation and it is missing south of this structure.

The *Cliff Springs Formation* (new name, see Appendix 1) changes in thickness and lithology across the Sheet area. Where the Mt Roe Basalt is missing, the formation rests unconformably on Archaean rocks. There is a gradual thinning of the formation from east to west and, west of Eramurra Creek, only 20 feet of pebbly arkosic sandstone is present. The formation is made up largely of tuff and agglomerate with some sandstone; lenses of conglomerate, arkose, shale, and dolomite are more common in the western half of the Sheet area. Volcanic pisoliths are present in several horizons and consist of concentrically banded, oblate or discoidal bodies of tuff which lie closely packed in a tuffaceous or calcareous matrix.

Trendall (1956a) has described them in more detail and commented on their genesis.

TABLE 2. CORRELATIONS IN THE FORTESCUE GROUP

Yarraloola	Pyramid (Kriewaldt & Ryan, in press)	Roy Hill (MacLeod and de la Hunty, 1966)	Marble Bar—Nullagine (Noldart & Wyatt, 1962)	Mt Bruce (de la Hunty, 1965)
Maddina Volcanics	Maddina Basalt	Mt Jope Volcanics Maddina Basalt Member	'Upper' Little De Grey Lava(*a*)	Mt Jope Volcanics(*a*) Boongal Pillow Lava Member
Pillingini Tuff	Pillingini Tuff	Mt Jope Volcanics Kuruna Siltstone Member Nymerina Basalt Member Tumbiana Pisolite Member	Tumbiana Pisolite(*a*)	Mt Jope Volcanics Pyradie Pyroclastic Member
Kylena Volcanics	Kylena Basalt	Mt Jope Volcanics Kylena Basalt Member	'Lower' Little De Grey Lava(*a*) 'Upper' Coongan Volcanics(*a*)	Mt Jope Volcanics Bunjinah Pillow Lava Member
Cliff Springs Formation	Cliff Springs Formation Lyre Creek Agglo- merate Member	—	'Lower' Coongan Volcanics(*a*) Green Hole Conglomerate(*a*) Glen Herring Shale(*a*) Beaton Creek Conglomerate(*a*)	Hardey Sandstone(*b*)
Mt Roe Basalt	Mt Roe Basalt	—	—	—

(a) These units are not shown as such on the maps.
(b) The Hardy Sandstone contains lavas and may be the equivalent of the Mt Roe Basalt as well as the Cliff Springs Formation.

The *Lyre Creek Agglomerate Member* (new name, see Appendix 1) comprises about half the Cliff Springs Formation east of the Maitland River. It is discontinuous in outcrop west of the Maitland River and is reduced in thickness. The formation is largely tuff and fine-grained agglomerate with a prominent quartzitic tuff at the base.

The *Kylena Volcanics* (changed from Kylena Basalt) are mainly basalt flows with some interbedded tuffs. The formations contain acid lavas around Eramurra Creek where it is reduced in thickness.

The *Pillingini Tuff* (Kriewaldt and Ryan, in press) is thinnest in the vicinity of Eramurra Creek. It is made up largely of tuff and shale with some jaspilite and dolomitic beds. Volcanic pisoliths are also present in the formation. Stromatolite colonies, with both a nodular and a tabular habit, are associated with the thin dolomitic beds.

The *Maddina Volcanics* (changed from Maddina Basalt) is very similar to the lower lava formations. There is an increase in the content of acid lavas westwards across the Sheet area. The formation is the end of the widespread vulcanicity of the Fortescue Group and volcanic rocks are restricted in area in the overlying Jeerinah Formation.

The *Jeerinah Formation* is the uppermost formation of the Fortescue Group and can be traced from Gregory Gorge at the eastern edge of the Sheet area, to 5 miles southwest of Mt Nicholson. It combines features common to both the Fortescue Group and overlying Hamersley Group, and is regarded as a transitional formation between the largely volcanic sequence below and the chemico-clastic sequence above.

The formation appears to lie conformably on the Maddina Volcanics. However, in the central and western part of the Sheet area, the patchy development of a coarse grit and breccia at the base of the formation may indicate a local disconformity. There is a persistent and generally uniform lithology which is in direct contrast to the lensing and variable lithology of the underlying volcanic rocks; and it is probable that the formation is transgressive on to flows of the Maddina Volcanics.

The *Woodiana Sandstone Member* (MacLeod and de la Hunty, 1966) is the basal unit. It has a maximum thickness of 80 feet and consists of impure sandstone, greywacke, and shale, with a persistent bed of black siliceous mudstone at the base. In places a coarse grit or breccia from several inches to 8 feet thick is developed beneath the siliceous mudstone.

The *Warrie Member* (MacLeod and de la Hunty, 1966) overlies the Woodiana Member, and is the thickest unit in the Jerrinah Formation. It is made up of a basal white shale, overlain by siliceous and ferruginous shale, chert, jaspilite, and some thin dolomite bands. A maximum thickness of 300 feet is present near Gregory Gorge.

The *Nallanaring Volcanic Member* (new name, see Appendix 1) is restricted to the Yarraloola Sheet area. It can be traced from about 5 miles northeast of the junction of Kumina Creek and the Robe River to a point 3 miles southwest of Bilanoo Hill; and south of Mt Enid it reaches a maximum thickness of about 200 feet. The upper part of the member is largely fine-grained basic lava that contains some good pillow structures. It is underlain by aphanitic and spherulitic acid lavas, with minor pyroclastics containing volcanic pisoliths.

The *Roy Hill Shale Member* (MacLeod and de la Hunty, 1966) lies at the top of the Jeerinah Formation and is a leached white shale, silicified in places, up to 120 feet thick. Black carbonaceous shales with pyrite nodules are developed at the base of the member near Gregory Gorge on the Fortescue River.

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It is conformably overlain by the Marra Mamba Iron Formation which commonly forms a hard capping on the less resistant shale. The conspicuous photo pattern of the member makes it a particularly good stratigraphic marker.

Hamersley Group

All the formations of the Hamersley Group are present in the Yarraloola Sheet area with the same lithologies described previously by MacLeod and others (1963). The group covers a wide area and crops out in a broad arc extending from the southeastern corner across to Deepdale homestead, thence north to the Fortescue River and Balmoral homestead. It passes northwards on to the Dampier 1 : 250,000 Sheet just east of the mouth of the Fortescue River. There is a progressive thinning of the formation to the west and north. The Brockman Iron Formation is only separated from the Maddina Volcanics near Balmoral by a poorly outcropping succession of shale and chert. These are thought to be the lateral equivalent of the formations that occur in the same stratigraphic position in the normal sequence. The Wittenoom Dolomite and Marra Mamba Iron Formation are not recognised and are presumed to be absent; the succession is thought to consist of the Jerrinah Formation in the lower part, and possibly the Mt McRae Shale and Mt Sylvia Formation in the upper part.

The jaspilites, mapped as Brockman Iron Formation in the Balmoral area, contain a bed of siliceous breccia that is probably a tuff. This breccia may be part of the Brockman Iron Formation but an alternative interpretation is that the breccia is the Woongarra Volcanics, and the jaspilites above, which contain shale, possibly belong to the Boolgeeda Iron Formation.

The *Marra Mamba Iron Formation* consists of jaspilite, ferruginous and siliceous shale, and ferruginous chert, exhibiting pinch and swell structure. It reaches a maximum thickness of at least 500 feet in the eastern part of the Sheet area; but is absent from the section north of Balmoral homestead.

The *Wittenoom Dolomite* crops out intermittently across the Sheet area and the formation, which erodes easily, is covered commonly by later superficial deposits. In the southeastern part of the Sheet area, at the base of the Hamersley Scarp, it is covered by calcrete, and by consolidated ferruginous outwash that is capped by a thin veneer of recent colluvium. Grey to light brown dolomite is exposed in the waters of Jimmawurrada Creek where the superficial deposits have been stripped off. Dolomitic shale and thin chert bands are present at the top of the formation. The total thickness of the formation is estimated to be about 500 feet.

A good exposure of the conformable contact with the underlying Marra Mamba Iron Formation was noted 2 miles east of Bullinnarwa Pool on the Fortescue River. Here, the orange-brown chert of the Marra Mamba develops irregular patches and lenses of yellow-brown dolomite and this is replaced gradually by pale-brown to grey dolomite with thin lenses of dark blue chert.

The *Mt Sylvia Formation* is probably not more than 80 feet thick. It is best developed in the eastern half of the Sheet where it contains three thin bands of jaspilite separated by dolomitic and siliceous shales. The uppermost jaspilite band, also known as Bruno's Band, is the most persistent unit and can be traced across the sheet to 3 miles south of Bilanoo Hill where it is 11 feet thick.

The *Mt McRae Shale* is made up of white-weathering, siliceous and dolomitic shale with interbedded chert. There is an increase in the chert content to the northwest, and the formation is 125 feet thick 3 miles south of Bilanoo Hill. The upper part of the Mt McRae Shale includes thinly interbedded jaspilite and chert, with some thin beds of shale.

The *Brockman Iron Formation* is well developed in the southeastern, southern, and central parts of the Yarraloola Sheet area. It is about 2,000 feet thick and consists of massive and laminated jaspilite interbedded with thin shale and chert. The stratigraphy and petrography of the formation have been described by Trendall (1965b). Edgell (1964) has also commented on the origin of this formation.

The *Weeli Wolli Iron Formation* is not easily recognisable over much of the area. Some thinly-bedded banded jaspilite and shale have been mapped with certainty in the Silver Grass Syncline in the southeast corner where the formation has been intruded by a thick dolerite sill. Elsewhere the formation, lacking the dolerite sill, has not been distinguished from the underlying Brockman Iron Formation.

The *Woongarra Volcanics* is a formation that is best developed in the Silver Grass Syncline; it also crops out intermittently through the south-central part of the Sheet area. It consists of aphanitic and porphyritic rhyolite and dacite lavas, many of which are silicified or chloritised. Welded tuffs and breccias are also present and thin beds of jaspilite and shale are intercalated with the lavas. The total thickness of these volcanic rocks is estimated to be 1,000 feet.

The *Boolgeeda Iron Formation* is confined to the central part of the Sheet area, where it is well exposed east of Red Hill and west of Deepdale homestead. It consists of laminated dark-blue jaspilite interbedded, particularly higher in the sequence, with thick micaceous shale and siltstone.

The top of the formation is missing and all contacts with the overlying Wyloo Group are faulted.

Wyloo Group

The Wyloo Group is only present in the southwest part of the Sheet area. The outcrop is generally poor and there is difficulty in recognising the formations in the lower part of the group. The resistant Duck Creek Dolomite is the first recognisable stratigraphic unit. It is underlain by poorly outcropping and undifferentiated shale, mudstone, siltstone, sandstone, and greywacke. Some tuff and altered lava crop out east of Red Hill homestead and between the Robe River and Peters Creek. There is continuous variation in the lithologies, and thinning and lensing of the sediments is common.

A detailed description of the formations (Turee Creek Formation, Beasley River Quartzite, and Mt McGrath Formation) is given by Halligan and Daniels (1964), but the insufficiency of outcrop has curtailed any attempt to carry the subdivisions into the Yarraloola Sheet area. However, a small outcrop of resistant quartz sandstone, 4 miles east of Red Hill homestead, could possibly be correlated with the Beasley River Quartzite. An outcrop, 6 miles northeast of the Broken Hill Proprietary camp at Deepdale, contains apatite, and has been described as a phosphatic siltstone.

The lower part of the Wyloo Group shows a decrease in grain size and better sorting of the clastic material northwards. This is coupled with a decrease in the proportion of volcanic rocks; it suggests that the source area may lie to the south, and that more stable conditions were present in the north.

The *Duck Creek Dolomite* lies in the southern and central parts of the Sheet area. It crops out almost continuously from Red Hill in the south, to northwest of the Broken Hill Proprietary camp at Deepdale where it passes beneath Cretaceous sediments.

It is about 2,000 feet thick and is composed largely of massive, buff to grey-coloured, calcitic dolomite with some thin interbedded shale. *Collenia* (Edgell, 1964), a fossil algae, is locally abundant and thin beds, nodules, and large irregular masses of chert are common.

The large chert masses are generally brecciated and discordant, and do not occupy any particular stratigraphic position. They are probably related to faulting. Although some of the chert is probably primary, replacement of the existing dolomite by secondary chert has taken place. Silicified *Collenia,* and a gradation from unaltered dolomite to chert and chert breccia, has been observed.

A suite of strongly chloritised and carbonated acid(?)lavas and intrusive rocks are associated with, and overlie, the Duck Creek Dolomite just northeast of the B.H.P. camp at Deepdale. Ferruginous shale, tuff, and thin beds of dolomite with *Collenia* are interbedded with the volcanic rocks. The sequence is restricted in area and is correlated with a similar association, the June Hill Volcanics (Daniels, in preparation), on the Wyloo Sheet area. A. F. Trendall regards the suite as having been formed by submarine effusion of lavas rich in carbon dioxide.

The field relationships suggest that the lavas are a lateral equivalent of, and were contemporaneous with, the upper part of the Duck Creek Dolomite. In which case the silica for the chert in the Duck Creek Dolomite may have been derived from volcanic sources. Where the volcanic rocks are missing, the Ashburton Formation lies conformably on the Duck Creek Dolomite.

The *Ashburton Formation* (Halligan and Daniels, 1964), which is present only in the southwestern part of the Sheet area, conformably overlies the Duck Creek Dolomite but may be disconformable on the suite of volcanic rocks. The outcrop is generally poor, and the best exposures are found on the sides of mesas that are capped by Cretaceous rocks.

The formation has a mixed lithology at the base with jaspilite, dolomitic shale, and greywacke, overlain by shale and fine-grained sandstone. Jaspilite, chert, and dolomite exposed near Warramboo Creek, belong to the highest part of the formation.

The more pelitic sediments have been altered to phyllite, mica schist, and quartz-mica schist in the west.

Mt Minnie Group

A conformable sequence of conglomerate, shale, and sandstone, which occupies an isolated tightly folded syncline 10 miles east of Peedamulla homestead, has been correlated with the Mt Minnie Group of Daniels (in preparation). It unconformably overlies the Ashburton Formation and is, in turn, unconformably overlain by the Cretaceous Nanutarra Formation.

Three formations have been recognised and they are similar to those described from the type area to the south by Daniels (in preparation).

The basal formation, named *Katanga Conglomerate* (new name) after the Katanga Bore, is correlated with the Brodagee Sandstone, the basal formation in the type area of the Mt Minnie Group (Daniels, in preparation). It is a poorly sorted conglomerate of variable thickness, containing irregular patches of coarse-grained ferruginous quartz sandstone. It has a maximum thickness of about 500 feet in a section 2½ miles southeast of Katanga Bore but further south it is only a few feet thick. A coarse quartz sandstone replaces the conglomerate in places.

The conglomerate contains boulders up to a foot in diameter and consists mainly of white and glassy quartz, quartzite, and chert with some fragments of jaspilite, shale, and schist; no granite boulders were seen. Angular fragments of shale and schist in the assemblage suggests that at least part of the conglomerate has been derived from local sources. The matrix is made up of small rocks fragments and sand.

The *Wabco Shale* (Daniels, in preparation) conformably overlies the conglomerate, and consists of about 100 feet of uniformly coloured brown shale with thin lenses of quartz sandstone towards the top. Commonly the sandstone is cross-bedded and shales show slumping and load casts. Cross-bedding indicates a general current movement from the south.

During folding, the shale has acted as an incompetent horizon and the development of 'pencil slates' is common, particularly in the axes of small folds.

The *Warramboo Sandstone* (new name, see Appendix 1) conformably overlies the Wabco Shale, and consists of a sequence of flaggy and massive quartz sandstone of unknown thickness. The weathered surface is commonly spotted. It crops out along Warramboo Creek for about 8 miles. It is overlain by Mesozoic rocks to the north.

Several resistant outliers of quartz sandstone, at Robe Trig. 2½ miles southeast of Yarraloola homestead, have been correlated with sandstones of the Mt Minnie Group. This massive glassy sandstone unconformably overlies shale and greywacke of the Ashburton Formation. Although the sandstone is tightly folded and partly recrystallised, faint traces of cross-bedding indicate a sedimentary origin. The relationship between the sandstone and a small granite pluton that intrudes the Ashburton Formation nearby, is not known. Daniels (in preparation) visualises the standstones as having been deposited in separate basins rather than a continuous region of sedimentation.

Tanpool Beds (New name, Appendix 1)

Sedimentary rocks that crop out in the Tanpool Hills and Peedamulla Hills 4 miles and 8 miles north of Peedamulla homestead have been called the Tanpool Beds. They form low parallel cuestas and are an inlier of Proterozoic rocks within the flat-lying Cretaceous Nanutarra Formation.

The beds are shallow dipping and consist of well-bedded quartz sandstone, glauconitic sandstone, pebble conglomerate and shale. They have been intruded by concordant medium-grained dolerite. The beds lies in a basin-like structure, separated from the rest of the Proterozoic rocks by a probably faulted trough containing Cretaceous sediments.

The Tanpool Beds are possibly a correlative of the Mt Minnie Group which they strongly resemble.

Intrusive rocks

The Proterozoic sequence is intruded by acid and basic rocks. Intrusions that predate and postdate the folding are present.

The *Cooya Pooya Dolerite* (Kriewaldt and Ryan, in press) is the oldest of the former type. It occupies a large area in the northwestern part of the Pyramid Sheet area and extends westwards on to the Yarraloola Sheet area near the Yannery Hills mine. It is tabular in form, and concordant, and has intruded along or near the boundary between the Kylena Volcanics and the Cliff Springs Formation. Indurated and dis-oriented blocks of both formations lie within it, and granophyre segregations are present.

The dolerite weathers to reddish black boulders and forms bold, black hills and mesas. Kriewaldt and Ryan (in press) consider that both intrusive and extrusive bodies are present on the Pyramid 1: 250,000 Sheet area, and that the dolerite originated from a vent centred just east of the Yarraloola Sheet boundary.

The Weeli Wolli Formation which crops out in the Silver Grass Syncline contains a sill of altered dolerite. It lenses out to the east on the Pyramid Sheet area.

Intrusive quartz-feldspar porphyry is present in the Woongarra Volcanics and is thought to be contemporaneous with them. Discordant contacts have been seen east of Red Hill and at Yeera Bluff.

Some small, highly altered intrusive rocks have been found within the suite of volcanic rocks at the top of the Duck Creek Dolomite one mile northeast of Deepdale camp. Their original composition is unknown, but their intrusive habit has been established in the field.

The Tanpool Beds contain concordant dolerite bodies that are probably sills.

Dykes of quartz-feldspar porphyry, that are similar to the porphyries associated with the Woongarra Volcanics, postdate the folding. They intrude rocks ranging in age from that of the Jeerinah Formation to that of the Ashburton Formation. The largest intrusion lies in Wittenoom Dolomite, 4 miles southeast of Bullinnarwa Pool on the Fortescue River.

A small outcrop of medium-grained, leucocratic granite occurs one mile southwest of Robe Trig. It has intruded shale and greywacke of the Ashburton Formation. It is tentatively correlated with Proterozoic granites of the Ashburton River area to the south that are described by Daniels (1965) and are dated at about 1,720 million years (Leggo and others, 1965).

The most common intrusive rocks are dykes of fresh to altered dolerite and quartz dolerite. They occupy straight, vertical and near-vertical fractures, some of which persists for tens of miles. Most of the dykes trend northeast, but some trend to the north or northwest. The northeasterly striking dykes are in most cases younger, but this relationship is not universal. The north and northwesterly trending dykes are the more persistent.

The dykes are very common in the Fortescue Group and to a lesser degree in the Hamersley Group and Wyloo Group. Some dykes with a similar trend and habit cut both the Mt. Minnie Group and the Bangemall Group south of the Sheet area (Daniels, in preparation). The great number of dykes in the lowest group is attributed partly to the proximity of this group to the source of the magma, and partly to the more competent nature of the lavas of the Fortescue Group, which has localising fractures. The intrusions probably continued throughout the Proterozoic, and this could also account for the proliferation of dykes in the older groups.

Metamorphism

In general, the Proterozoic rocks of the Yarraloola Sheet area have not been regionally metamorphosed. The rocks of the Ashburton Formation on the southwest corner of the Sheet area are the exception. These rocks, which are strongly folded and cleaved, have been subjected to regional metamorphism belonging to the lower greenschist facies. The grade of metamorphism is reflected in the pelitic material which forms mica schists, quartz-mica schist, and phyllite, There may be a relationship between degree of folding and metamorphic grade.

Contact alteration has been noted around the larger quartz feldspar porphyry intrusions.

MESOZOIC

During the early Cretaceous the western half of the Yarraloola Sheet area was inundated, and shallow marine and associated continental sediments were deposited (Table 3). The resultant thin but widespread cover has since been largely stripped off. Remnants of these sediments now form scattered buttes, mesas, and low tablelands.

TABLE 3. CAINOZOIC AND MESOZOIC STRATIGRAPHIC COLUMN

Era		Age	Map symbol	Estimated thickness in feet	Formation	Description	Geomorphology	Remarks
Cainozoic	Quaternary	Recent	Qr	10	Alluvium	Unconsolidated silt, beach sand, pebbles, gravel, and shingle	Fluviatile material; confined to present day drainage channels and coastal mud flats	Unconformable on older units
			Qg	50	Colluvium	Unconsolidated and loosely consolidated sand and gravels, kankar cement	Mainly piedmont deposits outwash, scree, talus, some fossil screes incised by gullies	Unconformable on older units; good aquifer
			Qa	50	Aeolian sand (coastal)	White to brown sand; unconsolidated	Restricted to present coast; foredunes, islands, lightly vegetated partly fixed coastal dunes	Silt and sand derived by aeolian redistribution at flood deposits (Ql)
					Aeolian sand (inland)	Red silt and sand; unconsolidated	Partly fixed sief dunes, vegetated, formed inland from coastal marsh	
			Ql	20	Alluvium	Mainly clay silt and sand, some gravels; unconsolidated	Flood deposits in form of silt sheets, levees and clay pans related to present day drainage patterns; overlies 'high-level' plain in places; incised by present day drainage	Correlated with *Anadara*-bearing beds on adjacent Sheet areas
		Pleistocene?	Qpt	10	Eluvium	Unconsolidated and loosely consolidated gravel and pebble deposits; quartz and quartzite pebbles	Low-angle rubble deposits, derived directly from underlying rocks; residual material, ferruginised in places,	Confined largely to the Ashburton and Marra Mamba Formations
			Qpd	20	Aeolian sand (old coastal)	Grey to white sand	Fixed dunes, well vegetated, steep sided, and eroded	Separated from mainland by coastal mud flats; correlated with 'high-level' plain
			Qp	50	Eluvium and Alluvium	Loosely consolidated red to brown clay, silt, sand, sandy clay, gravel; sheet kankar; with sand and gravel veneer in places; gilgais common	Piedmont; 'high-level' plain formed by retreating scarp	Main quaternary unit. Saline water from clay areas
			Qb	20	Alluvium	Unconsolidated sand, pebble and boulder deposits	Flat or gently-sloping dissected alluvial profile	Lies mainly on kankar and granite
			Qk	10	Kankar	Impure calcareous deposits and incrustations, with some siliceous nodules	In sheets and nodules, commonly along drainage channels and as cement in recent deposits of 'high-level' plain	Is the result of a still-active chemical process of deposition from lime-rich waters
	Tertiary		Czd	100	Duricrust	Indurated crust on Mesozoic and Proterozoic rocks	A rounded, mature surface now strongly dissected—the Hamersley Surface	Formed by a long period of deep weathering; wholly or partly equivalent to older colluvium, canga, calcrete, pisolite, and laterite
			Czl	20	Laterite	Consolidated, ferruginous, crumbly and cellular, mottled surface-weathering product	On low rounded hills, exposed in creek banks	Confined to and derived from shales and ferruginous sandstones of the Nanutarra Formation
			Czc	200	Older colluvium	Consolidated ferruginous valley-fill; gravels and boulders; including hematite-rich conglomerate (canga)	Dissected profiles, as low rounded hills	Contains pebbles of pisolite; is a source of iron ore
			Czk	60	Calcrete	Impure earthy limestone, weathers to light grey colour; includes surface deposits of white porcellanite	Scarp-forming but generally poor outcrop; covered by later deposits; exhibits normal limestone weathering features	Overlies alluvium in places; correlated in part with *Oakover Formation*
			Tp	200	Robe Pisolite	Pisolitic, oolitic and massive 'limonite'; goethite, hematite, and maghemite deposits containing fossil wood fragments and minor detrital material	Ferruginised valley-fill delineating old river channels; now forming dissected mesas	Source of iron ore; correlated with *Poondano Formation*, incised into Cretaceous sediments
Mesozoic			Kny	150	Yarraloola Conglomerate	Poorly-sorted conglomerate with shale, claystone lenses, and interbedded sandstone	As flat-lying, capping rock on low tablelands, mesas, and buttes; cliff forming	Contains plant fossils
			Kn	250	Nanutarra Formation	Shale, siltstone, micaceous siltstone; ferruginous and glauconitic quartz sandstone; some conglomerate	Low rounded hills, more resistant components from low mesas and buttes	Contains plant and marine fossils

Fossil material, both marine shells and plants, has been found in several widespread localities. H. S. Edgell has determined the age of pelecypods found in ferruginous grits as Aptian.

The sediments were derived from the Proterozoic rocks of the Hamersley Range. Two facies are present: the Nanutarra Formation, which represents a paralic environment; and the Yarraloola Conglomerate, which represents a continental environment. The two formations were originally defined by Hoelscher and McKellar (McWhae and others, 1958).

The *Nanutarra Formation* is present in the southwest part of the Sheet area. It extends from the Cane River north to Warramboo Creek where it is overlain by the Tertiary Robe Pisolite. The main outcrop is confined to a shallow trough, probably no more than 200 feet deep, between the Proterozoic rocks at Warramboo Creek and the Tanpool Hills. However, it is known to extend well to the southwest of the Sheet area and is also thought to underlie the coastal plain. It is bordered to the northeast and east by the Yarraloola Conglomerate.

The formation consists of a mixture of ferruginous sandstone, quartz sandstone, micaceous siltstone, mudstone, and claystone. A basal conglomerate, derived locally, crops out in the Cane River. Glauconitic sandstone has been found in well spoil both 7 miles northeast and 4 miles south of Peedamulla homestead. Plant fossils have been seen at Jabaddor Pool on the Cane River, and pelecypods have been found one mile west of Katanga Bore, which lies 13 miles north-east of Peedamulla homestead, and on an isolated butte 3 miles southwest of Weelumber Well, which lies 9 miles southeast of Peedamulla homestead.

A similar sedimentary sequence underlies the Yarraloola Conglomerate in Peters Creek, 14 miles north-northwest of Deepdale homestead, and is present as scattered outliers further north. Although not directly connected with the Nanutarra Formation further south, the sequence has been correlated with that formation on pelecypods obtained 2 miles southeast of Bullinnarwa Pool on the Fortescue River. It may represent an extension of the formation northwards. However, it is doubtful whether deposition took place in the intervening area around Robe Trig. where land probably existed during this time. The connection is thought to be to the west under what is now the coastal plain.

The *Yarraloola Conglomerate* was originally widely distributed in the central and southern parts of the Sheet area. It stretched from Red Hill and Darnell Hill to north and west of the Fortescue River. Remnants have also been found in the headwaters of the Jimmawurrada Creek to the east. Except for a dissected tableland around Peters Creek, only scattered remnants remain. The type area lies 7 miles south-east of Yarraloola homestead (McWhae and others, 1958).

The formation consists of poorly-sorted ferruginous and siliceous conglomerate containing lenses of white shale; and some ferruginous grits in the upper part. The conglomerates are fluviatile deposits which are made up almost entirely of flood gravel and shingle. The conglomerate, in beds up to 15 feet thick, appears to have been formed by torrential deposition, and is probably similar to flood gravel of the Fortescue River. The shale lenses and sandstone beds commonly contain plant remains.

The Yarraloola Conglomerate is regarded as transgressive on to the Nanutarra Formation. It is thought that the slightly older shallow marine basins were gradually encroached and filled by the flood gravel of the Yarraloola Conglomerate; a process that was probably accompanied by a marine regression to the west. The lack of coarse-grained material at the top of the Yarraloola Conglomerate is taken to represent the gradual cessation of the erosion cycle.

In the deeper and therefore older parts of the marine basins, and at the base of the Yarraloola Conglomerate in the more westerly part, there is an accumulation of well-sorted quartz conglomerate, sandstone, and siltstone. This is overlain by poorly sorted, ferruginous, conglomeratic material. Hence it is probable that, at the beginning of the Cretaceous sedimentation on the Sheet area, the source material came first from rocks belonging to the Wyloo Group which contain a high percentage of quartz. Later coarse clastic material derived from the more distant Hamersley Group was deposited on top. This suggests an increase in the erosion rate.

CAINOZOIC

A variety of Cainozoic deposits is present within the area, and they can be subdivided into two principal groups; an older association of consolidated to loosely-consolidated alluvial and chemical deposits that may range in age from late Cretaceous to early Quaternary, and younger mainly unconsolidated alluvium, eluvium, and colluvium that probably ranges in age from Pleistocene to Recent. The units are fully described in Table 3.

Robe Pisolite

The Robe Pisolite was defined by de la Hunty (1965) from the type locality east of Deepdale homestead. Detailed descriptions, and comments on its origin, are given by Harms and Morgan (1964), and MacLeod (1966).

It consists of oolitic, pisolitic, and massive goethite, hematite, and maghemite together with detrital material, fragments of fossil wood, and seams of clay. It has been formed along drainage channels by the deposition of iron derived from the Precambrian iron formations. These deposits are dissected and form mesas, some crudely terraced, that stand up to 100 feet above the present plain level. They are best developed along the Robe River, but pisolite is also present on Warramboo, Peters, Seven Mile, and Jimmawurrada Creeks, near Red Hill homestead, and on the Nullagine Plateau. At Warramboo homestead the pisolite passes beneath the coastal plain. It overlies Cretaceous rocks near Robe Trig., and although its age is assumed to be Early Tertiary, Harms and Morgan (1964) consider that deposition may have begun in the late Cretaceous.

Similar deposits have been found in many parts of the North-West Division of Western Australia. The pisolite has been correlated with the Poondano Formation of McWhae and others (1958). All these deposits are believed to be synchronous.

Calcrete

An impure earthy limestone or calcrete, containing bands of porcellanite, crops out on the Fortescue Plain between the Robe River and the eastern boundary of the Sheet area. It is interdigitated with colluvium, and overlies fluviatile sediments in places. Fragments of pisolite have been found in the calcrete.

The deposits are similar to the calcrete deposits of the Western Australian hinterland (Sofoulis, 1963), including those which cap the Oakover Formation in the headwaters of the De Grey River southeast of Port Hedland. They appear to have formed in areas of internal or restricted drainage, and are essentially similar to younger deposits of kankar (see below), from which they have been distinguished in the Sheet area by chronology.

Older colluvium

An earthy, ferruginous, poorly consolidated gravel is found in valleys throughout the Hamersley Range. It overlies pisolite and is laterally equivalent to calcrete in places. It also includes hematite-rich conglomerate (canga).

Laterite

Laterite has been developed on the shale and ferruginous sandstone belonging to the Nanutarra Formation. It is a ferruginous residual deposit and crops out on low rounded hills. It is dissected, and is tentatively correlated with the older colluvium and related deposits of the Hamersley Range.

Duricrust

The Proterozoic rocks of the Hamersley Range, and the Mesozoic rocks in the vicinity of Peters Creek, are capped by a dissected land surface that is characterised by severe induration. The surface is made up of a ferruginous zone underlain by a kaolinitic or siliceous zone. It has been named the Hamersley Surface by Campana and others (1964).

Younger unconsolidated sediments

Unconsolidated alluvial and residual deposits overlie all other units in the Sheet area. The deposits can be divided, on chronology, into three groups. However, they are closely related and tend to merge with each other. A facies change, which is related to the distance from the source area, is also evident within each group.

The oldest and largest group is the loosely consolidated and unconsolidated alluvial deposits that form the 'high level' of the coastal plain. The deposits are made up of crudely stratified clay, silt, sand, and gravel which form the gilgais, sand plains, and gravel veneers of the coastal plain. Gilgais (or crab holes) are also present on the Nullagine Plateau where sheets of mixed boulders and clay eluvium cover volcanic rocks. The composition of these deposits is directly related to the underlying rock. Old residual gravels which form over poorly-outcropping formations are also included in this group. Examples are the Ashburton Formation which yields a quartz rich gravel, and the Marra Mamba Formation which yields ironstone gravel.

Several forms of kankar, an impure limestone with siliceous incrustations, are present in the sediments. It acts as a cement in the partly consolidated material or forms thin sheet-like bodies within the alluvium. Thick accumulations are forming along present-day drainage channels, particularly along those which drain basic or calcareous rocks.

Old fixed coastal dunes, which are well-vegetated, are thought to be contemporaneous with the 'high level' plain. They are now being eroded and are separated from the plain by salt water marshes.

A group of younger alluvial deposits overlie the 'high level' plain. These are the flood deposits which include the levees, river terraces, and thin sheets of silt associated with the present-day drainage lines but which are incised and partly eroded by the drainage channels. Sief dunes have been formed from sand and silt derived from this surface. Some lightly vegetated and partly mobile coastal dunes are placed in the same group. The dunes, on the Roebourne and Dampier 1 : 250,000 Sheets, contain *Anadara* shells which have yielded an apparent age of 2,000 years (Kriewaldt, 1966).

The youngest group is made up of alluvial sand and shingle deposits and is restricted to the present-day drainage channels. The silt of the tidal flats and recent colluvial deposits consisting of talus, scree, and outwash also belong to this group.

STRUCTURE

The Sheet area can be divided into two tectonic regions which are separated by a complex zone of faulting (Figure 2). This zone trends roughly north and splits the Sheet area into two nearly equal portions. The eastern portion contains gently folded and faulted Lower Proterozoic rocks that are underlain by Archaean rocks at a shallow depth. The Archaean Roebourne Group is folded on a northeasterly axis and occupies

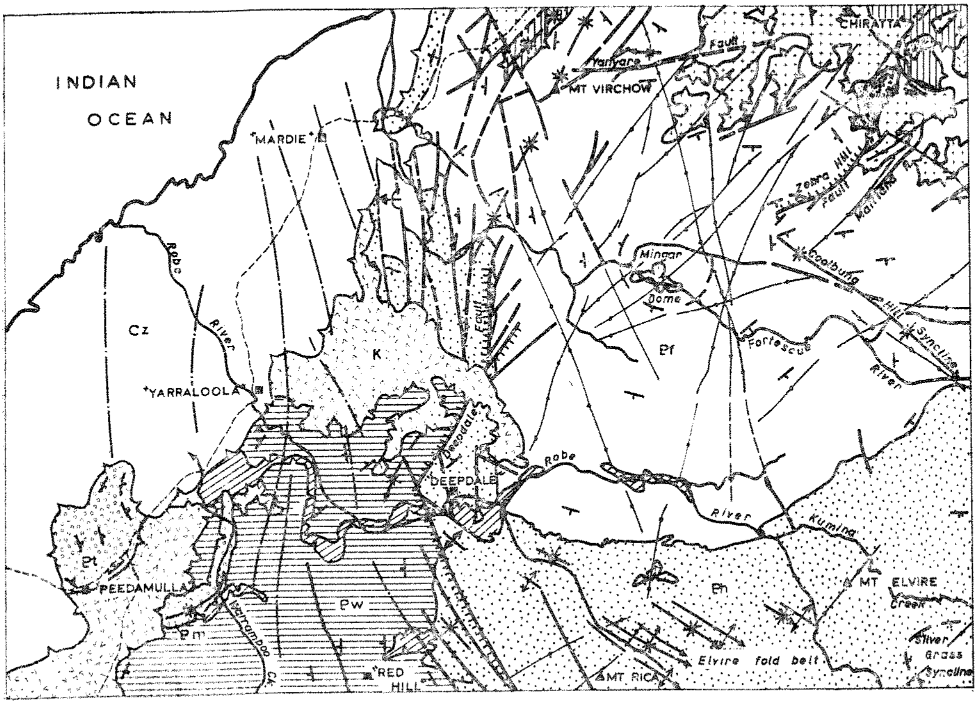

FIGURE 2

STRUCTURAL SKETCH MAP
YARRALOOLA SHEET SF50-6

SCALE OF MILES

10 0 10 20 30

REFERENCE

Cz Cainozoic

Robe Pisolite

K Cretaceous

Pt Pm Tanpool Beds and Mt. Minnie Group

Pw Wyloo Group

Ph Hamersley Group

Pf Fortescue Group

Roebourne Group

Dolerite dykes

Cooya Pooya Dolerite

Munni Munni Complex and associated intrusives

Granite and gneiss

Fault, showing downthrow

Fault, inferred

Lineament from aeromagnetic map

Unconformity

Geological boundary

Geographical boundary, position approximate

Dip and strike of beds

Dome

Basin

Anticline, showing plunge

Syncline, showing plunge

Monocline

Dip and strike of foliation

Dip and strike of layering

Homestead

Highway

Trig Station

a tight syncline near Devils Creek, and a complex synclinorium in the northeast corner of the Sheet area.

Two general fold directions are present in the Proterozoic rocks; they are to the northwest and northeast. The main structure is a large anticline which parallels the northeasterly direction and plunges to the southwest. The Elvire Fold Belt and the Coolbung Hill Syncline parallel the northwesterly direction. Axial planes belonging to this direction dip to the southwest and some overturning was observed 4 miles south-southwest of Deepdale homestead. The interference between the two fold directions has produced a series of shallow basins and domes. The most prominent of these is the Mingor Dome, which contains an inlier of Archaean rocks.

A series of fractures parallel the two fold directions. They are often filled with dolerite and movement along the fractures is usually small; an exception is the Zebra Hill Fault. The apparent displacement of many of the fractures is due to differential erosion of the flat-lying or gently dipping strata. In most cases these fractures are joints and the faulting is not parallel to the main fold directions.

The stable eastern portion is bounded on the western side by the complex north trending zone of normal faults. It includes the Deepdale Fault which has a downthrow to the west of about 7,000 feet.

The western portion of the Sheet area contains strongly folded and faulted Lower Proterozoic rocks that are overlain by younger Proterozoic and Phanerozoic sedimentary rocks. The fold axes in the Proterozoic rocks trend in a northerly direction and there is a well developed axial plane cleavage in pelitic rocks of the Ashburton Formation. The poor exposure and numerous faults have made it difficult to interpret the folding but examples of overturned, isoclinal, and recumbent folds have been seen west of Red Hill Station and just south of Robe Trig.

The rocks of the Mt Minnie Group are tightly folded in an arcuate syncline which trends in a northeast direction.

Halligan and Daniels (1964) recognised two fold directions in the Mt Bruce Supergroup; the Ophthalmian and the Rocklean. The former direction is represented by the fold axes striking northwest and the latter by the northeast trending axes in the eastern portion. The complex faulting in the western portion has made it difficult to recognise fold directions in this area. However the northerly trend is thought to belong to the Ophthalmian period.

Several prominent magnetic lineaments have been located north of Peedamulla homestead on the coastal plain. At least two are continuous with known faults.

Very little folding has taken place since the Proterozoic. The Mesozoic sediments are very gently warped and there is a gradual fall to the west in the order of 400 feet in 20 miles. The warping is probably related to the folding of the Carnarvon Basin which lies to the southwest.

GEOMORPHOLOGY

The oldest erosion surface that is found on the Sheet area predates the deposition of the Lower Proterozoic Fortescue Group. The surface has a relief of about 100 feet and is similar to the one formed on the Archaean rocks at the present time. The next recognisable surface is Lower Cretaceous. The remnants of this surface are restricted to the western half of the Sheet area where Aptian sediments are deposited on a mature land surface. Prominent Proterozoic outcrops, such as Robe Trig. and the sandstone hills along Warramboo Creek were probably islands in the Cretaceous sea. The buried land surface is being rejuvenated in the Peedamulla and Tanpool Hills region at the present time.

The Hamersley Surface (Campana and others, 1964) is best preserved, in the Hamersley Range, as an indurated crust on the iron formations. MacLeod (1966) considers that this surface represents the culmination of a long period of physiographic evolution and he has used the development of this surface to account for the formation of the high-grade hematite ores of the Hamersley Iron Province. The indurated surface of the Yarraloola Conglomerate and the laterite on the Nanutarra Formation are thought to be related to the Hamersley Surface. The profile of these indurated surfaces is continuous with that delineated by remnants of pisolite, canga and older colluvium, and it seems likely that these deposits were laid down contemporaneously with the formation of the Surface.

It would appear that the Hamersley Surface was formed on a mature topography and the fossil-wood fragments in the pisolites suggests that at least some parts of the land were vegetated.

The 'high level' coastal plain is thought to be a Pleistocene land surface. Kriewaldt and Ryan (in press) have called it the Yule Surface on the Pyramid 1 : 250,000 Sheet. The Fortescue Plain is probably the same age. This surface has been incised and partly buried by younger alluvium belonging to the present day erosion cycle.

GEOLOGICAL HISTORY

The extrusion of basic lavas in the lowermost part of the Roebourne Group is the earliest event that is recorded on the Sheet area. It was followed by a long period of volcanic activity and sedimentation which was accompanied by the intrusion of acid and basic dykes and sills. This succession was progressively folded, metamorphosed, and intruded by granite.

After uplift and erosion of the Archaean rocks, a thick sequence of flood basalts and pyroclastic material were laid down at the base of the Proterozoic. Periodic marine incursions are shown by patches of waterlain detrital sediments, stromatolites, and pillow lavas. Most of the volcanic activity ceased at the end of the Fortescue Group and was replaced by the chemical and pelitic sediments of the Hamersley Group. The westward attenuation of this group suggests that there was either an active positive area, or that there was less deposition due to the distance from the source area. The quiet conditions of the group were interrupted by one widespread phase of acid vulcanicity, the Woongarra Volcanics.

A return to unstable conditions is shown by the coarser-grained clastic material of the Wyloo Group. Volcanic activity is limited to small areas and the whole sequence is intruded by post-kinematic acid and basic dykes. Granite also intrudes the group.

The complete succession, called the Mt Bruce Supergroup, was subjected to erosion before the deposition of the Mt Minnie Group and Tanpool Beds. The clastic sediments of this group were probably laid down in small near-shore basins.

The next event recorded is the Lower Cretaceous marine incursion and the deposition of the Nanutarra Formation and its facies equivalent, the Yarraloola Conglomerate, along the western side of the Sheet area. When the Lower Cretaceous sea regressed westwards, terrestrial sediments were laid down on top of the marine sediments.

About this time, the Hamersley Surface was probably forming on the mainland and, after the uplift of the Cretaceous sediments, was extended on to those rocks. This uplift was followed by rapid erosion and later by the gradual infilling of the valleys with iron rich detrital rocks derived from the Hamersley Group. Climatic conditions at that time are thought to have caused the circulation of vast quantities of iron which was redeposited and enriched in suitable structural positions.

Further rejuvenation has dissected the iron deposits and produced fresh alluvial deposits and formed the extensive piedmont plain along the west coast. These are now being actively dissected.

The geological history is summarised in Table 4.

TABLE 4. SUMMARY OF GEOLOGICAL HISTORY

Era	Period	Event
Phanerozoic	Quaternary	Continental sedimentation, with contemporaneous erosion; minor changes in sea level
		Rejuventation
	Tertiary	Chemical deposition, widespread iron migration; cementation and induration; continental sedimentation
		Rejuvenation
	Cretaceous	Marine regression Shallow marine and continental sedimentation Marine transgression
		Erosion
Proterozoic	?Middle Proterozoic	Shallow marine sedimentation in small basins, followed by basic intrusion, folding and faulting
		Erosion
	Lower Proterozoic	Detrital and chemical sedimentation with local vulcanicity; minor igneous intrusion; followed by folding, faulting and low grade metamorphism; acid and basic intrusion
		Widespread vulcanicity with periodic marine incursion; cessation of vulcanism; marine inundation. Chemical and minor detrital sedimentation including one period of acid vulcanicity
		Erosion
Archean		Vulcanicity; chemical and detrital sedimentation; renewed vulcanism followed by acid and basic intrusions. Folding, faulting and low grade regional metamorphism; granite emplacement with contact metamorphism

ECONOMIC GEOLOGY

Iron

The most important metalliferous deposits are the massive pisolitic iron ores of the Robe Pisolite that extend along the drainage of the Robe River. Although first noted by Maitland (1909, p. 93) at Chalyarn Pool in the Robe River, they were not investigated thoroughly until 1960 and the following years (Harms and Morgan, 1964). Pisolitic iron ore bodies have been mapped elsewhere in the Yarraloola area, notably in the Red Hill, Warramboo Creek, and Jimmawurrada Creek regions. They are generally of lower grade and of limited tonnage. Detailed descriptions of the ore deposits and their mineralogy have been given by Harms and Morgan (1964) and MacLeod (1966).

MacLeod (pers. comm.) estimates that the Robe River deposits contain about 3,000 million tons of ferruginous ores, of which 1,000 million tons have a grade of more than 55% Fe. The ore is present in dissected tabular bodies which form mesas along the Robe River. Deposits in the lower part of the Robe River are held by The Broken Hill Pty. Ltd., and those in the upper part by Cliffs International, a subsidiary of Cleveland-Cliffs Iron Co. who acquired them from Basic Materials Pty. Ltd. Large deposits of high grade hematite ore, similar to those in other parts of the Hamersley Iron Province, have not been found in the Sheet area.

Copper

Traces of copper are present in many places, both in the Archaean Regal Formation, and the Proterozoic Ashburton Formation and Duck Creek Dolomite. These have been tested in many places, but in only three localities has any mining been undertaken: at Red Hill (Duck Creek Dolomite), Yarraloola (Ashburton Formation), and Yannery Hills and Whundo (Regal Formation).

Descriptions of the various deposits have been given by Blatchford (1913), Maitland (1919), Jones (1939), and Low (1963). Production from these centres is given in Table 5.

Gold

Auriferous quartz reefs have been reported from north of Deepdale homestead in the Maddina Volcanics, but attempts to find the diggings in 1964 were unsuccessful. Quartz reefs, located on faults, abound in this area, and many carry manganese stains. However, it is doubtful whether economic deposits of gold exist.

Tin

Placer tin has been reported from 'south of Chiratta homestead', but the locality of any deposits is unknown. Pegmatites are rare in the area.

Asbestos

A seam of white fibre, believed to be tremolite was found in Archaean metasediments on Eramurra Creek. Chrysotile seams occur in the serpentinites of the Munni Munni Complex. Thin seams of crocidolite including tiger eye (a silicified crocidolite) have been found in the Marra Mamba Iron Formation 12 miles southeast of Deepdale homestead and in the Brockman Iron Formation in scattered localities.

The deposits, so far, are not of commercial interest, but both chrysotile and crocidolite seams of suitable grade could be present. Tiger eye is used as a semi-precious stone.

Lignite

Woodward (1911, p. 115) reports that some lignite was supposed to have been found near Balmoral homestead, but he was not shown the locality. A probable source would appear to be the Yarraloola Conglomerate or Nanutarra Formation, relicts of which exist in this area.

Petroleum

The eastern limit of the Carnarvon Basin, is marked by the extent of the Cretaceous sediments. Petroleum deposits have been found elsewhere in the basin but it is doubtful whether prospective sediments exist within the Sheet area, except possibly offshore in the northwest corner.

TABLE 5. REPORTED COPPER PRODUCTION

A. COPPER ORE

Producer	Ore Tons	Metal Content Tons Cu	Value $
Red Hill Centre			
ML 62, 'Cane'	175.50	33.85	2,126
Yannery Hill Centre			
ML 138, 'Trouble'	23.21	6.22	343
ML 179/180, 'Whundo'	386.20	82.25	8,046
ML 192, 'Whundo'	213.00	38.34	4,260
ML 193, 'Whundo West'	113.00	20.34	2,260
ML 144, Yannery Hill copper mine	469.25	113.81	9,961
ML 144/192/193, Yannery and Whundo Copper Mining Co. Ltd.	404.50	85.14	8,116
ML 259, Yannery Hill copper mine	277.26	38.81	7,272

B. CUPREOUS ORE

Producer	Ore Tons	Assay % Cu	Value $
Red Hill Centre			
ML 165/166, Parkinson, Camp and Armstrong	46.95	15.03	1,957.25
Yarraloola Centre			
MC 54 Camp and party	2.71	14.60	88.75
Yannery Hill Centre			
ML 260, Whundo Copper Syndicate	1,039.29	9.83	15,465.63
ML 259, Yannery Hill copper mine	1,528.87	12.58	28,109.07
ML 262, T. Lee	19.87	5.20	40.00
Crown Land—Sundry persons	10.75	4.75	60.00

Figures supplied by W. A. Dept. Mines Statistics Branch

A total of about 3,500 tons of copper ore have yielded 700 tons of metallic copper assaying about 20%.

Industrial rocks

Ballast and road metal are plentiful in the Sheet area. The ferruginous Robe Pisolite makes particularly good road metal. Clean sand is less common, as the principal rivers contain mostly shingle. No high-grade limestone deposits are known.

Recommendations for prospecting

The Sheet area has reasonably good mineral potential, despite the general lack of prospecting success to date. It is unlikely that iron deposits of commercial size remain to be discovered, and the potential for gold is poor. However, the prospects for other metals is better, although it must be emphasized that the area has already been moderately well prospected and further discoveries are more likely to be made by the use of modern exploration techniques such as geophysics and geochemistry.

Some prospective rock units, and the minerals which might be present, are:

1. Munni Munni Complex—chrysotile, nickel, chromite
2. Regal Formation, and associated metasediments—copper, gold, semi-precious stone such as prase
3. Archaean granites—pegmatites, beryl, tin, etc.
4. Marra Mamba Iron Formation and Brockman Iron Formation—crocidolite, tiger eye, hematite
5. Jeerinah Formation—copper
6. Duck Creek Dolomite—copper, lead, silver
7. Ashburton Formation—copper.

Water supply

Stock water is drawn from 160 wells and bores and most of these lie in the western half of the area along the coastal plain. Nearly all groundwater is obtained at shallow depth from alluvium or colluvium, though a few deeper wells have tapped Cretaceous and Proterozoic sediments. The quality of the water depends principally on the proximity to the main drainage channels, where subsurface flow persists throughout the year. Most of the larger channels contain numbers of permanent or nearly permanent water holes which are used to supplement the groundwater supply when they lie in suitable areas.

Domestic water is drawn from wells and bores, and is generally of good quality. A search for large quantities of groundwater to supply the mining settlements which will be developed near the iron ore deposits, began in 1965. Suitable dam sites could almost certainly be found on the Fortescue River, or probably on other rivers.

No artesian bores or wells are known but there is an active mound spring at Mt Salt, northwest of Mardie homestead (Williams, 1965). Highly saline waters discharge from this spring, which stands about 25 feet above sea level and 10 feet above plain level. It is thought that the water is derived from the Cretaceous sediments and that the intake beds crop out in the lower reaches of the Fortescue River; from here they dip gently to the west towards the mound spring.

Table 6 shows some typical underground water supplies in the area, and the locations of wells and bores are shown in Figure 3. Further details may be obtained from the office of the Geological Survey of Western Australia in Perth.

TABLE 6.—TYPICAL UNDERGROUND WATER SUPPLIES

Name	No.	Equipment	Depth of Hole (feet)	Depth to Water (feet)	Quality in p.p.m.	Aquifer
MARDIE STATION INCLUDING BALMORAL STATION						
Windoo Well	M 1	Windmill	36	27	2,500	Alluvium
Homestead Well ..	M 6	Windmill	27	20	800	Alluvium
Kaninda Well	M13	Windmill	56	24	1,270	Kankar over basic volcanics
Shepherd's Well ..	M25	Abandoned	110	24	181	Alluvium over quartz sandstone (irregular supply) (aquifer)
Surprise Well	M29	Windmill	12	8	3,207	Alluvium
Balmoral Homestead Well	M32	Windmill	95	35	1,204	Shales
Tarquin Well	M33	Windmill	26	16	1,140	Basic volcanics
North Landing Well ..	M36	Abandoned	13	12	1,568	Coastal sand dunes (irregular supply)

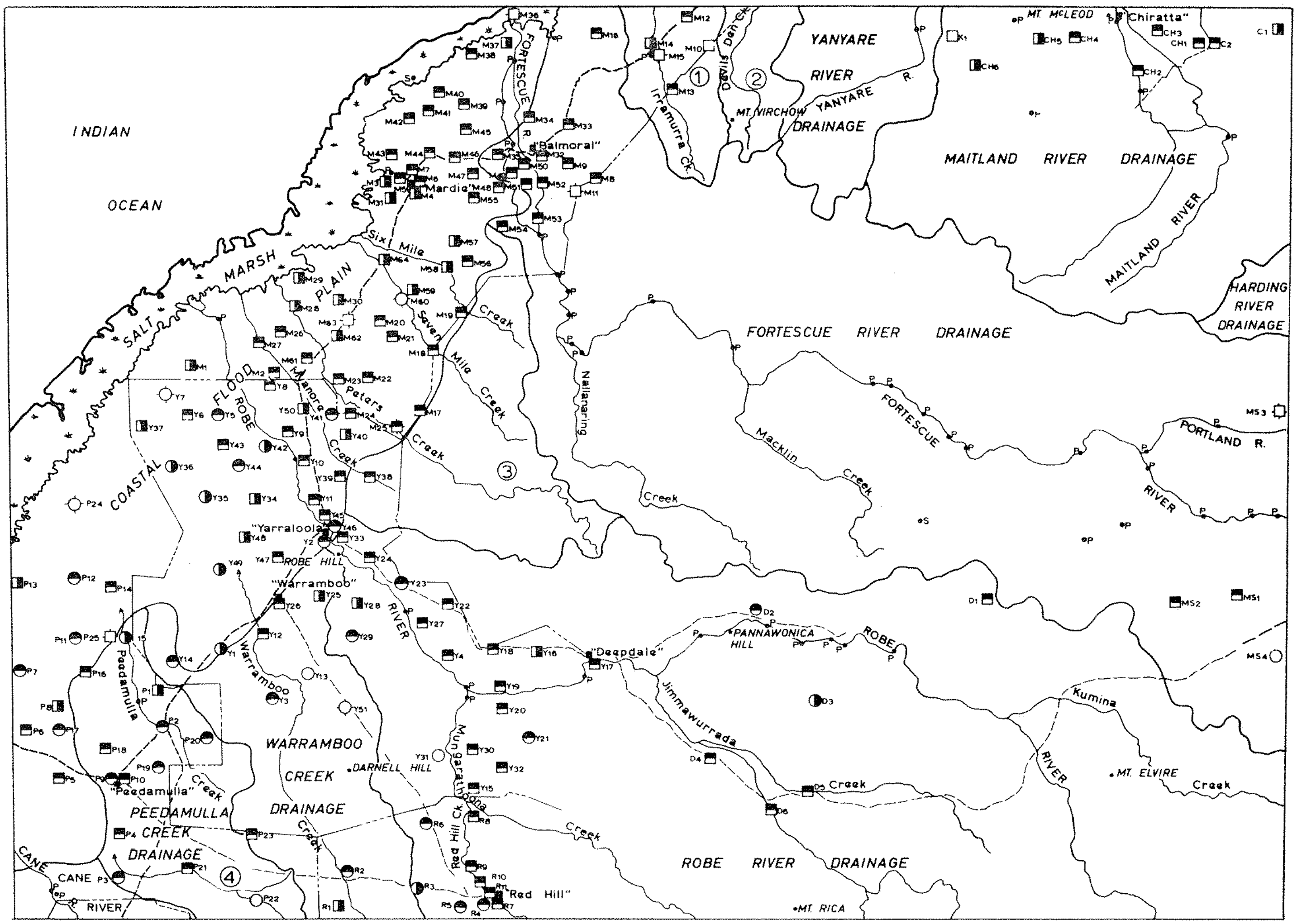

FIGURE 3

DRAINAGE PROVINCES AND WATER SUPPLY

YARRALOOLA SHEET SF50 - 6

SCALE OF MILES

0 5 10 15 20 25 30

REFERENCE

- NW. Coastal Highway
- Main road
- River, creek (non perennial)
- Coastal marsh (salt)
- Drainage province boundary
- Fences
- "Yarraloola" Homestead
- MT. ELVIRE Hill
- P. Pool
- S. Spring

Well - abandoned
- salinity unknown
- salinity >2,500 ppm
- 2,500 - 10,000 ppm
- <10,000 ppm

Bore - abandoned
- salinity unknown
- salinity >2,500 ppm
- 2,500 ppm - 10,000 ppm

① Irramurra Creek Drainage

② Devils Den Creek Drainage

③ Coastal Drainage
- a Peters Creek
- b Seven Mile Creek
- c Six Mile Creek
- d Myanore Creek

④ Includes unnamed creek South of Peedamulla and North of Cane River

TABLE 6. TYPICAL UNDERGROUND WATER SUPPLIES—*continued*

Name	No.	Equipment	Depth of Hole (feet)	Depth to Water (feet)	Quality in p.p.m.	Aquifer
MARDIE STATION INCLUDING BALMORAL STATION—*continued*						
Hilda Well	M42	Windmill	16	9	1,875	Alluvium
Secret Well	M47	Windmill	43	24	581	Alluvium
Hornes Well	M59	Windmill	44	28	10,277	Alluvium
Deep Well	M17	Windmill	100	77	620	Alluvium over shales
YARRALOOLA STATION INCLUDING WARRAMBOO STATION						
Katanga Bore	Y 3	Windmill	125	..	473	Alluvium
Deepdale Well	Y17	Windmill	45	30	847	River gravels
Yallangi Bore	Y21	Windmill N.I.U.	50	29	500	Colluvium over shales
Three Mile Well ..	Y25	Windmill	85	73	7,623	Colluvium over basic volcanics
Ashley Well	Y27	Windmill	30	17	681	Alluvium
Huberts Bore	Y29	Windmill	51	..	464	Colluvium
Daniels Bore	Y44	Windmill	35 (approx.)	..	1,000	Alluvium
Homestead Bore ..	Y46	Windmill	43	..	847	Alluvium
Bob Bore	Y49	Windmill	21	11	2,960	Alluvium
PEEDAMULLA STATION						
Hancocks Bore	P 2	Windmill	98	..	574	Colluvium
Toolunga Bore	P 3	Windmill	130	..	887	Colluvium and sandstone-shales
Eight Mile Well.. ..	P 8	Windmill	..	17	4,322	Alluvium
Homestead Well ..	P10	Windmill	..	78+	1,827	Alluvium
Mardie Bore	P12	Windmill	..	..	2,049	Alluvium
Soak Bore	P20	Windmill	100+	..	1,333	Colluvium of glauconitic sandstone
Deep Well	P23	Windmill N.I.U.	..	124	1,610	Alluvium of low grade mica schists
RED HILL STATION						
Brighton Bore	R 3	Windmill	126	26	4,833	Alluvium
Homestead Well ..	R 7	Windmill	40	..	110	River gravels
North Well	R 8	Windmill	23	13	788	Alluvium
DEEPDALE STATION						
Mt. Enid Well	D 1	Windmill N.I.U.	..	51	1,695	Basic volcanics
Wilson Well	D 2	Windmill	42	..	724	Alluvium overlying basic volcanics
Callawia Bore	D 3	Windmill	45	..	4,166	Colluvium
Yathala Well	D 6	Windmill	..	15	92	Alluvium
MILLSTREAM STATION						
Johnson Well	MS1	Windmill	..	..	678	Kankar
Jones Creek Well ..	MS2	Windmill	..	47	375	Alluvium, jaspilite and chert
CHIRATTA STATION						
Yannery Well	CH2	Windmill	36	17	1,600	Metamorphic rocks
4-mile Well	CH4	Windmill	17	8	1,350	Alluvium and kankar
Seven Mile Well ..	CH6	Windmill	36	19	2,780	Gneiss

N.I.U.=not in use

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APPENDIX 1—DEFINITION OF ROCK UNITS

The following formations have been introduced in the text:

1. Nickol River Formation.
2. Cliff Springs Formation.
3. Lyre Creek Agglomerate Member.
4. Nallanaring Volcanic Member.
5. Warramboo Sandstone.
6. Tanpool Beds.

They are defined as follows:

1. Nickol River Formation

Derivation of name: Nickol River, which flows into Nickol Bay, between Roebourne and Dampier.

Lithology: Interbedded metamorphosed sediments, with intercalated lavas in places; quartz, mica, amphibole, talc, sericite and chlorite schists; shale and siltstone; greywacke, sandstone, and some conglomerate; dolomite and metadolomite; chert and jaspilite.

Features: Contains chromium-stained rocks; fuchsite schist, green (nickeliferous) dolomite, and prase.

Distribution: Dampier, Yarraloola, and Roebourne 1 : 250,000 Sheet areas; from Eramurra Creek (Lot. 21° 6′ S, Long. 116° 14′ E approx.) in the west to the vicinity of Roebourne township in the east.

Thickness: Variable, estimated maximum about 1,000 ft.

Type section: Not measured. Near the Nickol River, Lat. 20° 47′ S, Long. 116° 57′ E.

Stratigraphic position: Near the base of the Roebourne Group. Overlain by the Regal Formation (basic and acid volcanic rocks), and underlain by volcanic rocks, amphibolites, and gneiss. Laterally may be equivalent to acid volcanic rocks at Whim Creek area. The formation has been used successfully as a stratigraphic marker bed.

Age: Archaean.

Topographic expression: Hog-back ridges, low hills, elongated parallel to strike; cuestas where dip is low; and low rounded hills where chert and jaspilite are less prominent.

2. Cliff Springs Formation

Derivation of name: From Cliff Springs, on Maitland River (Lat. 21° 9′ S, Long. 116° 56′ E approx.).

Lithology: Predominantly tuffaceous, but with clastic rocks and subordinate calcareous rocks more common between Maitland River and Cape Preston: green, bedded or massive tuff, with volcanic pisoliths in places; sandy tuff, tuffaceous siltstone and claystone; some agglomerate, with bombs of amygdaloidal lava; medium-grained volcanic breccia; tuffaceous sandstone, arkose, conglomerate; minor dolomitic lenses; calcareous cement in some beds.

Features: Current-bedding and ripple marks in some sandy members.

Distribution: From 1 mile west of Eramurra Well (Lat. 21° 3′ S, Long. 116° 15′ E)—on Yarraloola Sheet area, to Mumbillina Bluff (Lat. 21° 37½′ S, Long. 118° 18′ E) on Pyramid Sheet area; following line of scarp which marks the northern face of the Nullagine Plateau (Jutson, 1950).

Thickness: Up to 500 ft, very variable due to facies changes and basement relief.

Type area: Western Creek, a branch of the Harding River (Lat. 21° 13′ S, Long. 117° 2½′ E approx.).

Type Section: Not measured, as for type area.

Stratigraphic position: Unconformably overlies the Archaean or the Mt. Roe Basalt (Kriewaldt, 1964a) either conformably or disconformably. Conformably overlain by Kylena Basalt (MacLeod and de la Hunty, 1966) of Fortescue Group.

Age: Lower Proterozoic or older (by G. S. W. A. usage).

Correlatives: Hardey Sandstone (MacLeod and others, 1963) wholly or in part. Green Hole Conglomerate, Glen Herring Shale, Beaton Creek Conglomerate, Lower Coongan Volcanics (Noldart and Wyatt, 1962) wholly, or in part.

Fossils: Possible stromatolites, found in only one locality.

Topographic expression: Slopes of poor outcrop along scarp; low ridges, cuestas formed by more resistant members; tor-like areas in Harding River valley with elongated exfoliation giving spheroidal structures; low-lying areas with kankar.

3. Lyre Creek Agglomerate Member of the Cliff Springs Formation.

Derivation: Lyre Creek Well, on tributary of the Harding River (Lat. 21° 10′ S, Long. 117° 13′ E), on Pyramid 1 : 250,000 Sheet.

Lithology: Green, bedded and massive tuff, crystal tuff, agglomerate, with bombs of amygdaloidal lava; basal quartzitic tuff; some calcareous beds; volcanic pisoliths in places.

Distribution: As for Cliff Springs Formation.

Thickness: 0-250 ft.

Type area: Western Creek, a branch of the Harding River (Lat. 21° 13′ S, Long. 117° 2½′ E approx.).

Type section: Not measured, as for type area.

Stratigraphic position: Occupies the upper part of the Cliff Springs Formation, varying from half to less than one-fifth of total thickness of formation. Base in type area marked by thin buff-coloured quartzitic tuff. Overlain conformably by Kylena Basalt. Top taken at first lava flow, though tuff is present in overlying formation.

Age: Lower Proterozoic.

Topographic expression: Mainly concave slopes with poor outcrop below scarp edge, but in type area also rough low-lying tors with elongate exfoliation faces giving spheroidal structures; and flat kankar-covered areas.

4. Nallanaring Volcanic Member of the Jeerinah Formation.

Derivation of name: Nallanaring Creek, a northward flowing tributary of the Fortescue River, joining in vicinity of Bullinnarwa Pool (Lat. 21° 23′ S, Long. 116° 7′ E).
Lithology: Predominantly basalt, some minor pyroclastics, volcanic pisoliths and acid lavas towards the bottom. Pillow lavas in the upper portion of the member in several localities.

Distribution: The member lies wholly within the Yarraloola 1 : 250,000 Sheet area; from a point 7 miles southeast of Mt. Enid Well (Lat. 21° 44′ S, Long. 116° 40′ E) west to 3 miles southwest of Bilanoo Hill (Lat. 21° 19½′ S, Long. 116° 4′ E).

Thickness: 0-250 ft estimate; variable thickness due to the irregular distribution of the contained lava flows.

Type area: Nallanaring Creek (Lat. 21° 30′ S, Long. 116° 12′ E approx.).

Type section: Not measured, as for type area, approx. 100 ft thick.

Stratigraphic position: Lies conformably below the Roy Hill Shale Member (MacLeod and de la Hunty, 1966) and above the Warrie Member (MacLeod and de la Hunty, 1966) of Jeerinah Formation (MacLeod and others, 1963).

Age: Lower Proterozoic (G.S.W.A. usage).

Topographic expression: Poorly outcropping and easily eroded; generally low relief with rounded hills; covered by patches of outwash derived from the more resistant overlying and underlying cherts and jaspilites.

5. Warramboo Sandstone

Derivation of name: Warramboo Creek 12 milec east of Peedamulla Homestead (Lat. 21° 51′ S, Long. 115° 46′ E approx.).

Lithology: Massive to flaggy, thin-bedded to thick-bedded, fine-grained to coarse-grained, white, buff, brown and greenish quartz sandstone; some thin silty shales.

Features: The rocks have a high quartz content and are low in feldspar.

Distribution: Confined to an elongated area, trending north, 14 miles long, 9 miles east of Peedamulla Homestead, on the western side of Warramboo Creek. Isolated outcrops at Robe Trig.

Thickness: Greater than 2,000 ft, top of formation missing.

Type area: 9 miles east-southeast of Peedamulla Homestead (Lat. 21° 53′ S, Long. 115° 43′ E).

Type section: Not measured.

Stratigraphic position: Upper formation of Mt. Minnie Group, conformably overlies Wabco Shale (Daniels, in preparation).

Age: Lower Proterozoic?

Topographic expression: Low to moderate rounded hills.

6. Tanpool Beds

Derivation of name: Tanpool Hills, 4 miles north of Peedamulla Homestead (Lat. 21° 47′ S, Long. 115° 36′ E approx.).

Lithology: Interbedded fine-grained to coarse-grained massive and flaggy sandstone, shales, orthoquartzites, glauconitic sandstones.

Features: The rocks are typically high in quartz content and low in feldspar.

Distribution: The beds are confined to an isolated group of hills, the Tanpool and Peedamulla Hills, north of Peedamulla Station Homestead, and cover an area of roughly 9 miles by 6 miles wide.

Thickness: 8,000 ft plus; the upper and lower boundaries of the beds cannot be defined within the area of the outcrop.

Type area: One mile northwest of Peedamulla Trig—(Lat. 21° 43½′ S, Long. 115° 39′ E) a type section not measured.

Stratigraphic position: Direct relationship to other Proterozoic rocks is not known; is unconformably overlain by Mesozoic sediments belonging to the Nanutarra Formation (McWhae and others, 1958).

Age: Proterozoic.

Correlation: The beds have been tentatively correlated with the Mount Minnie Group (Daniels in press).

Topographic expression: The resistant sandstone and orthoquartzites form bold (150 ft high) parallel cuestas separated by shallow valleys containing less resistant shales and intrusive dolerites.

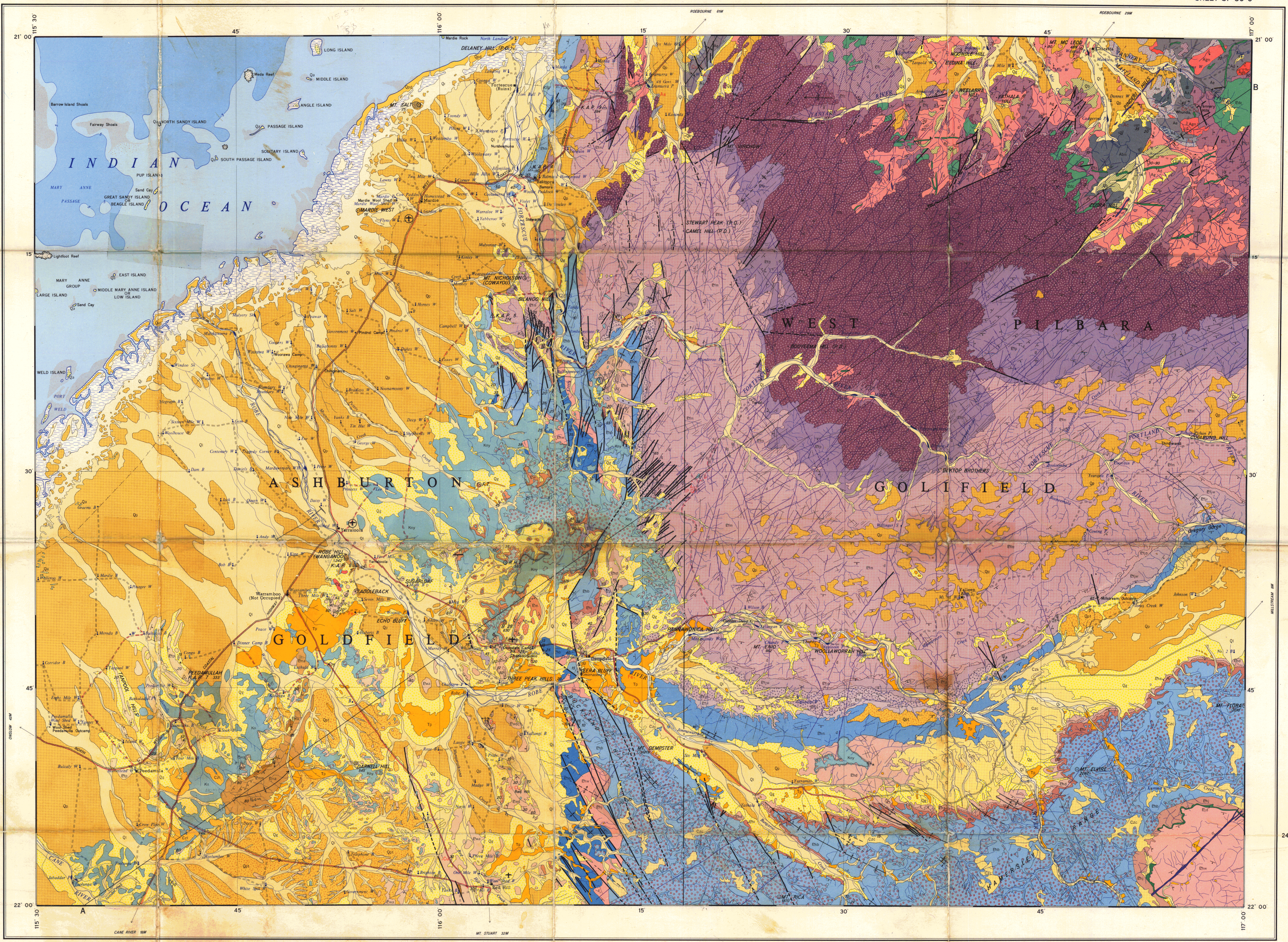
By Authority: A. J. Arthur, Commonwealth Government Printer, Canberra

YARRALOOLA

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET SF 50-6

SYMBOLS



REFERENCE

CAINOZOIC — QUATERNARY — TERTIARY

MESOZOIC — CRETACEOUS

PROTEROZOIC — LOWER PROTEROZOIC

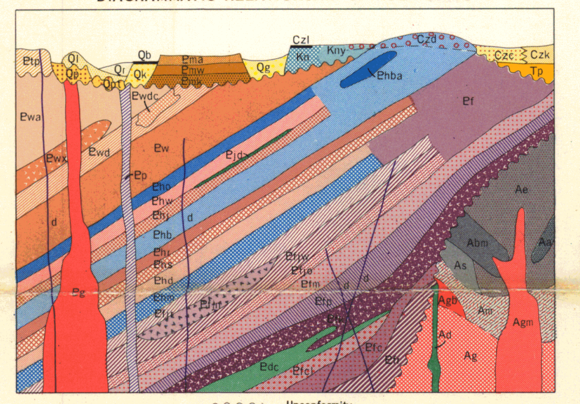
2440 million years

ARCHAEAN

INTRUSIVE ROCKS

MUNNI MUNNI BASIC COMPLEX. Fresh to altered gabbro, pyroxenite, serpentinite

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



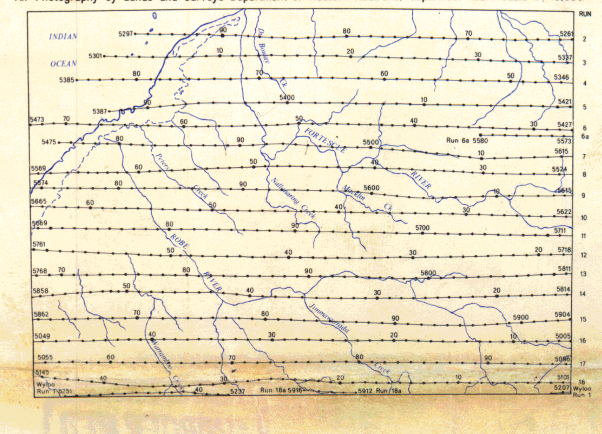
Unconformity

Geology by I.R. Williams, G.R. Ryan and R. Halligan 1963–1964

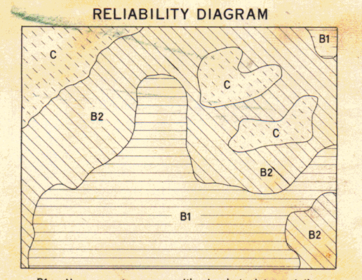
Compiled by Geological Survey of Western Australia. Cartography by Geological Drafting Section, Mines Department. Topographic base from compilations by Lands and Surveys Department.
Published by Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, Canberra, A.C.T.
Copies of this map may be obtained in Perth from the Geological Survey of Western Australia; or the Bureau of Mineral Resources, Geology and Geophysics in Canberra, A.C.T.

FLIGHT DIAGRAM

Air Photography by Lands and Surveys Department of Western Australia, September 1957. Scale 1:40,000



RELIABILITY DIAGRAM



HON. A. F. GRIFFITH, M.L.C.
MINISTER FOR MINES
J. H. LORD, DIRECTOR, GEOLOGICAL SURVEY

SCALE 1 : 250,000

0 5 10 15 20 Miles

0 10,000 20,000 30,000 Yards

0 5 10 15 20 25 30 Kilometres

TRANSVERSE MERCATOR PROJECTION
ZONE 1, AUSTRALIA SERIES

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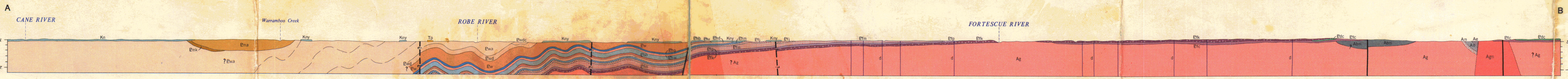
DECLINATION DIAGRAM

DIAGRAMMATIC SECTION A - B

NATURAL SCALE



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YARRALOOLA
SHEET SF 50-6

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