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The Geology of the Central Part of the Ngalia Basin, Northern Territory

by

A.T. WELLS, T.G. EVANS and T. NICHOLAS

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SUMMARY

The Ngalia Basin is a relatively small intracratonic depression in the southern part of the Northern Territory that covers an area of about 6,000 square miles. This report deals with the geology of the central part of the Ngalia Basin exposed on the Mount Doreen Sheet area.

The sediments in the basin are Proterozoic, Cambrian, Ordovician? and Carboniferous in age and are mostly arenaceous. The base of the Ngalia Basin sedimentary sequence is defined as the base of the Vaughan Springs Quartzite or the probably equivalent Central Mount Wedge Beds. The rocks unconformably underlying these formations are mostly metamorphic and granitic rocks and are termed basement. In one small area the rocks underlying the Ngalia Basin sequence are isoclinally folded metasediments including recrystallised tuff of Precambrian age. Their relationship to other Precambrian granitic and higher grade metamorphic rocks is not known but they are considered to be part of the basement because they are metamorphosed and probably intruded by granite.

The basin sediments are probably mostly shallow marine deposits with the exception of Proterozoic glacial beds and the Carboniferous continental deposits. The glacial beds are probably fluvioglacial in origin and the Carboniferous arenites are probably fluvial and partly deltaic.

The only fossils found include poorly preserved marine macrofossils of Cambrian age and plant fragments of Carboniferous age found towards the top of the Mount Eclipse Sandstone.

Geophysical surveys indicate that the basin is asymmetrical with the axis of the deepest part situated towards the northern margin of the basin. The maximum thickness of sediments is about 14,000 feet.

Deformation of the sediments is more pronounced in the northern part of the basin where there is a fault contact with Precambrian crystalline basement rocks which have been upthrust against the sediments. By contrast the sediments along the southern margin mostly dip northwards at moderate angles into the basin and show a normal sedimentary contact with the basement. In places the sediments here have been tilted by block faulting and

have assumed varying attitudes by differential movement of the underlying basement blocks.

The numerous unconformities in the sedimentary sequence show that the area has been subjected to several periods of minor epeirogenic movement. The main deformation however resulted from two main periods of tectonism. The first occurred after the deposition of the Ordovician sequence and epeirogenic movements caused major faulting and minor folding. After a period of erosion followed by the deposition of the Carboniferous sediments a period of diastrophism resulted in major folding and faulting. The fold axes in the sediments mainly trend easterly. The basin was stabilised after the last diastrophic period during which the Ngalia Basin sediments were deformed.

THE GEOLOGY OF THE CENTRAL PART OF THE NGALIA BASIN

INTRODUCTION

General

This report describes the sedimentary geology of the Mount Doreen 1:250,000 Sheet area which was mapped during the winter of 1967 by a field party from the Bureau of Mineral Resources, Geology and Geophysics. The geological map is the result of the work of three geologists: A.T. Wells, T.G. Evans and T. Nicholas. A. Tatarow was the draftsman with the party.

The mapping of these sediments is part of a joint programme of geological mapping and geophysical investigation of the Ngalia Basin which is being carried out by the Bureau of Mineral Resources.

Location and access

The area investigated is in the Northern Territory between latitudes 22°10' to 22° 55' south and longitudes 130° 30' to 132° east, and its locality is shown in Figure 1.

It includes the Naburula Hills, the Treuer and Walbiri Ranges in the northern part of the area and the Campbell, Siddeley and Stuart Bluff Ranges along its southern edge.

Graded roads link Yuendumu Native Settlement, Newhaven and Mount Doreen Homesteads with Alice Springs. All three settlements have aircraft landing grounds. Mail is flown out once a week from Alice Springs to Mount Doreen Homestead at Vaughan Springs and Yuendumu Native Settlement.

Telegraphic services and medical advice are available by transceiver radio from the Royal Flying Doctor Service Base at Alice Springs. The Hospital at Yuendumu Native Settlement was available in the event of an emergency.

The Party was camped near Kerridy Waterhole, 10 miles south of Yuendumu.

A track from Yuendumu to Central Mount Wedge, graded by a seismic party from a private company, passed close to the camp and provided a reasonably good access road from the camp to Yuendumu and to Central Mount Wedge.

Drinking water was obtained from Penhalls Bore and Yuendumu Native Settlement, or was transported in rubber water tanks from Alice Springs; water used for other purposes was obtained from Kerridy Waterhole. All known tracks and roads are shown on the map. The nearest railhead is at Alice Springs.

Climate

Climatic information concerning the area was obtained from the Bureau of Meteorology, Darwin, and is summarised in Figure 1a.

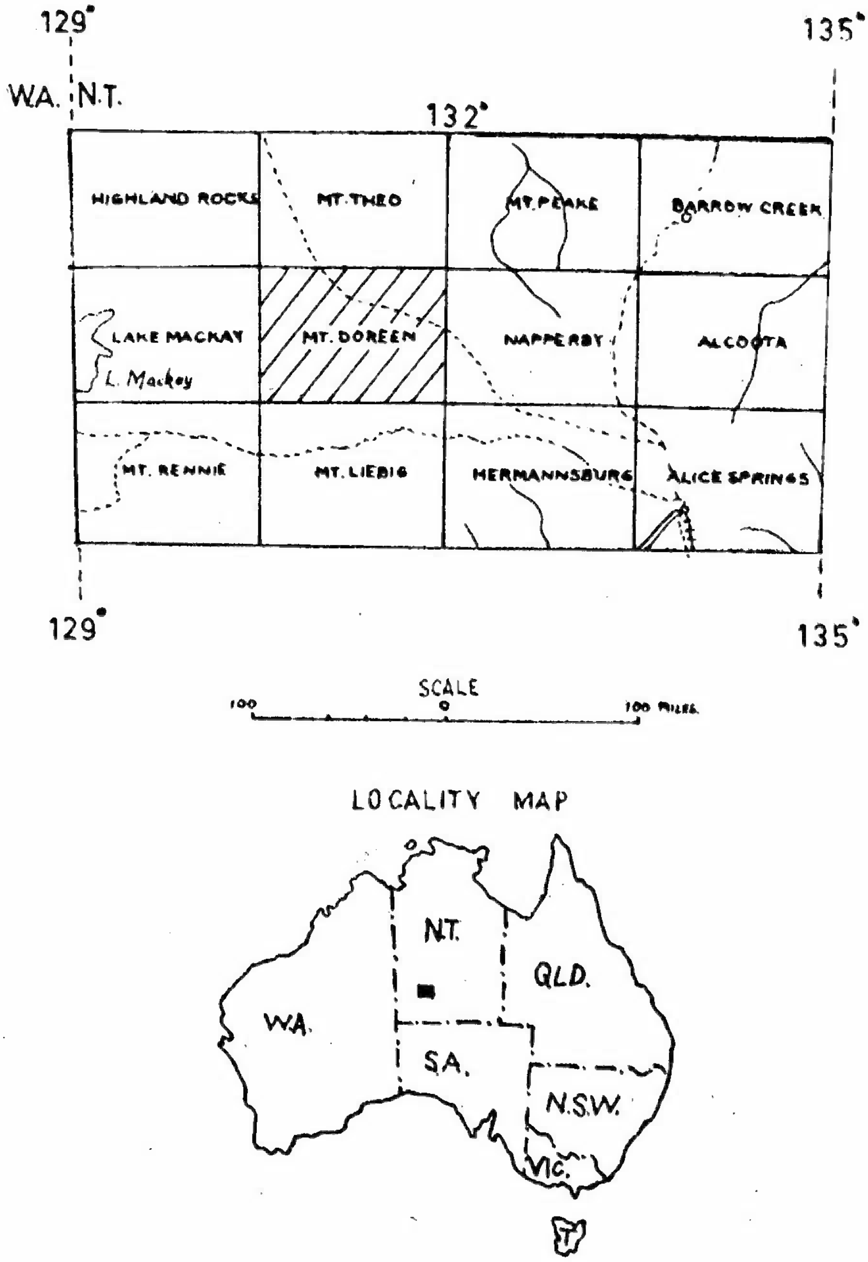
The region is in the less than 10" rainfall belt. The frequency and amount of rainfall is extremely irregular. The dominant wind direction is from the south-east. Temperatures are characterised by marked diurnal and seasonal fluctuations, and frosts are common in late June and early July.

Development

Most of the inhabitants on the Mount Doreen Sheet area are aboriginals living at Yuendumu Native Settlement, the largest native settlement in the Northern Territory. The homesteads at Vaughan Springs and Newhaven depend on the cattle industry for their existence; however there is not a great deal of good grazing land on this sheet area and a major part is covered by sand dunes and spinifex.

Fig 1

POSITION OF AREA MAPPED AND REFERENCE TO AUSTRALIAN 1:250,000 MAP SERIES



To accompany Record 1968/38.

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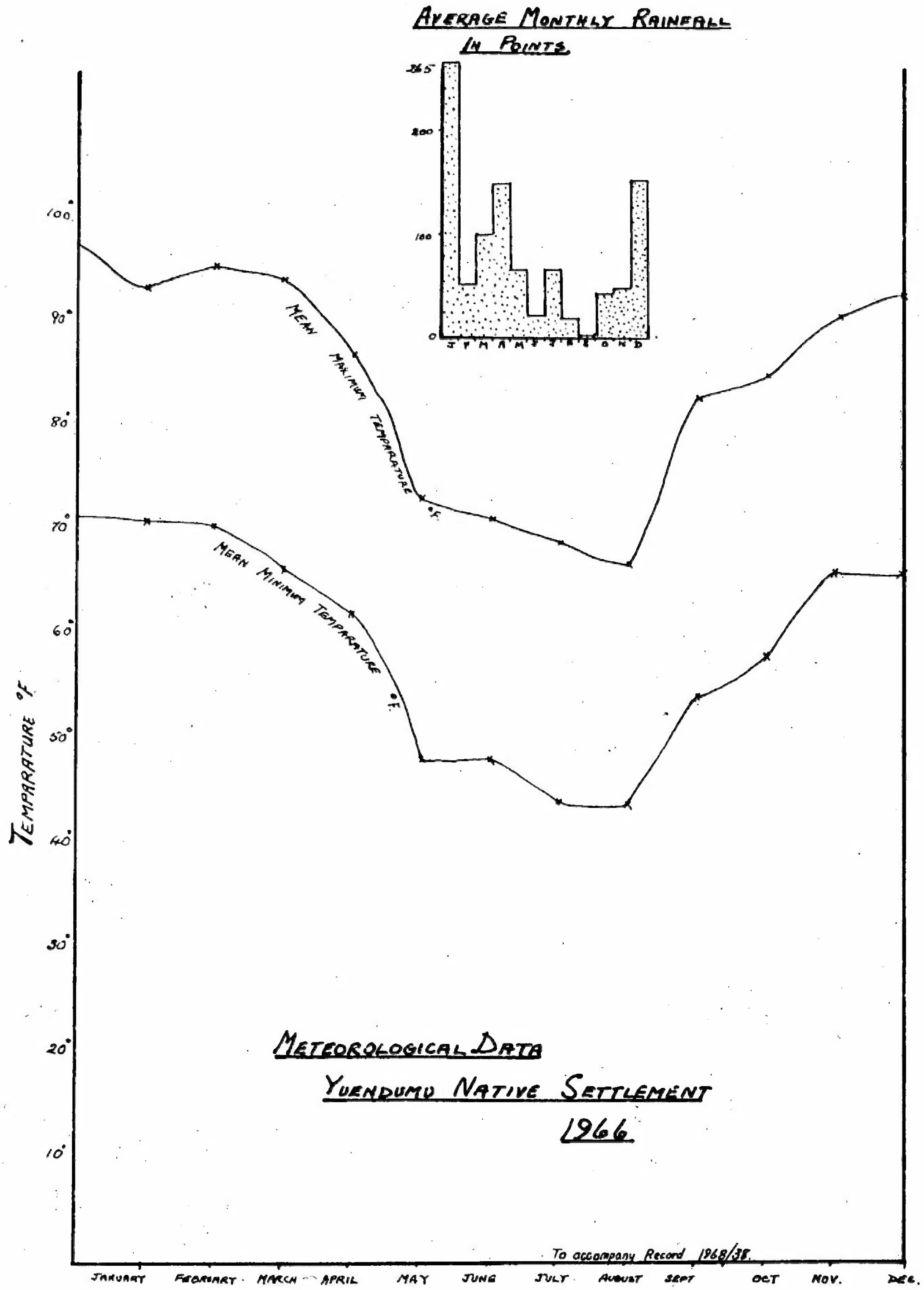
Fig 1a



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Survey method

The central part of the Ngalia Basin was mapped by means of reconnaissance traverses using 4-wheel drive vehicles. A chartered aircraft was used for brief aerial reconnaissance of the entire Ngalia Basin.

Geologic photo-interpretation of the area had been prepared by the Institute Françaises du Petrole. Transparent overlays with this photo-interpretation were available for each air photograph of the area (scale 1:46,500) taken by the R.A.A.F. in 1950. On these the geology was revised and corrected before being transferred to controlled photo-scale overlay sheets. The photoscale maps were reduced photographically to 1:250,000 scale and the maps redrafted at this scale for the preliminary edition.

Sections were measured at selected localities using tape, compass and Abney level.

PHYSIOGRAPHY

The area surveyed extends over approximately 4000 sq. miles of the Northern Territory west-north-west of Alice Springs.

The drainage consists of numerous small channels radiating out from the mountain ranges,and of these Gum Creek is the largest. Waite Creek is the only stream which floods out into the central part of the Ngalia Basin amongst the sand dunes and plains. The mean average rainfall is less than 10" per annum and as the evaporation rate far exceeds the rainfall there is a lack of surface water for most of the year.

The area surveyed has been divided into seven physiographic divisions. These are shown in Figure 2. For a more detailed analysis of the lands of the area the C.S.I.R.O. report 'Lands of the Alice Springs Area, Northern Territory, 1956-57 (Perry et al., 1962) should be consulted.

A.* Mountain ranges and quartzite ridges

Included in this division are the Treuer, Walbiri and Siddeley Ranges, the Naburula Hills and part of the Stuart Bluff Range. The ranges have an east-west trend with peaks ranging up to 1500 feet above the level of the plain.

The Siddeley and Stuart Bluff Ranges form prominent east-west quartzite ridges with the peak of Central Mount Wedge (3,500' above sea level) dominating the southern skyline.

These mountains and ridges are deeply dissected and commonly have alluvial fans and erosional tributary slopes. They have a little shallow soil and a vegetation cover of spinifex.

B. Aeolian sand surfaces

These are composed of sand plains and dune ridges. The sand plain which slopes gently westwards has some small isolated outcrops and covers the central part of the Ngalia Basin. Sand dunes up to 30' high and a few miles long are common in the western half of the area. They have stable flanks and some active sand on the dune crests. Where drainage channels enter this area numerous claypans are developed and with them an associated complex network of sand dunes. The vegetation cover is mainly spinifex and sparse shrubs.

C. Plains and peneplains on weathered granite with round domes and tors of granite

This division is found along the northern margin of the Ngalia Basin. It consists of several different land forms which are defined by the C.S.I.R.O. (Perry et al., 1962). They have been amalgamated in this report as they occur outside the area mapped. There is also an associated variation in the vegetation cover with mulga and spinifex the most common types.

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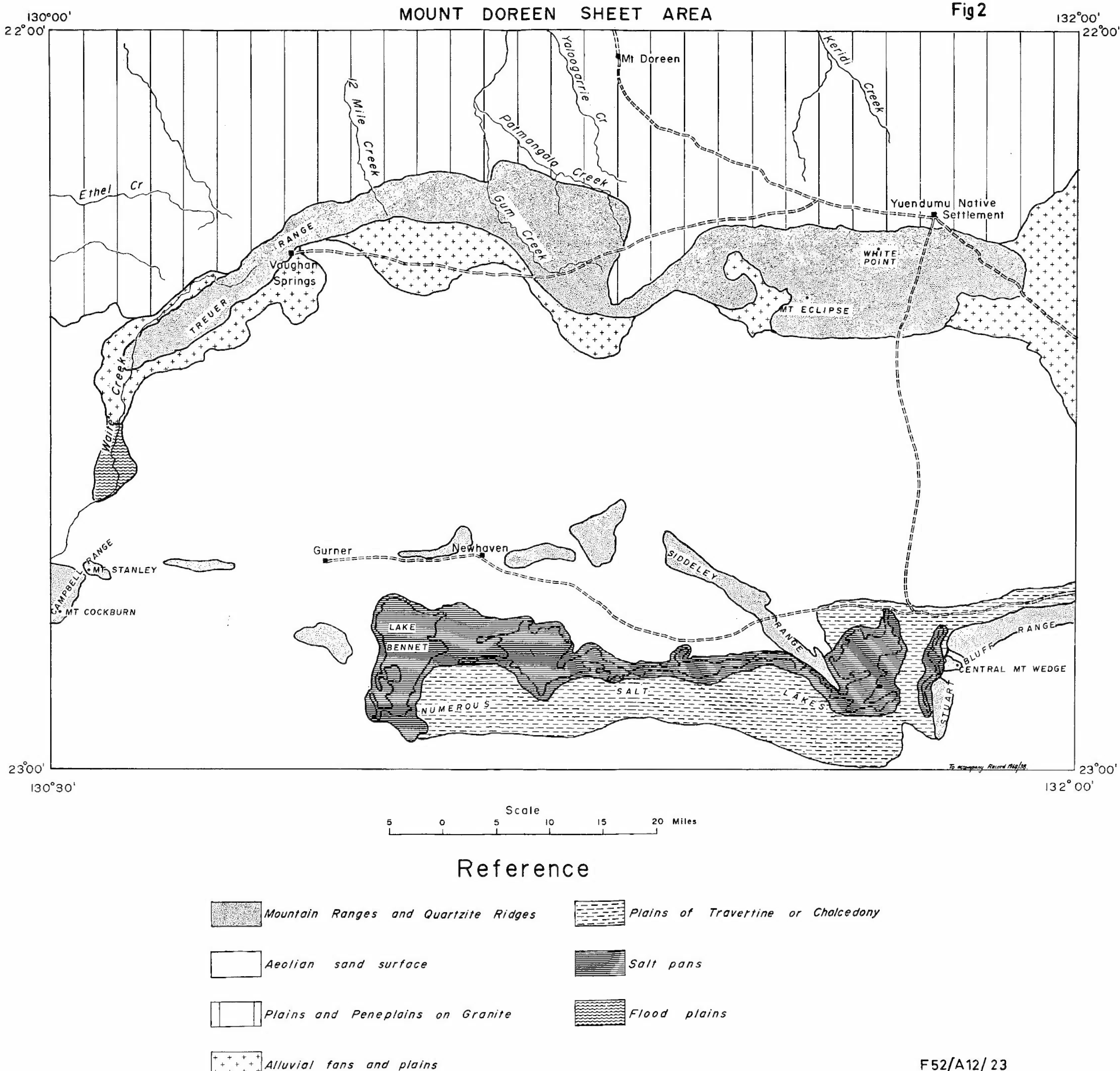
* The letters A.B.C. etc. refer to the legend of the accompanying map.

PHYSIOGRAPHIC DIVISIONS

MOUNT DOREEN SHEET AREA

Fig 2



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D. Alluvial fans and plains

These are formed about minor drainage outlets at the foot of mountain ranges where there is a sharp change in drainage gradient. The fans and plains commonly grade into the sand plains of division B. The associated vegetation cover consists of groves of mulga, spinifex and sparse low shrubs over short grass.

E. Plains of travertine or chalcedony with moderate sand cover

This division occurs along the northern edge of the Stuart Bluff Range and along much of the southern edge of the Ngalia Basin surrounding the salt pans included in division F. The relief is rarely over 10'. The soil type is mostly a shallow sandy calcareous earth with a vegetation cover of sparse shrubs over short grass and soft spinifex.

F. Salt Pans

The salt pans are remnants of much larger lakes which formed part of the adjacent plains of division E. The salt pans are believed to occupy depressions in which the water table is near the surface. They are probably replenished by subsurface drainage. As the evaporation losses are high little or no surface water is seen. The salt pans are found bordering the southern margin of the Ngalia Basin.

G. Flood plains

The flood plain of Waite Creek is the largest in this area. It peters out in the sand plain where there is a considerable admixture of the coarse aeolian sand with the waterborne sand. Some of the smaller creeks have flood plains but they are too small to be significant.

PREVIOUS INVESTIGATIONS

The first explorer to pass through the area was Colonel P. Egerton Warburton on his expedition from Alice Springs to Roeburne in Western Australia (Warburton, 1875). He named many of the major landmarks on his journey which took him from Central Mount Wedge to Mount Eclipse, the Treuer Range, Eva Springs and south to Mount Stanley in the Campbell Range. He identified 'basalt' at Glen Helen (now known as Pulca-Currinya Waterhole) in the Stuart Bluff Range - a misidentification of blackened, waterstained quartzite of the Central Mount Wedge Beds.

Although Tietkins (1891) did not enter the Mount Doreen Sheet area, he observed and named the Campbell Range and its highest point Mount Cockburn whilst making observations from Mount Leisler in the north-west of the Mount Rennie Sheet area.

Murray (in Maurice and Murray, 1904) on a journey from Fowler's Bay in South Australia to the Cambridge Gulf made a number of geological observations in the area, noting 'quartzose sandstone, quartzite and vein quartz' (the Central Mount Wedge Beds) in the Campbell Range; 'slate and quartz formation' (the Treuer Member and Vaughan Springs Quartzite) south-west of Mount Davenport; 'white quartzite and quartzose sandstone .... dipping about 70° NW' (the Vaughan Springs Quartzite) at Mount Davenport, and 'quartzose sandstone with hematite' at Vaughan Springs.

Chewings (1928) made the first geological observations of the quartzites and slates of the Hann and Stuart Bluff Ranges which he regarded as 'Cambrian (?)' in age. He correlated them with the 'Heavitree Gap quartzite' and other similar quartzites in the northern part of the Amadeus sunkland', and suggested that the Stuart Bluff Range was the 'northern limb of an arch, the southern limb of which may be recognised in the Mount Liebig quartzite ridge'.

A brief examination of the formations in the Hann Range-Cockatoo Creek area was made by Tindale in 1931-32. This author was the first to use the name Ngalia Trough (Tindale, 1933). He also proposed the name 'Hann Range-Uldirra Hill-Crown Hill series' for the unmetamorphosed sediments in this area.

The Mackay Aerial Survey Expedition to Central Australia in 1930 flew over much of the area, and a reconnaissance map was compiled by Commander Bennett (Mackay, 1934). Terry (1934) published brief notes on explorations he undertook in 1932 and 1933, and reported 'strong development of hornblendic granite .... schist and nicely mineralized reefs' to the west of Mount Davenport. He also prospected an area of 'quartz blows and ironstone reefs' to the south of Mount Stanley, but with negative results. Also mentioned in his paper is an occurrence of potassium nitrate about 250 miles west of Alice Springs (Thomas Reservoir) in 'vughs, side by side, like honeycombs or martin's nests'. He maintained that 'the salts seem to have been laid down with the sediments, for at the Ligertwood Cliffs (Mount Rennie Sheet area), 100 miles further west, and at a sandstone outcrop south of Mount Davenport, 80 miles north, occurrences similar to the original prospect were noted'. Although Terry suggested that the nitre was of sedimentary origin, it is more than likely that it was derived from the leaching of animal excreta and redeposited in its present form.

The first reports on economic mineral prospects were made by Madigan (1937) and Kiek (1941) who both examined the Mount Hardy copper and wolfram field. Catley (1954) and Ryan (1956) described several small copper prospects north-west of Yuendumu Native Settlement, and a general review of mineral deposits in the Mount Hardy area was made by Ryan (1962).

The hydrology of the Yuendumu Native Settlement has been the subject of a number of reports by Bureau of Mineral Resources geologists (Jones and Quinlan, 1958; Quinlan, 1958a, 1958b; Wiebenga, Goodchild and Bamber, 1959; Cook, 1962; and Kingdom, Woolley and Faulks, 1967).

A raised circular island of sand with a central depression lying within a large saltpan known as Lake Eaton which has excited interest as a possible site of meteoritic impact, was visited by Hossfeld in 1956 and briefly discussed by Sangster (1957). Dr. H.H. Nininger of the American Meteorite Museum who later flew over the area, stated that it was not of meteoritic origin (Sangster, 1959).

The geomorphology of the Alice Springs region, which includes the Mount Doreen Sheet area, was described by Mabbutt (1962), and a comprehensive account of the land systems of the area is given by Perry, Mabbutt, Litchfield and Quinlan, (1962).

A brief outline of the sediments occurring in the Ngalia Basin was made by Quinlan (1962), and the first comprehensive geological investigation undertaken by the Bureau of Mineral Resources was made by Cook (1963) who mapped the 850 square miles of the Yuendumu Native Reserve and made the first systematic description of sediments in the Ngalia Trough. Three sections measured by Woolley in 1960 are included in Cook (1963).

A photogeological interpretation of the Lake Mackay, Mount Doreen and Napperby 1:250,000 Sheet areas was undertaken by Rivereau (1965). Reconnaissance surveys of the Mount Doreen and Napperby Sheet areas were made in 1962 by P.J. Cook, and again in 1964 when Cook was accompanied by J. Perry, J Rivereau and K. Edgeworthy. I.F. Scott of the Australian Mineral Development Laboratories and W.R. Morgan of the Bureau of Mineral Resources were responsible for the petrographic descriptions. The results of these surveys are the subject of an unpublished record (Cook and Scott, 1966) and a published report (Cook and Scott, 1968; in press).

A large part of the Mount Doreen Sheet area has been covered by an airborne magnetometer survey carried out for the Pacific American Oil Company by Aeroservices Limited (Hartman, 1965). A gravity survey over part of the area (Nettleton, 1965) and a seismic survey (Hudson and Campbell, 1965) were also undertaken for the Pacific American Oil Company by Geophysical Associates Pty. Ltd.

In 1967 another reconnaissance gravity survey was made of the Mount Doreen Sheet area by Kenneth Macmahon and Partners under contract to the Bureau of Mineral Resources, the results of which are reported by Whitworth (1967; in prep). A seismic survey commencing near Davis Gap and extending towards the centre of the basin was also made in the same year by Bureau of Mineral Resources geophysicists (Jones, 1968, in prep.).

STRATIGRAPHY

General

Sediments of Proterozoic, Cambrian, Ordovician? and Carboniferous age have been mapped in the Ngalia Basin. These sediments lie unconformably on Precambrian crystalline basement rocks or in places on a thick sequence of Precambrian metasediments. The mapping of the basement has been limited to a division into metamorphic rocks and granite.

The sediments of the Ngalia Basin have been divided into ten new rock units and the aggregate thickness is about 20,000 feet. The base of the Ngalia Basin sedimentary sequence is placed at the base of the Vaughan Springs Quartzite or the probably equivalent Central Mount Wedge Beds. The rocks occurring below these units will be referred to as the basement to the Ngalia Basin. Most of the formations are separated by unconformities and a complete sequence is not present in any one area. Thickness of sediments in the deepest part of the basin on the Mount Doreen Sheet area is probably close to 14,000 feet. The maximum thicknesses of the sediments and their respective ages is 6000 feet of Proterozoic, 4,500 feet of Cambrian, 3,500 feet of Ordovician and 7,000 - 8,000 feet of Carboniferous.

The stratigraphy of the central part of the Ngalia Basin is shown in Table 1 and the measured thicknesses of formations in Table 2. The relationship of the formation is shown in a diagram on the geological map (Plate 8) and the geological succession exposed at selected places along the northern margin of the basin is illustrated on Figure 3.

A tentative correlation of the Ngalia Basin sequence with the formations in the Amadeus Basin is shown in Figure 4.

PRECAMBRIAN

Crystalline basement rocks

The crystalline Precambrian basement rocks were not mapped in detail and were only investigated locally around the margin of the Ngalia Basin mostly where they occur in contact with the unconformably overlying sedimentary sequence. Descriptions of selected samples of the basement rocks are given by Scott (1966) and Smale (1967). Details of the work by Scott (op. cit.) were incorporated by Cook in a report on the general geology of the Ngalia Basin (Cook and Scott, 1968 in press.). For mapping purposes the Precambrian rocks have been divided simply into metamorphics and granite as no details of petrogenesis were possible on the scale of the investigation and the limited area covered by the mapping.

Most of the rocks investigated at the margin of the basin and nearby areas are mainly granitic in composition and many types of granite were collected which show a variety of textures and composition. Quartz and pegmatite dykes are generally common in the granite outcrops. In many places particularly where basement rocks were examined immediately beneath the basin sediments they are deeply weathered and altered, and near fault zones are crushed, brecciated and lineated. Many of the schistose rocks present were probably originally granitic in composition but the original textures have been obliterated.

Basement granite underlying the Campbell Range is so badly decomposed in outcrop that it now consists of only kaolin and quartz fragments. To the south and south-east of Mount Cockburn, a large area of dark purple-brown to red-brown, fine grained, foliated, micaceous schist is intruded by massive quartz dykes up to 15 feet across.

From Mount Gurner to east of Newhaven Homestead the basement rock, where exposed, is a very deeply weathered granite with decomposed feldspar phenocrysts up to 1½" in length set in a matrix of quartz grains and pale green chlorite. Small aplitic dykes intrude this granite on the eastern end of Mount Gurner. About 1½ miles south-east of Castle Bore, there is an isolated exposure of purple metaquartzite composed of large shattered quartz fragments showing undulose extinction, small patches of sericite, and a groundmass of small, sutured, strained quartz grains. Finely disseminated hematite scattered throughout the rock accounts for the purple colour of the outcrop. Metamorphic grade is low, as the hematite has not been converted to magnetite.

TABLE I - STRATIGRAPHY OF THE CENTRAL PART OF THE NGALIA BASIN
MOUNT DOREEN SHEET AREA, NORTHERN TERRITORY

AGE		FORMATION	MAP SYMBOL	MAXIMUM THICKNESS	TOPOGRAPHIC EXPRESSION	LITHOLOGY	REMARKS
CAINOZOIC	QUATERNARY		Qa		River bed flood plain and flood out.	Alluvium	
			Qc		Talus and detrital slopes	Colluvium	
			Qs		Plains and dunes	Sand	
			Qt		Salt lakes and salt pans	Evaporites	
			Qr		Plains	Red soil	
			Ql		Low mounds	Travertine	
			Cz		Mesas and buttes of low relief and low rounded hills	Silcrete and ferruginized rock	
	CARBONIFEROUS	MOUNT ECLIPSE SANDSTONE	Pzt	7000 ±	Hogbacks, cuestas and prominent rounded hills	Pale brown and red-brown, coarse grained, poorly sorted, thin to massively bedded, cross-bedded, arkosic sandstone and subgreywacke, in part micaceous and calcareous. Cobble and boulder beds common and a few red micaceous siltstone interbeds.	Poorly preserved plant fossils of Carboniferous age
	ORDOVICIAN ?	KERRIDY SANDSTONE	Pzy	2300	Low, irregular hills with small sharp hogbacks	Red-brown, medium and coarse grained, moderately sorted, silty and in part calcareous and arkosic sandstone and subgreywacke with interbedded siltstone. The sandstone is thin to thick bedded and cross-bedding is common	
		DJAGAMARA FORMATION	Pzd	1050 +	Prominent hills, cuestas and strike ridges.	Laminated and thin bedded, siliceous, grey and white sandstone, in part glauconitic and with abundant clay pellets. Interbedded green shale is a major component of the formation in some areas.	Minimum age of 450 m.y. by K-Ar age determination.
	CAMBRIAN	BLOODWOOD FORMATION	Gb	650 +	Well rounded hills	Red-brown to purple-brown and pale green, thinly bedded siltstone and red sandstone. Both the siltstone and sandstone are in part richly micaceous.	Abundant trace fossils and rare macrofossils occur in beds near the middle of the formation. They suggest a Lower Cambrian age.
		WALBIRI DOLOMITE	Gw	1420 +	Dolomite forms rounded hills and low cuestas; other units in the formation occur in low mounds, beneath scree slopes and in valleys.	Light and dark grey, pink, thick bedded dolomite, green and blue siltstone, in part micaceous and thin interbeds of pink stromatolitic and oolitic dolomite and red and grey sandstone. Minor glauconitic dolomite near the base.	Abundant fragmentary marine macrofossils at the base of the formation. They indicate a Lower Cambrian or possibly lower Middle Cambrian age.

AGE	FORMATION	MAP SYMBOL	MAXIMUM THICKNESS	TOPOGRAPHIC EXPRESSION	LITHOLOGY	REMARKS
PROTEROZOIC	YUENDUMU SANDSTONE	Buy	2310 +	Mostly rounded hills and small cuestas	Fine and medium grained, moderately sorted, medium and thin bedded, flaggy, in part cross-bedded and slumped, red-brown and some pale brown sandstone. Minor coarse arkose occurs at the base of the formation.	
	MOUNT DOREEN FORMATION	Buq	370 +	Generally forms scree slopes with dolomite at top forming small scarp. Otherwise in valleys or at base of scarps.	Green siltstone with striated erratics of various rock types up to 12 feet across. Pink laminated dolomite and red shale at the top of the formation and green siltstone at the base with some dolomite lenses. Lenses of dolomitic sandstone and pebbly sandstone in the sequence with erratics. Dolomite is a major component of the formation in some sections and in places contains poorly preserved stomatolites.	
	VAUGHAN SPRINGS QUARTZITE	Buv	5700 ±	Mostly prominent resistant ridges.	White and pink, tough, closely jointed, thick bedded and massive quartzite, with a basal coarse grained and pebbly hematitic sandstone and pebble conglomerate. Small cross-beds common.	
PROTEROZOIC	TREUER MEMBER	But	1700	Mostly rubble covered flats with a few sharp low discontinuous ridges.	Thin to medium bedded sandstone, cross-bedded in places, and in part micaceous and rich in small clay pellets. Interbedded red and maroon siltstone. Sequence is deeply leached and evaporite encrustations are common.	Member occurs in lower half of the Vaughan Springs Quartzite. May contain interbedded evaporites.
	CENTRAL MOUNT WEDGE BEDS	Bus	1500 +	Very prominent cuestas and rare mesas and buttes. They form the highest landmarks in the area.	Pink, grey and white quartzite, massive to thick bedded, well developed cross-bedding and ripple marks very common in places. A local basal conglomerate is common. Minor interbedded green and blue shale with mud cracks and ripple-marks occurs above the conglomerate in places.	Correlated with the Vaughan Springs Quartztie.
PRECAMBRIAN	PATMUNGALA BEDS	pCp	3600 ±	Groups of irregular shaped hills low discontinuous strike ridges with high relief.	Silty sandstone, quartzite, siltstone, recrystallised vitric crystal tuff, minor interbedded stretched chert pebble conglomerate and shale. The beds are slightly metamorphosed.	
		pCg		Rounded hills and a few higher tors	Several varieties of granite.	These units were only investigated and mapped at the margins of the sedimentary basin.
		pCm		Rounded hills and some prominent strike ridges.	Schist, quartzite and amphibolite	

TABLE II – MEASURED THICKNESS OF FORMATIONS – NGALIA BASIN

MOUNT DOREEN SHEET AREA

FORMATION	MAP SYMBOL	WX1 WX3	WX2	WX4	WX5	NX1	NX2	NX3	NX4	EX1	EX3	EX4	EX5	EX6	EX7	EX8	EX9	EX10
Mount Eclipse Sandstone	Pzt	160+	NM	415+	NM	NM	NM	NM	NM	157+	NM	NE	NM	400+	NM	50+	1680+	NM
Kerridy Sandstone	Pzy	655	NM	535	NM	NPS	NPS	NPS	NPS	2310	NM	NE	760	A	NM	1090	NM	NM
Djagamara Formation	Pzd	950	40+	785+	770+	NPS	NPS	NPS	NPS	1050+	NM	NE	780+	170	NM	240+	NM	NM
Bloodwood Formation	Єb	A	A	A	A	NM	NM	650+	520+	NPS	NPS	NE	NPS	A	NPS	NE	NE	NPS
Walbiri Dolomite	Єw	A	A	A	A	538+	487+	NM	NM	NM	1420+	NE	NE	A	NE	NE	NE	NM
Mount Doreen Formation	Buq	270+	370+	P	P	A	A	A	A	A	A	A	A	P	A	A	A	A
Yuendumu Sandstone	Buy	A	A	A	A	920+	NM	NM	NM	NM	NM	NE	NM	A	2307+	NM	NM	1820+
Vaughan Springs Quartzite	Buv	A	A	A	A	NPS	NPS	NPS	P	P	P	590+	P	NM	P	NM	NM	1185+

KEY:

A – Absent from sequence

NE – Not exposed

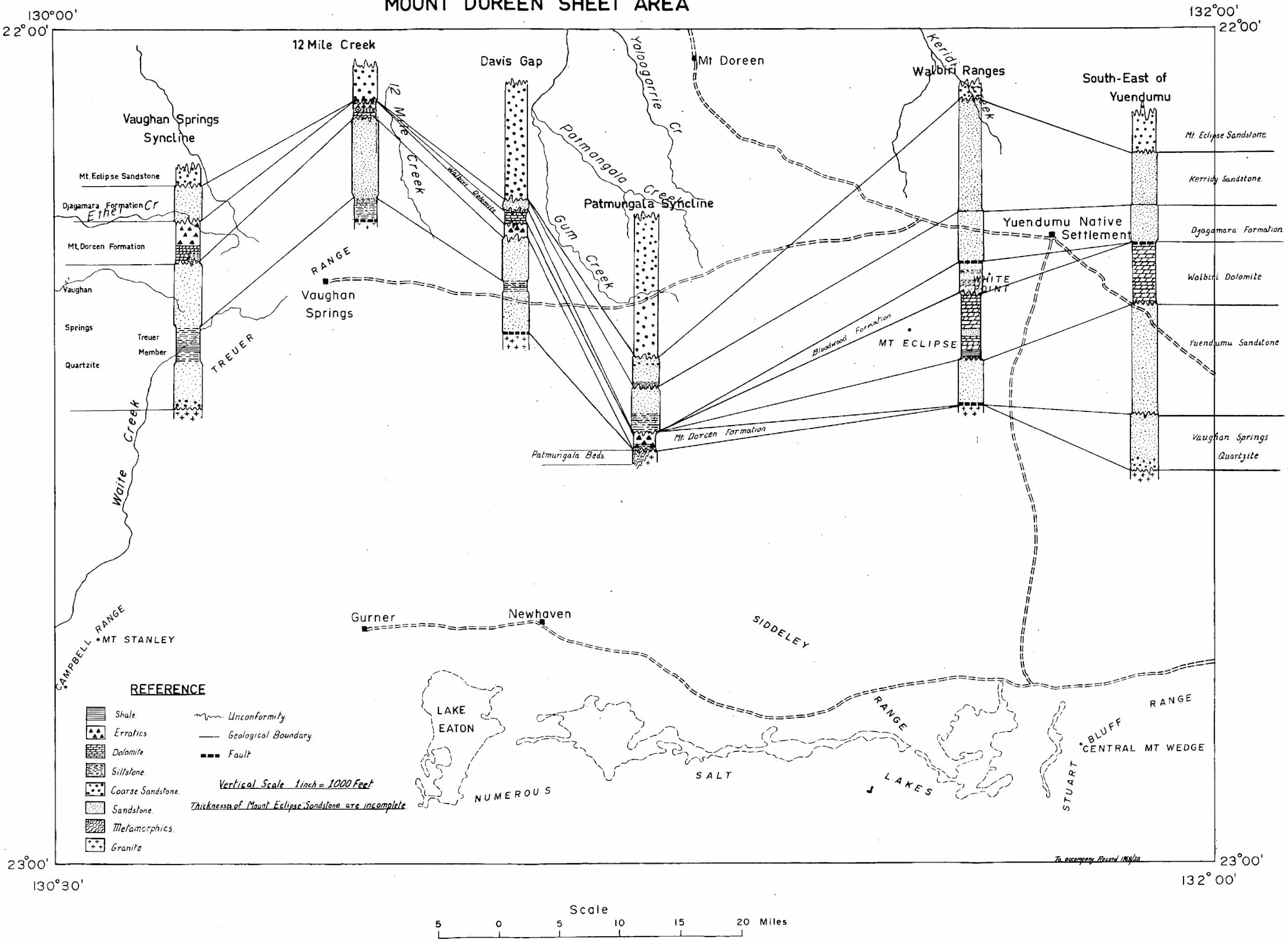
NPS – Not present due to structure and level of erosion.

P – Poor or incomplete exposure

NM – Exposed but not measured.

STRATIGRAPHIC COLUMNS AT SELECTED LOCALITIES ON THE MOUNT DOREEN SHEET AREA

Fig 3



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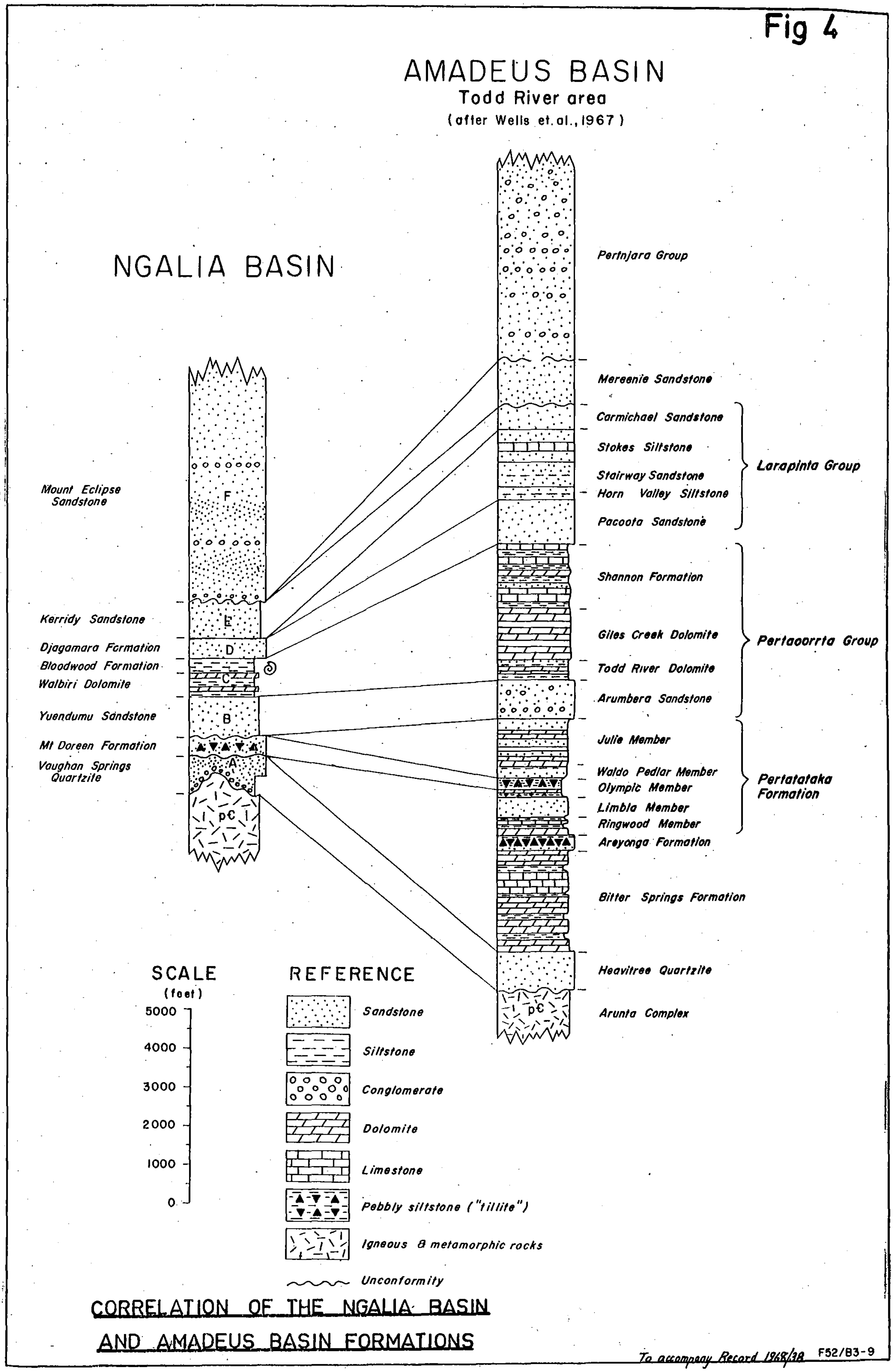


CORRELATION OF THE NGALIA BASIN AND AMADEUS BASIN FORMATIONS

To accompany Record 1968/38 F52/B3-9

An isolated outcrop about 4 miles west of the Siddeley Range is a cataclastic quartzite. It is essentially monomineralic, the quartz grains being lenticular and exhibiting marked preferred orientation. All grain boundaries are sutured, and all grains show severe strain extinction.

At the gap where the Central Mount Wedge-Newhaven road passes through the Siddeley Range, a small boss of coarse grained porphyritic granite intrudes basement schists and phyllites. Large phenocrysts of feldspar, up to 3" in length in the granite, exhibit linear parallelism. At the margin of the granite body xenoliths of schistose rock up to 2 feet in length have been incorporated.

Phyllite is well exposed just to the north of the gap. The quartz grains in it are unstrained, and contain numerous needles of rutile. Sericite is abundant, and limonite occurs in relatively coarse clusters and as a general dissemination throughout the rock. Tourmaline occurs as an accessory, and has also been observed as a dyke about 6" wide intruding the phyllite.

Further to the north, the basement rock is a sericite schist, and is intruded by numerous small pegmatite dykes containing graphic intergrowths of quartz and feldspar, some tourmaline and sheafs of muscovite.

About 3 miles south of the gap there is an outcrop of what may originally have been a rather impure feldspathic sandstone, but which is now essentially a quartz-sericite rock. The quartz grains are coarse, most grains have been shattered, and many of them exhibit deformation lamellae formed by gliding whilst undergoing shear stress.

The basement beneath the Central Mount Wedge Beds at the western end of the Stuart Bluff Range is mostly altered granitic rock. A sample from MD3 at Central Mount Wedge consists mostly of quartz and contains masses of chlorite and sericite, remnants of feldspar altered to sericite and some biotite. Irregular patches of coarse quartz and feldspar occur in the outcrop. A sample from MD4 just south of Central Mount Wedge is a quartz-feldspathic rock containing mica and some heavy minerals and shows secondary foliation. The rock is cut by large quartz veins and is probably an altered granite.

At the northern margin of the Ngalia Basin at Mount Allan there are several large outcrops of granite exposed at the base of cuestas of the Vaughan Springs Quartzite and in rounded hills further east.

The granite shows a pronouned alignment of the feldspar laths. Quartz veins and pegmatite dykes are common here. The medium grained, pink granite with pegmatite dykes exposed at MD12 to the north is probably part of the same body. Another outcrop of granite occurs at MD11 about 4½ miles north of Mount Allan where it is intruded by a large quartz-hematite dyke. A thin section of a sample from MD11 shows an altered quartz-rich rock with interspersed large masses of muscovite rich pods. The rock is an altered gneissic granite. About one mile north-west of MD11 at MD63 there is an isolated outcrop of gneissic granite which shows bands and patches of black ferromagnesian minerals.

Smale (1967) has described one basement rock sample from a outcrop three miles south-east of Yuendumu. The rock is a tourmaline granite with a grain size of 2-3 mm and consists of 65% microcline, 20% quartz and 15% tourmaline. The field relationships show that this rock occurs as dykes together with quartz veins in a medium grained, pink, lineated granite. A thin section of this rock shows a crushed granitic rock with graphic intergrowths of quartz and feldspar. The granite and intrusive dykes are exposed on the slopes of a small mesa which is capped by Vaughan Springs Quartzite. The lineation in the main body of granite trends at 92° and is vertical.

At MD9 about 4 miles south-west of Yuendumu there are several poor exposures of basement rocks in creek beds on the north side of the large fault and a hornblende diorite showing a pronounced lineation of the hornblende crystals is associated with quartz-feldspar-mica schists.

Weathered and sheared granitic rock cut by numerous quartz veins is present in the small inlier in the faulted structure south of 20 mile bore (Fig. 36).

Massive pink granite crops out below thin remnants of the Vaughan Springs Quartzite on the south side of the Naburula Hills and beneath the Mount Doreen Formation further north in the Patmungala Syncline. On the east and north-east side of the Patmungala Syncline there are east and north-east trending quartz dykes 50-200 feet wide in the granite that have filled large fault zones. The granite is mostly coarse grained with feldspar laths up to 1½" across and in most places is deeply weathered. At several localities in this region the granite is covered by Cainozoic siliceous duricrust deposits. At MD65 the granite has unusual round crystals of quartz about ½" across whereas the feldspar is angular. Unidentified crystals of a bright green mineral occur in this granite and also in a quartz-rich rock at MD64. A coarse weathered granite crops out at MD64 in the creek beds, on the eastern side of a prominent hill of Patmungala Beds. The granite at MD62 next to the Vaughan Springs road is comparatively fresh and has very large white feldspar phenocrysts.

Deeply weathered granite is present in poor outcrops along the north side of the Treuer Range and in places there are remnant blocks of fine quartzite that have been intimately intruded by the granite. The quartzite may be part of the Patmungala Beds or from an older quartzite.

Massive granite also crops out in tors on the north side of Mount Singleton on the lower slopes below ridges that are composed of Vaughan Springs Quartzite.

Metamorphic rocks are not abundant but they have been seen at several widespread localities. Dark purple-brown, fine and medium grained micaceous schist crops out beneath the Vaughan Springs Quartzite about 5 miles east-south-east of Yuendumu. A vertical lineated quartzite cropping out near the base of the Vaughan Springs Quartzite 5 miles south-east of Yuendumu where the main road crosses a ridge is dark grey, fine to medium grained and may be part of the basement.

A prominent ridge of lineated, tough, fine grained, basement quartzite crops out about 7 miles north-east of Vaughan Springs and is surrounded by outcrops of granite.

Schist and quartzite crop out at Mount Singleton about 24 miles north-north-west of Vaughan Springs and are faulted against blocks of Vaughan Spring Quartzite.

Patmungala Beds (new name)

Patmungala Beds is a new name proposed for a sequence of slightly metamorphosed silty sandstone, quartzite, siltstone, spotted recrystallised tuff and minor interbedded stretched chert pebble conglomerate. The thickness, precise order of rock types, and upper and lower contacts are not known with certainty. The beds are named from Patmungala Creek and the type area includes the outcrops between Patmungala Creek and the Naburula Hills about four miles west-north-west of Mount Djagamara. The beds have not been described or named previously.

The Patmungala Beds crop out in one area near the northern margin of the Ngalia Basin, north of Patmungala Syncline. The Beds are tightly folded, and the fold axes trend east. The total length of the outcrop area is about 10 miles. The beds form low strike ridges and irregular groups of hills.

The only well defined contact of the Patmungala Beds is the angular unconformity with the overlying Mount Doreen Formation. No other contacts were seen with other units of the Ngalia Basin sequence and their relationship to surrounding areas of Precambrian granitic rocks is not certain. In a prominent isolated hill about 3 miles north of Mount Djagamara the Patmungala Beds are steeply dipping and granite is exposed in small creeks at the base of the hill. A rubble covered interval about five feet wide covers the contact but the Patmungala Beds immediately above the rubble covered interval are nearly vertical. In another area on the south side of the same hill near MD64 a small quartz-muscovite veinlet cuts the beds. Quartz veins from a fraction of an inch up to 20 - 30 feet wide cut the Patmungala Beds. The largest veins occur in the northern-most outcrops. This evidence suggests that the contact with the Precambrian granite is probably intrusive.

No sections have been measured in the Patmungala Beds. The maximum exposed thickness estimated from measurements on air-photographs is about 3,600 feet.

Medium-grained, poorly sorted, tough, silicified, thin-bedded, grey sandstone forms the prominent ridges in outcrops of the formation. The sandstone is closely jointed and in places is well sorted and friable; cross-bedding and small ripple marks are rare. The sandstone is interbedded with thin bedded and laminated siltstone and in some places small cross-lamination is evident. The siltstone is deeply weathered and poorly exposed and commonly the weathered surface has thin encrustations of white salts. Interbeds of stretched chert pebble conglomerate, quartz and quartzite pebble conglomeratic sandstone and spotted recrystallized tuff occur at several localities.

The sandstone is generally grey or white but at MD47 a section of red sandstone about 10 feet thick is interbedded with laminated and banded siltstone and poorly bedded mottled claystone. The beds of sandstone are about 18 inches thick and are cut by numerous small quartz veins. The sub-angular quartz grains in the sandstone average about 0.5 mm across with some grains up to 1.5 mm. About 5% of the grains consist of chert and the matrix is fine quartz grains, sericite and small irregular patches of brown clay. The quartz grains show irregular or subaligned cracks and wavy extinction probably caused by the low grade metamorphism.

The spotted recrystallised tuff consists mostly of very fine grained matrix with minor sericitic material and about 10% of angular quartz and feldspar grains up to 0.2 mm across. In thin section there is no obvious difference in composition of the rock to account for the spotting effect. The rock is probably a recrystallised vitric crystal tuff.

The stretched chert pebble conglomerate shows elongated fragments of chert, chert with laminations of heavy minerals, quartzite with squeezed and flattened grains and a matrix mainly of crushed quartz grains. Some of the chert fragments have small quartz veins.

The environment of deposition and provenance area are unknown, and no fossils were found. The Patmungala Beds lie unconformably beneath the Mount Doreen Formation and are probably also older than the Vaughan Springs Quartzite. The base of the beds is not exposed but there is some evidence to suggest that they are intruded by granite. They are assigned a Precambrian age until more evidence can be found to give a more precise determination.

No beds of similar lithology and stratigraphic position occur at the northern margin of the Amadeus Basin. In the south-western part of the basin slightly metamorphosed sediments several thousand feet thick occur beneath the Dean Quartzite (equivalent of the Heavitree Quartzite). These sediments have been called the Dixon Range Beds (Wells et al., 1964) and the Bloods Range Beds. The Dixon Range Beds consist dominantly of sandstone, with interbedded micaceous siltstone and shale, arkose, arkosic grit, pebble conglomerate and probable greywacke. Cross-bedding and both current and wave ripple-marking are common. The Bloods Range Beds are metamorphosed and contain large thicknesses of igneous rocks. They consist of sandstone and quartzite, schist, porphyry and slate with interbedded basic volcanics.

PROTEROZOIC

Central Mount Wedge Beds (new name)

The Central Mount Wedge Beds is the only rock unit exposed in the prominent hills along the southern margin of the Ngalia Basin on the Mount Doreen Sheet area. The beds are named from Central Mount Wedge, 25 miles due south of Yuendumu Native Settlement. This prominent physiographic feature rises about 1,650 feet above the level of the surrounding country. The type locality is Central Mount Wedge, where the sequence consists of tough pink, grey and white quartzite, massive to thick bedded, friable pink and white sandstone, minor interbedded green and blue shale and local basal conglomerates. High angle cross-bedding is very common, and ripple markings, flow casts, mud pellet casts and mud cracks are well developed in places.

The Central Mount Wedge Beds crop out intermittently in the western extremity of the basin on the Lake Mackay Sheet area; they occur from the Campbell Range in the west to the Stuart Bluff Range in the east of the Mount Doreen Sheet area, and form the continuation of the Stuart Bluff Range on the Napperby Sheet area. The Central Mount Wedge Beds probably also occur in the Hann Range which terminates on the western edge of the Alcoota Sheet area.

The sequence was differentiated into two units by Cook & Scott (1968): Unit A' - a poorly sorted conglomerate and conglomeratic siltstone with minor sandstone, the base of the succession, and Unit A - the overlying strongly silicified sandstone. Cook reported the siltstone to be tillitic in aspect, but observed no striae on the boulders forming the conglomerate. Cook's Unit A' is no longer thought to be of glacial origin, but is considered to be the basal part of the sequence here described as the Central Mount Wedge Beds.

No stratigraphic section has been measured through the Central Mount Wedge Beds.

Topographic expression is generally uniform, with prominent cuestas forming Mount Cockburn (Fig. 5), Mount Gurner, the Siddeley Range and the Stuart Bluff Range. Mesas are formed where the beds are flat-lying. From Mount Cockburn in the west of the Sheet area to the eastern part of the Stuart Bluff range, the beds rest unconformably upon basement granites and metamorphics. No contact is exposed with any of the younger units of the Ngalia Basin sequence. The unconformity between basement and the overlying sediments has been observed at many localities along the southern margin of the basin, and where local basal conglomerates occur, they consist essentially of quartzite and vein quartz. Granitic boulders and cobbles are rare in the basal conglomerates.

The Central Mount Wedge Beds are presumed to be equivalent to the Vaughan Springs Quartzite which crops out along the basin's northern margin.

The thickest exposure of sediments is in the area of Central Mount Wedge where the beds are at least 1500 feet thick.

In the type area crystalline basement is overlain by a poorly sorted conglomerate that thickens locally to the west where it reaches a maximum development of 100 feet. The conglomerate is composed of poorly bedded, sub-rounded to rounded phenoclasts of quartzite from 6" to 10" and vein quartz from $\frac{1}{2}$" to 1" in diameter. The matrix is a poorly sorted feldspathic and micaceous siltstone with both fine and coarse sand lenses; near the base it contains concentrations of eroded euhedral authigenic magnetite.

The conglomerate is overlain by a uniform sequence of grey and white, usually highly silicified sandstone, massive to thick-bedded and commonly cross-bedded. The sandstone near the base is feldspathic, with patches of sericite, is poorly sorted, and contains mud cracks and euhedral casts of pyrite of probably authigenic origin. Throughout the upper part of the section there are bands of pink to white, very friable poorly bedded sandstone.

In the extreme east of the Sheet area there is development of green, blue and occasionally red shales and siltstones. They are finely micaceous, thin bedded to laminated, mud cracked and ripple marked. The shales and siltstones have been observed directly overlying basement, or else separated from it by a few feet of thin basal conglomerate, grit, or purple fine grained sandstone. Voids in the purple sandstone are sometimes infilled with chalcedonic silica. The shale and siltstone sequence reaches a maximum thickness of 75 feet, and is overlain by white to grey silicified, poorly sorted, medium grained sandstone with well developed cross-beds.

West of Central Mount Wedge, the thickest development of basal conglomerate underlies the highest point of the Siddeley Range where it reaches a thickness of 50 feet with phenoclasts up to 1 foot across. The overlying sandstone is grey to white, fine grained, highly silicified, ripple marked and cross-bedded. A coarse grained purplish sandstone with well rounded quartz grains occurs about 50 feet from the top of the section in the southern half of the Siddeley Range.

From the Siddeley Range to Mount Cockburn, the Central Mount Wedge Beds are a uniform sequence of pink to white, highly silicified, fine grained sandstone, massive to thick bedded and with high angle cross-bedding. The highly silicified sandstone rests unconformably upon basement, and contains interbeds of 'case hardened' very friable pink sandstone throughout the section. No basal conglomerate has been observed in this area.

The occurrence of sheets of sandstone with minor interbeds of green and blue clastic sediments at least 1500 feet thick and extending over at least 100miles, suggests shallow marine (epineritic) sedimentation. Apart from an isolated occurrence of unidentifiable trace fossils on the mud-cracked surface of the shale interbeds, no fossils have been found in the Central Mount Wedge Beds.

There is close lithological similarity between the Central Mount Wedge Beds and the Vaughan Springs Quartzite, which in the north unconformably underlies the glacial beds of the probably Proterozoic Mount Doreen Formation.

Fig. 5

Central Mount Wedge Beds overlying Precambrian crystalline basement rocks at Mount Cockburn, southern margin of the Ngalia Basin.

GA/745

Fig. 6

Basal boulder and pebble conglomerate of the Vaughan Springs Quartzite at the contact with Precambrian granite. South side of Naburula Hills.

M/732-19

The precise age of the Central Mount Wedge Beds is therefore uncertain, but they are assumed to be Proterozoic. Both the Central Mount Wedge Beds and the Vaughan Springs Quartzite are correlated with the Proterozoic Heavitree Quartzite of the Amadeus Basin, because of their similar lithology and stratigraphic position.

PROTEROZOIC

Vaughan Springs Quartzite (new name)

The Vaughan Springs Quartzite is defined as a formation of tough pink, grey and white, massive to thick-bedded orthoquartzite; a white, friable, and in places siliceous 'case-hardened' sandstone that weathers pink to red-brown and at the base of the section local basal conglomerate and pebbly hematitic conglomerate. The formation derives its name from Vaughan Springs in the north-western quadrant of the Mount Doreen Sheet area.

The first geological observations on the Vaughan Springs Quartzite were made by Tindale (1933) in an area south-east of Yuendumu, who referred to the unit as the 'Hann Range-Uldirra Hill-Crown Hill series' of unmetamorphosed quartzites and conglomerates. Cook (1963) and Cook and Scott (1968) preferred to leave all the units in the basin unnamed until the whole of the area had been systematically mapped, and designated the Vaughan Springs Quartzite as 'Unit A'.

The type locality is 2 miles south-east of Yuendumu Native Settlement; the type section is EX-10 (Plate 7) at the type locality.

The Vaughan Springs Quartzite forms a broken ridge from the eastern edge of the Mount Doreen Sheet area to just south of Yuendumu, and a few isolated pods lie faulted against basement to the north of White Point. The formation is exposed just south of the Yuendumu-Vaughan Springs road about 4½ miles south of Djagamara Peak, and crops out along the whole of the northern margin of the Treuer Range from Davis Gap to where Waite Creek floods out into the basin. It also forms the lowermost and most highly resistant beds of the prominent Vaughan Springs syncline.

The formation is strongly silicified and highly resistant to weathering, forming ridges and prominent escarpments.

At the type locality, and also at a few isolated outcrops north of White Point, the formation lies faulted against granitic basement, and is unconfomably overlain by the Yuendumu Sandstone. To the east of Yuendumu, the formation lies unconformably upon basement granite and is again unconformably overlain by the Yuendumu Sandstone. At the prominent escarpment south of Djagamara Peak, the Vaughan Springs Quartzite unconformably overlies basement granite and is presumed to be unconformably overlain by the Mount Doreen Formation. Exposure is poor however, and the Vaughan Springs Quartzite is separated from the overlying Mount Doreen Formation by an area of no outcrop. In the Treuer Range west of Davis Gap, faulted contacts are inferred between the Vaughan Springs Quartzite and the basement and the overlying Mount Eclipse Sandstone. Both the Mount Doreen Formation and the Mount Eclipse Sandstone can also be seen to unconformably overlie the Vaughan Springs Quartzite in places in this area. In the Vaughan Springs syncline, the formation unconformably overlies granitic basement and is unconformably overlain by the Mount Doreen Formation. The Treuer Member of the Vaughan Springs Quartzite is best developed on the western side of the syncline.

The maximum measured thickness of the formation is 1185+ feet in section EX-10. The base of the formation here is a fault contact with basement rocks. At a second measured section, EX-4, at Mount Allan, the Vaughan Springs Quartzite is 590+ feet thick. In the Vaughan Springs syncline, a thickness of 5700 feet has been estimated from aerial photographs.

The Vaughan Springs Quartzite is predominantly a pink, white or grey, massive to thick-bedded orthoquartzite, although some of the interbedded sandstones are extremely friable with a thin crust of surface silicification. At the type area the formation is a white orthoquartzite, moderately to well sorted, and thick to medium bedded. It is faulted against basement rocks, and the basal conglomerate is absent. Interbeds of light-brown friable sandstone, small-scale folds and kink bands and some clay pellets occur throughout the section. Specimens collected some 3 miles south-east of Yuendumu are fine to medium grained, poorly sorted, sub-rounded to rounded with all grains exhibiting undulose extinction. The base of the section in this area is a deep red, hematitic conglomerate, composed of angular fragments of quartz with the hematite of the groundmass being confined to the grain boundaries.

The Vaughan Springs Quartzite unconformably overlies basement granite on the south side of the Naburula Hills, and here about 25 feet of basal conglomerate composed of poorly rounded, poorly sorted quartzite boulders, cobbles and pebbles is exposed (Fig. 6). The largest clasts are up to 3 feet in diameter, and grade upwards into smaller cobbles and pebbles. Discontinuous interbeds of red and red-brown pebbly siltstone and mudstone occur throughout the upper part of the conglomerate. The siltstone is composed of pebbles and very poorly sorted, coarse grained, angular fragments in a groundmass of fine quartz and muscovite with powdery hematitic material. The clasts in the pebbly mudstone are sub-rounded to angular and unsorted. The silt size ground mass is of quartz with interstitial sericite, clay and minor amounts of muscovite.

About 30 feet above its base, the conglomerate is characterized by the extreme angularity and poor sorting of the clasts, which range from cobble to silt size. The larger fragments are set in a matrix of medium grained sand which in turn is enclosed in a sericitic clay cement.

A specimen collected from the eastern limb of the Vaughan Springs syncline near the base of the section is a friable pure orthoquartzite. The grains are sub-rounded to well rounded, medium grained, and with most grains exhibiting undulose extinction. Small amounts of hematite are restricted to the grain boundaries. Higher in the section, the orthoquartzite is fine to medium grained, tightly packed, and cemented by quartz overgrowths.

Some areas of intense small-scale folding associated with an upthrust are present on the eastern limb of the syncline, and medium-scale cross-stratification is common throughout the whole of the Vaughan Springs Quartzite.

An area of large, well developed oscillation ripple markings occur about 5 miles south-east of Mount Davenport. The ripple crests and troughs are rounded and symmetrical, wavelength is from 13" to 15", and amplitude is of the order of 1½" to 2½". A short distance away the wavelength is reduced to 4½", but the crests of the ripples have been truncated, exposing a core of coarser sand grains. The ripples are presumably wave-generated, and indicate deposition in a shallow standing body of water. No fossils have been found in the Vaughan Springs Quartzite.

The age of the Vaughan Springs Quartzite is not known with any certainty; it underlies the dolomite and glacial beds of the Mount Doreen Formation, and excluding the metamorphosed Patmungala Beds, is the oldest sedimentary unit in the Ngalia Basin. As mentioned previously on the basis of lithological similarity and relative stratigraphic position, the Central Mount Wedge Beds and the Vaughan Springs Quartzite are regarded as being contemporaneous deposits, and the age of both is assigned to the Proterozoic.

Treuer Member (new name)

The Treuer Member occurs near the base of the Vaughan Springs Quartzite, and is defined as a unit of laminated to thin-bedded, white to grey sandstone, cross-stratified in places, in part micaceous and with minor occurrences of small clay pellets. White, yellow and red siltstones are interbedded with the sandstone, and a thin bed of glauconitic sandstone occurs near the base of the sequence. The member may contain interbedded evaporites, as a powdery efflorescence is commonly present on the outcropping shales, and coarsely crystalline gypsum has been observed as a surface crust on outcrops near Eva Springs. The Treuer Member has not been previously recorded.

The Treuer Range, after which the member is named, lies in the north-western quadrant of the Mount Doreen Sheet area, and extends from Mount Davenport to Gum Creek. The Treuer Member parallels this range on its northern margin from south-west of Mount Davenport at Waite Creek, to a point about 9 miles west of Gum Creek. No outcrops are known east of Gum Creek.

The type locality lies about 12½ miles from Mount Davenport on a bearing of 238°. No section has been measured through the Treuer Member but in the type area a thickness of 1,700 feet is estimated from aerial photographs.

In the type area, massively bedded, fine grained, grey orthoquartzite of the Vaughan Springs Quartzite unconformably overlies granitic basement, although in other areas the basal Vaughan Springs Quartzite is a coarse sand or fine conglomerate. The orthoquartzite contains medium-scale cross-stratification and numerous clay pellet casts. The base of the Treuer Member is a fine grained, sub-angular to sub-rounded, pale grey, flaggy orthoquartzite containing considerable amounts of kaolin. The grains are tightly packed and are cemented by quartz overgrowths. This orthoquartzite is overlain by thin-bedded, white to pale yellow, fine grained siltstone. Above the siltstone is a compact, a medium-grained, glauconitic sandstone with rounded quartz grains, well rounded glauconite and scattered hematite of silt size. The original rock was loosely packed, but the interstices between the quartz grains are now cemented by quartz overgrowths. The glauconitic sandstone is overlain in turn by an alternating sequence of white, yellow, buff, purple and red siltstones and shales interbedded with grey to light brown orthoquartzites up to 10 feet thick. Both the siltstonesand sandstones are in many cases stained by iron and manganese oxides.

At locality MD 270,2 miles north-west of Vaughan Springs Homestead, the base of the Treuer Member is not exposed, and exposure is intermittent until the base of the Vaughan Springs Quartzite is reached. The lowest bed of the Treuer Member exposed in this locality is a yellow to white, cross-stratified, fine grained orthoquartzite, and is overlain by thin-bedded, white to yellow, iron stained, deeply weathered siltstone. This in turn is overlain by thin-bedded to laminated, pale grey kaolinitic orthoquartzite with clay pellet casts, cross-stratification and small-scale oscillation ripple marks traversed by numerous small worm? tracks. Approximately 100 feet of colluvium separates this upper bed from the tough, siliceous, purple-red hematitic pebble conglomerate of the Vaughan Springs Quartzite.

Apart from tracks and trails, no other fossils have been discovered in the Treuer Member.

The Treuer Member was probably deposited in a shallow-water marine environment;further, the presence of evaporitic material and glauconite in the Treuer Member indicates a partially restricted marine, possibly lagoonal origin for these sediments.

Mount Doreen Formation (new name)

The Mount Doreen Formation is a new formation name proposed for a sequence of rock types which crops out in the Naburula Hills and Treuer Range. The formation is composed chiefly of green and some red-brown siltstone. The siltstone commonly contains erratics of various rock types up to 12 feet across which are mostly subrounded, and commonly faceted and striated. Other lesser rock types in the formation include pink, laminated dolomite, red and green shale, and lenses of dolomite, dolomitic sandstone and conglomerate, and pebbly sandstone. Dolomite is a major component of the formation in some areas particularly in the basal part of the formation.

The formation has not been previously described although the existence of glacially derived deposits in the Mount Doreen Sheet area was probably first recognised by geologists of the Alice Springs Resident Geologists Office. Cook and Scott (1968) describe deposits of conglomerate that they considered to be of glacial origin at the base of the Vaughan Springs Quartzite. However, it has been demonstrated that this conglomerate is a basal conglomerate developed at the unconformable contact of the Vaughan Springs Quartzite with Precambrian crystalline basement rocks and bears no relationship to the Mount Doreen Formation.

The type section, WX-2 (Plate 6) lies about three miles south-south-east of Mount Djagamara in the Naburula Hills. Here the formation lies unconformably on basement rocks and is overlain unconformably by the Djagamara Formation. The formation is named from Mount Doreen in the northern part of the Mount Doreen Sheet area.

The area of outcrop of the formation is very small. The largest outcrops occur in an arcuate line around the eastern nose of the Patmungala Syncline and these are the most easterly exposures known. The outcrops occur on scree slopes below a small ledge of sandstone of the overlying Djagamara Formation. The outcrops to the west are poorly exposed and occur intermittently as far west as the Vaughan Springs Syncline in the Treuer Range. They form low mounds on valley floors or occur at the base of steep scarps.

In the type section the upper unconformable contact with the Djagamara Formation is well exposed and locally the basal beds of the Djagamara Formation consist of a subangular dolomite cobble conglomerate (Fig. 11) about 5 feet thick with a matrix of fine glauconitic sand. The phenocrysts are undoubtedly derived from the dolomite near the top of the Mount Doreen Formation. On the north side of the Patmungala Syncline there are well exposed unconformable contacts of the Mount Doreen Formation with the underlying Patmungala Beds and on the south side of the syncline the formation occurs stratigraphically above the Vaughan Springs Quartzite. The contact here is not exposed but is undoubtedly unconformable. In the Treuer Range between the Vaughan Springs Syncline and the Naburula Hills the Mount Doreen Formation lies unconformably between the Vaughan Springs Quartzite and the Mount Eclipse Sandstone. In the Vaughan Springs Syncline the formation lies unconformably between the Vaughan Springs Quartzite and the Djagamara Formation.

The contacts shown in the rock relationship diagram on the geological map infer unconformable relationships of the Mount Doreen Formation with the Walbiri Dolomite and the Yuendumu Sandstone. These contacts were not observed and are implied from the regional distribution and relative ages of the formations.

Two incomplete sections were measured in the formation. Both are in the Patmungala Syncline and the basal part of the formation was not exposed in either section. The thickness in section WX-1 was 270+ feet and 370+ feet in WX-2 (Plate 6). There is probably at least 200 to 300 feet of the basal part of the formation obscured. Exposures of the Mount Doreen Formation outside the Patmungala Syncline are poor. No more than 200 - 300 feet of the formation is exposed in the Treuer Range outcrops. In the Vaughan Springs Syncline the thickness of the formation is estimated at about 800 feet.

The Mount Doreen Formation in the Patmungala Syncline commences with 200 - 300 feet of poorly exposed green shale which rests unconformably on granitic basement rocks. The base of the shale commonly contains pods of dolomitic siltstone. The basal shale is overlain by about 250 feet of boulder beds, the matrix consisting of a poorly sorted green and some red-brown siltstone with angular fragments. Subrounded erratics are distributed randomly through it (Fig. 10). The erratics are up to 12 feet across and comprise a great variety of rock types. The largest are granite (Fig. 8) and pink and grey quartzite. The smaller erratics consist of several varieties of metamorphic and igneous rock types as well as a few sedimentary rocks including dolorudite, dolomite, and silicified sandstone. One fragment of stromatolitic, pink dolomite showed replacement in large part by jasper. Examples of striated and faceted erratics are numerous (Fig. 9). Lenses of pebbly, poorly sorted, dolomitic sandstone, pebbly, poorly sorted, siliceous sandstone and angular feldspathic sandstone occur near the base of the sequence with erratics. In some parts of the sequence the matrix of the glacial beds is dolomite (Fig. 7) and the included fragments vary in composition from one sample to another. In one specimen they consisted of pebbles and cobbles of angular assorted rock types, in another angular pebbles of feldspar and in another specimen flakes of mica up to $\frac{1}{4}$ inch across together with angular grains mostly of quartz and feldspar.

The siltstone beds with erratics are terminated abruptly by 10 - 15 feet of siliceous, laminated, pink and yellow-brown dolomite which contains dendrites and numerous small grains of manganese oxide. The dolomite forms a small ledge on the scree slopes and is succeeded by about 50 feet of poorly exposed, red-brown and some green shale which is overlain unconformably by sandstone or dolomite pebble conglomerate of the Djagamara Formation.

A thick sequence of dolomite occurs in the basal part of the Mount Doreen Formation in the south-western part of the Vaughan Springs Syncline; the dolomite is dark grey and blue grey, in places oolitic and sandy, and black chert fragments commonly occur as a residual on the outcrops. The dolomite is not found elsewhere in the syncline; the beds in the equivalent stratigraphic position are poorly exposed leached siltstones.

The siltstone with erratics occurs in the syncline above the dolomite or equivalent siltstone. Outcrop is poor and mostly is covered by scree and debris consisting of erratics left after the weathering of the silt matrix. Some laminated green siltstone occurs towards the base of the zone.

In one place at the north-eastern end of the syncline a bed of coarse arkose occurs in the upper part of the formation.

<u>Fig. 7</u>

Erratics in dolomitic matrix, Mount Doreen Formation, Patmungala Syncline.

GA/723

<u>Fig. 8</u>

Large granite erratic from the Mount Doreen Formation, Patmungala Syncline.

M/516-36

Fig. 9

Striated boulder from the Mount Doreen Formation, Patmungala Syncline.

GA/725

Fig. 10

Erratics in siltstone, Mount Doreen Formation, Patmungala Syncline.

M/516-28

The beds with erratics are overlain unconformably by the Djagamara Formation in the Vaughan Springs syncline; the upper beds of dolomite or red siltstone similar to the upper sequence in the Patmungala Syncline are not present. A few fragments of fine-grained, yellow-brown, laminated dolomite present in the scree with the erratics is similar to the beds of dolomite present in the upper part of the formation elsewhere.

In the Treuer Range between Davis Gap and Vaughan Springs, there are a few poor exposures of the Mount Doreen Formation. The outcrops are mainly of poorly sorted beds of red siltstone with erratics of various rock types together with interbeds of red siltstone, pink stromatolitic dolomite and beds of chert breccia with a friable, calcareous sandy matrix. The lithological sequence in the formation varies from outcrop to outcrop and although the presence of striated and faceted erratics in a poorly sorted matrix is common to most exposures it is not uncommon to find one particular rock type e.g. a lens of chert breccia, that is unique to one outcrop.

The abundance of striated and faceted erratics, their large size, the variety of rock types, the fine-grained, and the ill sorted, non-stratified sandy matrix all indicate that the sequence has a glacial origin. The major part of the formation was probably formed under aqueoglacial conditions with erratics transported by floating ice and dropped into the siltstone.

The glacial beds may have been deposited in a fluvial environment but the presence of stromatolitic dolomite in parts of the sequence suggests that some of the Mount Doreen formation may have been formed in a marine environment.

The erratics in the boulder beds indicate that the provenance included exposed crystalline basement rocks and parts of the Proterozoic sequence. The quartzite erratics are lithologically similar to the Vaughan Springs Quartzite. Other erratics of sedimentary rocks, mainly dolomitic in composition, have been derived from formations that are unknown in the Ngalia Basin sequence on the Mount Doreen Sheet area.

The sequence in the Mount Doreen Formation is similar to the Proterozoic glacial sequences of the Amadeus Basin in the Northern Territory, those of the Kimberley Region of Western Australia and the younger glacial sequence of the Marinoan Series in the Adelaide Geosyncline.

There is a close correlation of lithological units within the Mount Doreen Formation with those of the Olympic Member of the Pertatataka Formation in the Amadeus Basin (Wells et al. 1967). The Olympic Member has a fine-grained, laminated dolomite near the top which is underlain by boulder beds of glacial aspect. The lowermost beds of this member are fine-grained silt-stones.

The Mount Doreen Formation contains no fossils apart from the derived stromatolites in the dolomite phenoclasts. The main evidence for its age is its similarity to Proterozoic glacial sequences elsewhere in Australia. In the Ngalia Basin its stratigraphic position is below rocks of probable Ordovician age and above basement rocks of Precambrian age. The arkosic sediments at the base of the Yuendumu Sandstone are similar to some of the arkosic rocks that occur near the top of the Mount Doreen Formation. If these arkosic sediments in both formations are the same age then the bulk of the Mount Doreen Formation was probably deposited before the Yuendumu Sandstone. The correlation of the Mount Doreen Formation and the Yuendumu Sandstone with formations in the Amadeus Basin sequence also supports this idea of the relative ages.

The limited distribution of the formation suggests that it was deposited in restricted basins and the area may have only been subjected to local continental glaciation rather than a continent wide ice sheet. A similar restricted distribution is apparent in the younger glacial sequence in the Amadeus Basin.

Yuendumu Sandstone (new name)

The name Yuendumu Sandstone is proposed for the beds of mostly fine and some coarse-grained, red-brown sandstone which crop out in the area south of Yuendumu Native Settlement. The type section, EX-7 is 2½ miles south of Yuendumu where the formation has a minimum thickness of 2300 feet and lies with low angle unconformities between the Proterozoic Vaughan Springs Quartzite and the Lower Cambrian Walbiri Dolomite.

The formation has previously been referred to informally as 'Unit B' by Cook and Scott (1968).

The Yuendumu Sandstone crops out along the northern margin of the Walbiri Ranges in a narrow belt at the northern edge of the Ngalia Basin. Outcrops commence at a point about 10 miles east-south-east of Yuendumu Native Settlement and continue to the west to an area about 12 miles west of the Settlement. The formation is not known elsewhere on the Mount Doreen Sheet area.

The Yuendumu Sandstone forms rounded hills that have a few low pinnacles. In a few places low cuestas form in the topmost part of the formation particularly in places where the dip of the beds is relatively low.

Apart from the unconformable relationships already described at the type locality no other contacts with formations of the Ngalia Basin succession are known. The rock relationship diagram on the geological map shows unconformable contacts with the Mount Doreen Formation beneath and the Djagamara Formation above. These relationships are not visible in outcrops and are inferred from the relative ages of the formations and their distribution.

The maximum measured thickness of the formation is 2307+feet in section EX-7. Incomplete sections were also measured at EX-10 (1820+ feet) and NX-1 (920+ feet) (Plate 5). No inferences can be made on the variations in thickness either because the top of the formation is not exposed or the base of the formation is a fault contact.

In the type area the basal part of the formation is a coarse-grained, arkosic sandstone which is in many places silicified. The pink feldspar grains are in places fresh but mostly weathered to white grains of clay. The overlying beds consist mostly of red-brown, silty sandstone and subgreywacke with some interbeds of medium-grained pale brown, medium-bedded sandstone. The uppermost beds are thin-bedded, red-brown, fissile, micaceous sandstone which commonly show slump structures. Most of the sandstone in the formation is moderately sorted, and in part cross-bedded and slumped. The formation shows no marked lateral lithological changes.

The Yuendumu Sandstone was probably deposited in a shallow marine environment. The provenance area probably included areas of granitic basement rocks at least during the deposition of the oldest beds. The Yuendumu Sandstone contains no trace of animal life. It lies unconformably below Lower Cambrian rocks and is tentatively regarded as being Proterozoic in age. The formation is correlated with the Arumbera Sandstone of the Amadeus Basin succession. The basal part of the Arumbera Sandstone is considered to be Proterozoic and the upper part which contains numerous trace fossils is possibly lowermost Cambrian in age.

CAMBRIAN

Walbiri Dolomite (new name)

The name Walbiri Dolomite is proposed for the sequence of dolomite, siltstone, and minor sandstone that crops out in the Walbiri Ranges south of Yuendumu Native Settlement. The formation has been informally referred to previously as 'Unit C' by Cook and Scott (1968). The type section is EX-3, which is about $1\frac{1}{4}$ miles north-north-west of White Point bore. Here the formation has a minimum thickness of 1420 feet and it lies with a low angle regional unconformity on the Yuendumu Sandstone. Contacts with the overlying Bloodwood Formation are not exposed but two diamond drill holes about three-quarters of a mile north-west of White Point intersected the contact which is apparently conformable.

Outcrops of the Walbiri Dolomite are confined chiefly to the northern part of the Walbiri Ranges, from Penhalls Bore to about 5 miles south-east of 20 mile bore. Only one outcrop doubtfully identified as the Walbiri Dolomite occurs outside this area and forms low rounded hills about $1\frac{1}{2}$ miles north of Davis Gap near Gum Creek.

The dolomite of the formation forms rounded hills with low relief but the siltstone and shale generally forms the floor of valleys or occur on short scree slopes. Some of the interbedded red-brown sandstone forms low rounded hills.

In the Walbiri Ranges the formation lies unconformably above the Yuendumu Sandstone, and apparently conformably below the Bloodwood Formation. The top of the formation is mostly obscured by recent sand. A faulted contact of the Walbiri Dolomite against the Djagamara Formation is present near Penhall's Bore. The isolated outcrop of the formation near Davis Gap lies unconformably below the Djagamara Formation. The base is not exposed here but the distribution of nearby outcrops of the Mount Doreen Formation suggests that it probably unconformably underlies the Walbiri Dolomite.

The boundary between the Walbiri Dolomite and the underlying Yuendumu Sandstone at the type section, EX-3, appears to be a transgressive contact. At the eastern end of the outcrop fossiliferous shale and interbedded siltstone, pink dolomite and sandstone at the base of the Walbiri Dolomite overlies the Yuendumu Sandstone. Further west the basal sequence is overlapped by beds of massive dolomite and these beds are in turn overlapped by younger beds of red-brown sandstone which are in contact with, and almost indistinguishable from, the Yuendumu Sandstone. Further west along the Walbiri Ranges the basal siltstone, dolomite, red-brown sandstone sequence of the Walbiri Dolomite is missing and the Yuendumu Sandstone is overlain by a sequence which is apparently still younger than the beds at the base of the type section and therefore a transgressive contact with the Yuendumu Sandstone is present along the whole length of the outcrop on the northern side of the Walbiri Ranges.

Three incomplete sections have been measured in the formation. In section NX-1 it is 538+ feet thick, 487+ feet in NX-2 and in section EX-3, the type section, it is 1420+ feet thick. In each section the top of the formation is obscured. The measured sections are shown in Plate 4. At least 500 feet of dolomite is exposed in the outcrops of the Walbiri Dolomite near Davis Gap.

The sequence in the best exposed section 2 miles north-east of White Point commences with 120 feet of interbedded green and blue-grey siltstone, micaceous siltstone, fossiliferous mudstone, medium-grained, friable sandstone, red oolitic dolomite, and glauconitic dolomite. This sequence is overlain by thick bedded, blue grey, in part pelletal dolomite 230 feet thick, which is in turn overlain by about 200 feet of poorly exposed medium and some coarse grained, red-brown sandstone. The topmost beds exposed are mainly blue-grey and some pink dolomite with interbeds of pink stromatolitic dolomite, red siltstone and dolomitic medium-grained sandstone and cross-bedded thick-bedded, medium grained siliceous sandstone. Much of the dolomite in the well exposed outcrops near the middle of the formation is sandy with quartz and feldspar grains, is oolitic, fragmental, and in places contains phosphatic brachiopods.

The uppermost beds of the Walbiri Dolomite were intersected in a diamond drill hole about $\frac{3}{4}$ mile north-west of White Point. The drill penetrated 235 feet of the Bloodwood Formation and 568 feet of the Walbiri Dolomite. The Walbiri Dolomite consists mostly of massive to laminated blue-grey, in part sandy dolomite with minor dolomitic siltstone and silty dolomite and interbeds of micaceous shale, calcareous siltstone, red-brown sandstone and calcareous sandstone. Barytes occurs as veinlets and pods in the dolomite near the top of the formation at 235 feet and between 492 and 561 feet in the drill hole. A small outcrop just north of White Point also contains barytes. Variations in the lithology of the formation in the outcrops along the northern part of the Walbiri Range have already been described. The outcrop of dolomite near Davis Gap is laminated to thin bedded, fine-grained, fragmental in part and mostly has a mottled grey and pink appearance.

The formation was deposited in a shallow marine environment in which at times an abundant fauna flourished. The fossils include phosphatic brachiopods from the upper part of the formation, exposed near Penhalls Bore (MD1), and three genera of brachiopods (Botsfordia, Lingulella and an unidentified orthid) at least two hyolithids, and unidentifiable trilobite fragments from the base of the formation (MD31), exposed at the type section. Joyce Gilbert-Tomlinson (pers. comm.) suggests a probable Lower Cambrian age although an early Middle Cambrian age cannot be entirely discounted.

The Walbiri Dolomite has stronger lithological affinities to the lower Middle Cambrian formations in the Amadeus Basin than the Lower Cambrian formations. If the Walbiri Dolomite is Lower Cambrian then it is the same age as the Todd River Dolomite of the north-eastern part of the Amadeus Basin sequence.

As suggested it is also lithologically similar in many ways to the Giles Creek Dolomite and Tempe Formation of early Middle Cambrian age. The presence of two major red-brown sandstone and siltstone formations above and below the Walbiri Dolomite and a minor red sandstone bed within the formation suggests a correlation with the Cambrian sequence in the central Amadeus Basin. Hence the Yuendumu Sandstone could be correlated with the Eninta Sandstone, the basal part of the Walbiri Dolomite with the Tempe Formation, the red sandstone within the Walbiri Dolomite with the Illara Sandstone, the upper part of the Walbiri Dolomite with the Deception Formation, and the Petermann Sandstone with the Bloodwood Formation. Such correlation is purely speculative and implies the presence of several magnafacies between the basins. The implications of the proposed correlation can only be clarified after further detailed study of both sequences.

Bloodwood Formation (new name)

The Bloodwood Formation is a new name given to a sequence of red-brown and some pale green, micaceous siltstone and red sandstone that crops out on the north side of the Walbiri Ranges. Cook and Scott (1968) have informally referred to this unit as Unit C'. The type section was measured at NX-3 near Djuburula Peak, where the Bloodwood Formation is overlain by the Mount Eclipse Sandstone with an angular unconformity. The base of the formation is not exposed.

The name is derived from Bloodwood Bore on the Mount Doreen Sheet area.

The Bloodwood Formation crops out at Djuburula Peak and extends about 8 miles along the northern edge of the Walbiri Ranges; it is not known to crop out in any other part of the Mount Doreen Sheet area. The formation forms distinctive flat topped hills which have steep scarp edges but rounded profiles. However, towards the western end of the area of outcrop the unit forms no distinctive topographic features, the exposure is poor and area of outcrop small. The unit is cut by the faults which occur along the northern margin of the Ngalia Basin, but in the largest outcrop at and near Djuburula Peak the beds are only gently tilted.

The original relationship between the Bloodwood Formation and the Djagamarra Formation can only be suggested from a consideration of the distribution of both these units on the Mount Doreen Sheet Area. In the

Patmungala syncline the Djagamara Formation rests with an angular unconformity on the Mount Doreen Formation. The Bloodwood Formation is not present in this area. It is suggested therefore that the contact between the Bloodwood Formation and the Djagamara Formation is unconformable. At the White Point Fault Zone it is likely that the Bloodwood Formation is in faulted contact subsurface with the Djagamara Formation.

The structurally interesting area south of 20 mile bore has been described elsewhere in this report. In this area the Bloodwood Formation is believed to have a faulted contact with coarsely crystalline granite, but has a conformable contact with the underlying Walbiri Dolomite.

A diamond drill hole about 1 mile west-north-west of White Point passed through the Bloodwood Formation and at a depth of 235 feet entered the Walbiri Dolomite. A second drill hole 400 feet north of the first penetrated the contact between the two units at a depth of 175 feet. In both these drill holes the contact between the two units appears to be conformable.

Two incomplete sections have been measured through the Bloodwood Formation (Plate 3). The type section is NX-3 near Djuburula Peak where the Bloodwood Formation is 650+ feet thick. The other is NX-4 where the measured thickness was 520+ feet.

The measured sections show the dominant lithology is a fine grained, micaceous, thin bedded and laminated, purple-brown to red-brown well sorted, fissile and in places graded bedded siltstone with minor fine grained sandstone. Some siltstone beds in the Bloodwood Formation show slump structures and current ripple marks. Much of the outcrop is covered with scree.

The geological logs of the diamond drill holes 1 mile north-west of White Point were logged by D.J. Grainger (Resident Geologists Office, Alice Springs). The sequence penetrated consisted of red and chocolate-brown, micaceous, current laminated siltstones with minor mudstone intervals and some intraformational breccia. Some graded bedding and contorted current laminations were noted. Bedding planes measured in the cores show dips ranging from 30° to horizontal. Tentative correlations between the two drill holes are based on the depth of the contact between the Bloodwood Formation and the Walbiri

Dolomite and on the position of an 8 feet thick mudstone band and a few minor sandstone interbeds.

A few poorly preserved fossils have been found in the formation. D. Wolley (Resident Geologists Office, Alice Springs) collected a fossil which was subsequently identified as a Protichnites by A.A. Öpik. Dr. Öpik (pers. comm.) has also identified fossils collected from the formation by geologists of American Overseas Petroleum Ltd. They were dated as Lower Cambrian and consist of Pennatulaceans, the mollusc Helcionella (related to H. Rugosa (Hall)) and the trace fossils Protichnites and Rusophycus. All the fossils collected by the Company geologists were obtained from the sample locality LNT-53 approximately 1¾ miles north-west of Djuburula Peak.

During the 1967 field season several more trace fossils were collected from the Bloodwood Formation at sample locality MD 48, an isolated low hill between ½ and ¾ of a mile north of Djuburula Peak.

The fauna indicates a Lower Cambrian age and the unit is correlated with the Pertaoorta Group of the Amadeus Basin. The environment of deposition was probably shallow marine.

ORDOVICIAN?

Djagamara Formation (new name)

The name Djagamara Formation is a new name proposed for a sequence of thick bedded and laminated, siliceous, grey and white sandstone, which in places is interbedded with thick intervals of green shale. The sandstone is in part glauconitic and has abundant clay pellets.

The Djagamara Formation has been previously referred to informally by Cook and Scott (1968) as 'Unit D'.

The name is derived from Mount Djagamara in the Naburula Hills and the type section WX-5 was measured at this locality. Here the formation lies unconformably between the Kerridy Sandstone above and the Mount Doreen Formation below.

Outcrops of the formation are widespread. They occur along the northern margin of the Ngalia Basin in the Vaughan Springs Syncline, the western part of the Treuer Range, near Davis Gap, Naburula Hills and northern side of the Walbiri Ranges. The formation also occurs in the cores of eroded anticlines, such as the Kerridy Anticline, in the area between Yuendumu Native Settlement and Kerridy Waterhole.

The silicified sandstone beds are moderately resistant to erosion and the outcrops are mostly in prominent ridges. The more friable, massive sandstone and interbedded shale are easily abraded and generally form valleys. The siltstone is only exposed in creek beds or on the slopes of the steeper scarps.

The upper contact of the Djagamara Formation with the Kerridy Sandstone is unconformable and whilst there is little difference in dip and strike of the formations where they are in contact there is evidence of considerable erosion of the top of the Djagamara Formation. At Mount Djagamara the Kerridy Sandstone rests on resistant beds of glauconitic sandstone whereas about ½ mile to the south-west it rests on green siltstone of the Djagamara Formation which is about 200 feet stratigraphically lower in the formation. The presence of fragments in the basal part of the Djagamara Formation (Fig. 11) derived from the underlying Mount Doreen Formation indicates the presence of an erosional interval, but there is no angular discontinuity between the formations.

The beds in exposures of the Djagamara Formation east and west of White Point are conformable with the Kerridy Sandstone but a fault contact is present with the Walbiri Dolomite, and a structural interpretation of the area (Fig. 30) suggests that the contact with the Bloodwood Formation is also faulted. However, in the eroded anticlinal cores between Yuendumu and Kerridy Waterhole there is an angular unconformity between these formations.

In the area north of Davis Gap a small outcrop of the Djagamara Formation lies between outcrops of the Mount Eclipse Sandstone and dolomite tentatively identified as the Walbiri Dolomite. No contacts were seen. In the Vaughan Springs Syncline the Djagamara Formation lies unconformably between the Mount Doreen Formation and the Mount Eclipse Sandstone. In the

Fig. 11

Limestone pebble conglomerate of the Djagamara Formation at unconformable contact with the Mount Doreen Formation, Patmungala Syncline.

M/516-30

Fig. 12

Flow casts and small pits in glauconitic sandstone of the Djagamara Formation, Patmungala Syncline.

GA/733

rock relationship diagram an unconformable contact is shown between the Djagamara Formation and the Yuendumu Sandstone, but this unconformity is not exposed, and is inferred from the distribution and stratigraphic position of the formations.

Six sections have been measured in the Djagamara Formation (Plate 2) but only one is complete (WX-1,3) where 950 feet of the formation was measured in the Patmungala Syncline. The remaining sections and thicknesses are as follows - WX-4, 785+ feet; WX-5, 770+ feet; EX-1, 1050+ feet; EX-5, 780+ feet; and EX-6, 170+ feet. The sections measured in the Walbiri Ranges are incomplete because the base of the formation is a fault contact with older formations.

In the area of the type section in the Patmungala Syncline the Djagamara Formation contains thick sequences of uniform green shale with interbedded well sorted, medium-bedded, glauconitic sandstone which in many places has abundant clay pellets and some flow casts (Fig. 12). Sandstone is predominant in the upper part of the formation at Mount Djagamara and thin bedded and laminated, glauconitic sandstone is common. Some of the medium-bedded sandstone contains many trace fossils (Fig. 13) and some ripple marks and flow casts. Mostly the sandstone is tough and silicified and in many places the weathered surface of the sandstone is pitted (Fig. 12). This affect may be caused by weathering either of clay pellets or glauconite grains or both. There is no evidence of thick siltstone interbeds in the formation in exposures other than the Patmungala Syncline. In the Walbiri Ranges the formation is mostly medium and thin-bedded, well sorted, tough silicified sandstone with numerous small clay pellets, interbedded with thick bedded, friable, well sorted sandstone with fewer clay pellets. Large ripple marks were seen in some exposures of the silicified sandstone. Glauconite is uncommon in the Walbiri Ranges.

The formation was deposited in a shallow marine environment. The well sorted and rounded grains suggest considerable transport and probably winnowing of the sediment. Glauconite is considered to form under conditions of slow sedimentation in partially restricted environments (Galliher, 1935) and its presence is considered a sound criterion of marine origin.

Apart from the miscellaneous tracks and trails found in the prominent ledge-forming sandstone at Mount Djagamara no other fossil remains were found.

A radioactive age determination was made on glauconite from a sample of sandstone near the top of the formation at Mount Djagamara. The K-Ar dating was carried out by A.W. Webb and gave an age of 449 million years. As glauconite invariably give ages less than the true age of deposition, this date must be regarded as a minimum estimate of the age of formation of the unit. The date is Middle Ordovician on the currently accepted time scale, and supports the tentative correlation of this unit with Ordovician sandstones of the Amadeus Basin. The Djagamara Formation is lithologically similar to the Pacoota Sandstone of the Amadeus Basin but a correlation with the Stairway Sandstone cannot be dismissed.

Kerridy Sandstone (new name)

The Kerridy Sandstone is the name given to beds of purple and red-brown, medium to coarse-grained, moderately sorted, silty and in part arkosic sandstone with minor interbedded siltstones. It has previously been informally referred to as 'Unit E' by Cook and Scott (1968). The type section is EX-1 (Plate 1) approximately $\frac{1}{4}$ mile south-east of White Point on the Mount Doreen Sheet area. Here the unit appears to lie conformably on the Djagamara Formation and lies with an angular unconformity below the Mount Eclipse Sandstone.

The name is derived from Kerridy Waterhole, 10 miles south of Yuendumu Native Settlement on the Mount Doreen Sheet area.

The Kerridy Sandstone crops out at the northern margin of the Ngalia Basin as far west as the Patmungala syncline and in the area south and south-east of Yuendumu Native Settlement on the Mount Doreen Sheet area. It also crops out at Djabangardi Hill and other isolated hills in the centre of the Basin on this Sheet area. The formation is moderately resistant to erosion and forms low hills and ranges.

The Kerridy Sandstone is commonly tightly folded and faulted in the area south of Yuendumu when it appears to lie conformably on the Djagamara Formation and lies with an angular unconformity below the Mount Eclipse Sandstone. In the Patmungala Syncline it lies with an angular unconformity on the Djagamara Formation and is overlain with an angular unconformity by the Mount Eclipse Sandstone.

Fig. 13

Probable invertebrate tracks in the Djagamara Formation, Djagamara Peak.

GA/728

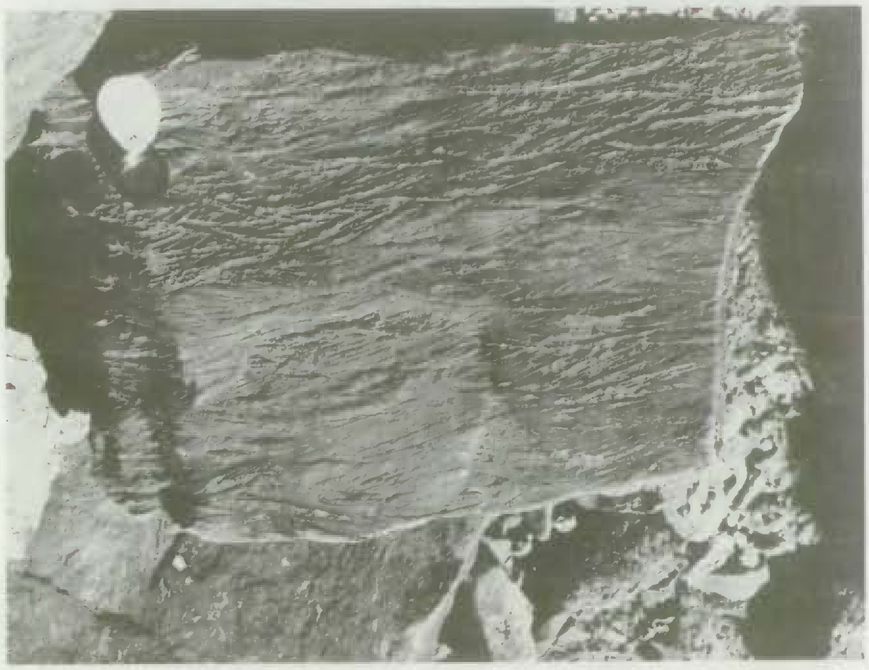


Fig. 14

Festoon cross-lamination in the Kerridy Sandstone, Patmungala Syncline.

M/547-7

Five sections have been measured in the Kerridy Sandstone (Plate 1). The maximum measured thickness is 2310 feet at the type locality (section EX-1). Approximately 1 mile east of Penhalls Bore it thins to 760 feet (section EX-5) and gradually thickens eastwards to 1090 feet at section EX-8, $2\frac{3}{4}$ miles east of Penhalls Bore. Thicknesses of 655 feet (WX-1, WX-3) and 535 feet (WX-4) were measured in the Patmungala Syncline. It is probable that the variable thickness is due to erosion at the top of the formation before the deposition of the Mount Eclipse Sandstone. At the type locality the sandstone is poorly to moderately sorted, medium to coarse grained with subangular to sub-round quartz and contains numerous clay pellets. It is a sub-mature to immature sandstone. There is little variation in the lithology of the formation in the Walbiri Ranges; however, in the Patmungala Syncline it is a purple and red-brown, poorly bedded, poorly sorted, moderately friable, calcareous, silty sandstone with some angular feldspar grains and clay pellets. A few thin interbeds of dark red-brown silty dolomite occur at this locality. It is usually coarse grained and micaceous and can easily be mistaken for the Yuendumu Sandstone in hand specimen. Cross bedding, cross-lamination (Fig. 14) and slumping (Fig. 16) were the only sedimentary structures seen in this unit which is usually medium bedded but variations from thin to thick beds occur. The sandstone beds commonly weather into blocks with very irregular shapes. This phenomenon is commonly referred to as 'skeletal' weathering (Fig. 15) and is probably caused by partial silicification of zones along joint planes which are resistant to erosion whereas the sandstone in the core of the joint block is relatively friable.

Despite the structural deformation the Kerridy Sandstone is not metamorphosed; the only alteration seen were changes that result from compaction and cementation. The finer quartz grains have sutured grain boundaries and quartz overgrowths; these features formed as a result of pressure solution and subsequent cementation. There are variations in the type of cement with silica cement common in the Walbiri Ranges and carbonate the most common cementing material in the Patmungala Syncline.

The Kerridy Sandstone was probably deposited under shallow marine conditions. No fossils have been found in the formation.

From its stratigraphic position above the Djagamara Formation and Walbiri Dolomite and below the Mount Eclipse Sandstone the Kerridy Sandstone is believed to be of Middle Palaeozoic age. Its conformable relationship with the probable Ordovician Djagamara Formation in the area south of Yuendumu suggests that it may also be Ordovician.

CARBONIFEROUS

Mount Eclipse Sandstone (new name)

The Mount Eclipse Sandstone is a new name proposed for a pale brown, coarse grained, poorly sorted, in part micaceous, thin to massively bedded, cross bedded, arkosic sandstone with cobble and boulder beds and a few silty interbeds, which unconformably overlies most of the older rock units of the Ngalia Basin sequence.

The unit has previously been informally referred to as 'Unit F' by Cook and Scott (1968). The type locality is at the Mount Eclipse syncline, 10 miles south-west of Yuendumu Native Settlement. The name is derived from Mount Eclipse 21 miles south-west of Yuendumu Native Settlement.

The Mount Eclipse Sandstone crops out along the northern part of the Ngalia Basin from the eastern part of the Lake Mackay Sheet area to the western part of the Napperby Sheet area. The largest outcrop areas occur along the northern part of the Mount Doreen Sheet area. Recent sand and undifferentiated Cainozoic deposits cover a considerable portion of the Mount Eclipse Sandstone in the central part of the Ngalia Basin and no younger rock units are exposed.

The Mount Eclipse Sandstone has moderate resistance to erosion and generally crops out as low hills and ranges or in places as prominent strike ridges.

The unconformable contacts of the Mount Eclipse Sandstone with other rock units in the Ngalia Basin is usually well exposed. The formation is the youngest rock unit mapped in the Ngalia Basin. In the Treuer Range, north-east of Vaughan Springs and west of 12 mile Creek, the Mount Eclipse Sandstone rests with an angular unconformity on the Vaughan Springs Quartzite which is the oldest rock unit in the Ngalia Basin sequence. Further along the Treuer Range between 12 mile Creek and Gum Creek the contact between the two units is a normal fault. Nowhere on the Mount Doreen Sheet area does the Mount Eclipse Sandstone come into contact with the Yuendumu Sandstone.

Fig. 15

'Skeletal' weathering commonly found in the Kerridy Sandstone. Near Kerridy Waterhole.

M/516-20

Fig. 16

Slump structures in the Kerridy Sandstone, Patmungala Syncline.

M/547-9

In the Treuer Range east of 12 mile Creek an angular unconformity exists between the Mount Eclipse Sandstone and the Mount Doreen Formation. This angular unconformity is only seen locally as the normal fault on this locality removes much of the Mount Doreen Formation and in many places brings the Mount Eclipse Sandstone into faulted contact with the Vaughan Springs Quartzite. There are no other contacts between the Mount Eclipse Sandstone and Mount Doreen Formation exposed on the Mount Doreen Sheet area.

At Djuburula Peak the Mount Eclipse Sandstone rests with an angular unconformity on the Bloodwood Formation. South of Djuburula Peak the Mount Eclipse Sandstone rests with an angular unconformity on the Djagamara Formation and the Kerridy Sandstone. The angular unconformity between the Mount Eclipse Sandstone and the underlying Ordovician? formations has been mapped in many other areas on the Mount Doreen Sheet area.

The thickest measured section in the Mount Eclipse Sandstone is 1680+ feet in EX-9 (Plate 1). However, the maximum thickness from aerial photograph interpretation is estimated to be of the order of 8,000 feet.

Despite its considerable thickness (the formation is the thickest in the Ngalia Basin) the lithology is mostly uniform. Where variations in lithology do exist they cannot be traced for any considerable distance along strike, which prohibits their use as marker horizons.

The most obvious characteristic of this unit is the abundance of phenoclasts of quartzite varying in size from small pebbles to large cobbles. The presence of phenoclasts distinguishes the formation from some of the older sandstone units which it otherwise resembles. Another most distinctive feature of this unit is the well developed cross-stratification; the most common type of cross-stratification is planar cross-stratification (of McKee and Weir 1953). The sets are usually wedge shaped or tabular. The size of the cross-strata varies, but the most common is medium scale cross-stratification, from 1 to 20 feet in length. The orientation of most of the cross-strata suggest that the dominant current direction was from the north-east.

The percentage of phenoclasts and their size varies. For the most part pebbles are randomly distributed throughout the formation, but in a few areas, notably the Treuer Range near the headwaters of 12 mile Creek and also south of Smiths Gift Bore on the Napperby Sheet area, large boulder and cobble beds are exposed. The boulders in these beds are commonly ellipsoidal or ovoid in shape. At the Treuer Range locality the boulders and cobbles have been fractured and shattered as a result of the faulting in the area (Fig. 21). The boulder beds attain a thickness of 6 to 8 feet. Mostly the phenoclasts consist of vein quartz, ortho-and meta-quartzite. Pebbles of recrystallized, reddish brown and dark grey limestone are found in a few localities north and south of Mount Eclipse (Fig. 20) and east of 12 mile Creek in the Treuer Range. They are usually set in a dark grey-brown, calcareous matrix.

A small pebble of recrystallised reddish-brown limestone (MD 108A) contains fragments of bryozoans and echinoderms, as well as indeterminate organic remains. Rounded and ellipsoidal pellets containing angular quartz grains resemble phosphatic pellets recorded by Cook (1966, fig. 64) from the Stairway Sandstone of the Amadeus Basin. Similar pellets also occur in the late Lower Ordovician Nora Formation of the southern Georgina Basin. A post-Tremadocian Ordovician age seems to be indicated (Joyce Gilbert-Tomlinson pers. comm.). No rocks of this age have been found in situ in the Ngalia Basin.

The formation is predominantly red brown to pale brown and occasionally grey. It is usually coarse grained, sub-angular, poorly sorted, thin to massively bedded with a few micaceous red siltstone interbeds. The grain size is variable with coarse grains of quartz most common. The composition is usually quartz, feldspar, some muscovite mica, clay minerals and rock fragments. The percentage of quartz is always over 50%. The feldspar content is variable. In many cases the feldspar has been broken down by intense weathering to form clay minerals. Fresh feldspar grains are nevertheless not uncommon.

The sand grains are commonly coated with iron oxide and are usually cemented by silica. Local variations in the cement occur with calcite being the next most common. The boundaries of the quartz grains have in many cases been affected by pressure solution and quartz overgrowths are not uncommon. The presence of fresh feldspar, the coarse sub-angular grains, and the immature nature of the sandstone, indicate the proximity of a source area of predominantly igneous and metamorphic crystalline basement. Some of the rock fragments and minerals were undoubtedly derived from the older Ordovician? formations.

Sedimentary structures in the formation include mud cracks, mud pellet markings, flow casts, load casts, cross-stratification, scour and fill structures as well as the more problematical structures mentioned below.

At Djuburala Peak the basal part of the Mount Eclipse Sandstone is slightly different in lithology and the sandstone is much finer grained. The rock is fine to medium grained, the grains are cemented by quartz overgrowths, are irregular in shape and have coatings of iron oxides. The iron oxides make up nearly 5% of the rock. Sorting is mostly poor and the sandstone contains a large proportion of clay. Clasts of quartzite are not common whilst abnormal amounts of chert pebbles are present.

Another lithological variation within the Mount Eclipse Sandstone is also present east of Penhalls Bore where section EX-9 was measured. Here, laminated, fine grained, calcareous sandstone with interbeds of chocolate-brown, micaceous siltstone occur. These beds are usually thin to laminated with small clay pellets common in places. Sedimentary structures at this locality includes slumps, cross stratification, scour and fill structures and current lineation. The cross strata here indicate that the current direction was from the north-west. This lithological variation within the Mount Eclipse Sandstone is underlain here by at least 1,000 feet of normal Mount Eclipse Sandstone. Correlation of the two different lithological variations in the formation suggests that deposition occurred earlier in the area east of Penhalls than at Djuburula Peak.

At Djuburula Peak the variation from the normal Mount Eclipse Sandstone is emphasised by the presence of problematical bedding plane markings which are preserved in the finer grained sandstone. Organic trace fossils (Fig. 18) were seen but they have not been identified and give no evidence of the age of the formation. The angular casts (Fig. 17) are believed to have been formed as a result of the infilling of impressions on a bedding plane made by unidentified mineral crystals. Figure 22 illustrates what are believed to be sedimentary structures possibly formed by slumping. Probable gas pits occur in the Mount Eclipse Sandstone at this locality (Fig. 19).

The absence of marine organisms, the well developed cross-stratification, the sedimentary structures and the remains of plant fossils suggest that the deposit is continental and probably formed in fluvial and piedmont environments.

The plant fossils from localities MD 109, MD113, and MD 116 give no clear cut evidence of age, but this deposit is clearly of fresh water origin and no older than late Palaeozoic. (Joyce Gilbert-Tomlinson pers. comm.)

The other plant fragments from localities MD 135 and MD 43 have been identified and dated as Carboniferous in age (Mary White pers. comm.). The plant fragments occupy a stratigraphic horizon close to the top of the formation. The age of this unit then may range from possibly Upper Devonian to definite Carboniferous.

The Mount Eclipse Sandstone has been tentatively correlated with the Pertnjara Group in the Amadeus Basin. The Pertnjara Group is dated as Devonian to possibly Carboniferous in age (Wells et al., 1967) but the only fossils found in it are Upper Devonian spores and fish fossils from the base of the Group. The Mount Eclipse Sandstone is the only confirmed Carboniferous deposit in the Northern Territory.

CAINOZOIC

Undifferentiated

Cainozoic deposits cover a large area of the Ngalia Basin. They occupy a much greater area than the older sedimentary rocks exposed in the Basin but their formation is dependant to a great extent on the presence of these sediments. Other factors have influenced their formation, notably climate and topography.

Silcrete, ferricrete and other chemically altered rocks which go to make up a duricrust capping have been mapped in many areas along the northern margin of the Walbiri Ranges, around the Vaughan Springs syncline,

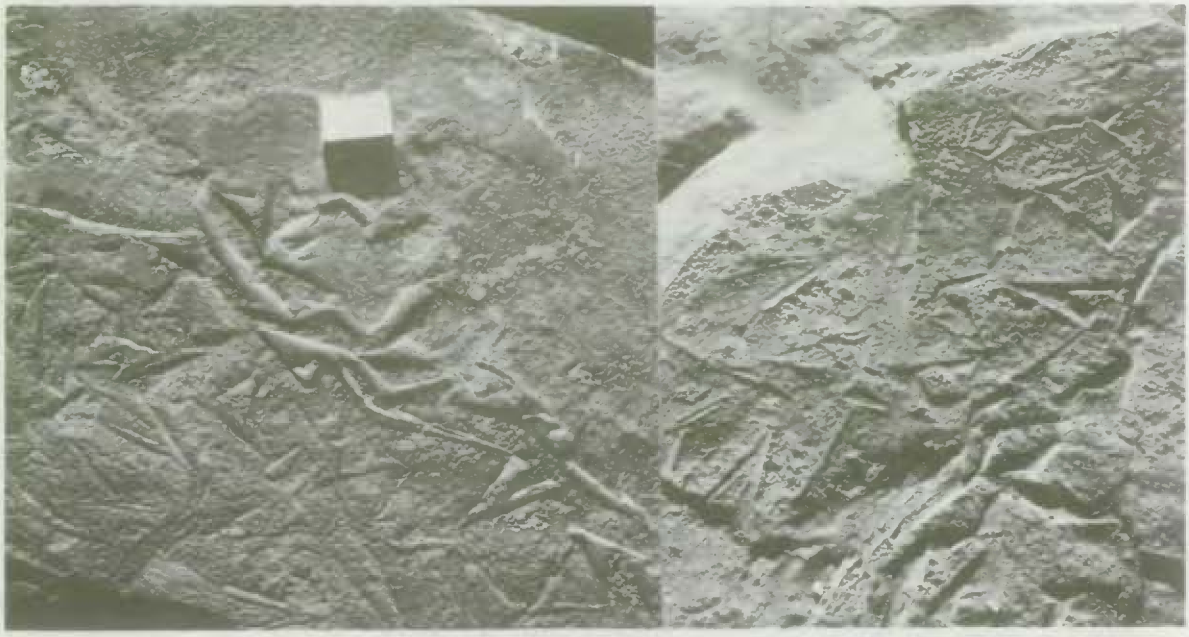


Figure 17: Pseudomorphs probably after mineral crystals on bedding plane, basal Mount Eclipse Sandstone, Djuburula Peak. Neg.GA/466, 467.

Figure 18: Probable invertebrate track in basal Mount Eclipse Sandstone, Djuburula Peak.
Neg. GA/465

Fig. 19

Probable gas pits in basal Mount Eclipse Sandstone, Djuburula Peak.

GA/736, 743

Fig. 20

Limestone pebble conglomerate, Mount Eclipse Sandstone, about 5 miles east of Kerridy Waterhole.

M/547-34

Fig. 21

Fractured cobbles in the Mount Eclipse Sandstone, Treuer Range near major fault zone.

GA/726

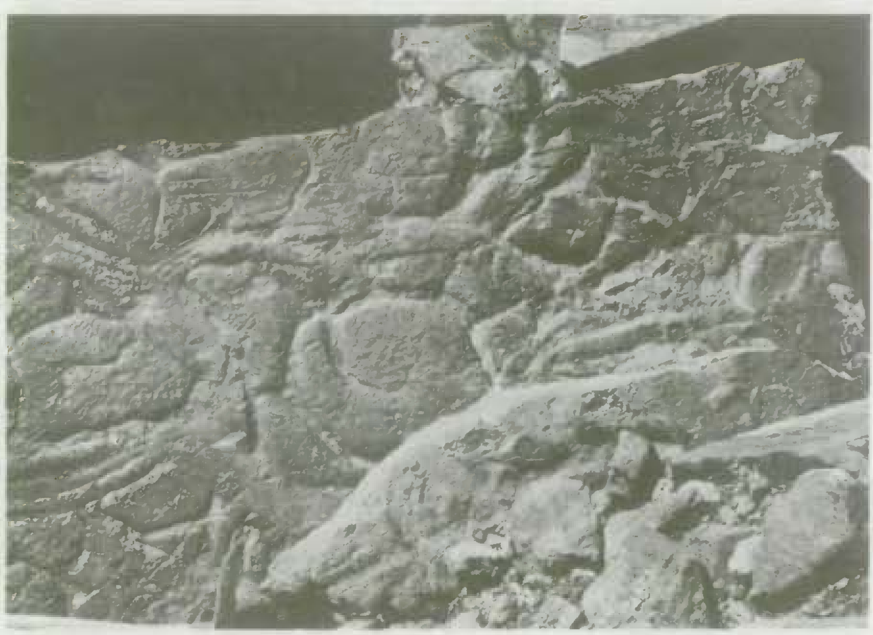


Fig. 22

Casts and moulds of indeterminate origin in the Mount Eclipse Sandstone, Djuburula Peak.

GA/721

the Patmungala syncline and the Treuer Range. They occur as a capping on both sedimentary and basement crystalline rocks. At Vaughan Springs the Cainozoic deposit (Fig. 23) has a white pebbly sand at its base passing upwards into the ferruginous sandy and silty, vughy quartzite from which the warm spring flows. The deposit is up to 100 feet thick. This is possibly the remnant of a much larger lacustrine deposit. Indeterminate features which are believed to be due to the effect of ground water on a duricrust capping were also seen in the Cainozoic deposits. These features are small closely spaced, vertical pipes that are usually found close to the upper surface of the duricrust capping and impart a fluted affect on the outcrops (Fig. 24). Good examples of this feature are found at sample locality MD 67, south east of 20 mile Bore, and in a small outcrop six miles south-east of Yuendumu.

QUATERNARY

Travertine is found in the area between the Stuart Bluff Range and the Siddeley Range and in large areas east and west of Lake Eaton. It forms hummocky terrain and is usually composed of white nodular limestone. It is believed to have been precipitated from ground water. Common opal has been found associated with the travertine deposits in the area south of the Vaughan Springs - Yuendumu Road, near the Naburula Hills.

Alluvium and red soil consisting of sand, silt and clay particles have been deposited over large areas surrounding the mountain ranges. The material is carried by streams flowing from the mountain ranges, and in many places supports a thick cover of mulga and low shrubs.

Many of the rivers enter the spinifex covered sand plain which occupies the centre of the Ngalia Basin. Sand dunes are present in the area adjacent to Waite Creek and sporadically throughout the sand plain. They are usually seif type dunes less than 3 miles long and up to 30 feet high. They are aligned in a north-east direction and are stablised by spinifex growing on their flanks with only the crests having loose sand.

Colluvium has been mapped in areas adjoining the mountain ranges where there is a rapid change in relief of the land surface.

Quaternary evaporites are restricted to a chain of salt lakes and salt pans on the southern margin of the basin that extend from the south-east corner of the Mount Doreen Sheet area near Central Mount Wedge to Lake Eaton in the west.

The salt pans are the relics of originally much larger lakes which have formed from downslope flood-outs of the drainage system controlled by the Amunurunga and Belt Ranges which form the northern margin of the Amadeus Basin in this area. The salt pans were features originally formed as a result of surface drainage, but with changing climatic conditions they are now replenished only by subsurface drainage which despite evaporation losses maintains the water-table near the surface.

The evaporites are composed mainly of halite with associated gypsum, and form a surface encrustation. The sediments of the salt pans are grey, foetid, waterlogged saline clays in which saline ground water can be found at shallow depth.

Deposits of windblown red sandridges form fringing dunes, and islands of sand are present in the larger salt lakes.

STRUCTURE

General outline

The Ngalia Basin is a relatively small intracratonic structural depression covering about 6,000 square miles. Its maximum width on the Mount Doreen Sheet area is about 48 miles. Geophysical evidence as well as the structures revealed in the sediments suggest that the basin is asymmetrical and that the maximum thickness of sediments is about 14,000 feet in the northern part of the basin. Outcrops of sediments occur mainly in a strip along the northern margin of the basin and deformation of the sediments is

Fig. 23

Cainozoic ironstone and pebbly sandstone in two prominent mesas in foreground abutting ridge of Vaughan Springs Quartzite, Vaughan Springs.

GA/732

Fig. 24

Cainozoic silcrete showing fluting 6 miles south-east of Yuendumu.

M/516-7

greatest in this region. A structural interpretation of the Mount Doreen Sheet area is shown in Fig. 25.

The northern and southern margins of the basin are well defined. The northern margin is in most places a high angle thrust fault with the crystalline basement rocks upthrust in relation to the basin sediments. In most places the beds are steeply overturned to the north next to the fault zone. South-west of Yuendumu the basal part of the sedimentary sequence is mostly faulted out and younger formations are in fault contact with the crystalline basement.

By contrast the sediments in the southern part and at the southern margin of the basin are relatively undisturbed and for the most part only slightly tilted by block faulting. Mostly the sediments exposed in this region dip northwards into the basin at low or moderate angles.

The unconformities in the sedimentary sequence indicates that the basin was subjected to at least three relatively minor epeirogenic movements before the deposition of the Kerridy Sandstone. The major faulting and folding of the sediments took place during two periods of diastrophism in the Middle Palaeozoic. Table III summarises the various types of movements that have affected the Ngalia Basin, the name of the event and a tentative correlation with the Amdadeus Basin. The first major event, the Kerridy Epeirogeny occurred after the deposition of the Kerridy Sandstone and was responsible for major faulting of the sediments. During this period the major upthrust of the basement rocks against the sedimentary sequence was probably initiated. This period of faulting and subsequent erosion may have commenced in the Silurian.

The second period of diastrophism, the Mount Eclipse Diastrophism, occurred after the deposition of the Mount Eclipse Sandstone and can be dated as post Lower Carboniferous. The movements that took place during this diastrophism caused major folding and faulting of the sediments and in some cases minor renewed movements on the pre-existing fault planes. The renewed movements were the reverse of the original fault movement that took place during the preceeding diastrophism.

The folds in the sediments mostly trend westerly and in most cases are doubly plunging. The wave length of the folds is generally about two miles in the exposures along the northern edge of the basin. Faults are mostly parallel to the fold axes and the movement is generally north side up except where a reversal has been caused by later movements.

The degree of basement involvement in the disturbed belt of sediments in the Ngalia Basin is not certain. However, there does not appear to be any major décollement above the level of the basement so that it may be assumed the mapped faults descend steeply into the Precambrian crystalline basement rocks. A décollement in the sequence would mean that most of the thrust faults would flatten downwards into bedding plane faults. This would imply the presence of overthrusts of large horizontal displacement and the stratigraphic section above the décollement surface would consist of several thrust sheets with repeated sections.

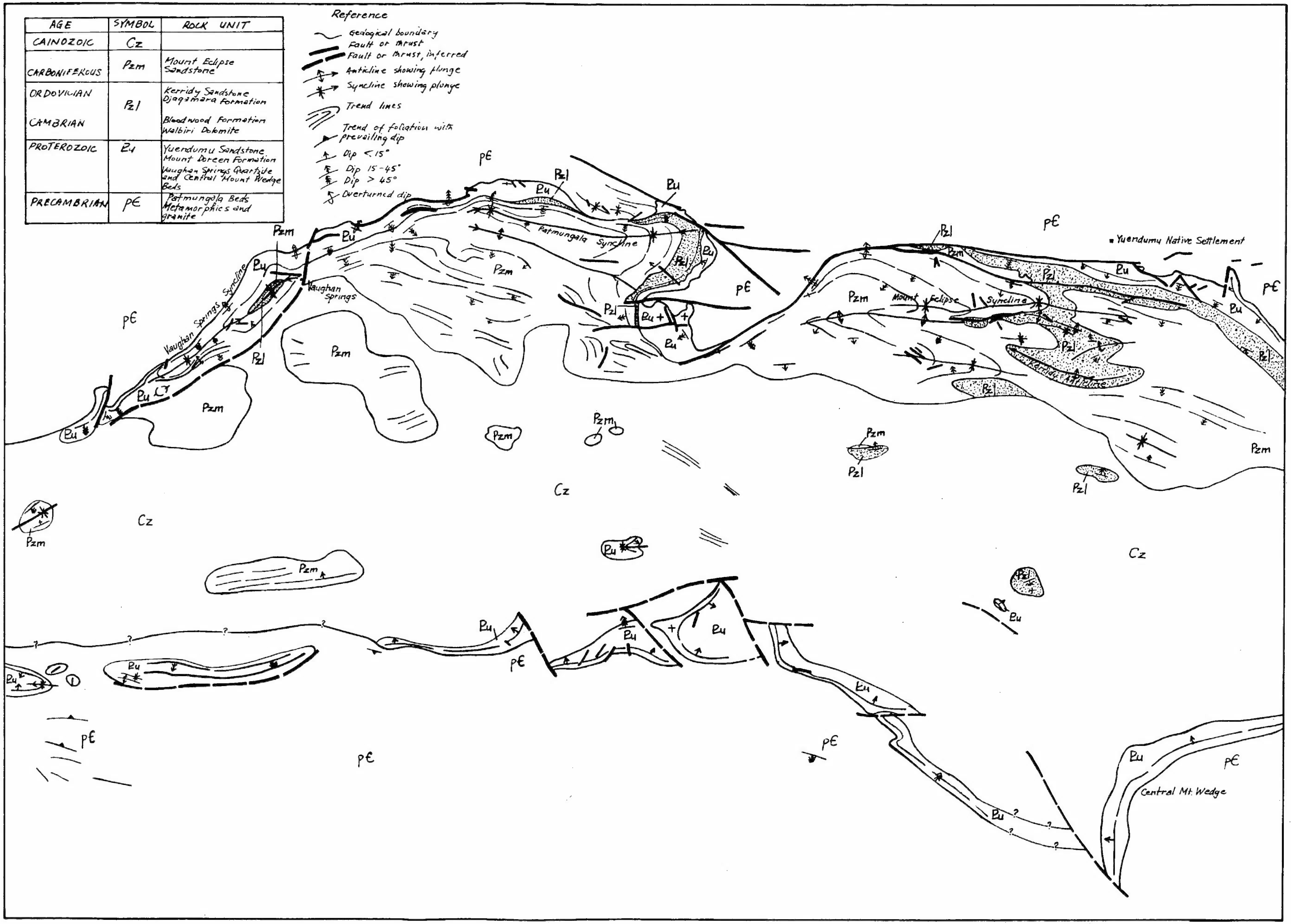
The only incompetant beds in the Ngalia Basin sequence are possible salt beds in the Treuer Member of the Vaughan Springs Quartzite. In some areas these beds show incipient buckling because of their incompetancy. No other formations show incompetant folding to any degree although by correlation with the Amadeus Basin sequence there could possibly be evaporites in the Lower Cambrian sediments of the Ngalia Basin.

The structure of the northern margin of the basin with the basement rocks upthrust against the sedimentary sequence, the lack of any evidence of repetition of the sedimentary sequence in thrust slices and the structure of the sediments along the southern margin of the basin suggests that block faulting of the basement and differential movement of these blocks has been responsible in large part for the deformation of the overlying sediments. It is concluded that the faults in the sediments probably persist into the basement.

There is some comparison possible between the major tectonic movements that occurred in the Amadeus and Ngalia Basins. There were four main tectonic events in the Amadeus Basin that were responsible for uplift of provenance areas and for the folding of the sedimentary sequence. They were the Kulgera Tectonism, Petermann Ranges Orogeny, Rodingan Movement and the

STRUCTURAL INTERPRETATION MOUNT DOREEN SHEET AREA

Fig. 25



To accompany Record 1968/38

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TABLE III EPEIROGENIC AND DIASTROPHIC EVENTS IN THE NGALIA BASIN AND CORRELATION WITH THE AMADEUS BASIN

	Stratigraphic Sequence	Type of Movement	Name of Event	Correlation with Amadeus Basin
	- - - - - - - - - - - - - - - -	Major folding, faulting and upthrusts	Mount Eclipse Diastrophism	Alice Springs Orogeny
CARBONIFEROUS	Mount Eclipse Sandstone			
	- - - - - - - - - - - - - - - -	Major faulting and minor folding followed by prolonged erosion	Kerridy Epeirogeny	Rodingan Movement
	Kerridy Sandstone			
ORDOVICIAN?	- - - - - - - - - - - - - - - -	uplift, tilting and erosion	Djagamara Movement	-
	Djagamara Formation			
	- - - - - - - - - - - - - - - -	uplift and erosion?	-	
	Bloodwood Formation			
CAMBRIAN				
	Walbiri Dolomite			
	- - - - - - - - - - - - - - - -	uplift, tilting and erosion followed by marine transgression	Yuendumu Movement	-
	Yuendumu Sandstone			
PROTEROZOIC				
	Mount Doreen Formation			
	- - - - - - - - - - - - - - - -	uplift, tilting and erosion	Vaughan Springs Movement	Kulgera Tectonism or Petermann Ranges Orogeny?
	Vaughan Springs Quartzite			
	- - - - - - - - - - - - - - - -	Isoclinal folding, low grade metamorphism and probably granite intrusion	-	
	Patmungala Beds			
PRECAMBRIAN	- - - - - - - - - - - - - - - -			
	Granitic and Metamorphic rocks	Formation of high grade metamorphics and intrusion of granite. Relationships of these rocks to Patmungala Beds not certain. Relative ages of diastrophic events not known.	-	Arunta Orogeny?

Alice Springs Orogeny. The Kulgera Tectonism occurred in Proterozoic times and was responsible for uplifts along the southern margin of the basin which became provenance areas for later Proterozoic sediments. The Petermann Ranges Orogeny caused recumbent and isoclinal folding of the Proterozoic sequence in the south-western part of the basin in the late Proterozoic or early Cambrian. The effects of these orogenies are not significant in the Ngalia Basin and either could be related to the unconformity at the top of the Vaughan Springs Quartzite.

The Rodingan Movement tilted a large area of the north-eastern part of the Amadeus Basin probably in the Silurian and several thousand feet of sediments were eroded before the Devonian and probable Carboniferous rocks were deposited unconformably on the truncated edges of several of the older formations. Large scale faults and upthrusts occurred in the Ngalia Basin after the deposition of the Kerridy Sandstone and a considerable period of erosion ensued. This diastrophism may be the same age as the Rodingan Movement.

The latest orogenic movements in the Amadeus Basin are considered to have commenced in the Devonian and ceased after the folding of the Devonian-Carboniferous? Pertnjara Group. The orogeny was responsible for major uplifts along the northern part of the basin and recumbent folding on a large scale with infolding of sediments with basement rocks facilitated by a décollement in the sedimentary section. The diastrophism that occurred after the deposition of the Mount Eclipse Sandstone, which resulted in folding and faulting of the Ngalia Basin sediments, is probably the same age as the Alice Springs Orogeny.

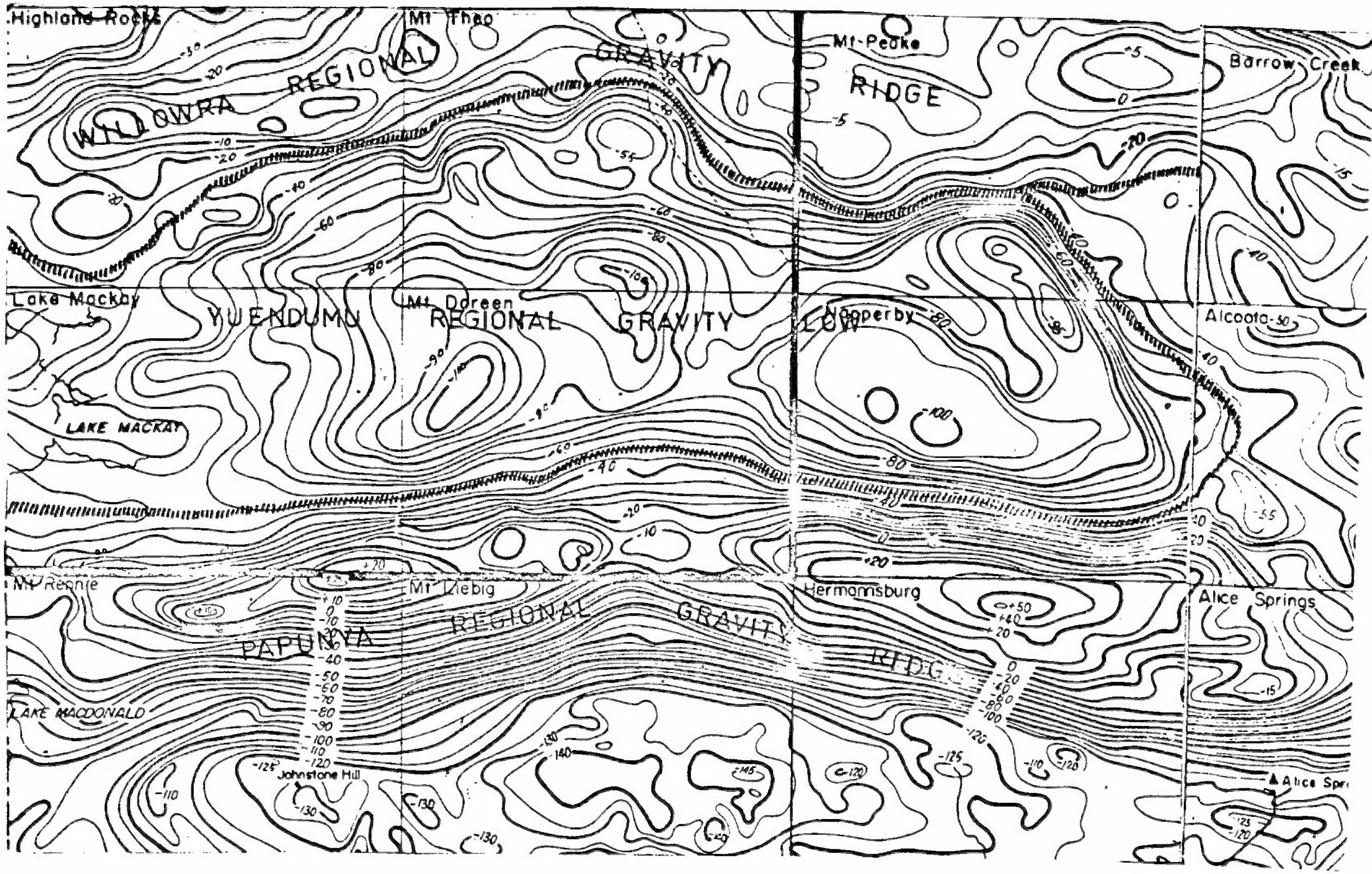
The presence of large thicknesses of sediments at the faulted or eroded margin of the basin and the preservation of downfaulted blocks of sediment outside the basin margin suggests that the sediments in the Ngalia Basin were probably at least in part continuous with those in the Amadeus Basin to the south and undoubtedly continued a good deal further north. Uplift and erosion of the sediments to the north and south of the basin probably commenced before and during the deposition of the Carboniferous Mount Eclipse Sandstone. The Mount Eclipse Sandstone contains phenoclasts derived from many of the older formations and lies with an angular unconformity on most of the formations.

The Ngalia Basin was stabilised after the post Lower Carboniferous diastrophism and became a structural entity at this time. Large thicknesses of the sediments overlying basement uplifts to the north and south of the Ngalia Basin were removed and crystalline basement was exposed. Areas of Precambrian basement rocks now separate the Ngalia Basin from the surrounding sedimentary basins, although in some areas such as Mount Singleton there are outliers of sediments which are preserved as downfaulted blocks in the basement rocks.

During the Middle Palaeozoic diastrophic events the Ngalia Basin was subjected to southward directed forces that produced high angle overthrusts dipping northwards at the northern edge of the Basin. The recumbent folding along the northern part of the Amadeus Basin also involved southward transport of the basement and infolded sedimentary pile. The interaction of these movements probably produced a zone of tension along the southern part of the Ngalia Basin in the area of the Stuart Bluff Range - Campbell Range area. The presence of a tensional zone would probably result in block faulting of the basement rocks and may account for the tilted outliers of basal quartzite present in this area. These tilted blocks of quartzite have probably assumed this position because of differential movement of the underlying fault blocks in the Precambrian basement.

Gravity surveys

Two regional gravity surveys have been undertaken in the area. The first was made by Geophysical Associates Pty Ltd for Pacific American Oil Co. and the results interpreted by Nettleton (1964). The gravity readings were made at seismic shot points after a seismic survey had been completed in the area. The results of the gravity analysis were plotted as observed gravity values and a residual gravity map. The interpretation of the gravity anomalies as set out in the report are as follows. The northward gravity decrease may be caused by the northward slope of the floor of the Ngalia Basin to an axis near its northern outcrop, but there may also be a northwards regional contribution from density contrasts deep within the crust. The residual map shows strong shallow disturbances above the horizons mapped by the seismic survey and the presence of two thrust slices is suggested as one possible structure



Feature Boundary

-65 Isogals from Bouguer Anomaly map prepared by the Geophysical Branch of the B.M.R.

Fig 26 BOUGUER ANOMALIES AND GRAVITY FEATURES

SCALE

40 0 40 80 120 Miles

To accompany Record 1968/38.

NT/B2-5

to account for the anomalies. In one other area near the southern part of line 1 (Fig. 28) a residual minimum gravity anomaly of 7 mgs could be caused by salt movement. The anomaly corresponds with an area of no reflections which may indicate an area of strong uplift.

The second regional gravity survey, undertaken under contract to the Bureau of Mineral Resources in 1967, covered a large part of the Northern Territory and included the Mount Doreen Sheet area. Two major gravity units are present in the Sheet area - the Yuendumu regional gravity low and the Papunya regional gravity ridge (Fig. 26).

The Yuendumu regional gravity low is one of the most significant gravity features in Central Australia with values of - 105 mgs. The southern boundary of the gravity feature is characterised by a very steep gravity gradient that decreases gradually to the west. Its northern boundary lies to the north of the Mount Doreen Sheet area, well north of the northern boundary of the Ngalia Basin. There are two closures in the Yuendumu regional gravity low, one lying on the western side of the Mount Doreen Sheet area and encompassing areas of both crystalline basement rocks and sediments of the Ngalia Basin. The other lies further east on the Napperby Sheet area and is centred over areas of Precambrian granitic rocks very close to the northern margin of the Ngalia Basin.

The following explanations for the Yuendumu regional gravity low have been postulated.

1. Density variations within the basement rocks such as large granite intrusions.

2. Variations in crustal thickness. Allowing for the effect of the low density sediments in the Ngalia Basin a structural relief on the Moho of 15,000 feet would account for the bouguer anomalies (R. Whitworth, pers. comm.).

3. Basement rocks have been thrust over the Ngalia Basin sediments for several tens of miles.

4. The presence of a faulted Proterozoic - Palaeozoic Basin to the north of the Ngalia Basin with some southwards overthrusting and large thicknesses of sediments preserved on the down thrown blocks.

There is little, if any, field evidence to support the views either that basement rocks are thrust over the sedimentary pile of the Ngalia Basin or that large down faulted blocks of sediments are present in the area of the Yuendumu gravity low to the north of the Ngalia Basin.

The basement rocks surrounding the Ngalia Basin are primarily granitic in composition and probably the density of these rocks and the Ngalia Basin sediments do not differ significantly. Descriptions of the rocks of the Arunta Complex that underlie the Papunya regional gravity-ridge indicate that they are generally more basic in composition and of higher density. As well as this a significant thinning of the crust may have taken place in this area as a result of major uplifts of the basement during the Alice Springs Orogeny. The net effect of these density variations within the Precambrian basement rocks and the crustal foreshortening may explain the gravity anomaly pattern of the region.

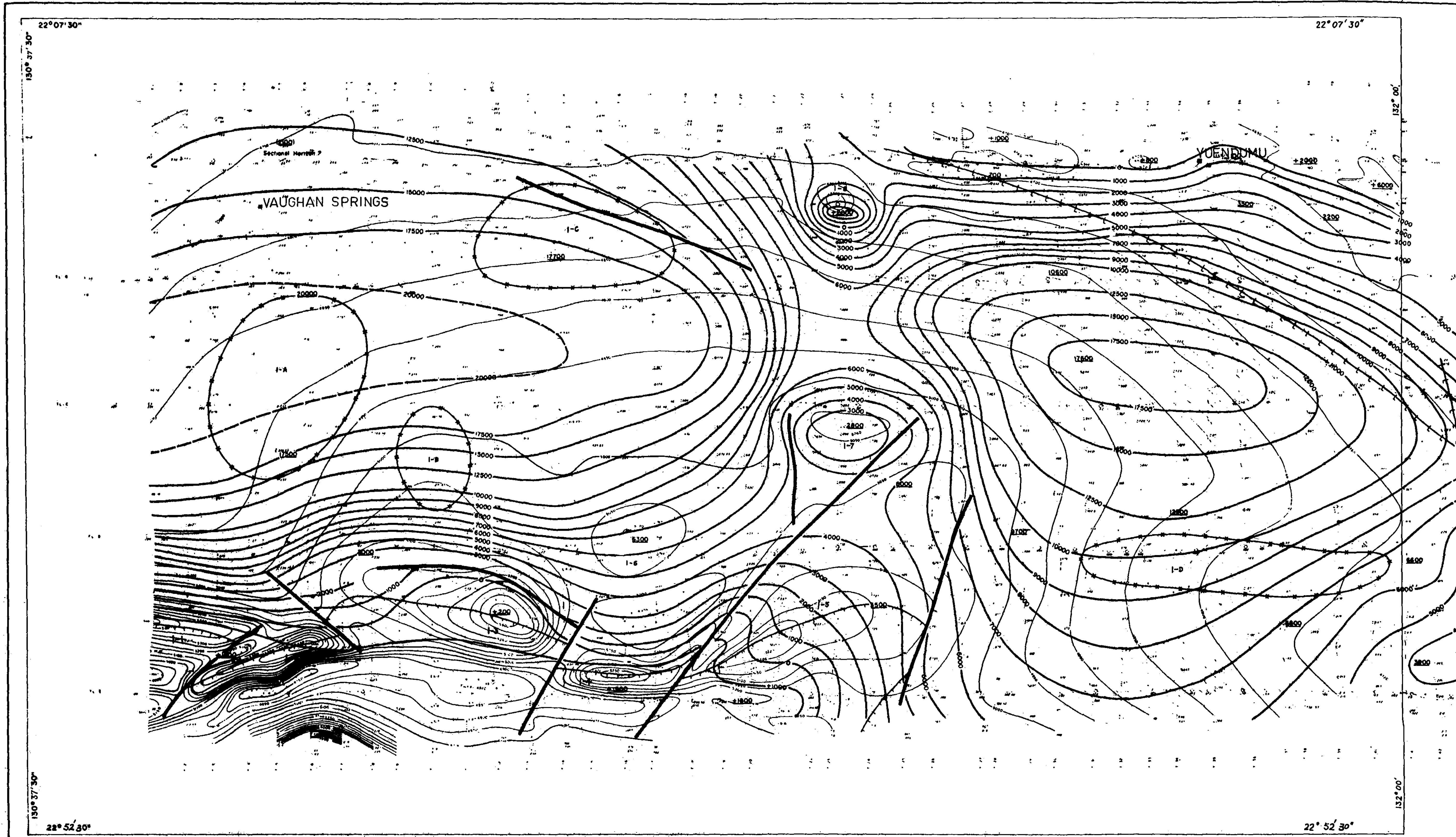
Aeromagnetic survey

An aeromagnetic survey which included the Mount Doreen Sheet area was carried out by Aeroservice Ltd, for Pacific American Oil Company (Hartman, 1963). The results were plotted as total magnetic intensity maps and an interpretative map showing estimates of depth to magnetic basement (Fig. 27).

The contours on the map using the estimated depths to magnetic basement indicate that the Ngalia Basin on the Mount Doreen Sheet area can be divided into two sub-basins separated by a north-south trending basement swell. The estimated maximum depth to magnetic basement in the eastern sub-basin is about 17,500 feet below sea level and about 20,000 feet in the western sub-basin.

An intense magnetic pattern is present along the southern part of the Sheet area and the intensity gradually decreases northwards and eastwards. Several smaller magnetic anomalies are superimposed on this broad gradient.

MAGNETIC BASEMENT CONTOURS FROM AEROMAGNETIC SURVEY Fig 27



LEGEND

2000 DEPTH ESTIMATE

LINEAMENT RESULTING FROM FAULT OR CONTACT IN THE BASEMENT AND POSSIBLY HAVING REGIONAL INSIGNIFICANCE

APPROXIMATE NORTHERN LIMIT OF TOP OF HIGHLY MAGNETIC, STEEPLY DIPPING ROCKS AT SOUTHERN EDGE OF SURVEY

—2000— DEPTH TO BASEMENT CONTOUR

INTERPRETED FAULT

ZONE OF POSSIBLE MINOR STRUCTURAL SIGNIFICANCE AFFECTING THE SECTION

SCALE

5 0 5 10 15 Miles

AFTER HARTMAN 1963

Interpretation by R R HARTMAN

Surveyed & Compiled by AERO SERVICE LTD Sydney

To accompany Record 1968/98

The area of intense anomalies and the magnetic pattern along this southern part of the basin has been interpreted as indicating north-east trending faults cutting basement blocks that have varying attitudes. The analysis of the anomalies suggests that the magnetic bodies dip northwards at 20° to 45° and because the depth estimates indicate a northward plunge these dips may indicate the slope of the basement surface.

Magnetic anomalies in the central part of the Mount Doreen Sheet area suggest the presence of shallow basement horsts that bisect the basin. The estimated depth of the magnetic source beneath anomaly 1-7 is 2800 feet below sea level. The northernmost anomaly here occurs over a prominent south west trending fault where the Carboniferous Mount Eclipse Sandstone is probably faulted against Precambrian basement rocks.

The abrupt change in the magnetic pattern on the north-eastern part of the Sheet area is interpreted as a fault which corresponds roughly to the northern margin of the basin. The fault zone occurs, for the most part, to the north of the lineament shown on the map.

A depth estimate of 2100 feet below sea level about five miles north of Vaughan Springs was considered by Hartman (op. cit.) to be the result of a magnetic horizon within the section. However, a reappraisal of this area appears necessary as the contours on interpreted depths to magnetic basement with values of the order of 10,000 feet below sea level occur over areas where Precambrian granitic rocks crop out.

Seismic surveys

The location of seismic traverses in the Mount Doreen Sheet area is shown in Fig. 28.

A reflection seismic survey was carried out in the eastern part of the Mount Doreen Sheet area by Geophysical Associates for Pacific American Oil Co. (Hudson and Campbell, 1965). The results of the survey are presented as a depth contour map (Fig. 28a) based on a horizon tentatively identified as Lower Palaeozoic. Migrated dip sections of the company results were prepared by the Geophysical Branch of the Bureau of Mineral Resources (Fig. 29).

A series of east-west trending faults are shown on the depth contour map and have been interpreted by Hudson & Campbell (op. cit.) as thrust sheets with overthrusting from the north. This is seen as the dominant structural feature in the basin.

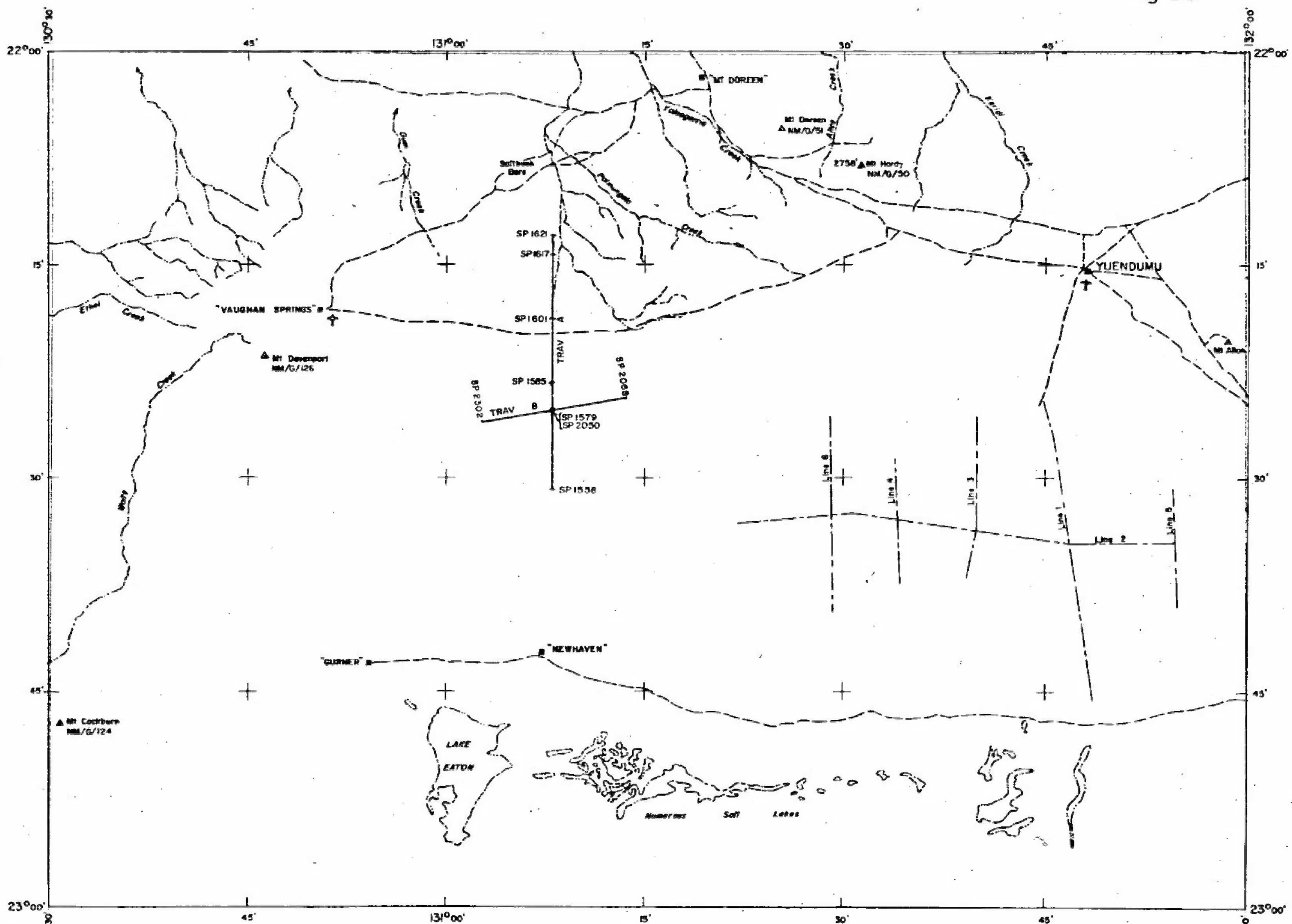
The maximum depths to the Lower Palaeozoic horizon were 12,000 feet on the north side of line 3 and 13,000 feet at the intersection of lines 2 and 5.

The survey confirmed the presence of a deep basin that had been indicated previously by an aeromagnetic survey. Hudson and Campbell (op. cit.) suggest that salt in the sedimentary section may have acted as a 'glide plane' for the postulated overthrusting from the north and that the main movements occurred during or after the deposition of the Mount Eclipse Sandstone. Normal faulting associated with a major basement uplift was probably subsequent to the thrust faulting. The basement high is inferred from a major aeromagnetic high in the western part of the area surveyed. A velocity analysis indicated high velocities below the Upper Palaeozoic horizon, but did not give any definite indication of the presence of Lower Palaeozoic sediments. An apparent unconformity below the mapped event may be near the top of Proterozoic rocks.

A seismic survey was carried out by the Bureau of Mineral Resources in 1967 in the western half of the Ngalia Basin along a line trending south of Davis Gap. Twenty one miles of continuous reflection profiling was shot on traverse A (Fig. 28). Results were of fair quality and showed the presence of a thick sedimentary sequence with major faulting and some folding. The following results are summarised from the party progress report (Jones, 1968).

At the northern end of the seismic line between S.P.'s 1600 and 1621 (Fig. 29) two strong deep reflections were recorded between 0.65 - 0.85 sec. and 0.85 - 1.25 sec. and some weaker discontinuous shallow events. To the south between S.P.'s 1600 - 1559 only one strong event is present between 0.8 - 1.4 sec. with some impersistent shallow events and a deeper strong event between S.P.'s 1569 - 1559. This deep event occurs at 1.05 sec. under S.P. 1559 and 1.3 sec. under S.P. 1569.

Fig 28



LOCATION OF SEISMIC TRAVERSES

MOUNT DOREEN SHEET AREA

LOCATION DIAGRAM

REFERENCE TO AUSTRALIA STANDARD 1:250,000 MAP SERIES : MT DOREEN

LEGEND

- Mission
- Homestead
- River or creek } Intermittent
- Lake } Intermittent
- Track
- Previous seismic survey

5 0 5 10 15 20 MILES

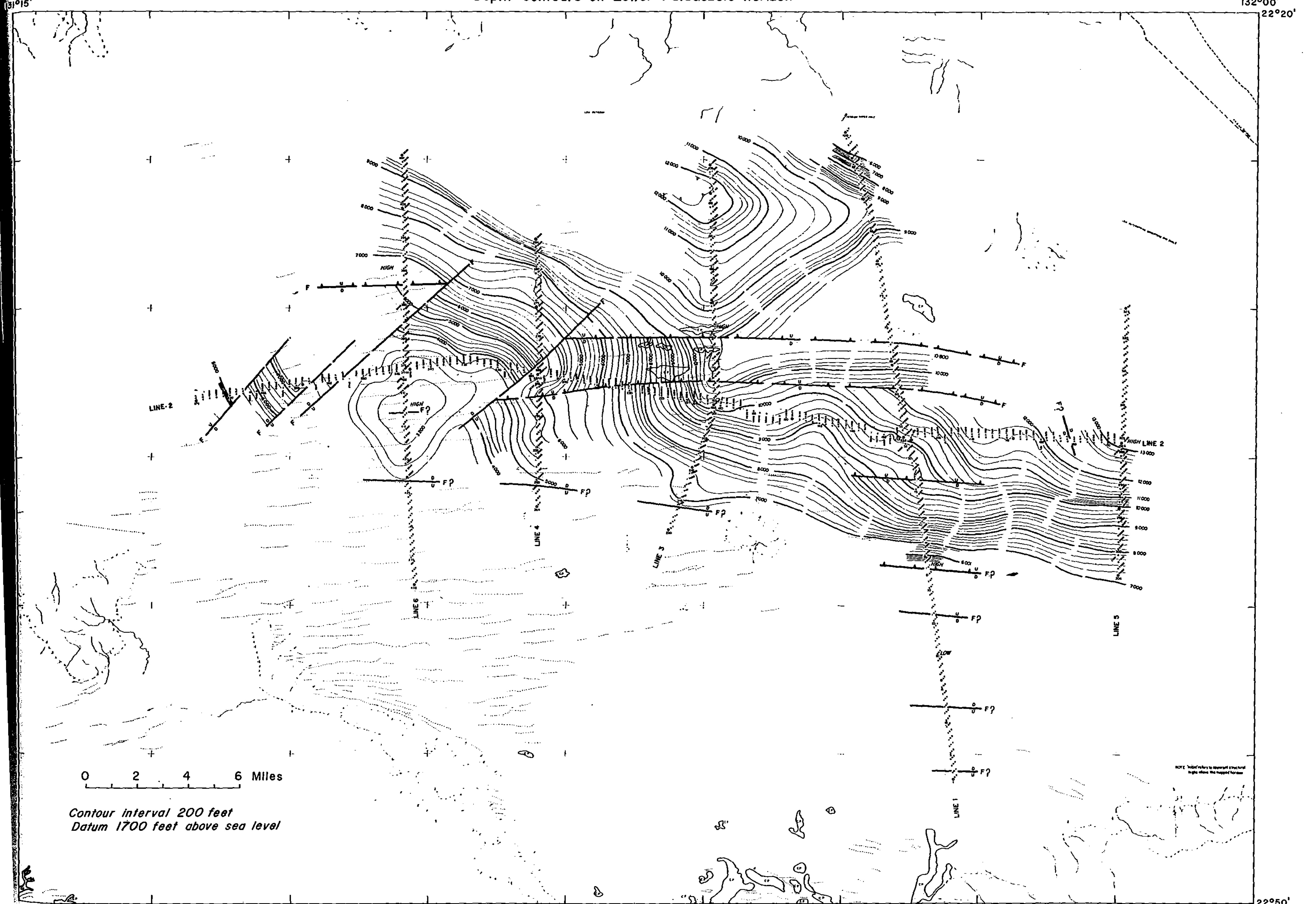
5 0 5 10 15 20 25 30 KILOMETRES

To accompany Record 196?/58

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F52/B3-1

Fig.28a NAPPERBY SEISMIC SURVEY

Depth contours on Lower Palaeozoic horizon



To accompany Record 1968/38

From Hudson & Campbell, 1965

F52/A12/22

A migrated dip section for traverse A is shown in Figure 29. The section has a general north dip with only minor dip reversals. The deeper of the two strong events between S.P.'s 1600 and 1621 shows evidence of faulting with downthrow to the north of 500 - 800 feet. The major dip reversal in the two strong events between S.P.'s 1604 and 1601 is probably associated with the major fault which occurs to the south.

Only one strong event is present between S.P.'s 1599 - 1570. This deep reflector is at a depth of about 12,500 feet (1.6 sec.) at S.P. 1599 and decreases in depth to 7500 feet (1.0 sec.) at S.P. 1573. Faulting is also present near S.P.'s 1570 and 1569.

To the south of the fault between S.P.'s 1559 and 1569 two strong events are present which dip to the north. The deeper one is at 7,800 feet (1.04 sec.) under S.P. 1559 and 10,000 feet (1.35 sec.) under S.P. 1568.

The shallow events along the traverse line appear to show the same structure as the deeper strong events.

A short refraction probe on traverse A between S.P.'s 1617 and 1621 showed a near surface refraction velocity of 14,500 feet/sec. in an area where Carboniferous sandstones crop out.

A refraction probe on traverse B between S.P.'s 2032 - 2068 showed refractors with average velocities of 12,800, 14,500, and 19,800 feet/sec. The depths of these refractors are as follows:-

Shooting from S.P. 2032 Apparent velocity (ft/sec.)	Depth below datum at S.P. 2032 (ft.)
13,100	330
14,600	1500
20,600	8000

Shooting from S.P. 2068	Depth below datum at S.P. 2068 (ft.)
12,500	125
14,500	1100
19,000	6400

(Datum is 2000 feet above sea level)

Reflection profiling in the centre of traverse B showed one strong horizontal reflection at a depth of about 9000 feet. This strong reflection may correspond to the 19,800 ft/sec. refractor calculated to occur at a depth of about 8000 feet on traverse B.

The survey showed that the northern part of the basin has been affected by large scale faulting with some associated folding. The refractor with a high velocity at a depth of 8000 - 9000 feet could be a useful marker for mapping. No positive identification of the reflection events is possible until the seismic line can be extended as far as the northern and southern margins of the basin. Some correlation may then be possible between reflectors and outcropping formations.

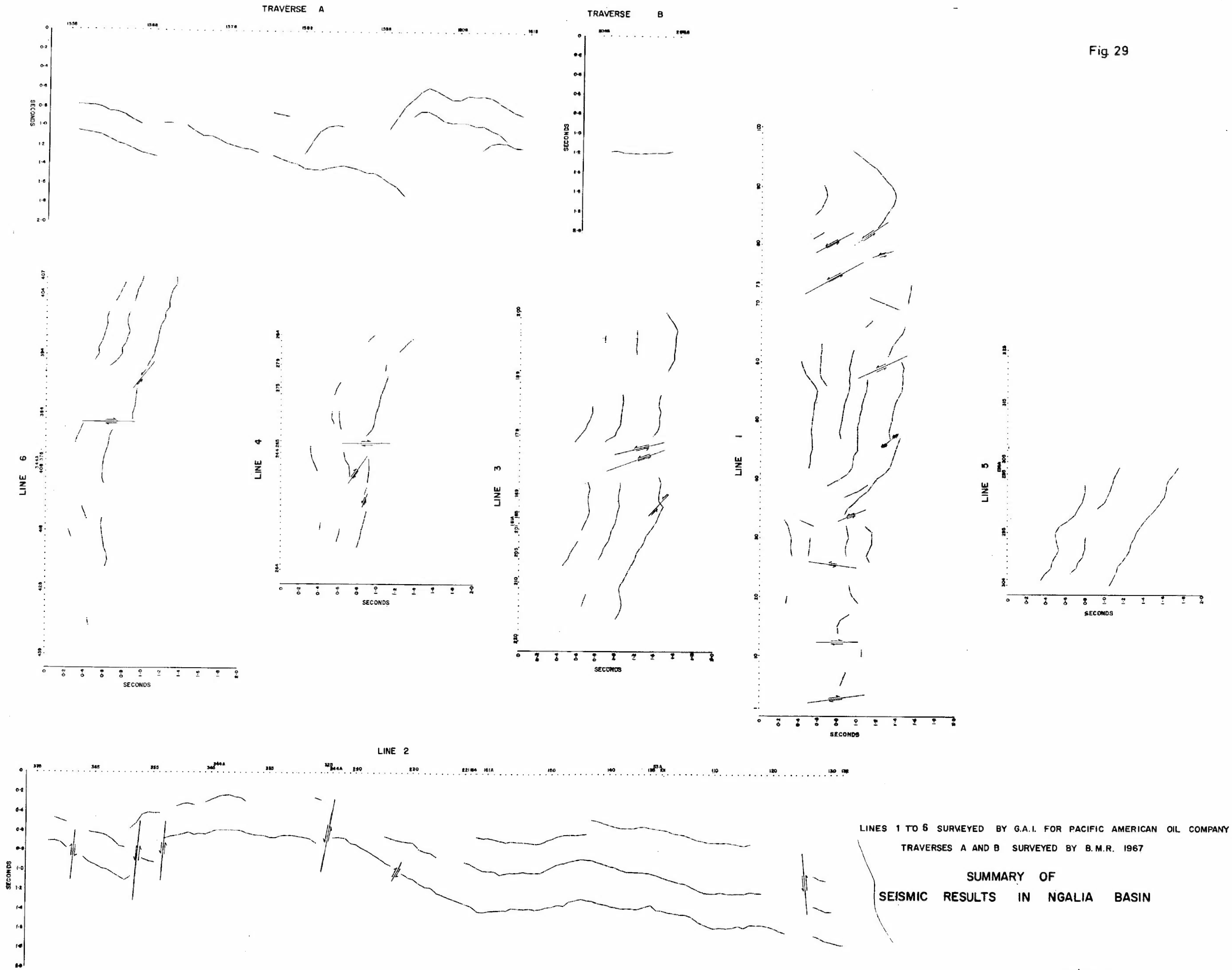
DESCRIPTIONS OF SELECTED STRUCTURES

White Point Fault Zone

The White Point fault zone is a structurally complex area that lies about 5 miles south-west of Yuendumu Native Settlement, in the northern part of the Walbiri Ranges. It encompasses the prominent outcrops at Djuburula Peak and White Point. The five exposed rock units that are affected by the faulting are the Walbiri Dolomite the Bloodwood and Djagamara Formations, and the Kerridy and Mount Eclipse Sandstones. A sketch map and cross-section (Fig. 30) illustrates the relationship between each of these five formations.

The Djagamara Formation which forms a prominent east striking ridge, appears to be overlain conformably by the Kerridy Sandstone at this locality. Both formations are believed to be Ordovician in age. The Cambrian Walbiri Dolomite and the Bloodwood Formation are separated from the Ordovician formations by a major thrust fault. A smaller thrust fault to the south of, and undoubtedly related to the larger thrust, has pushed the Djagamara Formation over the Kerridy Sandstone whilst the larger thrust has caused the tight folds seen in the Djagamara Formation where it occurs in a narrow thrust slice. These tight folds have amplitudes of about 300 feet and their axial planes dip to the north. By contrast the Cambrian formations of the northern block were only slightly tilted by the thrust movements.

Fig. 29



LINES 1 TO 6 SURVEYED BY G.A.I. FOR PACIFIC AMERICAN OIL COMPANY

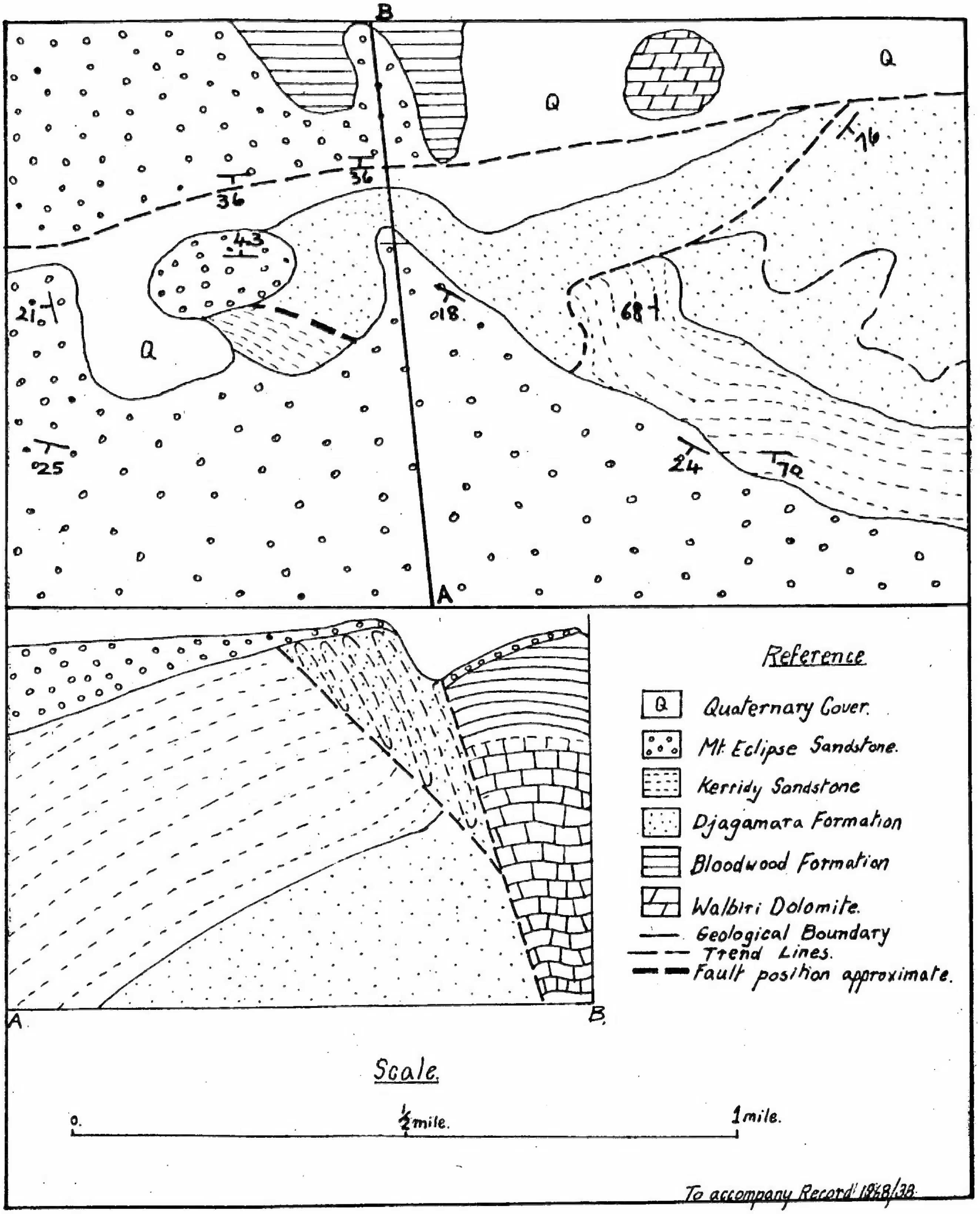
TRAVERSES A AND B SURVEYED BY B.M.R. 1967

SUMMARY OF SEISMIC RESULTS IN NGALIA BASIN

To accompany Record 1968/38. F52/B3-6

SKETCH MAP AND CROSS SECTION OF THE WHITE POINT FAULT ZONE

Fig. 30



To accompany Record 1958/38.

F52/A12/17

There seems little doubt that the Ordovician formations were originally present to the north of the large thrust above the Cambrian rocks and after the faulting were completely removed by erosion, prior to the deposition of the Mount Eclipse Sandstone. The Ordovician formations present south of the thrust have a measured thickness greater than 3000 feet. Their absence on the north side of the larger thrust together with the presence of the Bloodwood Formation there in fault contact with the Djagamara Formation shows that the vertical displacement between the major fault blocks is at least 1000 feet.

The Mount Eclipse Sandstone rests with an angular unconformity on all the older formations in the region of the fault zone but there is about 200 feet difference in elevation between the base of the Mount Eclipse Sandstone at the closest points where the contacts are visible on either side of the large thrust fault. There is evidence of relief on the pre-Mount Eclipse Sandstone surface by local differences in elevation of the unconformity at the base of the formation (Fig. 32). In addition there are angular blocks of Djagamara Formation up to 1 foot across in the basal Mount Eclipse Sandstone where the two formations are in contact about $\frac{1}{2}$ mile south of Djuburula Peak. However, a depositional surface of high relief cannot explain the south dips of 36° in the Mount Eclipse Sandstone immediately north of the major thrust fault. The more logical explanation is that a small normal fault has downfaulted the northern block by about 200 feet. The normal fault occurred after the deposition of the Mount Eclipse Sandstone by renewed movements on the pre-existing thrust fault. The movement was the reverse of that on the original thrust fault.

Treuer Range Fault Zone

Three rock units are affected by the faulting in the area, the Vaughan Springs Quartzite, the Mount Doreen Formation and the Mount Eclipse Sandstone. An air-photograph of the Treuer Range near the fault zone (Fig. 31) shows the topographic expression of these formations. A cross section (Fig. 33) illustrates the relationship between the units.

All three units are overturned to the north which can be explained by postulating a large thrust on the northern side of the Vaughan Springs

Quartzite, between the Quartzite and the Precambrian basement rocks. A normal fault which brings the Mount Eclipse Sandstone into contact with the Vaughan Springs Quartzite has caused the repetition of beds of the Mount Doreen Formation and the Mount Eclipse Sandstone.

The order of displacement of the two faults is believed to differ considerably. The thrust which has caused overturning of the beds by as much as 38° is believed to be of much greater magnitude than the normal fault.

A cobble bed serves as a local marker horizon in the Mount Eclipse Sandstone and this bed is repeated by the faulting. The maximum measured thickness of the Mount Doreen Formation is 370 feet and the formation also has beds repeated by the fault in this area. These two facts suggest that the amount of displacement on the normal fault is not great.

The thrust is believed to have formed as a result of differential movement of basement blocks. The thrust plane is probably a curved plane steepening to near vertical with increasing depth.

The normal fault has probably been caused by the squeezing of a wedge of sediments immediately to the south of the major fault and downward displacement of the wedge by the overthrust movement.

Vaughan Springs syncline

The Vaughan Springs syncline lies in the north-western quadrant of the Mount Doreen Sheet area. It is a doubly plunging structure with steep dips of up to 80° in the narrow south-east and north-west flanks, and much shallower dips of about 35° in the broad northern and southern noses.

The area was not affected by orogenic movements until the formation of the syncline in the post Carboniferous and the contemporaneous deformation of the axis into and elongated 'S' shape by lateral compressive movement directed from the north or north-west. It is thought that the syncline is comparatively shallow-bottomed with steep flanks and could be termed a boxfold. The presence near the base of the sequence of the in-

Fig. 31

Trever Range near Davis Gap. Ridges of Vaughan Springs Quartzite at northern edge of the Ngalia Basin and Mount Eclipse Sandstone to the south in foreground.

GA/705

Fig. 32

Prominent hill of Djagamara Formation surrounded by outcrops of the Mount Eclipse Sandstone, White Point Fault Zone.

GA/717

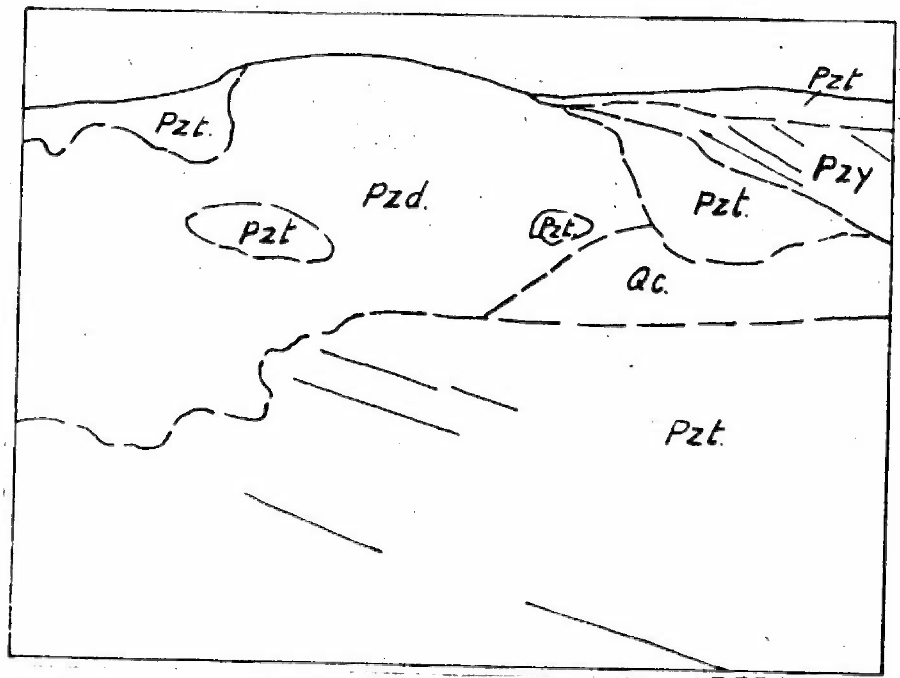
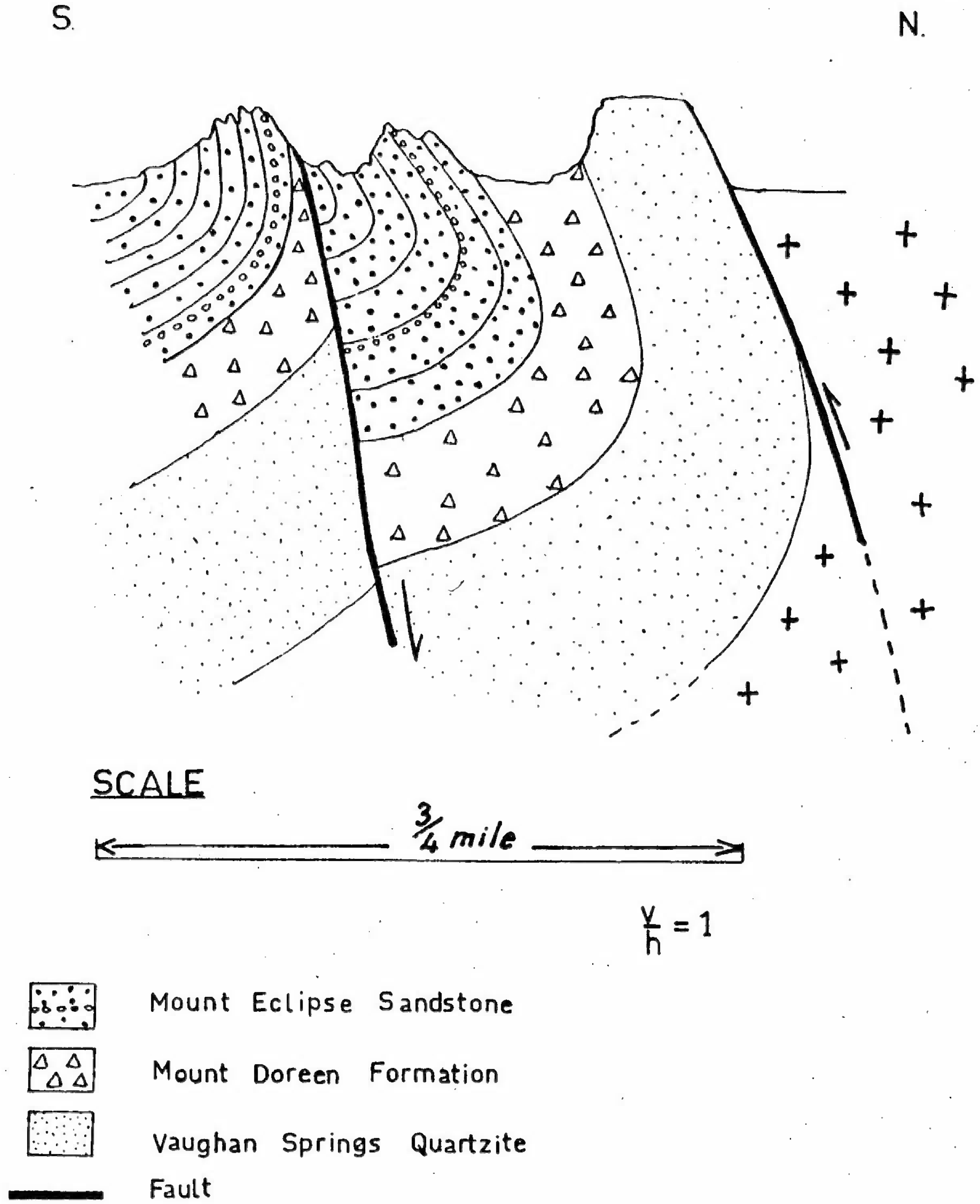


Figure 32A: Line drawing of Figure 32. Pzt - Mount Eclipse Sandstone, Pzd - Djagamara Formation, Qc -Colluvium.

Fig 33

Sketch Cross-Section of the Treuer Range Fault Zone



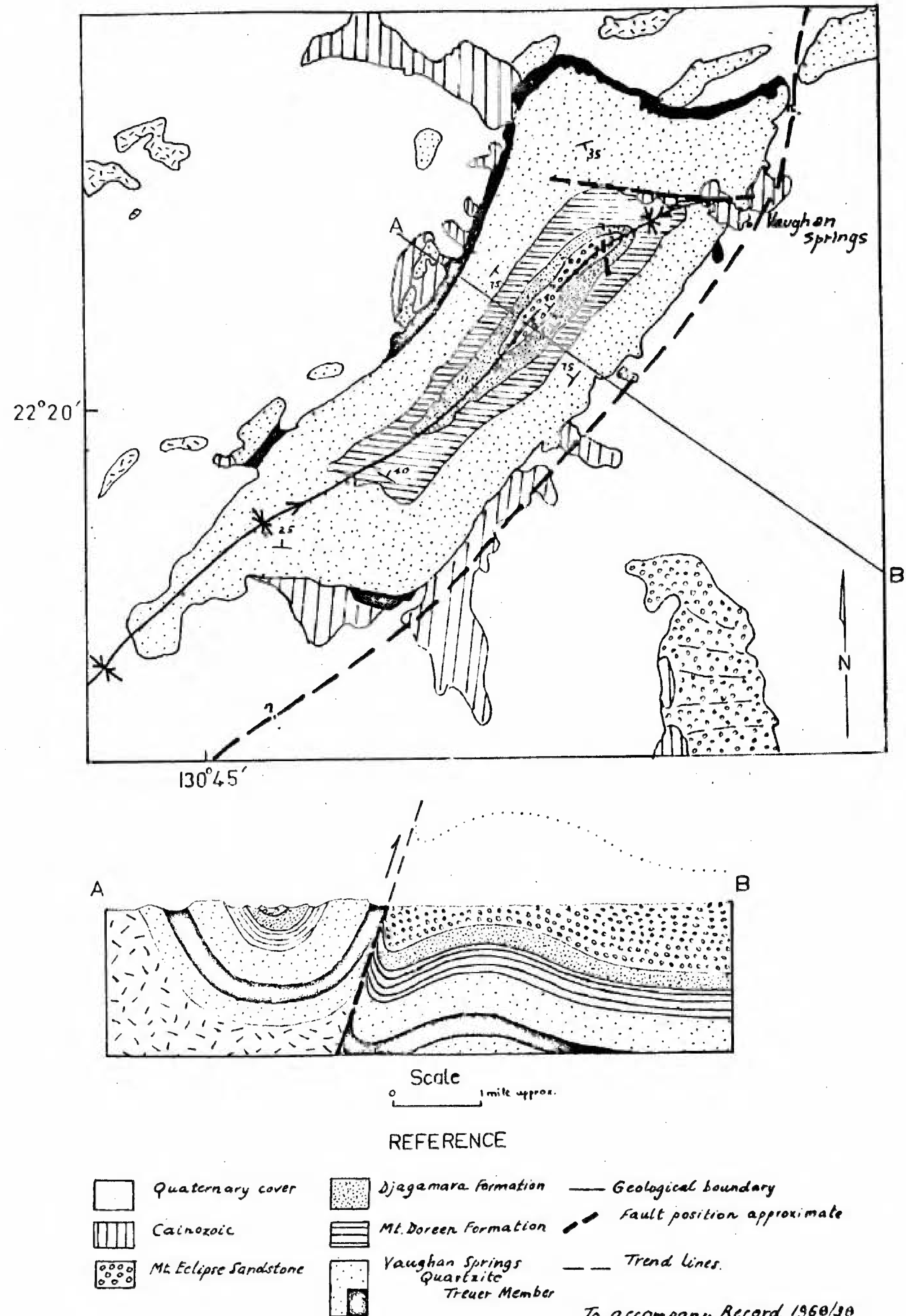
To accompany Record 1968/38

F52/A12/16

Fig. 34

VAUGHAN SPRINGS
SYNCLINE

Fig. 35 Cross-section of the Vaughan Springs Syncline



To accompany Record 1960/30

F52/A12/18

competent, possible evaporitic, Treuer Member of the Vaughan Springs Quartzite has facilitated the formation of this concentric type of folding.

The complementary anticline has been faulted out by an upthrust originating in the basement. The fault strikes along the south-eastern margin of the syncline from Waite Creek in the south-west to Vaughan Springs where it swings to the north. This fault line is inferred, as nowhere in this area has a faulted contact been observed to bring the Vaughan Springs Quartzite into contact with the Mount Eclipse Sandstone.

An upthrust is suggested because of the very competent, steeply dipping Vaughan Springs Quartzite, intense minor folding and shearing in the Vaughan Springs Quartzite and Treuer Member to the south-west of Mount Davenport, and small isolated outcrops of fault breccia which probably correspond to the position of the fault line. In addition, scattered outcrops of the Mount Eclipse Sandstone, occurring just south of the Treuer Range and also south-south-west of Mount Davenport, dip very steeply to the south-east, and may indicate drag along the fault. Further out into the basin the Mount Eclipse Sandstone is either flat lying or dips gently to the south-east.

The alternative explanation of the structure by detachment along a basal shearing plane in which gliding has taken place on the incompetent Treuer Member is unlikely, as the Vaughan Springs Quartzite is in normal contact with the basement on the west side of the syncline, and there is little evidence of deformation and faulting in the Treuer Member here which would be expected if the upper beds of Vaughan Springs Quartzite had acted as a décollement surface.

The structure in the Treuer Range on the northern margin of the basin further east also supports the interpretation of an upthrust in the area.

Patmungala Syncline

The Patmungala Syncline is situated about 30 miles west of Yuendumu Native Settlement. It plunges to the west and is bounded on all but its western margin by prominent fault zones. Most of the fault zones are filled with wide quartz veins. To the south there are prominent mesas comprising Vaughan Springs Quartzite unconformably overlying Precambrian granite separated from the syncline by an easterly trending quartz filled fault zone. On the eastern nose of the syncline the Mount Doreen Formation unconformably overlies Precambrian granite and a prominent north-west trending fault cuts diagonally across the fold axis and is the eastern boundary of the syncline. The Mount Doreen and Djagamara Formations are cut by this fault and are intensely brecciated and microfolded next to it. In places there are isolated pockets of brecciated Mount Doreen Formation preserved on the south west side of the fault zone outside the area of the main outcrop of the formation exposed in the syncline.

On the north side of the syncline the beds of the Djagamara Formation and Kerridy Sandstone are transgressed by the Mount Eclipse Sandstone. All the beds here are vertical or nearly so and are separated from outcrops of the Patmungala Beds to the north by a valley with no outcrop. The absence of any quartz veining in the area and the presence of a sedimentary contact between the Mount Doreen Formation and the Patmungala Beds at the eastern end of the valley suggests that the contact is probably not faulted and that the present relationship is a result of tight folding in the area with the Patmungala Beds exposed in the core of an eroded anticline in the younger rocks. The Vaughan Springs Quartzite had most likely been eroded before the Mount Doreen Formation was deposited, and in neighbouring areas normal sedimentary contacts between the Mount Doreen Formation and the Precambrian granite and Patmungala Beds are common.

Southern Ranges

Field evidence of faulting along the southern margin of the Ngalia Basin on the Mount Doreen Sheet area is restricted to small-scale minor faults in the Central Mount Wedge Beds; all major faulting to account for the present structure is, of necessity, inferred. The position of these inferred faults is shown in the structural interpretation of the Mount Doreen

Sheet area (Fig. 25). Interpretation of aeromagnetic surveys tends to support the position of some of these inferred faults in the Siddeley Range-Newhaven-Gurner area.

The whole of the southern margin has been affected by block-faulting with tilting of the blocks so that marked changes of strike occur from one outcrop to another. Except in the extreme west of the Mount Doreen Sheet, folding has payed little part in the structural history of the sediments. A synclinal exis trending east-west passes just north of Mount Cockburn, and extends an unknown distance onto the Lake Mackay Sheet.

An uplifted area between the southern margin of the Ngalia Basin and the northern margin of the Amadeus Basin is now occupied by outcrops of crystalline basement rocks. In the southern half of the Ngalia Basin, sediments dip shallowly into a gradually deepening basin, whilst in the northern part of the Amadeus Basin the basal part of the sedimentary sequence has been infolded with the basement rocks, and in places over-folded to the south. This folding appears to have occurred in the Upper Palaeozoic, and it seems likely that the folding of the sediments in the west of the Mount Doreen Sheet area is also of this age.

Structure south of 20 mile Bore

Figure 36 is a north-south cross section of the area five miles south-east of 20 mile Bore and seven miles west-north-west of Djuburula Peak, where the Proterozoic Yuendumu Sandstone and Cambrian formations have been affected by major faulting. Only one fault zone is exposed on the surface but to explain the structure a second fault is inferred.

The exposure is poor but it is possible to measure the dip and strike of overturned beds of Yuendumu Sandstone and also to see the repetition of beds of Cambrian Walbiri Dolomite.

The fault zone between a small outcrop of granite and the Yuendumu Sandstone is filled by a quartz vein, and is believed to mark the position of a thrust. The evidence for thrusting is the presence of overturned beds of Yuendumu Sandstone which dip 82° to the north and form the footwall of the fault; Precambrian granite forms the hanging wall. The position of the granite outcrop can be explained only if thrusting has taken place, as nowhere is there an intrusive contact seen between the granite and sediments.

In an adjacent area to the west, beds of the Mount Eclipse Sandstone are overturned. It is thought that these overturned beds were formed as a result of the movement along the continuation of the same thrust plane, and thus the age of the faulting is post Carboniferous.

The presence of coarsely crystalline granite cropping out between outcrops of sediments is difficult to explain. The granite is known to have a faulted contact with the Yuendumu Sandstone, whilst the contact between the Cambrian Bloodwood Formation and the granite outcrop is concealed. There is little doubt that it is also a faulted contact, and this inferred fault is believed to be a normal fault.

The combination of thrusting and normal faulting enable the unusual sequence of overturned and repeated beds, and the position of the granite outcrop to be explained.

A sequence of sketched cross sections (Fig. 36) shows the suggested interpretation of the structural history of the area.

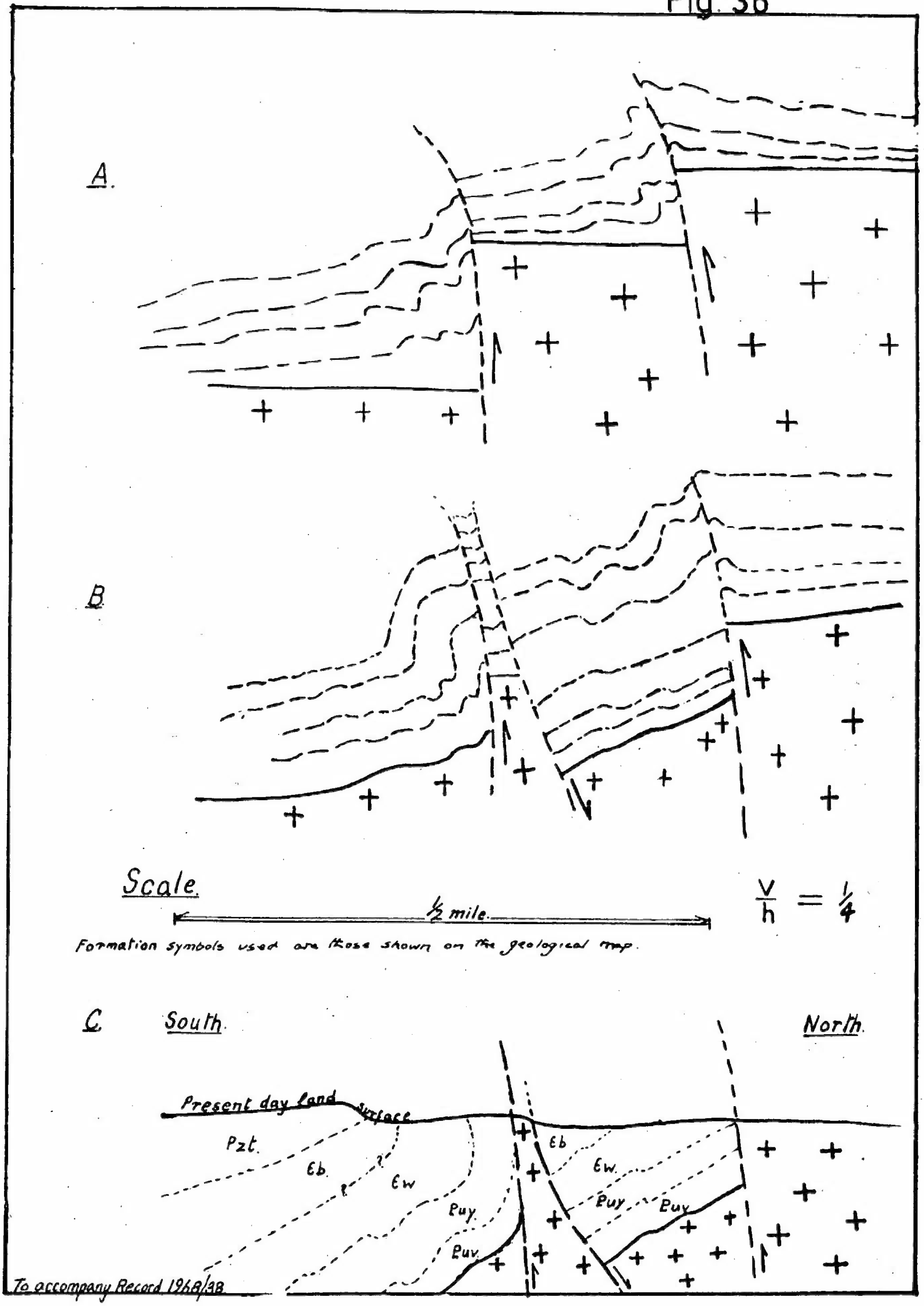
The thrust, which may have been active on several occasions prior to the deposition of the Carboniferous sediments, is believed to have been reactivated by movement of basement blocks. This later movement is dated as post Carboniferous.

The normal fault between the granite and the Cambrian sediments was formed after, and probably as a result of, the thrust.

Sanford (1959) has reproduced fault structures similar to the one seen at this locality by experimental laboratory studies.

From consideration of the structure mapped east of this area, along the northern margin of the basin, south of Yuendumu, it is likely that another thrust fault exists between the Walbiri Dolomite and the Precambrian crystalline basement. The two thrust faults may be genetically

Fig. 36



Sketch Cross-Sections Showing the Structural Evolution of the Area South of 20 Mile Bore related and they have probably been caused by upthrusting of Precambrian basement blocks.

The structure in the Treuer Range which has already been described is somewhat similar to that present near 20-mile Bore and although only one thrust fault and a normal fault cut the sediments the relative movement of the fault blocks is the same.

GEOLOGICAL HISTORY

The sedimentary history of the area mapped began with the deposition of arenites and lutites on unknown Precambrian rocks. Low grade metamorphism has affected these sediments and it is believed that they have been intruded by granite. These low grade metamorphic rocks are called the Patmungala Beds and are of Precambrian age. The relationship between the Patmungala Beds and higher grade Precambrian metamorphic rocks is not known.

The Precambrian igneous and metamorphic rocks were uplifted and eroded prior to the deposition of a thick sequence of marine orthoquartzites and shales of the Vaughan Springs Quartzite. They are Proterozoic in age and are the earliest sediments of the Ngalia Basin. The Vaughan Springs Quartzite crops out over a wide area and is indicative of a period of mild subsidence with considerable winnowing and transport of sediments. Cross bedding and ripple marks suggest that the sea was shallow. It is believed that the sea covered the entire Ngalia Basin and that the Central Mount Wedge Beds are the lateral equivalent of the Vaughan Springs Quartzite. Interbedded green and blue shales in the Central Mount Wedge Beds have well developed mud cracks which indicate exposure of the clayey sediments to the atmosphere and deposition probably on tidal mud flats.

A glauconite bed found in the Treuer Member of the Vaughan Springs Quartzite provides added support to the idea that the sea was shallow. Glauconite forms where accumulation of sediment is slow in partially restricted marine environments. It is possible that evaporites were also deposited during this time.

A period of uplift and erosion followed. The Vaughan Springs Quartzite was removed from most of the Naburula Hills area and the Mount Doreen Formation was deposited on crystalline basement rocks and the Patmungala Beds in this locality. The Mount Doreen Formation was deposited on the Vaughan Springs Quartzite elsewhere in the western part of the Mount Doreen Sheet area.

The provenance for the Mount Doreen Formation included areas of Vaughan Springs Quartzite and Precambrian basement rocks. The striated and faceted pebbles and boulders were transported by glaciers and prboably re-distributed in fluvial and lacustrine environments.

No exposure of the Mount Doreen Formation is seen in the Walbiri Ranges. It is likely that the area of the Walbiri Ranges was continental at this time with at first a shallow sea covering the Naburula Hills and Treuer Range area during deposition of the shale and stromatolitic dolomite of the basal part of the Mount Doreen Formation. The environment then probably changed to fluvial and lacustrine when the glacial meltwater deposits were laid down.

Epeirogenic movements caused subsidence and deposition of the Yuendumu Sandstone probably in a shallow marine environment. The Yuendumu Sandstone was probably deposited in the Proterozoic and is believed to be younger than the Mount Doreen Formation. This is deduced from correlations with other areas in Central Australia.

Rejuvination to a land surface was accompanied by slight folding followed by some erosion prior to the invasion of the shallow Cambrian sea. The fossiliferous Walbiri Dolomite and Bloodwood Formation were deposited in the early Cambrian Sea which is known to have extended, at times, at least as far west as Davis Gap. The area was probably land during late Cambrian and early Ordovician times.

Widespread subsidence of the land surface in the Middle Ordovician resulted in a marine transgression with the deposition of the glauconitic quartz sandstone of the Djagamara Formation. The sediments are very well sorted with rounded quartz grains indicating considerable winnowing in a shallow sea. Authigenic glauconite suggests that the sea was partially restricted.

By Upper Ordovician times the Ngalia Basin had again been uplifted and eroded. This was followed by a shallow marine transgression which enabled the Kerridy Sandstone to be deposited. Uplift during Ordovician times was probably greater in the west of the Mount Doreen Sheet area as there is an unconformity between the Djagamara Formation and the Kerridy Sandstone in this area, and the Kerridy Sandstone was eroded from the Vaughan Springs area prior to the deposition of the Mount Eclipse Sandstone. Much of the material which was obtained to form the Kerridy Sandstone was derived from many of the older sedimentary rock units as well as from Precambrian basement rocks.

Post-Ordovician and pre-Carboniferous epeirogenic movements caused severe folding and faulting along the northern margin of the Ngalia basin. Large blocks of sediments were uplifted and several thousand feet of sediment were eroded. All the pre-Carboniferous sediments were affected and a pene-contemporaneous conglomeratic continental deposit; the Mount Eclipse Sandstone was deposited.

Post-Carboniferous diastrophic movements caused considerable folding and faulting of all the sediments of the Ngalia Basin and raised the land above sea level where it has remained to the present day.

Silcrete cappings are found on sediments ranging in age from Precambrian to Carboniferous. The silcrete is believed to have been formed during a period of weathering in the Tertiary. Thin Tertiary lacustrine sandstone and pebbly sandstone were deposited in small local areas.

Aeolian sand in dunes and plains cover a large part of the Ngalia Basin and are indicative of an arid climatic phase. The sand dunes trend south-east and reflect the dominant wind direction. The sand is now mostly fixed by vegetation indicating the onset of a pluvial climatic phase.

ECONOMIC GEOLOGY

Petroleum Prospects

The aggregate thickness of sediments in the Ngalia Basin is about 20,000 feet using the known maximum measured thicknesses of the formations. However, the maximum preserved thickness of sediments in the deepest part of the basin on the Mount Doreen Sheet area is probably about 12,000 - 14,000 feet. As far as petroleum source rocks are concerned the sediments consist of about 3500 feet of non-prospective Proterozoic sediments, and 7,000 - 8,000 feet of non-prospective Carboniferous continental deposits. The only likely source rocks are the Cambrian and Ordovician sediments which constitute about 40% of the thickness of the sedimentary column. The formation that appears to have possibility of producing hydrocarbons is the Walbiri Dolomite, the main reason being that it is the only Palaeozoic formation in the basin that shows any sign of originally containing marine organic material.

Reservoir rocks are abundant throughout the sedimentary sequence, and the most important formation as far as its stratigraphic position and porosity of the sediments, is the Djagamara Formation. The grains in the sandstone of this formation are well rounded, there is little silty matrix and although much of the formation is silicified there are thick interbeds of friable, clean sandstone in some outcrops. Other possible reservoir sandstone beds occur in the Kerridy Sandstone, Mount Eclipse Sandstone and some thin sandstone interbeds in the Walbiri Dolomite.

Cap rocks of silt and shale beds occur as interbeds in the Walbiri Dolomite, Bloodwood Formation, in some outcrops of the Djagamara Formation, and interbeds in the Kerridy Sandstone. Minor red micaceous siltstone interbeds occur in the Mount Eclipse Sandstone but they are probably too thin to be classified as potential cap rocks.

Large anticlines are present in the sedimentary sequence and probably most of these were formed by the post Carboniferous diastrophism. The folds mainly trend westerly, a large proportion are doubly plunging and areas of structural closure are assumed. Some of the fold in the area south of Yuendumu have been breached to the Djagamara Formation whereas several other anticlines are present in the Mount Eclipse Sandstone which have not been breached as far as the underlying formations. The stratigraphic sequence at depth, particularly beneath the unbreached anticlines, cannot be predicted with any certainty because of the numbers of unconformities in the sequence. Several large thrust and normal faults occur in the sediments and may also form structural traps.

The lateral variation in lithology of some of the formations particularly those with reservoir characteristics, and the large numbers of unconformities in the sequence suggests that stratigraphic traps may be present. The Djagamara Formation for example is primarily a well sorted sandstone in outcrops south of Yuendumu whereas siltstone is a major component of the formation in the Patmungala Syncline.

The large number of unconformities in the Ngalia Basin sequence and the wide disparity of ages of the formations shows that there were long periods of non-deposition during which the formations were exposed and eroded. During these periods a large proportion of the inherent hydrocarbons in the sediments could have been dissipated.

The number of unconformities in the relatively thin sequence, the paucity of thick source beds and the fact that the only likely source beds are Cambrian in age are the main reasons for rating the petroleum potential of the area as low.

Water Supply

The Native Walfare Settlement at Yuendumu and the two homesteads of Vaughan Springs and Newhaven are the only permanent settlements on the Mount Doreen Sheet area. The subsurface water they obtain is used both for domestic purposes and the rearing of livestock.

The area lies within the less than 10 inch annual rainfall isohyet and often experiences long droughts. Surface water is not plentiful. Streams flow intermittently and mostly flood out into the surrounding sand plains. Native wells are found close to, or in, these stream channels but yield very little water. Waterholes at Kerridy Waterhole, Oodnapinna Waterhole and at Pulca Currinya often retain water all the year round but have been known to dry up. These waterholes provide ample water locally for the native fauna but are not sufficiently reliable or of suitable quality for permanent settlement needs.

Natural Springs occur at Annie Springs, Eva Springs, Emu Springs, Albinia Springs and Vaughan Springs. Of these Vaughan Springs is the largest and provides 1600 gallons per hour of fresh water which is ample for the needs of the homestead which is sited close by. The other springs are much smaller and do not provide sufficient supplies of drinkable water adequate to maintain a permanent settlement.

To maintain the Settlement at Yuendumu and the homestead at Newhaven use has been made of water bores. The yield from bores at Yuendumu substantially increases the amounts retained in earth dams which have been constructed to retain such surface water as there is.

Up to January 1967 over one hundred and seventy water bores and wells had been completed on the Mount Doreen Sheet area. Details concerning the location of these bores are available in Kingdom et al. (1967) Bore data sheets providing all the information available for each individual water bore are available on file in the Resident Geologists Office Alice Springs. A duplicate set is also present in the Technical Files of the B.M.R. in Canberra. Figure 37 shows the location of most of the water bores and Table 4 gives the names of these bores, and the available information.

Ground water prospects on the Yuendumu Native Reserve were discussed by Quinlan (1958) and the associated problems enumerated by Jones and Quinlan (1958).

As a result of Jones and Quinlans recommendations a geophysical investigation of underground water at Yuendumu was carried out and a report written by Wiebenga et al. (1959). Water bore sites chosen as a result of these investigations were drilled and proved unsuccessful. These bore sites penetrated Quaternary sediments and Precambrian basement rocks.

LOCATION OF WATER BORES MOUNT DOREEN SHEET AREA

Fig 37

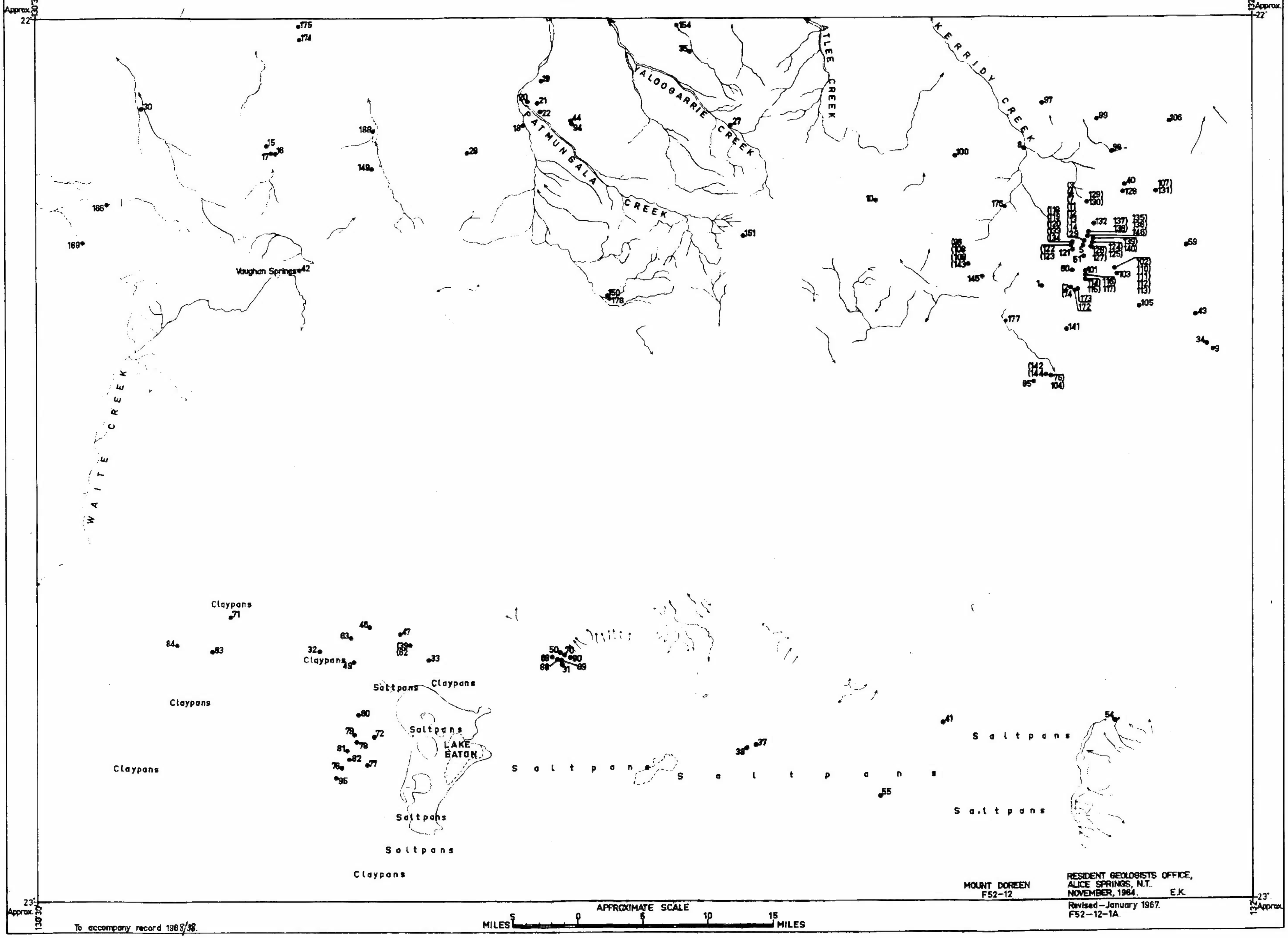


TABLE IV   WATER BORES - MOUNT DOREEN SHEET AREA

(From Kingdom Woolley & Faulks, 1967, and additional information from the Resident Geologists Office, Alice Springs).

Bore No.	Lease	Name	Total Depth (feet)	Depth to first aquifer (feet)	Standing Water Level (feet)	Supply (gals per hour)	Quality (Total dissolved salts in parts per million)
F52/12 - 1	North West Stock Route	White Point Bore	187		140	1000	1915
2	Yuendumu	Penhalls Bore	$258\frac{1}{2}$		138	500+	Good
3	"	Settlement No. 1 Bore	137	85	93	1400	1194
4	"	Settlement No. 2 Bore	111	85	85	1100	Good
5	"	Settlement No. 7 Dud	70 - 80				
6	"	Dud (1945) $1\frac{1}{2}$ miles SW of Settlement					
7	"	Settlement No. 3 Dud	127	117	117	Nil	
8	"	Kerridy Creek No. 1 Dud	167			Nil	
9	North West Stock Route	Boundary Bore	235	95	90	1000?	4050
10	Mt. Doreen	20 Mile Bore	100 - 120		?80		5600
11	Yuendumu	Settlement No. 3A Dud	50			Nil	
12	"	Settlement No. 4 Dud	133			Nil	
13	"	Settlement No. 5 Dud	100			Nil	
14	"	Settlement No. 6 Dud	87			Nil	
15	Mt. Doreen	10 Mile Bore	220	80 - 87		Small	Stock
16	" "	No. 2 D.R. No. 1 Try Dud	112			Nil	
17	" "	No. 2 D.R. No. 2 Try Dud	170			Nil	
18	" "	Saltbush Bore	85				Good stock
19	" "	Dud Well 12 miles WSW of Old Homestead	25			Nil	
20	" "	Dud Well $12\frac{1}{2}$ miles WSW of Old Homestead	35			Nil	
21	" "	Dud Well $12\frac{1}{2}$ miles WSW of Old Homestead	30			Nil	
22	" "	Dud Well $12\frac{1}{2}$ miles WSW of Old Homestead	25			Nil	
* 23	" "	Dud Well 7 miles S of W of Old Homestead	<50			Nil	
* 24	" "	Dud Well 7 miles S of W of Old Homestead	<50			Nil	
* 25	" "	Dud Well 7 miles S of W of Old Homestead	<50			Nil	
* 26	" "	Dud Well 17 miles SW of Old Homestead	35			Nil	
27	" "	8 Mile Bore	40				
28	" "	Limestone Bore	120	80		3000	Good but hard
29	Yuendumu	Settlement No. 8 Dud	107			Nil	
30	Mt. Doreen	No. 2 D.R. No. 3 Try Dud	185			Nil	
31	Newhaven	No. 1 Taboo Bore	50	18 - 20	18	600	1331
32	Gurner	No. 2 Dud	60	45	40	Large	13,556
33	"	No. 1 Boundary Bore	30	15	14	±900	6,893
34	Mt. Allan	Abandoned Bore			90		
35	Mt. Doreen	Old Homestead Well	60		50	500	1,626
36	" "	Budger Bore	301	120	60	1400	
37	Newhaven	No. 3 White Spur Bore	40	23		1000+	9,926
38	"	No. 4 Limestone Ridge Bore	35	30			11,976
39	Gurner	No. 3 Bore (Homestead)	30	$12\frac{1}{2}$	13	Good	3,023
40	North West Stock Route	Napperby Stock Route No. 4	143		87	300	Good

* Not plotted on Fig. 37   D.R. = Drought Relief

Bore No.	Lease	Name	Total Depth (feet)	Depth to first aquifer (feet)	Standing Water Level (feet)	Supply (gals per hour)	Quality (Total dissolved salts in parts per million)
F52/12 - 41	Central Mt. Wedge	Christmas Bore	35	12	12	1500	1189
42	Mt. Doreen	Vaughan Springs (New Homestead)				1600	118
43	Mt. Allan	Limestone Bore					Fair
44	Mt. Doreen	Silver King Mine				Bad	High metal content
* 45	" "	Dud Bore 34 miles W of Old Homestead	80	50	55		Becoming saltier with depth
46	Gurner	3 Gap Duds	20 - 27		17	Nil	+5000
47	"	No. 4 Gap Bore	35	21	21	800	4059
* 48	"	No. 5 Castle Bore	29	19	19	Good	5513
49	"	No. 6 Seawater Bore Dud	38	28	28	Good	32,218
50	Newhaven	No. 2 Taboo Homestead Bore	40	18	15	720+	1,095
51	Yuendumu	Site "A" Bore	177	96	84	400	Good
* 52	Newhaven	No. 5 Dud	28				14,482
* 53	"	No. 7 Robs Bore	70	23	15	Large	5,372
54	Central Mt. Wedge	Currinya Bore	25		11	1000	7,189
55	" " "	Yellabbra Bore	25	14	13	2000+	6,084
* 56	Water Search Permit No. 3	No. 1 Hollow Log Bore	25	11	13	1500	6,421
* 57	" " "	No. 2 O.P., Bore	42	12	13	2000	3,579
* 58	" " "	Native Well					3,065
59	Mt. Allan	D.R. No. 1 Try Dud	142	42	34	30	Good
60	Yuendumu	Site "C" Bore	400	290	290	Very small	2,000
* 61	Gurner	No. 8 Claypan Bore	40	17	17	600	8,700
62	"	No. 9 Homestead Bore	60	16 - 20	16	1,500	ca. 3,000
63	"	No. 7 Dud	40	27	27	Very small	Good
* 64	Central Mt. Wedge	New Currinya Bore	25				5,058
* 65	" " "	Rib Bone Bore	33		14		6,680
* 66	" " "	Bore	55	16	13	2000	
* 67	Newhaven	Wild Camel Bore					
68	"	No. 9 Dud	80	27	25	50	1,717
* 69	Gurner	No. 10 Tuppies Bore		11	11	1000	3,362
70	Newhaven	No. 13 Homestead Bore	40	13		1100	980
71	Gurner	No. 11 Dud		76		Good	21,268
72	"	No. 12 Dud	50	27	27	Small	17,340
* 73	Mt. Doreen	Cox's Well Bore	68	49	47	650	Fair
*74	Yuendumu	Job 71 No. 2 Try, Penhalls Replacement Bore	300	148	138	1800	Fair
75	"	Job 25 No. 2 Try Dud	85			Nil	
76	Gurner	No. 13 Dud	110	80	80	15	354
77	"	No. 14 Dud	70	40	40	Good	17,320
78	"	No. 15 Dud	24			Nil	
79	"	No. 16 Dud	70			Nil	
80	"	No. 17 Dud	53	30	30	Small	Very salty
81	"	Black Hills No. 1 Site Only (Advice)					
82	"	Black Hills No. 2 Site (Advice) No. 18 Dud	14			Nil	
83	"	West Gurner No. 1 Site Only (Advice)					
84	"	West Gurner No. 2 Site Only (Advice)					
85	Yuendumu	Job 25 No. 3 Try Bore	181	170	96	1200	3,867
* 86	Newhaven	No. 6	40	9 -10			

Bore No.	Lease	Name	Total Depth (feet)	Depth to first aquifer (feet)	Standing Water Level (feet)	Supply (gals per hour)	Quality (Total dissolved salts in parts per million)
F52/12 -*87	Newhaven	No. 8 Mallee Point Bore		27			Very salty
88	"	No. 10 Dud	60			Nil	
89	"	No. 11 Dud	49			Nil	
90	"	No. 12 Dud	29			Very small	
* 91	"	No. 14	35	14		2000	7,744
* 92	"	Babbler Bore					
* 93	Central-Mt. Wedge	Emu Spring					
94	Mt. Doreen	Silver King Mine Bore					
95	Gurner	Black Hills No. 3 Site (Advice) No. 19 Bore	125	110	75	500+	2,468
96	Yuendumu	Job 24 No. 2A Try Dud (Limestone No. 1)	140			Nil	
97	"	Woculbar No. 1 Site					
98	"	Woculbar No. 2 Site					
99	"	Woculbar No. 3 Site					
100	"	Woculbar No. 4 Site					
101	"	Job 24 No. 1 Try Dud	80			Nil	
102	"	WRB/Y1	120			Nil	
103	"	WRB/Y2	69			Nil	
104	"	Kerridy Waterhole Dud	50			Nil	
105	"	Sandstone Site					
106	"	Quartz Site					
107	"	Manganie Site WRB/Y11	119	99	99	Very small	Good
108	"	Job 24 No. 2B Try Dud (Limestone No. 2)	50			Nil	
109	"	Job 24 No. 3 Try Dud	197			Nil	
110	"	WRB/Y3	10			Nil	
111	"	WRB/Y4	7			Nil	
112	"	WRB/Y5	7			Nil	
113	"	WRB/Y6	8			Nil	
114	"	WRB/Y7	300	218	218	Drilling supply	2000-3000
115	"	WRB/Y8	275	220	220	Small	2000-3000
116	"	WRB/Y9	400	215	300	2000	Fair
117	"	WRB/Y10	300	209	217	ca. 150	Fair
118	"	WRB/Y12	230	130	105	100	Fair
119	"	WRB/Y13	95			Nil	
120	"	WRB/Y14	95			Nil	
121	"	WRB/Y15	98			Nil	
122	"	WRB/Y16	36			Nil	
123	"	WRB/Y17	63			Nil	
124	"	WRB/Y18	12			Nil	
125	"	WRB/Y19	28			Nil	
126	"	WRB/Y20	14			Nil	
127	"	WRB/Y21	266	95	88	200	Fair
128	"	WRB/Y22	120			Nil	
129	"	WRB/Y23	30			Nil	
130	"	WRB/Y24	70			Nil	
131	"	WRB/Y25	120	60	68	ca. 100	Fair
132	"	WRB/Y26	19			Nil	
133	"	WRB/Y27	102			Nil	
134	"	WRB/Y28	231	109	103	120	Fair
135	"	WRB/Y29	10			Nil	
136	"	WRB/Y30	16			Nil	

Bore No.	Lease	Name	Total Depth (feet)	Depth to first aquifer (feet)	Standing Water Level (feet)	Supply (gals per hour)	Quality (Total dissolved salts in part per million)
F52/12 - 137	Yuendumu	WRB/Y31	21			Nil	
138	"	WRB/Y32	32			Nil	
139	"	WRB/Y33	19			Nil	
140	"	WRB/Y34	15			Nil	
141	"	WRB/Y35	60			Nil	
142	"	WRB/Y36	73			Nil	
143	"	Job 24 No. 3 Try Deepened Dud	300			Nil	
144	"	Job 25 No. 1 Try Dud	230	138	96	400	Very salty
145	"	Job 25 No. 1 Try Dud	237			Nil	
146	"	Job 71 No. 1 Try Dud	30			Nil	
147	Central Mt. Wedge	Kliswan Bore	40			Nil	
148	" " "	Yunduch Bore	66				
149	Mt. Doreen	A88/1 Dud (No. 1 Try)	167	70	70	540	40,200
150	" "	A88/2 Dud	170	72	60	75	Fair
151	" "	A88/3 Site	200	185	110	300	Bad
* 152	" "	Cox's Well					
* 153	" "	Annie Spring					
154	" "	Mines Bore					
* 155	" "	Meecantie Native Well					
* 156	" "	Eva Spring					
* 157	" "	Albinia Spring					
* 158	" "	Native Well					
* 159	Newhaven	Cuckoo Bore	20	14	14	3600	12,000
* 160	"	New Cuckoo Bore	20	13	13	Large	10,090
161	"	Eagle Bore	18	15	15	3600	10,714
* 162	"	Last Chance Bore	17	14	14	3600	13,100
* 163	"	No. 21 Bore	120	30	30	Large	2950
* 164	"	No. 22 Bore	61	27			2466
* 165	"	No. 23 Bore	43	30			18,750
166	Mt. Doreen	A88/5 No. 2 Try Dud	147	100	100		Fair
* 167	" "	A88/4 No. 1 Try Dud	350	165	100	240	Good
168	" "	A88/1 No. 2 Try Dud	105	75	75	50	34,300
169	" "	A88/5 No. 1 Try Dud	350	96	96	30	Good
* 170	" "	A88/5 No. 3 Try Dud	165			Nil	
* 171	" "	A88/4 No. 2 Try Dud	302	180	180	Seepage	6,200
172	Yuendumu	YM No. 1 Bore	301	160	137	3000+	2,677
173	"	YM No. 2 Bore	300	170 - 282	150	4000	2,347
174	Mt. Doreen	A88/6 No. 1 Site					
175	" "	A88/6 No. 2 Site					
176	Yuendumu	Dam Site 3. Yds No. 1 & 2				Nil	
177	"	Dam Site 2. Yds No. 1 to 7				Nil	
178	Mt. Doreen	A88/2 No. 2 Site	125	115	57	300	Good
179	" "	A88/7 No. 1 Try	200	95	50	460	Good

In 1962 Cook wrote a report on the availability of ground water in the Yuendumu Native Reserve, and in 1963 incorporated these suggestions in his record on the geology of the Reserve (1963). This record summarises the results of previous hydrological investigations at Yuendumu, and comments on the suitability of the sediments of the Ngalia Basin as aquifers.

Drilling undertaken as a result of these investigations and reports has eased the water supply problem at Yuendumu Native Settlement; Vaughan Springs homestead has a plentiful water supply from the naturally occurring spring, but at Newhaven homestead on the southern margin of the Ngalia Basin the owners continue to experience difficulty in providing sufficient water for their stock. Shallow water bores drilled at sites close to the homestead have produced up to 1000 gallons per hour from Quaternary kunkar and clay. Other bores drilled in the same locality have been dry.

Despite the seemingly large number of water bores drilled on the Sheet area the availability of water remains a problem as many of these bores were either failures or the water proved to be too saline for either human or cattle consumption. Artificial storage of surface water in earth dams is practised at Yuendumu but the duration of these supplies depends on the storage capacity of the dams, the annual rainfall, the amount of evaporation and quantity of water lost by seepage.

Most of the water bores have been drilled in alluvium overlying basement rocks; few have been drilled in the Ngalia Basin sediments. Of those that have penetrated sedimentary rocks south of Yuendumu Native Settlement the results have been inconsistent. White Point Bore produces 1000 gallons per hour and is used as a stock bore; the water is however good enough for human consumption. Penhalls Bore produces 1800 gallons per hour and most of this water is pumped up to the native settlement at Yuendumu. Despite the availability of good water in both these bores other water bores penetrating similar sediments have proved to be dry. The White Point Bore derives its water from the Walbiri Dolomite. Penhalls Bore penetrates red sandstones and siltstones probably of the Yuendumu Sandstone.

A Geophysical Seismic Party from the B.M.R. on a reconnaissance survey of the Ngalia Basin in Sept. - Nov. 1967 struck water in many of their shot holes. Fresh water was obtained from shot holes 1559 to 1566 on Traverse 'A' (Fig. 28). One water sample was taken for analysis from shot hole 1561. The result of this analysis is not yet available. The shot holes were drilled to a depth of 120 feet and water was struck at depths between 80 and 100 feet. It is likely that the water was obtained from the recent cover of alluvium, sand and gravel. Some shot holes entered the Mount Eclipse Sandstone. The fresh water-bearing shot holes are sited approximately 11 miles south of the Vaughan Springs - Yuendumu Road.

The lack of surface water and failure of many water bores suggests that water supplies will continue to be a problem in the future. Of the eight sedimentary rock units mapped in 1967 only two, the Walbiri Dolomite and the Yuendumu Sandstone, have supplied water suitable for human consumption from aquifers within the formations. The other formations have either not been drilled or the bore holes drilled through them produced unsatisfactory results. The most likely aquifers yet to be tested are the Djagamara Formation and the Vaughan Springs Quartzite. The fresh water present in the seismic shot holes might also indicate that the Mount Eclipse Sandstone is not altogether devoid of aquifers; however, the generally poor sorting and high percentage of matrix in this unit as well as in the Kerridy Sandstone suggest that these two units together with glacial deposits of the Mount Doreen Formation should only be considered as water producers after the other remaining rock units have been fully tested.

Miscellaneous Deposits

Minor mineral occurrences are known in several places on the northern half of the Mount Doreen Sheet area as well as some larger deposits that have been mined in the past. Most of the mineral deposits occur in the Precambrian basement rocks but a few are known in the sediments. The mineral occurrences include secondary copper deposits, wolfram, barytes, fluorite, galena and iron oxides. Other non-metallic deposits that may be of importance include building stone, dolomite and limestone, Cainozoic gravels and Recent evaporites. The only deposits that are being worked at present are the copper deposits at Mount Hardy, and building stone from the Yuendumu Sandstone south of Yuendumu Settlement.

Copper and tungsten minerals generally occur together particularly where they are found in Precambrian basement rocks. They have been worked at Wolfram Hill near old Mount Doreen Homestead, the Clarke Mine, Mount Singleton, and at Mount Hardy. Numerous other small deposits of copper and tungsten minerals occur in the basement rocks but none have been found in economic quantities. The copper ore at Mount Hardy is hand picked and sorted by natives from the Yuendumu Native Settlement and copper concentrates prepared. Small secondary copper concentrations occur in the basal part of the Walbiri Dolomite about four miles south-west of Yuendumu Native Settlement. The copper occurs as malachite and azurite in veinlets, fissure fillings and encrustations in the massive dolomite of the formation, and also in the basal shale and siltstone near the contact with the underlying Yuendumu Sandstone. The deposits have been explored by small costeans but there is no evidence of extensive mineralization.

Malachite, chrysocolla and galena occur in the Patmungala Beds. Malachite and chrysocolla are associated in small quartz veins in the Patmungala Beds about 8 miles west-north-west of Mount Djagamara. The veins occur on the lower slopes, and on the north side, of a prominent ridge of interbedded tough, siliceous siltstone, sandstone, claystone and shale. The copper mineralization is associated with beds of black shale and spotted black and light grey, splintery, recrystallised tuff. The deposits have been investigated by small costeans but the mineralized veins are discontinuous and narrow. Small deposits of galena occur in quartz veins in the Patmungala Beds about four miles north-west of Mount Djagamara where they are also associated with beds of recrystallised tuff.

Barite occurs in small veins and pods 2-3 feet across in an isolated outcrop of the Walbiri Dolomite about half a mile north of White Point. Minor amounts of barite were recorded from two diamond drill holes that intersected the Walbiri Dolomite near Djuburula Peak.

Purple fluorite occurs in small quartz veins about one mile north of Mount Djagamara where the country rock is the Mount Doreen Formation. Fluorite also occurs in a very coarse grained pegmatitic granite of Precambrian age near the headwaters of Waite Creek. Quartz veins with tourmaline cut the granite in the areas where fluorite is found.

Small veins and masses of specular hematite occur in quartz dykes in Precambrian granite and gneiss about 12 miles west of Yuendumu Native Settlement. Ironstone deposits about 20 feet thick occur in the uppermost beds of Cainozoic sediments at Vaughan Springs. The beds rich in hydrated iron oxides contain a large percentage of sand and gravel and are of small extent.

The flaggy, salmon coloured, micaceous sandstone from the upper beds of the Yuendumu Sandstone is used chiefly as a facing and paving stone for buildings, retaining walls and paths at the Settlement. The sandstone is hand picked from a quarry about 3 miles south of Yuendumu.

Large deposits of dolomite and limestone occur in the Walbiri Dolomite but in many places the carbonate rocks are sandy and silty and selective mining of restricted beds in the formations would be necessary if any use were to be made of these deposits.

The Cainozoic gravels have been screened and used for road-making in areas where they occur adjacent to the Alice Springs-Yuendumu road. Gravels that have been used for this purpose occur south of Yuendumu on scree slopes on the northern side of ridges of outcropping Vaughan Springs Quartzite.

Evaporites occur in the salt lakes on the southern part of the Mount Doreen Sheet area the largest of which is Lake Eaton. The composition of the evaporites is not known and they are probably only thin surface accumulations.

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REFERENCES

Most unpublished references can be consulted at the Bureau of Mineral Resources, Parkes, Canberra, A.C.T.

CATLEY, D.E., 1954 - Report on the Yuendumu copper prospect, Yuendumu Native Settlement, Northern Territory. Report, Resident Geologists Office, Darwin N.T. (unpubl.)

CHEWINGS, C., 1928 - Further notes on the stratigraphy of Central Australia. Trans. Roy. Soc. S. Aust. 52, 62-81.

COOK, P.J., 1962 - The availability of groundwater, Yuendumu Native Reserve, Northern Territory. Report Resident Geologists Office, Alice Springs. (unpubl.)

COOK, P.J., 1963 - The geology of the Yuendumu Native Reserve, Northern Territory. Bur. Miner. Resour. Aust. Rec., 1963/37. (unpubl.)

COOK, P.J., 1966 - The Stairway Sandstone. A sedimentological study. Bur. Miner. Resour. Aust. Rec., 1966/1 (unpubl.)

COOK, P.J. and SCOTT, I.F., 1966 - Reconnaissance geology and petrology, Ngalia Basin, Northern Territory. Bur. Miner. Resour. Aust. Rec., 1966/73 (unpubl.)

COOK, P.J. and SCOTT, I.F., 1968 - Reconnaissance geology and petrography, Ngalia Basin, Northern Territory. Bur. Miner. Resour. Aust. Rep. 125 (in press)

GALLIHER, E.W., 1935 - Geology of glauconite. Am. Assoc. Petrol. Geol. Bull. 19, 1569-1601.

HARTMAN, R.F., 1963 - Interpretation report of airborne magnetometer survey over portion of Oil Permit No. 81, Ngalia Trough, N.T. Report by Aeroservices Ltd. for Pacific American Oil Co. (unpubl.)

HUDSON, H.B. and CAMPBELL, J.H.B., 1965 - Napperby Seismic survey, Oil Permit 81, Northern Territory of Australia. Report by Geophysical Associates Pty. Ltd. for Pacific American Oil Company. (unpubl.)

JONES, P., 1968 - Ngalia Basin Seismic Survey Progress Report, Northern Territory. Bur. Miner. Resour. Aust. Rec. 1968/ (in prep.)

JONES, N.O. and QUINLAN, T., 1958 - The groundwater problem, Yuendumu Native Reserve, Northern Territory. Bur. Miner. Resour. Aust. Rec., 1958/51 (unpubl.)

KIEK, S.N., 1941 - The Mount Hardy copper field, Central Australia. A.A.G.S.N.A. Rep. 55.

KINGDOM, E., WOLLEY, D., and FAULKS, I., 1967 - Water bore locations in Central Australia. Bur. Miner. Resour. Aust. Rec., 1967/83 (unpubl.)

MABBUTT, J.A., 1962 - Geomorphology of the Alice Springs area. In Perry et al (1962), General Report on Lands of the Alice Springs area, N.T., 1956-1957. Sci. ind. Res. Org. Melb., Land Res. Ser. 6, 163-184.

MACKAY, D., 1934 - The Mackay Aerial Survey Expedition, Central Australia. Geogr. Jour. 84(6), 511-514.

MADIGAN, C.T., 1937 - Report on a reconnaissance in the Mount Doreen mineral area. Report. Resident Geologists Office, Alice Springs. (unpubl.)

MAURICE, R.T. and MURRAY, W.R., 1904 - Journal of exploration from Fowlers Bay to Cambridge Gulf. S. Aust. Parl. Pap. 43.

McKEE, E.D. and WEIR, G.N., 1953 - Terminology for stratification and cross stratification in sedimentary rocks. Geol. Soc. Amer. Bull. 64

NETTLETON, L.L., 1965 - Report on interpretation of gravity results, Napperby area. Oil Permit 81, Northern Territory of Australia. Report by Geophysical Associates Pty. Ltd. for Pacific American Oil Company. (unpubl.).

PERRY, R.A., MABBUTT, J.A., LITCHFIELD, W.H. and QUINLAN, T., 1962 - Land systems of the Alice Springs area. In Perry et al (1962), General Report on lands of the Alice Springs area, N.T., 1956-1957 Sci. ind. Res. Org. Melb., Land Res. Ser. 6, 20-108

QUINLAN, T., 1958a - Report on groundwater prospects, Yuendumu Native Reserve. Bur. Miner. Resour. Aust. Rec. 1958/1 (unpubl.)

QUINLAN, T., 1958b - Supplementary report on groundwater prospects, Yuendumu Native Settlement. Report, Resident Geologists Office, Alice Springs (unpubl.)

QUINLAN, T., 1962 - An outline of the geology of the Alice Springs area. In Perry et al (1962) General Report on lands of the Alice Springs area, N.T., 1956-1957. Sci. ind. Res. Org. Melb., Land Res. Ser. 6, 129-146.

RIVEREAU, J., 1965 - The photogeology of the Ngalia Basin, Northern Territory. Bur. Miner. Resour. Aust. Rec. 1965/255 (unpubl.)

RYAN, G.R., 1956 - Report on the Yuendumu copper reef at Yuendumu Native Settlement, N.T. Bur. Miner. Resour. Aust. Rec., 1956/123 (unpubl.)

RYAN, G.R., 1962 - The mineral deposits of the Alice Springs area. In Perry et al (1962), General Report on Lands of the Alice Springs area, N.T., 1956-1957. Sci. ind. Res. Org. Melb., Land. Res. Ser. 6, 147-149.

SANGSTER, R.L., 1957 - Another meteorite crater in Australia? Sky and Telescope, 429

SANGSTER, R.L., 1959 - Letters to the Editor. Sky and Telescope, June.

SANFORD, A.R., 1959 - Analytical and experimental study of simple geologic structures. Geol. Soc. Amer. Bull. 70

SCOTT, I.F., 1966 - A series of rocks from the Ngalia Basin, N.T. Australian Mineral Development Laboratories, Rep. MP1595-66. (unpubl.)

SMALE, D., 1967 - Twenty-two samples from the Ngalia Basin. Australian Mineral Development Laboratories Rep. MP827-68 (unpubl.)

TERRY, M., 1934 - Explorations near the border of Western Australia. Geogr. Jour. 84(6), 498-510.

TIETKINS, W.H., 1891 - Journal of the Central Australian Exploring Expedition, 1889. Adelaide.

TINDALE, N.B., 1933 - Geological notes on the Cockatoo Creek and Mount Liebig country, Central Australia. Trans. Roy. Soc. S. Aust. 57, 206-217.

WARBURTON, P.E., 1875 - Diary of Colonel Warburton's exploring expedition to Western Australia in 1872-3. S. Aust. Parl. Pap. 28.

WELLS, A.T., FORMAN, D.J. and RANFORD, L.C., 1964 - Geological reconnaissance of the Rawlinson-Macdonald 1:250,000 Sheet areas, Western Australia. Bur. Miner. Resour. Aust. Rep., 65.

WELLS, A.T., RANFORD, L.C., STEWART, A.J., COOK, P.J. and SHAW, R.D., 1967 - The geology of the north-eastern part of the Amadeus Basin, Northern Territory. Bur. Miner. Resour. Aust. Rep. 113 (in press.)

WELLS, A.T., FORMAN, D.J., RANFORD, L.C. and COOK, P.J., 1967 - The geology of the Amadeus Basin. Bur. Miner. Resour. Aust. Bull. 100 (in press.)

WIEBENGA, W.A., GOODCHILD, R.J. and BAMBER, B., 1959 - Preliminary report on a geophysical investigation of underground water at Yuendumu, Northern Territory. Bur. Miner. Resour. Aust. Rec., 1959/7 (unpubl.)

WHITWORTH, R., 1968 - Reconnaissance Gravity Survey using Helicopters of Arnhem Land, N.T., and the Kimberleys, W.A. Bur. Miner. Resour. Aust. Rec. (in prep.)

APPENDIX I

Plant Fossils from the Mount Eclipse Sandstone, Ngalia Basin, Northern Territory

by

Mary E. White

Summary:

Carboniferous plant species Cardiopteris polymorpha Goeppert and Lepidodendron veltheimianum Sternberg, are identified in the Mount Eclipse Sandstone. This is of considerable interest as the collection represents the first substantial suite of late Palaeozoic plants from the Central Australian region.

Introduction:

Plant fossils were collected at four localities in the Mount Doreen 1:250,000 Sheet area in 1967. Field information states that the fossils occur in a clastic formation whose temporary field designation is 'Unit F' (Cook and Scott, 1968). Its formal name is "Mount Eclipse Sandstone". It is the youngest Palaeozoic formation recognised in the Basin.

Preservation of the specimens is poor, but some remarkably fine photographs taken by H.M. Doyle have been of assistance in determining the plants.

Details of localities and descriptions of specimens follow:-

1. LOCALITY MD 43

Locality: 38 miles west of Yuendumu Native Settlement, and 7 miles west-south-west of Djagamara Peak.

Specimens: F 22953.

These specimens contain impressions of decorticated Lycopod stems. Leaf bases are crowded and arranged in ascending spirals. Figure 1 shows an example of one of the stems. It is a photograph of a rubber cast of an impression. All the decortication forms are of general Lepidodendron veltheimianum type.

Age: Carboniferous

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2. LOCALTY MD 135

Locality: 8 miles south of Vaughan Springs Homestead

Specimens F 22954

These specimens contain indeterminate stems and an indeterminate fern frond.

Age: Indeterminate

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3. LOCALITY MD 135 A

Locality: 8 miles south of Vaughan Springs Homestead

Specimens: F 22955 and F22956

A poorly preserved frond of Cardiopteris polymorpha Goeppert is revealed in some detail by the photographs seen in Figures 2 and 3 of specimen F 22955.

Cardiopteris polymorpha Goeppert is a Carboniferous form. It occurs in the Carboniferous at Stroud, N.S.W., in the Joe Joe Formation, Qld. (Records 1964/7, Springsure), in the Glacial Stage and Upper Kuttung of N.S.W., in passage beds into Lower Bowen at St. Helens, Qld., and in the Silver Valley Series in Qld.

In specimens F 22956 are examples of decorticated Lepidodendron of the Lepidodendron veltheimianum general type.

Age: An association of Cardiopteris and Lepidodendron indicates Carboniferous age.

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4. LOCALITY MD 145

Locality: 300 yards East of Gum Creek West; 3 miles S.W. of Limestone Bore, and 10 miles N.E. of Vaughan Springs Homestead.

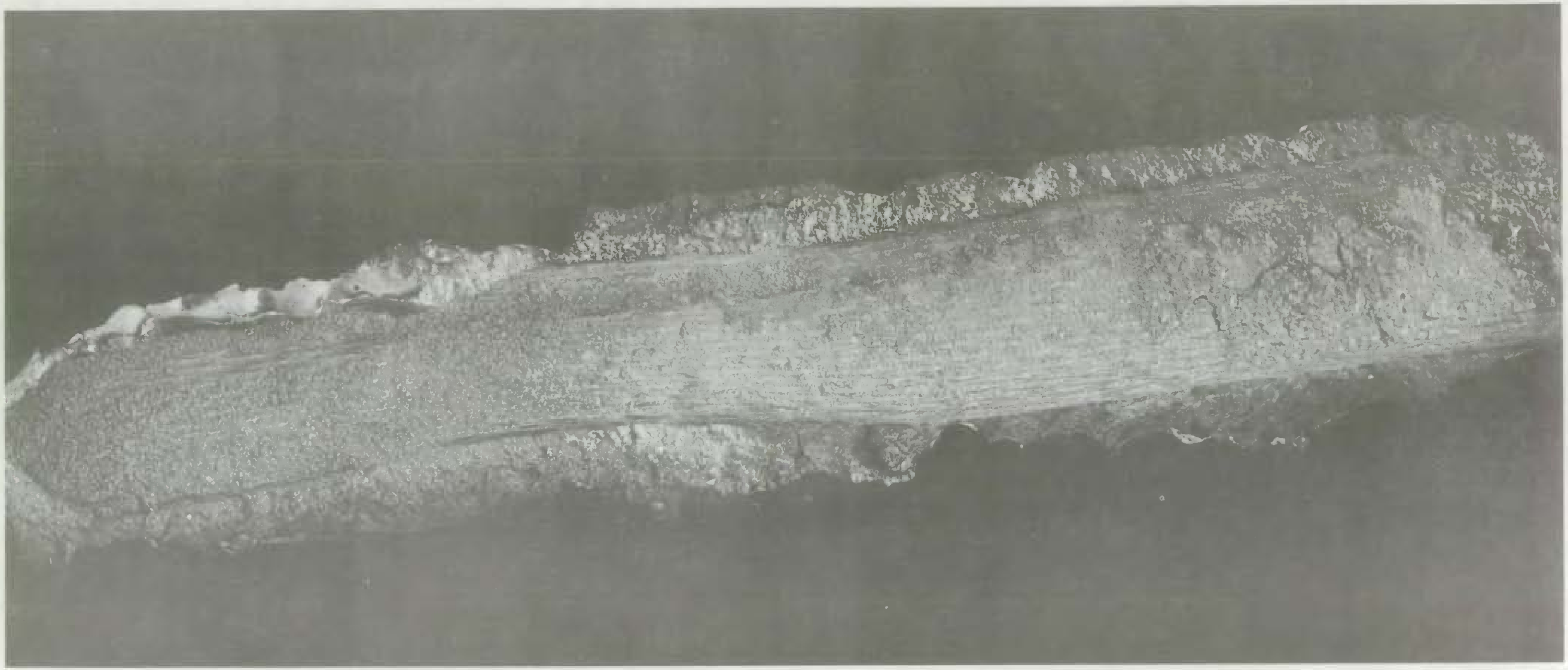
Specimens F 22957

Indeterminate stem cast

Age: Indeterminate

Fig.1

Decorticated Lepidodendron veltheimianum Sternberg (x1)



JG-T/230

Fig. 2
Cardiopteris polymorpha Goeppert (x2)

JG-T/224

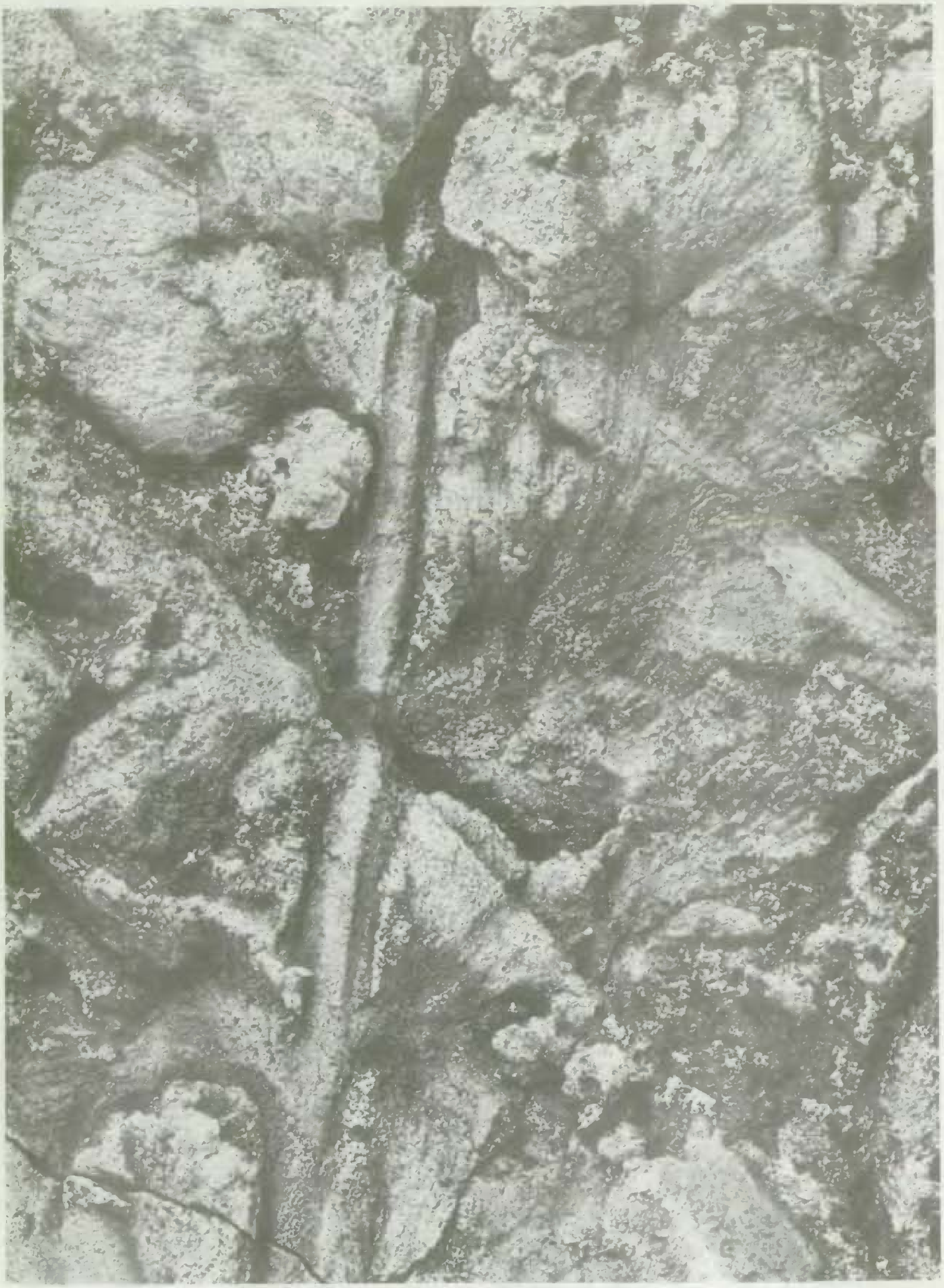
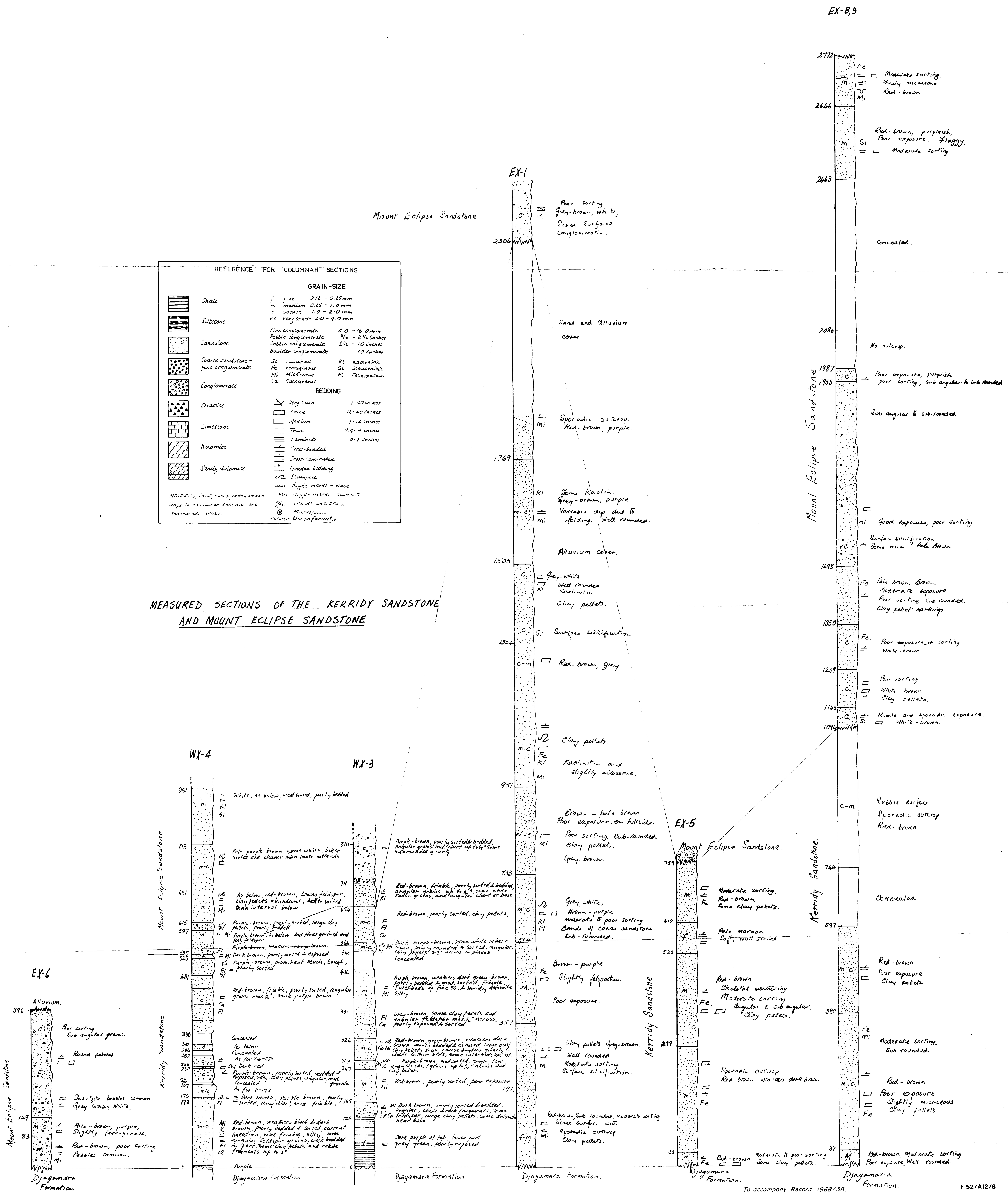


Fig. 3
Cardiopteris polymorpha Goeppert - part of frond x7.

PLATE 1



To accompany Record 1968/38.

F 52/A12/8

MEASURED SECTIONS IN THE DJAGAMARA FORMATION

Thickness in feet

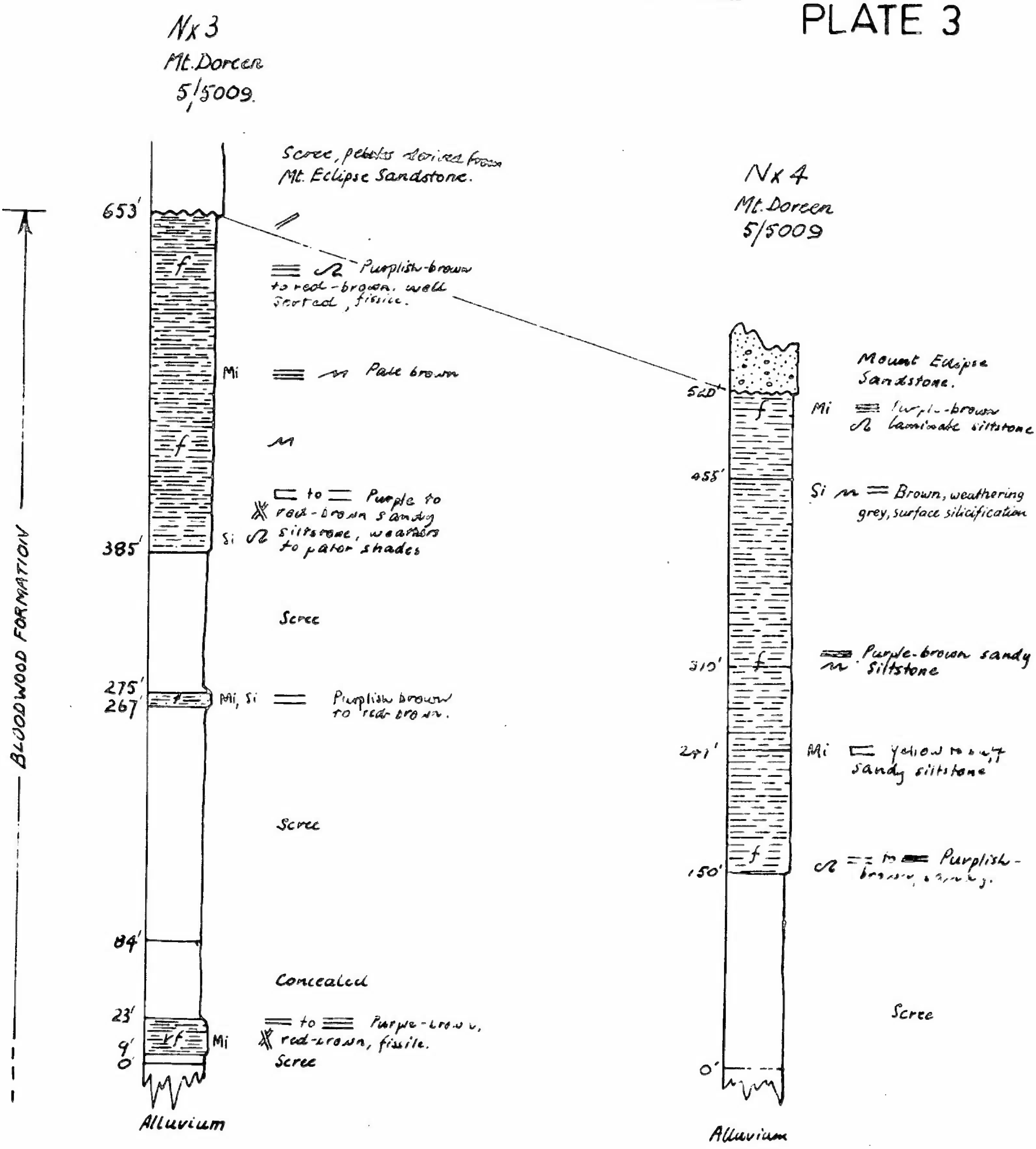
PLATE 2

To accompany Record 1968/38.

F 52/A12/9

MEASURED SECTIONS IN THE BLOODWOOD FORMATION

PLATE 3



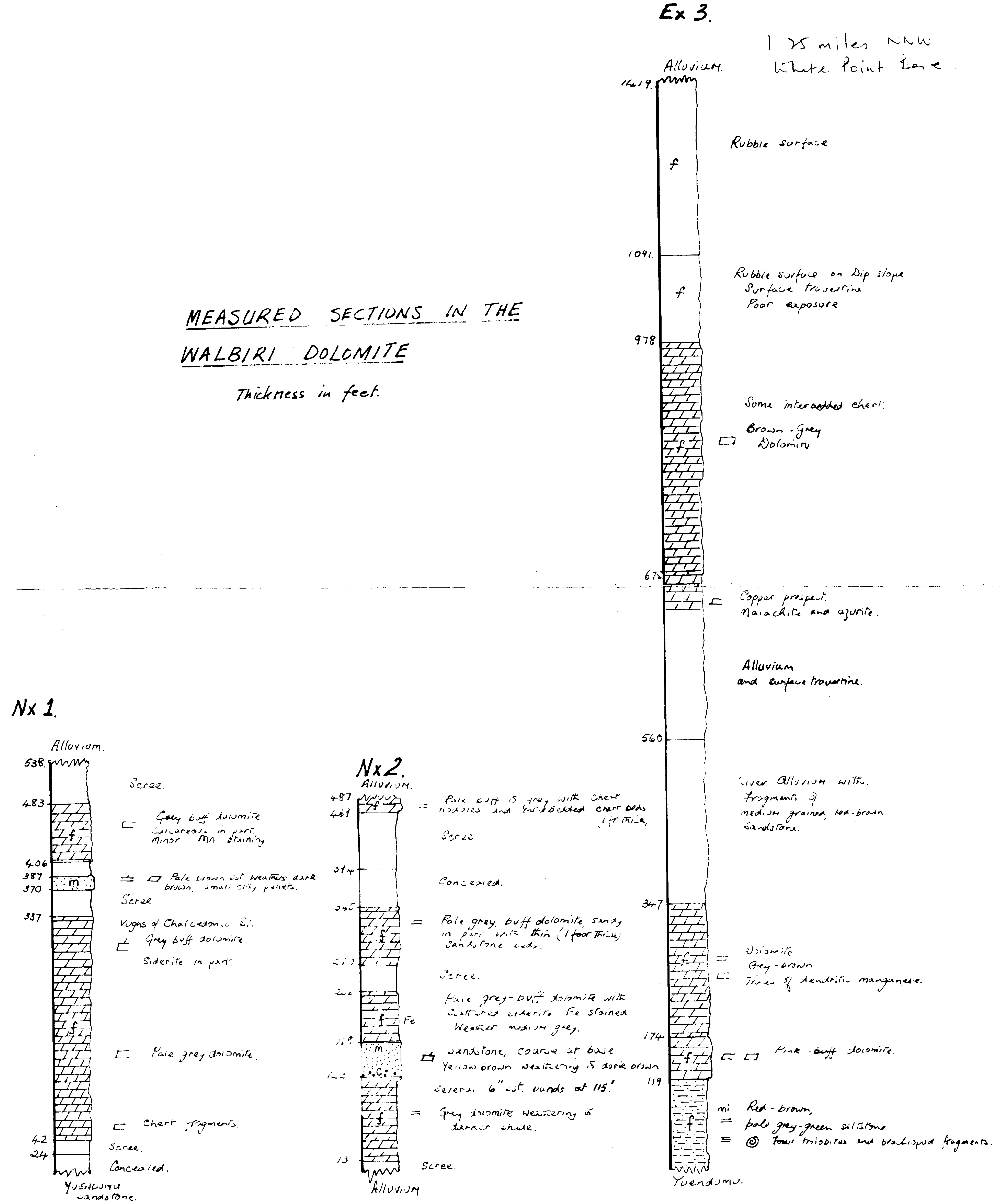
To accompany Record 1968/38.

F52/A12/10

PLATE 4

MEASURED SECTIONS IN THE WALBIRI DOLOMITE

Thickness in feet.

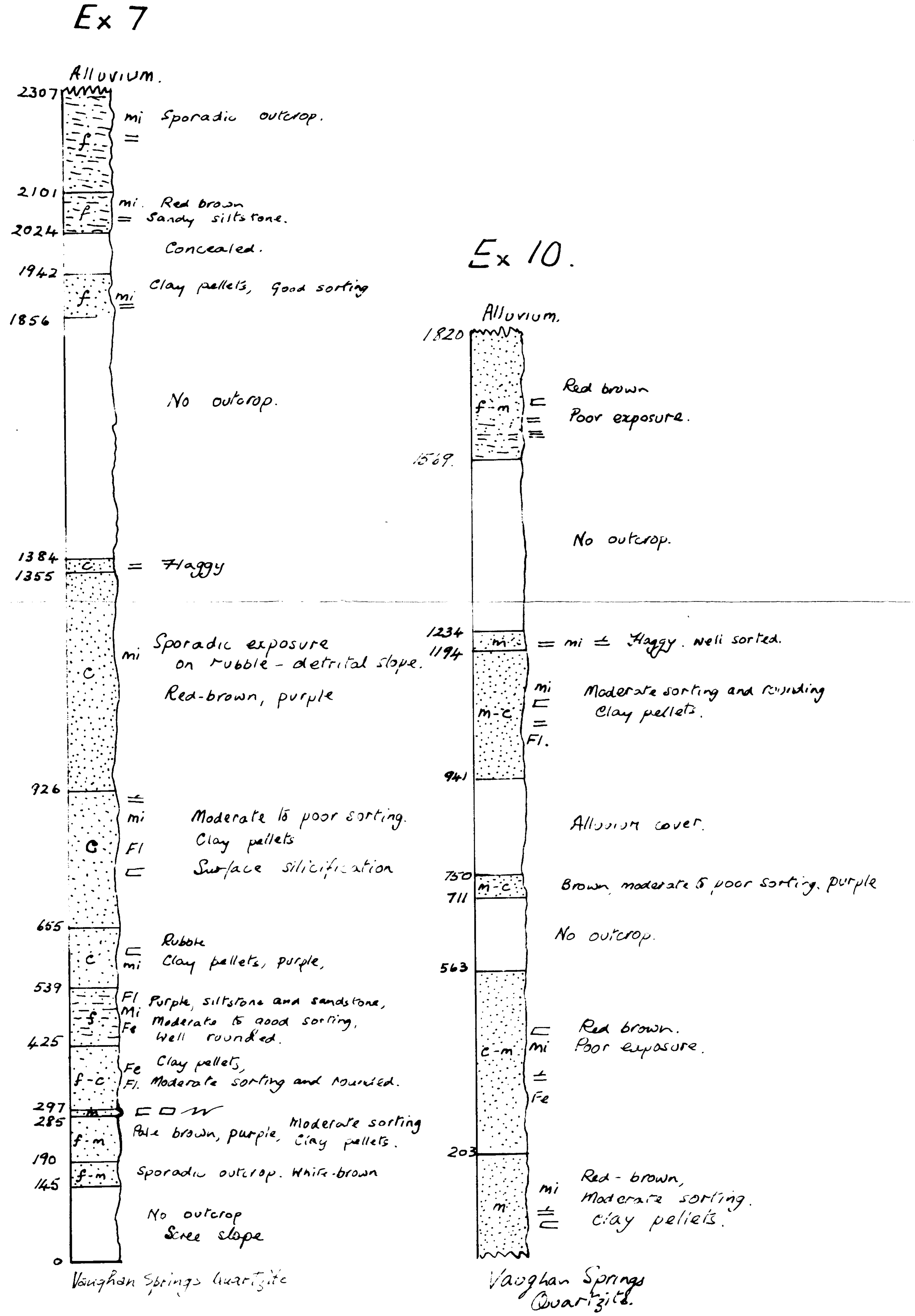


MEASURED SECTIONS IN THE YUENDUMU SANDSTONE.

Thickness in feet.

PLATE 5

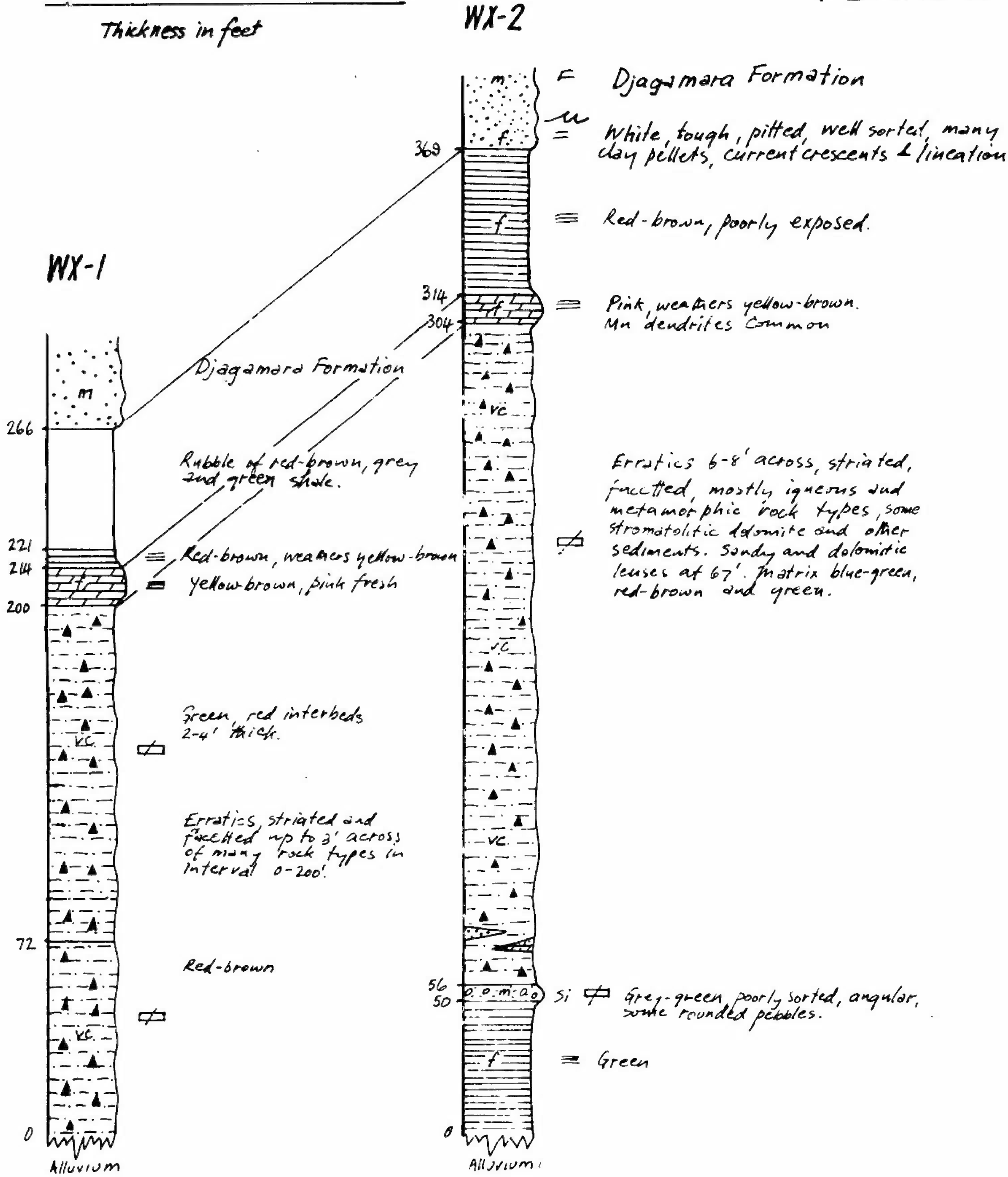
? 5 miles S of Yuendumu



MEASURED SECTIONS IN THE MOUNT DOREEN FORMATION

PLATE 6

Thickness in feet



To accompany Record 1968/38.

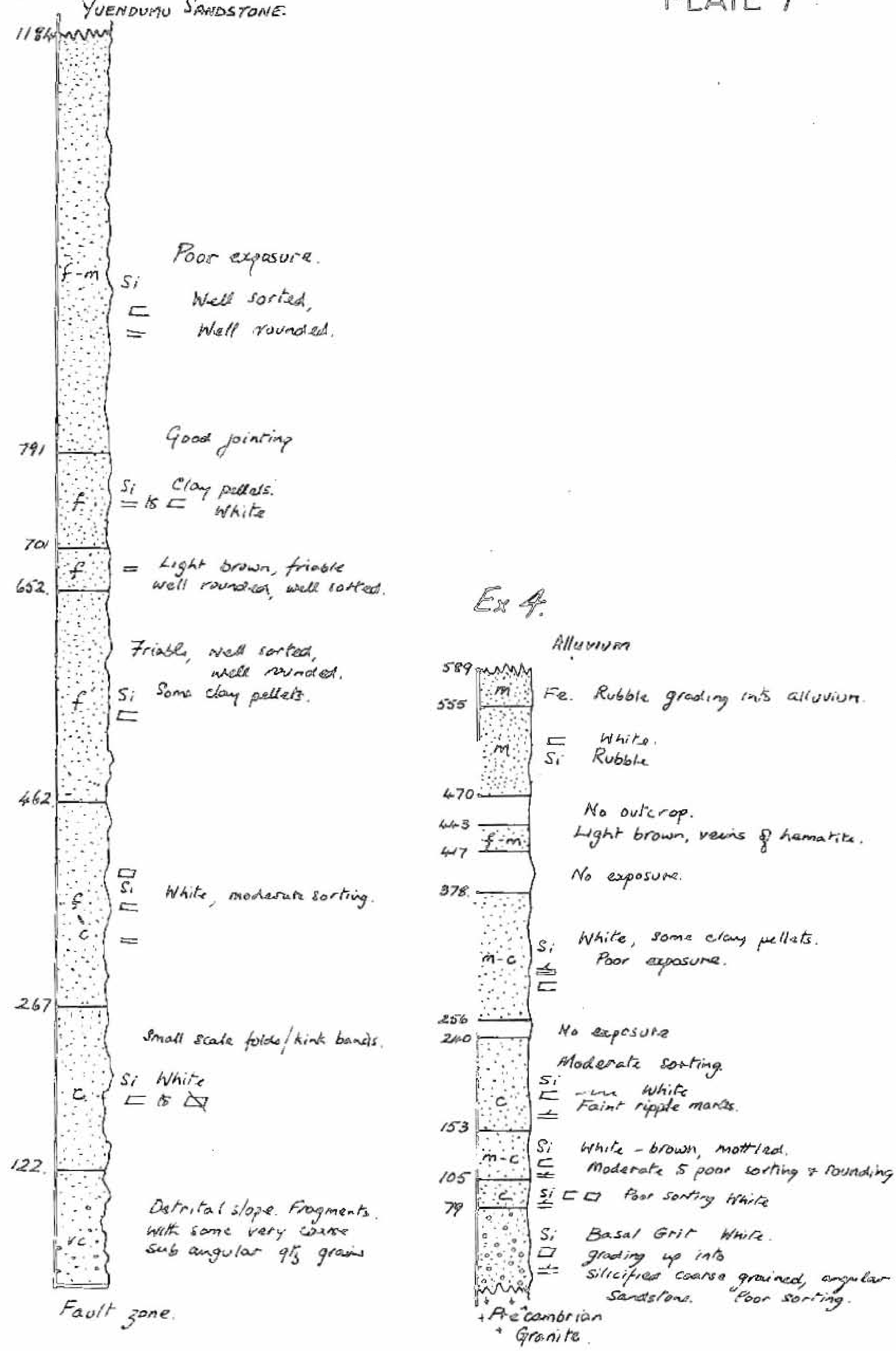
F 52/A 12/13

MEASURED SECTIONS IN
THE VAUGHAN SPRINGS QUARTZITE.

THICKNESS IN FEET.

PLATE 7

Ex 10.

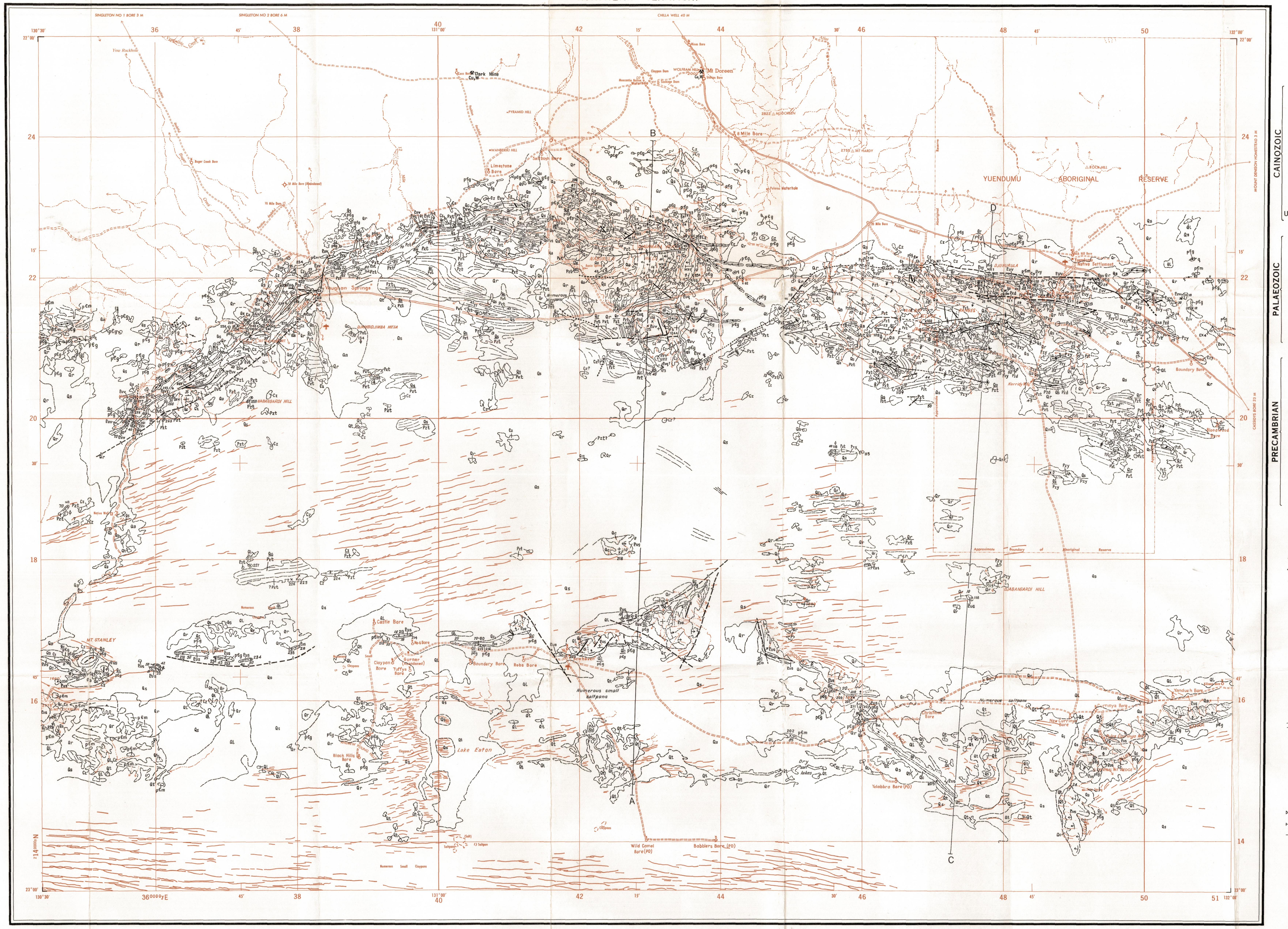


AUSTRALIA 1:250.000 GEOLOGICAL SERIES

MOUNT DOREEN

NORTHERN TERRITORY

SHEET SF 52-12



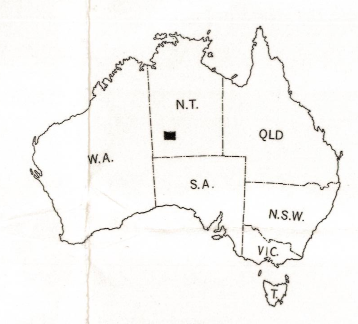
Reference

CAINOZOIC	QUATERNARY		Qa	Alluvium
			Qc	Colluvium
			Qs	Aeolian sand
			Qr	Red soil, alluvium
			Qt	Evaporites
			Ql	Travertine
	UNDIFFERENTIATED		Cz	Silcrete and ferruginized (lateritized) rock
PALAEOZOIC	CARBONIFEROUS	Mount Eclipse Sandstone	Pzt	Coarse-grained, arkosic sandstone; subgreywacke, minor cobble conglomerate and red micaceous siltstone
	ORDOVICIAN ?	Kerridy Sandstone	Pzy	Red-brown, silty, arkosic and calcareous sandstone; subgreywacke and interbedded siltstone
		Djagamara Formation	Pzd	White, well-sorted sandstone, glauconitic; abundant clay pellets. Interbedded green shale in places
	CAMBRIAN	Bloodwood Formation	Ꞓb	Red-brown micaceous siltstone and sandstone. Abundant trace fossils and rare macrofossils
		Walbiri Dolomite	Ꞓw	Dolomite, siltstone and minor stromatolitic, oolitic and glauconitic dolomite and sandstone. Abundant fragmentary marine macrofossils
PRECAMBRIAN	PROTEROZOIC	Yuendumu Sandstone	Ꝑuy	Red-brown sandstone, minor coarse arkose at the base
		Mount Doreen Formation	Ꝑuq	Green siltstone with erratics, lenses of dolomitic sandstone and pebbly sandstone; siltstone, pink laminated dolomite, red shale. Thick dolomite sequence in places
		Vaughan Springs Quartzite	Ꝑuv	Thick bedded quartzite, basal pebbly sandstone and pebble conglomerate
		Treuer Member	Ꝑut	Thin bedded sandstone, siltstone. Possibly interbedded evaporites
		Central Mount Wedge Beds	Ꝑus	Thick bedded quartzite, basal conglomerate, minor blue and green shale
		Patmungala Beds	pꞒp	Silty sandstone, quartzite, siltstone, spotted claystone, minor stretched chert pebble conglomerate and shale
			pꞒg	Granite
			pꞒm	Schist, quartzite and amphibolite

Geological boundary
Anticline, showing plunge
Syncline showing plunge
Fault
Where location of boundaries, folds, and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes
Strike and dip of strata
Vertical strata
Horizontal strata
Overturned strata
Dip < 5°
Dip 5-15°
Dip 15-45°
Dip >45°
Trend lines
Joint pattern
(Dip symbols, trend lines and joint pattern: air-photo interpretation)
Strike and dip of foliation
Prevailing strike and dip of foliation
Direction and plunge of lineation
Macrofossil locality
Plant fossil locality
x45 Specimen locality Text reference prefix MD
WX-1 Type-section locality
EX-1 Measured section
Dyke; q- quartz
Abandoned mine
Minor mineral and rock occurrence
Ba Barite
Bs Building stone

Cu Copper
Fl Fluorite
Pb Lead
W Tungsten
DD○800 Diamond drill hole showing depth in feet
Bore
Abandoned bore
Bore with windpump
Spring
Well
Tank
Earth tank
Dam on stream
WH. Waterhole
Sand dunes
Road
Vehicle track
Fence
"Newhaven" Homestead
Landing ground
Yard
Trigonometrical station
Astronomical Station
2002' Spot height in feet
(PD) Position doubtfull

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. David Fairbairn, Minister for National Development. Base map compiled by the Division of National Mapping, Department of National Development. Commonwealth aerial photography; complete vertical coverage at 1:46,500 scale Transverse Mercator Projection



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Showing Magnetic Declination

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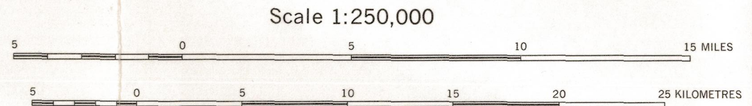
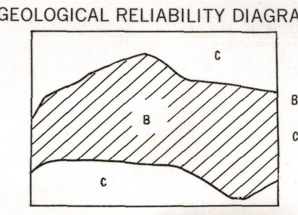
ANNUAL CHANGE 1' E

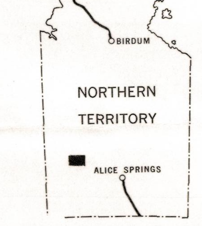
Scale 1:250,000



GEOLOGICAL RELIABILITY DIAGRAM

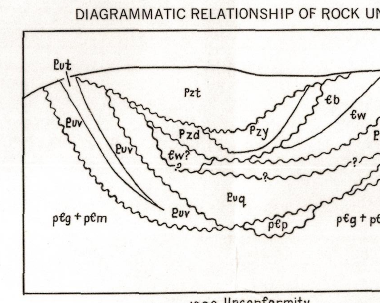


B Reconnaissance - traverses and air-photo interpretation
C Area not mapped



Geology, 1967, by: A.T. Wells, T.G. Evans, and T. Nicholas
Compiled 1967, by: A.T Wells, T G Evans T. Nicholas and A. Tatarow
Drawn by: A. Tatarow

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

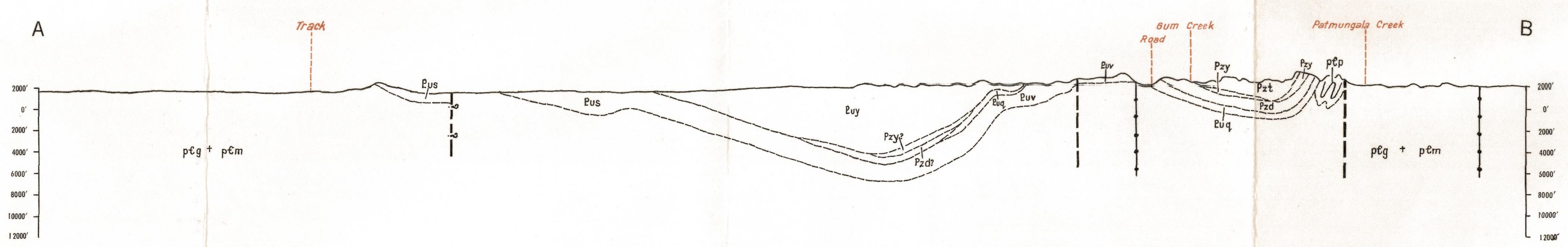


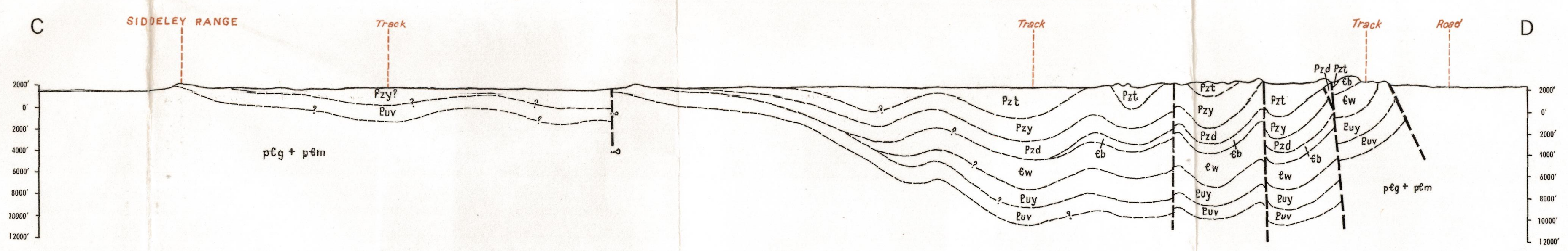
Unconformity

Sections

Cainozoic sediments omitted from section

Scale: $\frac{V}{H} = 2$





PRELIMINARY EDITION, 1968

SUBJECT TO AMENDMENT

MOUNT DOREEN

SHEET SF 52-12

Complimentary