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BUREAU OF MINERAL RESOURCES
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RECORDS.

1960/104

THE GEOLOGY OF THE SOUTHERN PART OF THE HERMANNSBURG 4-MILE SHEET

by

C.E. Prichard and T. Quinlan

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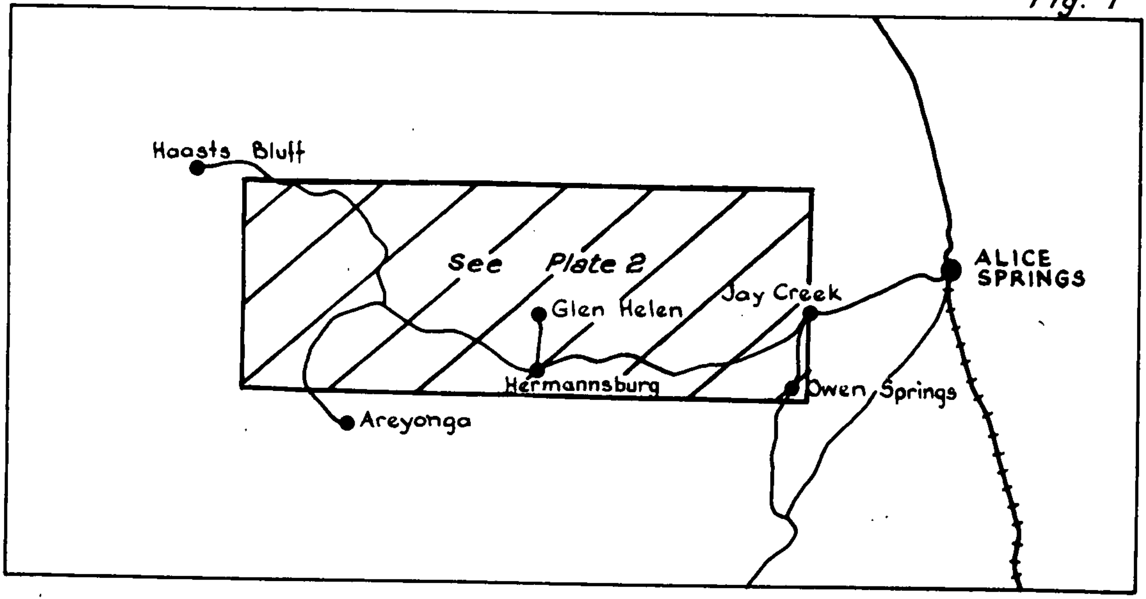
Fig. 1


Haasts Bluff
See Plate 2
Glen Helen
Jay Creek
ALICE SPRINGS
Hermannsburg
Owen Springs
Areyonga

SUMMARY

The Geology of the southern part of the Hermansburg 4-mile sheet was examined by reconnaissance traverses during the winter of 1956.

A sequence of 3500 feet of sedimentary rocks, containing sandstone, greywacke, limestone and siltstone from Upper Proterozoic to ?Silurian, rests unconformably on an Archaean basement of schist, gneiss, and granite in what has been termed the Amardeus Geosyncline. The sequence includes two disconformities and one glacial formation and an algal limestone formation. The sediments were laid down in shallow water in a slowly subsiding depositional area. Later folding has produced only broad folds, but in conjunction with the continuous down warping of the basement during deposition it has produced steep dips and some overturning in the earlier formations. Two diapirs are described.

Resting unconformably on these sediments and basement are small residuals of a thin cover of Lower Cretaceous siltstone and sandstone and some gravels etc. of Tertiary age.

No mining of any value has ever been carried on in the area. Two copper prospects are known.

The prospects for oil in the area are not very high but the area is useful because a sequence poorly exposed elsewhere is well exposed here.

Dams are considered the best means, at present, of getting water in the area.

INTRODUCTION

The MacDonnell Ranges extend west from Alice Springs for 200 miles. They consist of a series of parallel ridges and valleys eroded in sediments which dip steeply south off a basement of crystalline metamorphic rocks.

In the southern half of the Hermannsburg Four Mile Sheet, (Pl. 2): a section from Upper Proterozoic beds at the base to post-Ordovician conglomerate at the top is generally well exposed, and structure is less complex than in adjacent areas. This half sheet was selected for field examination to determine the stratigraphic sequence which would form a basis for correlation and mapping of much of the southern part of the Northern Territory.

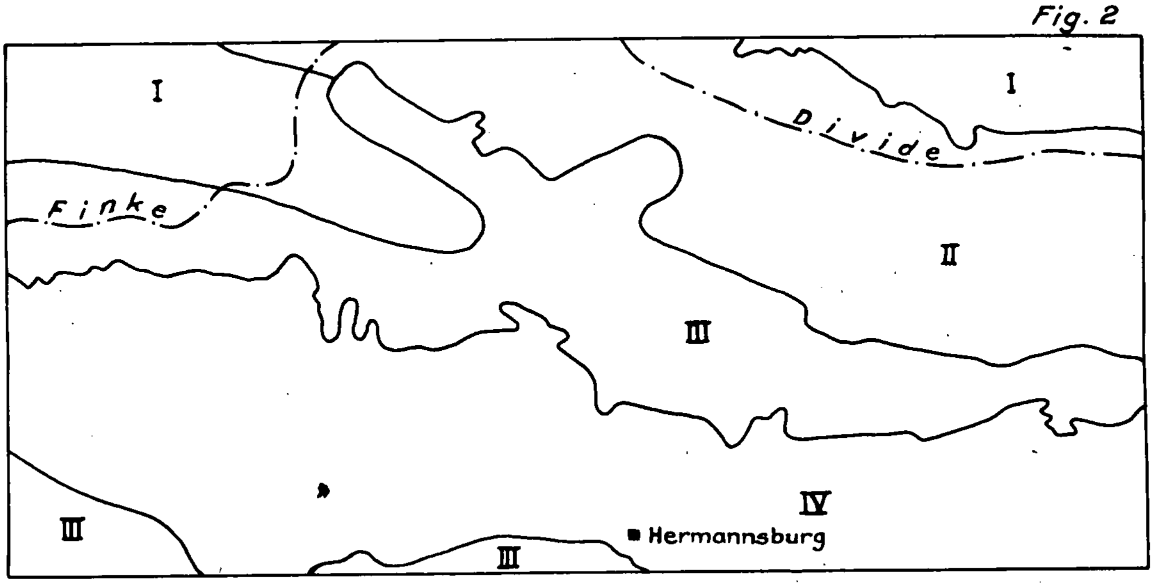
Fieldwork was done by geologists of the Bureau of Mineral Resources, Geology and Geophysics during the winter of 1956. The party consisted of C.E. Prichard (Party Leader), T. Quinlan, W.M. Burnett (May to July), Joyce Gilbert-Tomlinson (Palaeontologist, September), and G. Jenkins (August).

PHYSIOGRAPHY

The area mapped is divided into four physiographic units (Figure 2). From north to south the units are: the Burt Plain, the Arunta Highlands, the Ranges, and the Missionary Plain.

The Burt Plain covers nearly all the northern half of the Hermannsburg 4-mile Sheet and extends into the north-eastern and north-western corners of the area mapped. It is, as Hossfeld (1954) stated, essentially a depositional plain. The north-eastern corner of the area mapped is typical of most of the plain; the north-western corner is not so typical and is really an intermontane erosional plain sloping to and merging with the Burt Plain to the north.

Fig. 2



The Arunta Highlands rise abruptly 200 feet to 500 feet above the Burt Plain; the highest peaks are towards the west. The highest mountain in the Northern Territory, Mt. Zeil (4955 ft.) is a few miles north of the western part of the area mapped. Local relief in the Arunta Highlands is more than 2,000 feet near Mt. Zeil, but is generally less than 1,000 feet. Streams occupy youthful valleys in the north, but are incised twenty to forty feet in broad mature valleys in the south towards Heavitree Range.

The Chewings Range extends across the Arunta Highlands from the Ormiston Pound to beyond Standley Chasm. It is an abrupt ridge of steeply dipping quartzite through which streams have cut narrow gorges.

The Ranges extend from Heavitree Range in the north to Mereenie Range in the south, and, south of Missionary Plain, Gardiner Range and Krichauff Range. Five parallel flat-topped ridges are separated by four parallel valleys. Local relief

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Fig. 2

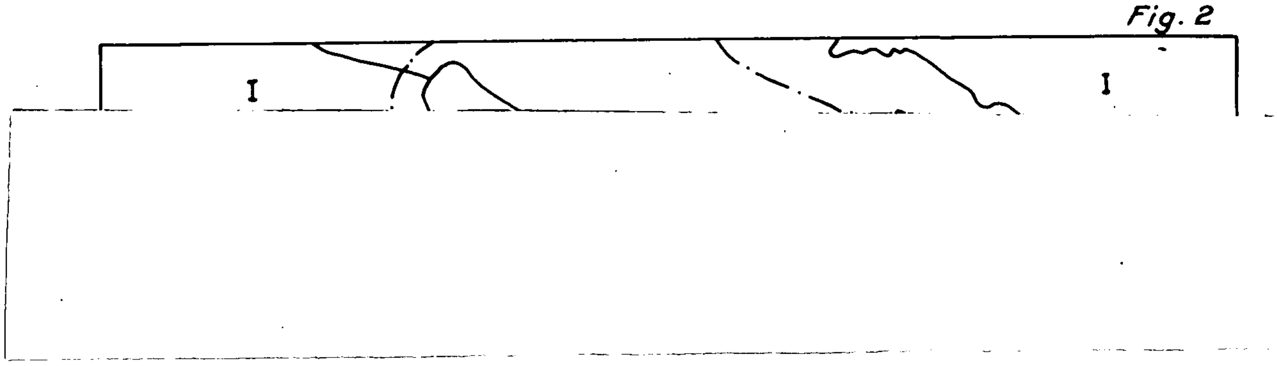

Figure 2 - Physical regions of the Hermannsburg 4-mile sheet.
I - Burt Plain, II Arunta Block, III - Macdonnell and James Ranges, IV Missionary Plain.

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The Ranges extend from Heavitree Range in the north to Mereenie Range in the south, and, south of Missionary Plain, Gardiner Range and Krichauff Range. Five parallel flat-topped ridges are separated by four parallel valleys. Local relief is about fifty feet near the head of Arumbura Creek but is more than 1000 feet towards the western end of the Mereenie Range. Between Finke River and Ellery Creek it is about 500 feet and this is more general. Drainage is antecedent. South flowing streams have cut narrow gorges at right angles through the ridges and are shallowly incised in alluvium or braided across the intervening valleys. Subsequent tributary streams flow at grade in flat-bottomed valleys between the ridges.

In the Gardiner Range and the anticlinal Krichauff Range the sediments strike less regularly and dip less steeply. Here also, antecedent streams flow in gorges through the ranges; and subsequent tributaries are structurally controlled.

Missionary Plain lies between the MacDonnell Ranges to the north and the James Ranges to the south. From the foothills along the MacDonnell Ranges the surface slopes gently towards the south and, regionally, towards the east. Much of the northern and eastern part of Missionary Plain is covered by a layer of pebbles and cobbles derived from the conglomerate of the Pertnjara Formation; the western part of the plain is covered by sand with low dunes fixed by vegetation.

Most of the area mapped is within the Lake Eyre drainage basin. The Finke River and its tributaries Ellery Creek and Hugh River are the major streams. Their headwaters drain the Arunta Highlands, except for the northern part which is drained by short creeks flowing north onto the Burt Plain, and part of Mereenie Valley in the west is drained by Deering Creek, which flows towards Lake Mackay. All three drainage systems are internal and no water flows into the sea from the area. The main streams are again antecedent.

Access

Dirt roads link Hermannsburg Mission, Areyonga, Haasts Bluff, Glen Helen, and Owen Springs through Jay Creek to Alice Springs.

Travelling within the MacDonnell Ranges is difficult except along some of the strike valleys. Motor roads pass through the ranges only at Jay Creek and between Hermannsburg and Haasts Bluff. A few of the other gaps and passes can be negotiated by landrover. Travelling by vehicle on Missionary Plain is easy but north of the Heavitree Range the surface of the crystalline rocks is boulder strewn and it is generally impracticable to use vehicles.

For most of the field season the party was camped at Ellery Creek Big Hole, which was reached by a bush track, suitable for a 3-ton International truck, from Jay Creek past Long Hole and Boggy Hole bores.

All supplies, including mail, have to be collected from Alice Springs. Beef can usually be obtained from the cattle stations. Telegraphic services and medical advice are available by transceiver radio from the Royal Flying Doctor Service base at Alice Springs. There are aircraft landing strips at Hermannsburg, Areyonga, and Haasts Bluff.

Water Supply

Good potable water is scarce. Pools in gorges in the ranges provide excellent water for part or all of the year. Equipped bores are generally potable, though some contain appreciable undesirable salts. Springs along the northern edge of Krichauff Range have small flows of potable water.

Climate

The area is in the general climatic zone of a low latitude desert (Köppen 1936). It has an average annual rainfall of ten inches, of which more than seven inches falls between October and March.

The average annual temperature is 70°F. Between December and March the day temperature often exceeds 100°F, but at night it usually falls below 70°F. The winters are very pleasant and, although there are many heavy frosts in June, July, and August, the maximum day temperature is usually above 65°F.

Vegetation

Vegetation is sparse. Spinifex (Triodia spp.) occurs almost throughout; Triodia longiceps favours limestone outcrops and calcareous soils, T. clelandii occurs on sandstone ridges, and T. basedowii on sand plains. Eucalypts are represented by mallee (Eucalyptus oleosa), which grows on limestone outcrops, ghost gums (E. papuana) on sandstone ridges and alluvial flats, and river gums along watercourses. Shrubs present are mostly Cassia spp. and Acacia spp. with some Hakea spp. and Grevillea spp. Annual herbs and grasses grow on the valley floors and flood outs.

Development

The land is used for raising beef cattle. It is held in leases which average about 1,000 square miles and 5,000 head of cattle. The land could carry more stock if there were more stock water and fences, but the increase would be limited by the climate, the soil and the vegetation.

Survey Method

The Geology was plotted directly onto aerial photographs at a nominal scale of 1 to 50,000 in the field, and then transferred to overlay photomosaics. (1 inch to 1 mile). These photomosaics and the slotted template bases used in the preparation of the final maps were provided by the Division of National Mapping.

Stratigraphic sections at Ellery Creek and Stokes Pass were measured by chain and compass.

PREVIOUS WORK

The earliest knowledge of the geology of Central Australia was acquired during lengthy exploring trips. The difficulties of travel were such that observations were necessarily scattered and incomplete. H.Y.L. Brown was one of the first geologists to visit and write about the area. In reports published between 1889 and 1902 (Brown, 1889, 1890, 1897, and 1902) he distinguished between the sedimentary rocks, which he regarded as Cambrian, and the metamorphic basement.

Chewings' first paper on the geology of Central Australia was published in 1891, and other papers by him appeared until 1935. He spent more time actually in the field than any other geologist who has worked on the area, and his papers report many observations from localities that have not been revisited. Chewings (1935) postulated the fault-bounded Amadeus Sunkland to explain the preservation of the sediments and to account for other features he had noted.

The Horn Expedition to Central Australia (1894) travelled over much of the Western MacDonnell Ranges. Tate & Watt (1896) collected Ordovician fossils from the "Horn Valley" and regarded all the sediments as Ordovician; their report is the earliest record of geological mapping rather than traversing of the Western MacDonnell Range.

Mawson & Madigan (1930) divided the sediments into "series" of Ordovician, Cambrian, and Proterozoic age. Madigan (1932 a and b) revisited the area and mapped it in more detail. He confirmed the stratigraphic succession set up in the joint paper

HERMANNSBURG AREA - SUMMARY OF STRATIGRAPHY

AGE	RANK: GROUP OR BEDS	FORMATION	MEMBER	TYPE LOCALITY	MAP SYMBOL	THICKNESS (in feet)	LITHOLOGY (thickness in feet)	ADDITIONAL INFORMATION
Quaternary Tertiary Cretaceous						500'	Chiefly argillaceous with some beds of silty sand. Conglomerate at the base.	
					U N C	O N F O R M I T	Y	
?Silurian		Pertnjara Formation			Sp	21,500'	8000' Conglomerate 3000' Soft massive calcareous greywacke 8000' Conglomerate, sandy matrix, commonly calcareous 1000' Quartz greywacke with interbedded pebble conglomerate 250' Conglomerate 1000' Dark red brown fine/medium grained felspathic quartz sandstone and lenses of sandstone pebble conglomerate	A north and east provenance
		Mereenie Sandstone			O/Sm	2000' Stokes Pass 1300 Finke River 900 Ellery Ck.	640' Friable light red-brown, medium grained sandstone. 260' Hard red-brown fine-grained quartz sandstone.	
		Stokes Formation			Oal	2000'	Upper: Dark Red and purple shale and fine-grained very silty greywacke. Lower: Siltstone with thin Limestone beds and calcareous horizons.	
					D I S	C O N F O R M I	T Y	
Ordovician	Larapinta Group	Stairway Greywacke			Oml	1075' (T.S.) 1400' Finke River. 1500' Stokes Pass.	60% fine-grained and medium-grained rather silty quartz greywacke and 40% cleaner quartz sandstone.	
		Horn Valley Formation			Olh	440' (T.S.) 1000' Finke River 1400' Stokes Pass	Siltstone with thin limestone beds	Richly Fossiliferous
		Pacoota Sandstone			Olp	2700' Ellery Creek 2000' Stokes Pass 3000' Ross River	Fine grained and medium grained quartz sandstone mostly cemented by silica. Some beds of quartz greywacke. Commonly crossbedded "Pipe Rock" 400' from base. Top 200' are thin beds of micaceous siltstone.	Ripple marks and sun cracks preserved.
Cambrian	Pertaoorrta Group	Goyder Formation			Єup	1600'	Dominantly fine-grained to medium grained quartz greywacke - commonly micaceous and calcareous Limestone forms about 20% of lower 900 feet. Limestone algal sometimes and commonly oolitic. A few siltstone beds near the base.	
		Jay Creek Limestone			Єmw	175' Ellery Creek 3000' Finke River	Well bedded dolomitic limestone with minor interbeds of shale.	Part of Ross River section may be Hugh River Shale.
		Hugh River Shale			Єlp	1600'	Shale with some siltstone and interbedded dolomitic Limestone (beds < 10' thick) 8%. A few thin beds of soft [illegible] ined calcareous greywacke near top.	

HERMANNSBURG AREA - SUMMARY OF STRATIGRAPHY

AGE	RANK: GROUP OR BEDS	FORMATION	MEMBER	TYPE LOCALITY	MAP SYMBOL	THICKNESS	LITHOLOGY	ADDITIONAL INFORMATION
Upper Proterozoic		Arumbera Greywacke			P/Ꞓa	800' (T.S.) 2800' Stokes Pass	270' Felspathic micaceous fine-grained quartz greywacke. 90' Purple-red micaceous siltstone 440' Red-brown medium grained felspathic quartz greywacke with a few siltstone beds.	
		Pertatataka Formation			Bup	2200'	Red and green siltstone. 300' to 30' Calcareous section - begins with 2' hard yellow limestone 100' Shale with laminae of fine-grained sandstone. 5' Fine to medium grained felspathic (15%) silicified qtz. greywacke 950' Red and green siltstone.	Poor outcrop.
		Areyonga Formation			Bun	1300'	550' Current bedded medium-grained quartz greywacke. 750' Interbedded tillitic siltstone (65%) and quartz greywacke and pebble conglomerate (35%). At 620'-680' above base thin beds of yellow limestone.	Upper member widely distributed, lower are not always present. Erratics in tillitic siltstone: chert, dolomitic limestone, quartzite, schist, gneiss, granite, acid and basic igneous and serpentine. Soled and striated. Largest is 3' x 2' x 2' (Granite). From Upper Proterozoic to Arunta.
		DISCONFORMITY						
		Bitter Springs Limestone			Bub	2500' Ellery Creek	80% hard dark grey well bedded and often laminated dolomitic and cherty limestone, interbedded with dark shale and siltstone (never more than continuous 70' thick). Colonial Algae usually present in limestone. Basal 100' of dark grey siltstone.	3 forms of Collenia at Ellery Creek including C. Australica (Howchin). Shallow stable shelf deposits - with very little terrigenous materials.
		Heavitree Quartzite			Buh	500' (Heavitree Gap) 1500' (Ellery Creek)	500' Upper: Medium grained quartz greywacke (silicified quartzite) with a pale yellow brown argillaceous quartz siltstone (100') below topmost quartzite bed. 200' Middle: Coarse siltstone with 40% medium to coarse quartz grains. 700' Lower: Medium & coarse grained quartz sandstone cemented to quartzite 10' to 30' Basal: Soft argillaceous bed.	Extends from Haast's Bluff (W) to East of Bitter Springs Gorge (200 miles).
		UNCONFORMITY						
Archaean	Arunta Complex				Aa		Gneiss, schist, gneissic granite, granite, acid and basic dykes.	Oldest rocks exposed. High degree of regional metamorphism.

The Quartzites of the Chewings Range are not included in the above table (see Text).

with Mawson and measured over 24,000 feet of Proterozoic, Cambrian, Ordovician, and post-Ordovician beds. His geological map of the Western MacDonnell Range was a major advance on any previous map.

The sediments of the MacDonnell Ranges and the Amadeus Geosyncline were discussed by Hossfeld (1954) in his paper on the stratigraphy and structure of the Northern Territory. He doubted Madigan's sequence and thicknesses.

Joklik (1952) claimed that strike faulting has caused multiple repetition of beds in the Western MacDonnell Ranges and that the true thickness is only a fraction of the apparent thickness. In a later paper (1955) he described the geology and structure of part of the Eastern MacDonnel Ranges; many of his conclusions apply equally to the Western MacDonnell Ranges.

In 1952 Mawson recognized glaciofluvial conglomerates in the Proteroic beds at Ellery's Creek (Mawson, 1957). He correlated these with the Sturtian Tillite in the Flinders Ranges.

Many others have investigated various aspects of the geology and structure of parts of the area. Of these, reports by Resident Geologists stationed at Alice Springs and the results of regional gravity investigations by Marshall & Narain (1954) in the Alice Springs area may be mentioned.

STRATIGRAPHY

Stratigraphical Succession

In Table I and Figure 3 are set out the main features of the stratigraphy of the southern half of Hermannsburg Sheet.

In the north, the sedimentary sequence lies unconformably on, or is faulted against, Precambrian schist, gneiss, and granite. The oldest units of the sedimentary sequence, which are Upper Proterozoic, are followed by units of the Cambrian and Ordovician Systems without significant unconformity. Erosional and very slight angular unconformities separate the Larapinta Group from the Mereenie Sandstone, and both from the Pertnjara Formation. A major unconformity separates Palaeozoic and Precambrian rocks from scattered Mesozoic and Tertiary sediments.

Nomenclature.

The stratigraphical nomenclature used follows the Australian code of stratigraphic nomenclature (Raggatt, 1950 and 1953). Miss Joyce Gilbert-Tomlinson studied the algae in situ and examined the Lower Palaeozoic faunal succession. The fossil names given in this report are her field determinations. Until her detailed examination of the material is completed, the fossil lists and ages based on them must be considered tentative.

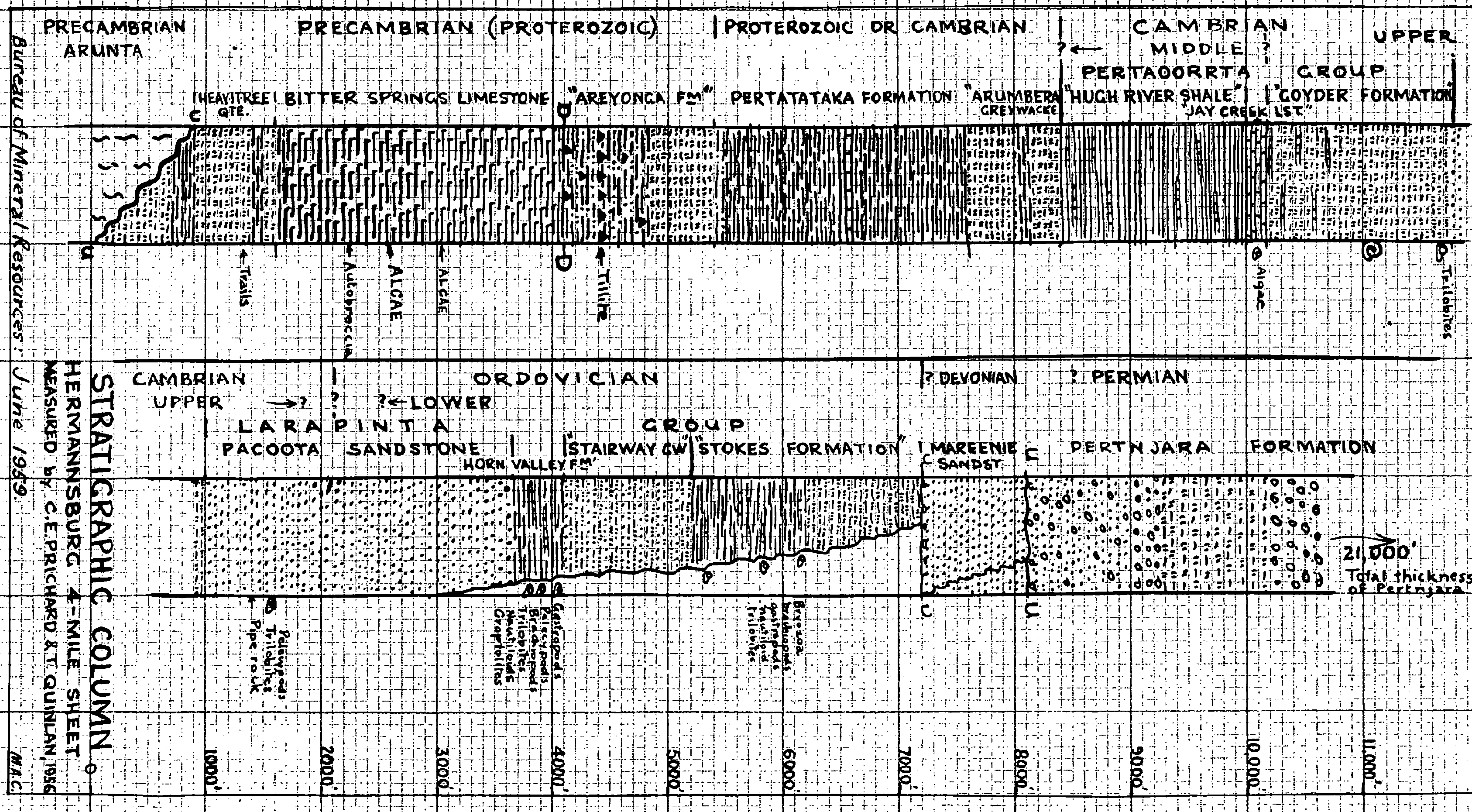

Bureau of Mineral Resources June 1959
STRATIGRAPHIC COLUMN
HERMANNSBURG 4-MILE SHEET
MEASURED by C.E. PRICHARD & T. QUINLAN, 1956
M.A.C.
PRECAMBRIAN
ARUNTA
PRECAMBRIAN (PROTEROZOIC)
PROTEROZOIC OR CAMBRIAN
CAMBRIAN
MIDDLE
UPPER
PERTAOORRTA GROUP
HEAVITREE QTE.
BITTER SPRINGS LIMESTONE
"AREYONGA FM"
PERTATATAKA FORMATION
"ARUMBERA GREYWACKE"
"HUGH RIVER SHALE"
"JAY CREEK LST."
"GOYDER FORMATION"
Trails
Autobreccia
ALGAE
ALGAE
Tillite
Algae
Trilobites
CAMBRIAN
UPPER
ORDOVICIAN
LOWER
? DEVONIAN
? PERMIAN
LARAPINTA GROUP
PACOOTA SANDSTONE
HORN VALLEY FM
"STAIRWAY GW"
"STOKES FORMATION"
MAREENIE SANDST
PERTNJARA FORMATION
21,000' Total thickness of Pertnjara
Pelecypods
Trilobites
Pipe rock
Gastropods
Pelecypods
Brachiopods
Trilobites
Nautiloids
Graptolites
Bryozoa
Brachiopods
Gastropods
Nautiloids
Trilobites
1000'
2000'
3000'
4000'
5000'
6000'
7000'
8000'
9000'
10,000'
11,000'

Fig. 3

TABLE I

Stratigraphical Nomenclature

Pre 1932		Madigan 1932		Chewings 1935		Prichard & Quinlan	
Walker Creek Series (1)	Pertnjara Series (3)	Pertnjara Series		Pertnjara Series		Pertnjara Formation	
		Larapintine Series	Mareenie Sandstone	Larapinta Series	Marena Red Sandstone		Mereenie Sandstone
Mareeno Bluff Series (1)			(not seen)		Marena Valley Shales & mudstone	Larapinta Group	Stokes Formation
			-		Stairway Quartzite & sandstone.		Stairway Greywacke
			Horn Valley Beds		Stairway Valley Beds		Horn Valley Formation
	Pacoota Quartzite		"No. 4 quartzite"		No. 4 Quartzite		Pacoota Formation
Patacoorrta Series (2)	Pertaoorta Series (3)	Pertaoorrta Series	-	Pertaoorta Series	-	Pertaoorrta Group	Goyder Formation
			-		-		Jay Creek Limestone
			-		-		Hugh River Shale
			"No. 3 quartzite"		No. 3 Quartzite		Arumbera Greywacke
Glen Helen Series (1); Pataknurra Series (2)	Pertaknurra Series (3)	Pertatataka Series	-	Pertatataka Series	-		Pertatataka Formation
			"No. 2 quartzite"		No. 2 Quartzite		Areyonga Formation
		Pertaknurra Series	-	Pertaknurra Series	-		Bitter Springs Limestone
			Heavitree quartzite		No. 1 Quartzite		Heavitree Quartzite
Arunta Comples		Arunta Complex		Arunta Complex		Arunta Complex	

(1) Chewings 1894

(2) Mawson & Madigan 1930

(3) Chewings 1931.

ARCHAEAN

Arunta Complex

The crystalline igneous and metamorphic rocks north of Heavitree Gap were named the Arunta Complex by Mawson and Madigan (1930); the name is that of the local aboriginal tribe. No specific type locality was given. Madigan (1932a) states the complex consists of gneisses, schists, gneissic granite, granite, and acid and basic dykes.

The Arunta Complex crops out as a belt of hilly country between the ridge of Heavitree Quartzite and the Burt Plain. In the western part of the area it forms low plains with very poor outcrop. North of Goyders Pass an inlier of Arunta Complex is surrounded by Heavitree Quartzite and Bitter Springs Limestone.

The Arunta Complex is the oldest rock unit in the area and forms the basement on which the sedimentary sequence was deposited. Because of its stratigraphical position and the uniformly high degree of regional metamorphism over an area of many thousand square miles the Arunta Complex is considered Archaean.

No attempt was made to map lithological units or details of structure within the Complex.

PROTEROZOIC

The oldest sediments filling the Amadeus Geosyncline (Hossfeld, 1954) are regarded as Upper Proterozoic. They are the Heavitree Quartzite, the Bitter Springs Limestone, the Areyonga Formation, the Pertatataka Formation, and probably the Arumbera Greywacke.

Possible correlation of this sequence and the overlying Cambrian beds with the Adelaidean System and Cambrian System of South Australia is discussed later in this report.

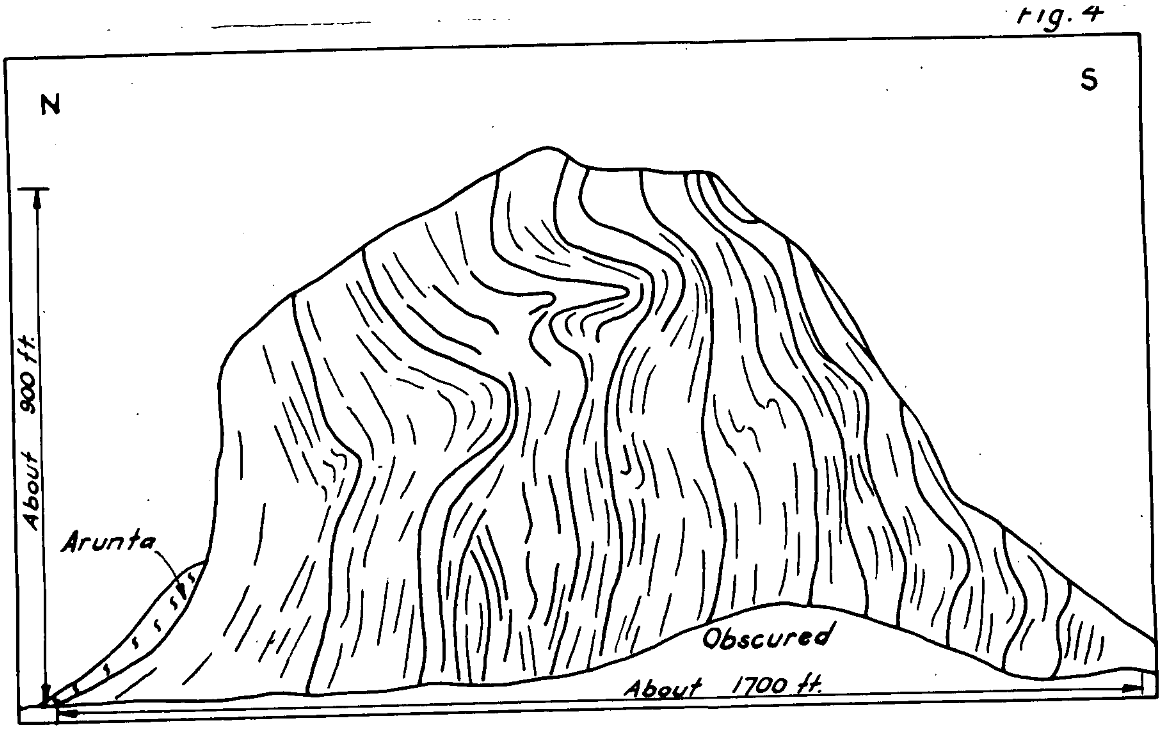
Heavitree Quartzite

The quartzite in which Heavitree Gap, near Alice Springs, is eroded has been referred to by all authors on the geology of Central Australia. It has been variously called No. 1 Ridge quartzite (Ward, 1925), Heavitree Gap quartzite and No. 1 quartzite (Chewings, 1928), Heavitree Range quartzite and Heavitree quartzite (Madigan, 1932a), and Heavitree Quartzite (Joklik, 1955), and has often received several names in the one paper. Heavitree Gap may be inferred as the type locality.

In the area mapped the Heavitree Quartzite extends as a high ridge from Jay Creek west to Mt. Razorback and then as outliers beyond the map boundary. In the Heavitree Range, the quartzite is generally unconformable on the Arunta Complex and is conformably succeeded by the Bitter Springs Limestone, which is in turn overlain without angular unconformity by about 12,000 feet of Proterozoic, Cambrian, and Ordovician beds.

No section through the Heavitree Quartzite at the type locality has been published, but Joklik (1955) says it is about 600 feet thick here. Madigan (1932a) says its maximum measured thickness is 1440 feet at Ellery Creek Big Hole and also gives 600 feet as the thickness at Heavitree Gap. M.A. Condon (personal communication, 1957) measured 500 feet of Heavitree Quartzite at Heavitree Gap between siltstone conformably below and the Bitter Springs Limestone above. The Heavitree Quartzite was examined in many places without success for a section whose thickness could be accurately measured.
Though the quartzite faces south in the Heavitree Range, and no major beds are repeated or omitted, minor structures and rapid changes of dip prevent an accurate measurement of the thickness. Figure 4 shows the structure of the east wall of Ellery Creek Big Hole. It is this section which Madigan (1932a) gives as 1440 feet; but as he did not reach the northern boundary of the Heavitree Quartzite (Madigan, 1944, p. 194), this must be an estimate based on an assumed average dip and estimated outcrop width, and is of the right order.

Fig. 4



-6-

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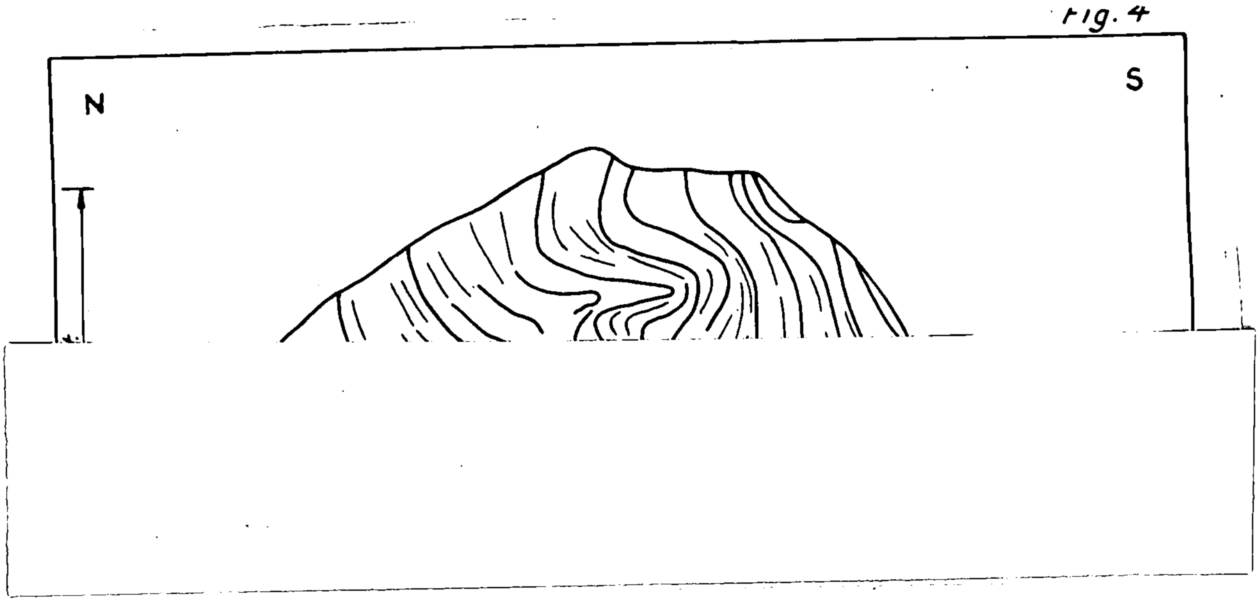

Figure 4 - Sketch section of the Heavitree Quartzite, east wall of Ellery Creek.

The Heavitree Quartzite consists of three members in the area mapped. The basal member is a medium-grained and coarse-grained quartz sandstone commonly cemented to quartzite. it is 700 feet thick at Ellery Creek and rests unconformably on the Arunta Complex. The middle member, about 200 feet thick, consists of coarse siltstone containing about 40% of medium and coarse quartz grains. The top member is medium-grained quartz greywacke, usually also silicified to quartzite, containing pale yellow-brown argillaceous quartz siltstone up to 100 feet thick below the topmost quartzite bed. This member is about 500 feet thick at Ellery Creek.

Both Hossfeld (1954) and Joklik (1955) report 10 to 30 feet of soft argillaceous beds conformably below the Heavitree Quartzite and unconformably above the Arunta Complex at the northern end of Heavitree Gap. However these beds were not found in the area mapped, despite many excellent exposures of the base of the formation. The basal bed of Heavitree Quartzite in the mapped area differs from higher beds in one respect only. It is neither coarser grained nor dirtier but does contain angular to subangular pebbles of white vein quartz at its base; these pebbles are up to two inches in diameter.

The apparent thickness of the Heavitree Quartzite does not vary markedly from Jay Creek to the Finke River. It is known to extend from Haasts Bluff to east of Bitter Springs Gorge, a distance of over 200 miles. Except where affected by faulting, the order of thickness is constant.

No fossils were found in the Heavitree Quartzite. East of the area mapped, at Temple Bar Gap and near Bitter Springs, M.A. Condon (personal communication) has recognised possible invertebrate burrows. It was deposited on a mature surface of the Arunta Complex (with older beds intervening at some localities) and is conformably overlain by the Bitter Springs Limestone, which contains Upper Proterozoic algae; the Heavitree Quartzite is probably of the same age.

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* M.A. Condon (personal communication) in 1958 measured a section along Ormiston Creek, where he found 500 feet of quartz greywacke resting unconformably on the gneiss of the Arunta Complex, overlain conformably by 200 feet of phyllitic siltstone and fine-grained quartz greywacke, which in turn is overlain by several hundred feet of silicified quartz sandstone. He considers that this uppermost sandstone unit is the Heavitree Quartzite, and the phyllitic siltstone and fine-grained quartz greywacke unit is equivalent to the siltstone underlying the Heavitree Quartzite at Heavitree Gap. He considers that the name Heavitree Quartzite should be used only for the arenite formation that outcrops at Heavitree Gap; the top of this formation is not exposed at the Gap but the base is exposed, conformably overlying siltstone and fine-grained quartz greywacke; this siltstone and quartz greywacke formation should not be included in the Heavitree Quartzite.

Meta-Quartzite of the Chewings Range

The Chewings Range, several ridges south of it, the ridge running north-east from Mt. Sonder, and the western part of a ridge north of Goyder Pass consist of closely jointed metamorphic recrystallized quartzite. Dips are irregular but are generally between 30° and 70° north. Isoclinal folding was recognized at several places; one well exposed example three miles east of Ormiston Creek has a core of quartzose mica schist and about 40 feet of metaquartzite visible in each limb.

All these quartzites occur north of the Heavitree Range within the Arunta Complex and are not accompanied by Bitter Springs Limestone or younger members of the sedimentary sequence.

The Chewings Range is the major occurrence of these metaquartzites, wh[illegible] outcrop is laterally continuous with that of the quartzite which forms the northern wall of Ormiston Pound. This quartzite, which dips north, is physically and structurally continuous with the Heavitree Quartzite which, as part of the Heavitree Range, forms the southern wall of the Pound. Lithology grades from silicified quartzite in the southern and western part of the wall to recrystallized quartzite along the northern wall. Though there are structural discontinuities at the north-eastern and south-eastern corners of the Pound, outcrop of quartzite is physically continuous. * Like the metaquartzite of the Chewings Range east of Mt. Giles, the undoubted Heavitree Quartzite of the western and northern wall of Ormiston Pound dips north in[illegible] the Arunta Complex and overlying sedimentary formations are absent.

The metaquartzite ridge extending north-east from Mt. Sonder into the Arunta Complex is also physically continuous and apparently structurally conformable with Heavitree Quartzite of the west plunging anticline which forms the mountain.

If these metaquartzites are much older than the Heavitree Quartzite and are part of the Arunta Complex it is certainly a remarkable coincidence that they occur only as linear outcrops, which are continuous and structurally conformable with Heavitree Quartzite, or as isolated blocks between such linear outcrops and the Heavitree Quartzite.

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M.A. Condon considers that a strong structural discordance between the Heavitree Quartzite and the metaquartzite is displayed (in air-photographs) in the area 3½ to 4½ miles north of Mt. Giles: the Heavitree Quartzite dips steeply north and transgresses across the north-south trend of the metaquartzite, dipping very steeply east.

However, if they are Heavitree Quartzite a structural and tectonic reason for their occurrence in the Arunta Complex and the absence of overlying formations of the sedimentary sequence north of Heavitree Range must exist. The presence of undoubted Heavitree Quartzite in the north-western wall of Ormiston Pound shows that Heavitree Quartzite does occur in essentially the same structural position. Text-figure 7 presents a postulated explanation of a similar structure at Mt. Sonder.

The Chewings Range and the ridge extending north-east from Mt. Sonder are considered to be Heavitree Quartzite. Even if this is correct some outcrops of metaquartzite within the Arunta Complex could be of older quartzites, but on the accompanying maps all metaquartzite outcrops are shown as possible Heavitree Quartzite (?Buh).

Bitter Springs Limestone

Joklik (1955) named the Bitter Springs Limestone and designated Bitter Springs Gorge, 40 miles east-north-east of Alice Springs, as the type locality. He gave no section or thickness. Madigan (1932a and b) had earlier mapped the same formation from Ellery Creek to Bitter Springs Gorge. Inspection of the latter locality leaves no doubt that the dolomitic limestone and siltstone formation at Ellery Creek which overlies the Heavitree Quartzite conformably and which is disconformably succeeded by the Areyonga Formation is the same unit; this is Madigan's (1932a) Pertaknurra (B) series.

The Bitter Springs Limestone crops out as rugged foothills south of the Heavitree Ridge from Jay Creek west to Mt. Sonder, and a second belt extends north-west from near Areyonga into the area mapped south of Missionary Plain. Beyond the area mapped the formation occurs at Haasts Bluff and south of the Heavitree Ridge as far east as it has been followed. It may also occur in the core of several anticlines near Tempe Downs.

A section was measured through the formation along the east bank of Ellery Creek. Here, as elsewhere in the area mapped, the lower part is much disturbed by folding, but exposures are good enough to show that beds are neither duplicated nor omitted and to provide good and frequent dip information. The base is put at the top of the highest quartzite bed of the Heavitree Quartzite. The basal 100 feet crops out poorly and consists mostly of dark grey siltstone easily distinguished in outcrop from the pale yellow-brown siltstone in the Heavitree Quartzite below the quartzite bed. The Bitter Springs Limestone contains almost 80% of hard, dark grey, well bedded and often laminated dolomitic and cherty limestone, inter-bedded with dark shale and siltstone which, except for the basal bed, nowhere exceeds 70 feet in continuous thickness. From 1270 feet to 1890 feet above the base much of the limestone is argillaceous and dull red. This red limestone is not dolomitic nor does it contain algae. In the upper part of the formation most of the darker dolomitic limestone beds contain colonial algae. Towards the middle, many of the beds are algal biostromes and occasional small Collenia bioherms were noted. Chert occurs throughout the formation but is most prominent near the top and bottom; it does not occur in the red limestone. The interbeds of siltstone are dark, argillaceous, and mostly laminated. The top of the formation is put at the top of the highest dark cherty dolomitic limestone bed, or just above this, at the change from the almost black siltstone to the light sandy tillitic siltstone and fine-grained greywacke which are the basal beds of the Areyonga Formation. At Ellery Creek the Bitter Springs Limestone is 2500 feet thick.

Because of the complex folding usual in the lower part of the formation, it was not practicable to measure other sections, but the same general sequence and thickness appears to be present throughout the area mapped. From Jay Creek to halfway between Ellery Creek and the Finke River only the lower part of the Bitter Springs Limestone is folded, but farther west the amount folded rapidly increases, and the whole formation is intricately folded at Ormiston Creek.

The mechanism appears to be that the bounding fault of the depositional area of the Bitter Springs Limestone was active while, or immediately after, it was laid down, so that the numerous small movements threw the limestone into intricate folding penecontemporaneous with deposition. Hence the angular unconformity with overlying beds does not indicate any considerable erosion or time-break; and in fact the top of the Bitter Springs Limestone is not differentially eroded over the whole of its mapped contact with overlying rocks, from Loves Creek in the east to the Finke River in the west.

At Ellery Creek three forms of the alga Collenia were observed; one of them resembles C. australica (Howchin), originally described from Acacia Well in the Eastern MacDonnell Ranges, where Bitter Springs Limestone is present. The other two forms are not at present specifically identifiable, but they appear to be Proterozoic forms (J. Gilbert-Tomlinson, personal communication).

Two other problematic structures, possibly of organic origin, occur at higher levels in the Ellery Creek section. No comparable forms have been described in the literature.

The rocks of the Bitter Springs Limestone indicate that it was deposited on a shallow stable shelf which received only a small amount of fine grained terrigenous material. The unit does not change significantly in composition from Bitter Springs Gorge to Finke river or south to Areyonga. The occurrence of algae shows that deposition was in shallow water throughout, despite the thickness of the formation.

Areyonga Formation (new name)

The Areyonga Formation is defined as the sequence of interbedded siltstone and quartz greywacke which disconformably overlies the Bitter Springs Limestone at Ellery Creek and is conformably overlain by the Pertatataka Formation. It is the same unit as Madigan's No. 2 quartzite (Madigan, 1932a) at Ellery Creek, which he included in his Pertatataka Series: "Between Nos. 2 and 3 quartzites lie 3,000 feet of arenaceous sediments... and slates in which limestone beds are relatively unimportant... This series was included in the Pertaknurra in our joint paper (Mawson and Madigan, 1930), the unconformity at No. 2 quartzite not being appreciated. The second series is now named Pertatataka". As thus defined and mapped by Madigan this "series" consists of two formations of which the lower (his No. 2 quartzite) is the thinner and more restricted geographically. It is here named Areyonga Formation and the name Pertatataka restricted to the upper formation. Areyonga is a Government native settlement about 32 miles south-west of Hermannsburg Mission.

At the type section, which is along Ellery Creek $\frac{1}{2}$ to $\frac{3}{4}$ miles south of the boundary of the Arunta Complex and sediments, the formation consists of two members. The lower member, 750 feet thick, consists of interbedded tillitic siltstone (65%) and quartz greywacke and pebble conglomerate (35%). The siltstone contains scattered pebbles, cobbles, and boulders, which, in one bed 305 to 342 feet above the base, are concentrated to form a boulder bed. Lenses of pebble conglomerate a few feet thick and several tens of feet long occur in the siltstone. Between 620 and 680 feet from the base a few thin beds of yellow limestone are present. The siltstone is poorly sorted and contains a proportion of larger grains. It is not clayey but appears to consist of rock flour.

The erratics are of chert, dolomitic limestone sometimes algal, quartzite, schist, gneiss, granite, acid and basic igneous rocks, and a few of serpentine. They have been derived from the underlying Upper Proterozoic beds as well as the Arunta Complex. The largest boulder found was granite; it was about three feet by two feet by two feet. The boulders are mostly rounded, but many smaller erratics are soled and many striated specimens were found - chert from the underlying Bitter Springs Limestone preserves striations especially well. This lower member of the formation is present only from near Eight Mile Gap to nine miles east of the Finke River. The only other known occurrence is near Areyonga.

The higher member is uniform and consists of current bedded medium-grained quartz greywacke 550 feet thick. The rock, which consists chiefly of sub-angular to sub-rounded quartz, feldspar (up to 15%), and a fine white non-clayey matrix probably of rock flour, outcrops poorly and weathers massively. The topmost 25 feet are silicified. This member is more widely distributed than the lower member and was mapped from Jay Creek to one mile west of the Finke River; it was also seen near Areyonga.

The whole of the Areyonga Formation is the product of a glacial environment. The lower member of siltstone, with included boulders and striated erratics is bedded, and impact distortion can be seen around the erratics in good exposures showing that it was water laid; its extent - about 30 miles along strike and a further occurrence about 30 miles down dip - suggests that it is marine. The upper member is probably also marine, formed during the retreat of the ice sheet when there was no longer floating ice to transport erratics.

Portatataka Formation

The Pertatataka Formation is defined as that sequence of siltstone which conformably overlies the Areyonga Formation and is conformably succeeded by the Arumbera Greywacke. This is the major and more extensive part of the Pertatataka "Series" of Madigan (1932a) from which only the Areyonga Formation (his No. 2 quartzite) has been separated.

The Pertatataka Formation extends across the area mapped from east to west and from the south-west corner towards Areyonga. It is believed to extend eastwards as far as Loves Creek, as mapped by Madigan (1932b). Outcrop is mostly poor: the formation occupies an alluviated valley between the ridge of Arumbera Greywacke to the south and the hills of Bitter Springs Limestone to the north.

A section was measured across the formation three miles west of Ellery Creek. The base is at the top of the thin prominent bed of silicified quartz greywacke which is the top bed of the Areyonga Formation. This bed is conformably succeeded by siltstone with thin interbeds of dark grey-green silicified quartz greywacke for the first hundred feet. For the next 950 feet the formation consists of poorly exposed red and occasionally green siltstone. Above this a remarkably persistent five-foot bed of fine to medium-grained felspathic (15%) silicified quartz greywacke crops out. It is succeeded by 100 feet of shale with laminae of fine-grained sandstone which gradually become less common. Then occurs a two-foot bed of hard yellow limestone which is the first bed of a calcareous zone about thirty feet thick in this section. This zone is also persistent along the strike but its thickness and the amount of limestone in it vary. Near the Finke River, where it contains 60% limestone, it is 300 feet thick, but is elsewhere less than one hundred feet. Typically it consists of several hard limestone bands in calcareous siltstone. The limestone is commonly clastic and in many places oolitic.

Above the calcareous zone red and green siltstone continues till at 2,200 feet above the base fine-grained and medium-grained dark red-brown felspathic quartz greywacke indicates the base of the conformable Arumbera Greywacke.

Despite the variation in the calcareous zone the Pertatataka Formation from Ellery Creek to Stokes Pass has a constant thickening towards the west of slightly less than 40 feet per mile. If it thins similarly towards the east it will not be present very far east of Alice Springs.

No fossils have been found in the Pertatataka Formation in the Western MacDonnell Range and its age is judged solely from its stratigraphical position. Madigan (1932b) states that algae occur in his Pertatataka series in the Eastern MacDonnell Ranges.

The Pertatataka Formation is probably Upper Proterozoic, although a Lower Cambrian age is not impossible.

PROTEROZOIC OR CAMBRIAN

Arumbera Greywacke (new name)

The feldspathic micaceous quartz greywacke with interbedded micaceous siltstone which conformably overlies the siltstone of the Pertatataka Formation and is conformably overlain by shale and limestone of the Hugh River Shale is named Arumbera Greywacke. This unit has not been previously named, though Madigan (1932a) referred to it at Ellery Creek as No. 3 Quartzite and included it in his Pertaoorrta Series.

The name is taken from Arumbera Creek, which flows north-west before joining Derwent Creek and flooding out over the western part of the Burt Plain (Plate 2).

The Arumbera Greywacke crops out as a dark red-brown ridge from east to west across the area mapped. It also extends from the south-east corner of the map towards Areyonga. It extends east of the area at least as far as Ross River.

The type section was measured three miles west of Ellery Creek, where the formation is 800 feet thick. It consists of 440 feet of red-brown medium-grained feldspathic quartz greywacke with a few thin siltstone beds, followed by 90 feet of purple-red micaceous siltstone below 270 feet of feldspathic micaceous fine-grained and medium-grained quartz greywacke, with thin siltstone interbeds, especially near the top.

The base of the Arumbera Greywacke is placed at the lithological change from the siltstone of the Pertatataka Formation to quartz greywacke, and the top is at the change from quartz greywacke to the interbedded shale and limestone of the Hugh River Shale, the lowest formation of the Pertaoorrta Group.

The Arumbera Greywacke thickens slightly from Ellery Creek to the Finke River, and appears to thicken much more rapidly farther west - a thickness of 2800 ft. was measured at Stokes Pass. Eastwards the formation does not show such variation and Joklik (1955) reports 600 feet of "Cambrian quartzite" at Ross River (35 miles east of Alice Springs). This is probably the Arumbera Greywacke.

No fossils have been found in the Arumbera Greywacke and its age is inferred from its stratigraphical position. It is conformably succeeded by the Pertaoorrta Group, which contains Upper Cambrian fossils near the top. In the absence of direct evidence it is best regarded as Proterozoic or Cambrian in age.

CAMBRIAN

The Cambrian succession consists of the Hugh River Shale, the Jay Creek Limestone, the Goyder Formation, and the lower part of the Pacoota Sandstone. The underlying Arumbera Greywacke may also be Cambrian. The Pacoota Sandstone is described with the Ordovician System.

Pertaoorrta Group

Mawson & Madigan (1930) first used the term "Pataoorrta Series" for "the middle quartzite (i.e. Arumbera Greywacke) to the base of the upper or Pacoota quartzite". Chewings (1931) altered the spelling and Madigan (1932a) says "the Pertaoorrta Series lies between Nos. 3 (Arumbera Greywacke) and 4 (Pacoota Sandstone) quartzites and includes No. 3".

In the same paper Madigan uses the heading "No. 3 Quartzite and Pertaoorrta Series" and by inference does not include his No. 3 quartzite in the Pertaoorrta Series.

Joklik (1955) writes "The name Ross River Group is here given to the Cambrian sediments of the post-Proterozoic succession". The beds he included in his Ross River Group are those previously named Pertaoorrta Series by Madigan. Joklik's definition is hence invalid; also it makes use of a rock term (Group) in a time-rock sense.

The name Pertaoorrta Series was used essentially as a rock term and is hence changed to Pertaoorrta Group, which is defined as consisting of the Goyder Formation, Jay Creek Limestone, and Hugh River Shale.* The Group is conformable between the Arumbera Greywacke below and the Pacoota Sandstone above.

The Hugh River Shale and the Goyder Formation crop out right across the area mapped and continue both eastward and westward. The Jay Creek Limestone crops out from east of the area mapped to one mile west of the Finke River, increasing in thickness towards the east. Within the area mapped this increase seems to be mostly by lateral lithological change of the lowest beds of the overlying Goyder Formation; to the east the lithology of the underlying Hugh River Shale also becomes more calcareous, and at Ross River (35 miles east of Alice Springs) Madigan (1932b) records a thickness of over 3000 feet of limestone which directly overlies the Arumbera Greywacke.

The whole of the Group is Cambrian. Lower Ordovician and Upper Cambrian fossils have been found in the overlying Pacoota Sandstone, Upper Cambrian trilobites near the top of the Goyder Formation, and Girvanella and other algae in the Jay Creek Limestone.

* These formations are equivalent to Madigan's (1932a) beds Db, c, and d, De, and Df, and g, respectively.

In Australia Girvanella usually indicates a Middle Cambrian age. From Stokes River in the west to Ross River in the east, the Group maintains a purely constant thickness of 3500 feet.

Hugh River Shale (new name)

The Hugh River Shale, which is the oldest formation of the Pertaoorrta Group, is defined as the sequence of shale and interbedded dolomitic limestone that conformably overlies the Arumbera Greywacke and is conformably overlain by the Jay Creek Limestone or, where that formation is not present, by the Goyder Formation. The Hugh River Shale has not previously been referred to as a unit but appears in Madigan's (1932a) Ellery Creek Section as beds Db, Dc, and Dd. It is named from the Hugh River, which flows across the formation a few miles west of Jay Creek (Plate 2).

The type section is one mile west of Ellery Creek, 1.4 to 1.6 miles south of the boundary of Arunta and sediments. The base of the formation is at the top of the highest hard quartz-greywacke bed of the Arumbera Greywacke, which is succeeded by shale with interbedded hard blue-grey limestone. The highest shale bed of the Hugh River Shale is succeeded by the sequence of dolomitic limestone of the Jay Creek Limestone. The Hugh River Shale consists of shale with some siltstone and has interbedded dolomitic limestone in beds up to 10 feet thick comprising 8% of the total thickness. A few thin beds of soft fine-grained calcareous greywacke occur near the top. The thickness is 1600 feet. Towards the west the limestone content decreases and the formation becomes coarser-grained. Near Stokes Pass and to the south near Areyonga, sandy siltstone and calcareous silty fine-grained quartz greywacke are the dominant lithologies.

No fossils have been found in this formation. Its position immediately below the Jay Creek Limestone, which contains Girvanella, indicates a Lower or Middle Cambrian age.

Jay Creek Limestone (new name)

The Jay Creek Limestone consists of biostromal (algal) and oolitic limestone and very minor shale. It conformably overlies the Hugh River Shale and is conformably succeeded by the Goyder Formation. This formation has not previously been named; it is the D.e. beds of Madigan (1932a).

The formation is named from Jay Creek, near the eastern edge of the area (Plate 2).

From Jay Creek to Ellery Creek the formation is continuous, but west of Ellery Creek it occurs as lenses only; the most westerly outcrop is one mile west of the Finke River. It is not present where the Pertaoorrta Group crops out farther to the west.

The outcrops form low rounded spinifex-covered limestone ridges.

The type section one mile west of Ellery Creek contains 175 feet of well-bedded dolomitic limestone with minor thin interbeds of shale. Many beds of the limestone, which is dolomitic, are algal biostromes. Clastic limestone, much of it oolitic, is also important. The limestone beds are usually blue-grey or yellow-brown; many clay galls probably due to intraformational bre[illegible] occur in the upper part. The base of the formation is placed at the base of the thick limestone sequence which overlies the shale and interbedded thin limestone of the Hugh River Shale. The top of the formation is placed at the top of the sequence dominantly of limestone with a few shale interbeds which is followed by quartz greywacke of the Goyder Formation.

East of the type section the formation thickens steadily. Outcrop is poor and no reliable complete section could be measured in the area mapped. At Ross River (35 miles east of Alice Springs) Madigan (1932b) records a thickness of over 3,000 feet of limestone which directly overlies the Arumbera Greywacke. This suggests that the thickening eastward may be due to change of lithology in the underlying Hugh River Shale.

West of the type section lenticular outcrops of the formation occur. Whether these represent discrete lenses or tongues extending from the main body of the formation is not clear. That they are not erosional remnants of a formerly continuous sheet of the formation is shown by their gradational boundary, both vertically and laterally, with the overlying quartz greywacke of the Goyder Formation. A bed of limestone along its strike becomes sandy and less calcareous, and finally calcareous quartz greywacke.

The formation is rich in algal fossils. Girvanella is present near the base at the type section and, in Australia, this usually indicates a Middle Cambrian age. Early Upper Cambrian trilobites have been collected near Temple Bar Gap.

Goyder Formation (new name)

The top formation of the Pertaoorrta Group is defined as the quartz greywacke with interbedded limestone in the lower half and some quartz sandstone in the upper part which conformably overlies the Jay Creek Limestone or, where that formation is not present, the Hugh River Shale, and is conformably succeeded by the Pacoota Sandstone. This unit has not been named previously but is beds Df and Dg. of Madigan (1932a). It is here named Goyder Formation after Goyder Pass, which is 16 miles west of Finke Gorge.

The Goyder Formation crops out from east to west across the area mapped and also in its south-western corner. It is known to occur in the Waterhouse Range near the south-eastern corner of the area. The formation forms a low pediment sloping from the ridge of Pacoota Sandstone.

The type section is half a mile west of Ellery Creek, where the formation is 1600 feet thick. It is dominantly fine-grained and medium-grained quartz greywacke which is often micaceous or calcareous. Limestone forms about 20% of the lower 900 feet. Some is algal and some oolitic, and few individual beds persist along the strike. Near the base a few beds of siltstone are present. No limestone beds were seen in the upper part, although much of the quartz greywacke is calcareous. A few thin beds of quartz sandstone occur towards the top.

The base of the formation in the Ellery Creek area is placed at the change from almost continuous limestone of the underlying Jay Creek Limestone to the dominant quartz greywacke of this formation. The top is at the change from dominant quartz greywacke, often calcareous, to the dominant quartz sandstone, often silicified, of the overlying Pacoota Sandstone.

Near Ellery Creek the Jay Creek Limestone and Goyder Formation are 175 feet and 1600 feet thick respectively. The combined thickness is thus 1775 feet. This combined thickness is constant to the west. Thus at the Finke River, where a lens of the Jay Creek Limestone is 300 feet thick, the top formation is 1500 feet thick; one mile farther west, where the Jay Creek Limestone is absent, the Goyder Formation is approximately 1800 feet thick, and it is the same thickness near Stokes Pass. Near the Hugh River (about twelve miles east of Ellery Creek) each formation is about 1,000 feet thick.

Fossils have been found in the Goyder Formation at only two localities in the area mapped. In the Lawrence Gorge through the northern flank of the Waterhouse Range two genera of trilobites were collected from near the top of the formation, and in the type section, 900 feet above the base, poorly preserved fossil fragments were found. The trilobites from the Waterhouse Range indicate an Upper Cambrian age; the fossils of the type section have not been examined. The overlying Pacoota Sandstone contains Lower Ordovician (Tremadocian) fossils as well as Upper Cambrian forms.

CORRELATION OF CAMBRIAN AND PROTEROZOIC SEQUENCE

The presence of an apparently continuous sequence from Upper Proterozoic to Cambrian beds in the MacDonnell Ranges suggests the possibility of correlation with the Adelaidean and Cambrian successions of South Australia.

Lower Cambrian beds are widespread in South Australia, but Middle Cambrian is known only in the Lake Frome area (Daily, 1957). Though Lower Cambrian appears to be present in central Australia (Opik 1957, p.47), no beds of this age have been identified in the area mapped. In the MacDonnell Ranges Cambrian beds have been proved to range from early Upper Cambrian to late Upper Cambrian only. The presence of Girvanella in beds below the proven early Upper Cambrian suggests that Middle Cambrian may also occur. Hence the Cambrian beds of the MacDonnell Ranges cannot be correlated with those of South Australia.

The Adelaidean System consists of Torrensian Series, Sturtian Series, and Marinoan Series. In the type area near Adelaide the system is about 28,000 feet thick. It has been mapped from south of Adelaide north to Leigh Creek and north-east to Olary. Throughout this area the Sturt Tillite has been recognized and ranges from about 2000 feet thick in the Adelaide area to more than 10,000 feet thick in the north (Campana and Wilson 1955). Deposits of such a lengthy and widespread glaciation could be expected in other areas.

A much younger glaciation has been recognized in Adelaidean System by Mawson (1949). This glaciation, in the Marinoan Series, was apparently not very widespread and has been recognized only in the northern area.

Mawson (1957) correlates the glacial beds of the MacDonnell Ranges (i.e. Areyonga Formation) with the Sturtian glacial horizon of South Australia, the overlying Pertatataka Formation with the Marinoan Series, and the underlying formations with the Torrensian Series. Noakes (1957) mentions Precambrian tillite from the Tobermory area and suggests correlation with the Marinoan glacials because of the marked red colour of the accompanying beds. Wilson (1951) has reported two horizons of Precambrian glacial sediments near the Everand Ranges in northern South Australia. Wilson correlates these with the Sturt Tillite but offers no supporting evidence.

The beds near Everard Range and Tobermory are the closest known Precambrian glacial deposits to the Areyonga Formation; both are within 300 miles of its outcrop. The three deposits were probably laid down during the same glaciation; but which of the Precambrian glaciations recognized in South Australia was concerned is not clear.

CAMBRO-ORDOVICIAN

The lower part of the Pacoota Sandstone contains Upper Cambrian trilobites and the upper part Ordovician fossils. It is described with other units of the Ordovician System - the Horn Valley Formation, the Stairway Greywacke, and the Stokes Formation.

ORDOVICIAN

Larapinta Group

The name "Larapintine Series" was first used by Tate (1896) as a heading in the Palaeontology section of the Report of the Horn Expedition. It was neither deferred nor described. In the General Geology section by Tate & Watt of the same Report, the term is not used, but the heading "Ordovician" appears synonymous. It is apparent that the "Larapintine Series" of Tate includes all beds between the Precambrian metamorphics (Arunta Complex) below and the post-Ordovician conglomerate (Pertnjara Formation) above.

The term was not used very much for the next thirty years, and authors who rather casually mention it do so as synonymous with what they regard as Ordovician; that is, it was used as a time-rock term.

Madigan (1932a) says "the Larapintine Series" is "the original name for the Ordovician beds, given by Tate and Watt". He mapped as Larapintine Series all the beds which he regarded as Ordovician. Although he "arbitrarily decided on No. 4 quartzite as the base of the Larapintine" he had found no diagnostic fossils till more than 3,500 feet higher in the sequence. Thus in fact Madigan's Larapintine Series was set up and mapped as a rock unit. The lower 9,700 feet (Madigan's thickness) of the sedimentary sequence which was apparently included in the "Series" by Tate is excluded by Madigan, who divided these beds into three other "Series" which he referred to the Cambrian and Proterozoic.

Chewings (1935, p. 142) used "Larapinta Series", but subsequent authors have followed Madigan, i.e. they have called a sequence of approximately 6,000 feet of sediments (of which only about 240 feet were known by contained fossils to be Ordovician) Larapintine Series. All users of the name have excluded the Pertnjara Formation, whose age is still unknown and which could prove to be Ordovician. Chewings states (1935, p. 142) that Larapinta is a corruption of Leerapeenta which means Spring Creek. As Larapinta is the geographic name it is proposed to define the Larapinta Group as a rock unit.

The Larapinta Group consists of the following four formations (in ascending order): Pacoota Sandstone, Horn Valley Formation, Stairway Greywacke, and Stokes Formation. It conformably overlies the Pertaoorrta Group and is separated from the overlying Mereenie Sandstone by a regional unconformity. This differs from Madigan's Larapintine Series only in the inclusion of the Stokes Formation (which was not seen by him) and the exclusion of the Mereenie Sandstone. The Mereenie Sandstone is not included in the Group because its lithology indicates a significantly different environment and because it is separated from the Group by a regional unconformity.

Every formation of the Larapinta Group is fossiliferous, and the thin limestone beds in the two siltstone formations are especially rich in fossils. The age of the fossils ranges from Upper Cambrian and Lower Ordovician in the Pacoota Sandstone to possibly Upper Ordovician in the Stokes Formation.

<u>Pacoota Sandstone</u>

The quartzite "so powerfully developed at the Finke Gorge Waterhole" was named the Pacoota quartzite by Mawson and Madigan (1930) and was regarded as the basal member of the Larapintine Series. The two names were not synonymous although Madigan (1932a) writes: "This (i.e. Larapintine Series) is the original name for the Ordovician beds, given by Tate and Watt. The Larapintine fauna is well known in literature, so that our former name of Pacoota is now abandoned in favour of the better known one". The formation consists essentially of sandstone so the name is altered to Pacoota Sandstone.

The Pacoota Sandstone is the formation of silicified quartz sandstone conformably overlying the Goyder Formation of the Pertaoorrta Group and succeeded conformably by the Horn Valley Formation. This is the unit originally defined by Mawson and Madigan and is the lowest of four lithological units recognized by the latter in his Larapintine Series. Madigan calls it No. 4 or Finke Gorge quartzite.

The Pacoota Sandstone forms a high flat-topped ridge about half a mile wide from near the Hugh River to the western boundary of the area mapped. It is also present in the south-western corner of the area. The main outcrop of Pacoota Sandstone trends east almost to the railway line, but has not been recognized farther east.

The measured section is along Ellery Creek, where the base of the Pacoota Sandstone is placed at the change in lithology from the dominant soft and often slightly calcareous quartz greywacke of the Goyder Formation to fine-grained and medium-grained quartz sandstone mostly cemented by silica. Similar silicified quartz sandstone forms the bulk of the formation. Some beds of quartz greywacke are also present. Much of it is crossbedded; ripple marks and suncracks are also preserved.

About 400 feet above the base occurs a bed of "pipe rock". This is lithologically similar to the rest of the formation but is packed with worm tubes normal to the bedding planes. Most tubes are about one sixteenth of an inch in diameter and eight to twelve inches long, although the largest are one eighth of an inch in diameter and two feet long, and are usually closely spaced with up to fifty present per square inch of bedding plane. Similar "pipe rock", in single beds or a succession of beds up to 20 feet thick, recurs throughout the Pacoota Sandstone. Similar worm tubes are also present in the Stairway Greywacke but are rarely sufficiently close together to form "pipe rock" in that formation.

The Pacoota Sandstone is 2700 feet thick along Ellery Creek. The top of the formation is at the top of the bed of hard quartzite, which is succeeded by the soft dark siltstone with thin lenses of quartz sandstone at the base of the Horn Valley Formation. The top 200 feet of the Pacoota Sandstone contains thin beds of green micaceous siltstone, but despite this evidence of gradual change of environment the boundary is readily mapped in the field.

Near Stokes Pass the Pacoota Sandstone is 2000 feet thick, and much less "pipe rock" is present. Above the quartz sandstone is 850 feet of glauconitic medium-grained quartz greywacke, which is generally not silicified. This member extends east to near the Finke River; its western extent is not known.

At the Finke River the Pacoota Sandstone is about 3000 feet thick. The upper part is poorly exposed and the boundary with the Horn Valley Formation was not seen. The glauconitic member if present is less than 100 feet thick here.

Fossiliferous bands are rare in the Pacoota Sandstone, and it is not yet possible to date the lower and upper boundaries of the formation. Upper Cambrian and Lower Ordovician trilobites were collected in the Ellery Creek section. The age of the Pacoota Sandstone thus extends from high in the Cambrian to low in the Ordovician.

Horn Valley Formation

The Horn Valley Formation first adequately defined by Madigan (1932a), who called it the Horn Valley beds and located it both geographically and stratigraphically in his Ellery Creek section. The name Horn Valley was apparently first used by members of the Horn Expedition of 1894, but its position was never precisely fixed, nor was it shown by Winnecke (Leader and surveyor of the party) on his map. Tate (1896) used Horn Valley as a locality from which fossils had been collected, but did not use the term stratigraphically. However, since the Horn Expedition reports were published, other authors have referred to the Horn Valley "series", "beds", "horizon", and similar terms. As the unit is essentially a lithological one it is here named Horn Valley Formation and defined as the siltstone formation containing thin limestone beds which conformably overlies the Pacoota Sandstone and is conformably succeeded by the Stairway Greywacke. Madigan's type section is retained.

At Ellery Creek the base of the Horn Valley Formation is at the top of a hard quartzite bed (Pacoota Sandstone) which is succeeded by 180 feet dominantly of siltstone but containing thin beds and lenses of quartz sandstone and quartz greywacke some of which are glauconitic. Above this is 240 feet of siltstone with thin interbedded greenish limestone beds which are very fossiliferous. A few fossils occur in the siltstone, which is marly towards the top. The top 20 feet of the formation are of soft siltstone and silty fine-grained quartz greywacke, which are followed conformably by the hard beds of the overlying Stairway Greywacke. The Horn Valley Formation is 440 feet thick at Ellery Creek.

Towards the west along the same line of outcrop the Horn Valley Formation is thicker. At the Finke River it occupies a flat-bottomed, alluvium-covered valley; neither upper nor lower boundaries can be accurately located, but it is about 1,000 feet thick. Near Stokes Pass outcrop is better and the formation is 1400 feet thick. Near Areyonga, about forty miles south of Stokes Pass, it is about 300 feet thick. The Horn

Valley Formation is reported from Tempe Downs and Henbury Stations, but its thickness at these localities is not known.

The Horn Valley Formation is richly fossiliferous. A few forms are represented by rare individuals in the basal 190 feet, but the rest of the formation contains numerous individuals representing many genera. Five different gastropods, at least two brachiopods, two asaphid and one amphyx trilobites, six or more nautiloids, and lamellibranch casts were collected from this part of the formation at most localities examined. Graptolites were found only near Stokes Pass. The fauna indicates a late Lower Ordovician or an early Middle Ordovician age.

Stairway Greywacke

The formation of quartz greywacke and quartz sandstone which at Ellery Creek conformably overlies the Horn Valley Formation and is there followed unconformably by the Mereenie Sandstone does not appear to have been formally named, although Chewings (1935) referred to it in a Table as "Stairway Quartzite". It is here named the Stairway Greywacke. West from Ellery Creek the Stokes Formation conformably overlies it.

The Stairway Greywacke crops out as a prominent flat-topped ridge from Ellery Creek westward to the limit of the area mapped. East of Ellery Creek the ridge becomes narrower because of increasing erosion before the deposition of the Mereenie Sandstone; near the Hugh River the formation has been completely removed by the effect of erosion before and after the deposition of the Mereenie Sandstone. Little is known of its extent beyond the area mapped; it probably crops out to the south in the James Ranges.

At Ellery Creek the formation is 1075 feet thick and is uniform from top to bottom. It consists of about 60% of fine-grained and medium-grained usually rather silty quartz greywacke and about 40% of cleaner quartz sandstone. Most, but not all, beds are silicified. Bedding is generally thinner than in the Pacoota Sandstone, and the silt fraction is greater than in that formation. "Pipe rock" is rare, although widely spaced tubes perpendicular to the bedding are present at many localities. Trails parallel to the bedding are common, and many beds a few inches thick consist essentially of a mass of trails of various types and sizes. Cruziana is well represented among these, and trilobite fragments as well as gastropod and lamellibranch moulds occur sparsely throughout the formation. At Ellery Creek the top of the formation is placed at the change from white or pale yellow-brown silicified quartz greywacke and quartz sandstone to the dark red non-silicified quartz sandstone of the Mereenie Sandstone.

The disconformity was not recognized at this spot but is demonstrated by the relationship of the Stairway Greywacke to the overlying formations.

At the Finke River the Stairway Greywacke is 1460 feet thick and at Stokes Pass it is 1500 feet thick. At both these localities it is conformably overlain by the Stokes Formation, and as the Stokes Formation is present to within a mile of Ellery Creek, very little if any of the Stairway Greywacke has been removed from the top of the measured section there.

Gastropods, lamellibranchs, and trilobites have been collected from the formation. Field determinations of the gastropods and trilobites suggest a Middle Ordovician age.

Stokes Formation

The formation of siltstone and fine-grained silty greywacke which conformably overlies the Stairway Greywacke and is disconformably succeeded by the Mereenie Sandstone is the top formation of the Larapinta Group. Chewings (1935) referred to it as the Marena Valley shales and mudstone, but the similarity of this name to the overlying Mereenie Sandstone renders its use undesirable. Other authors either have not referred to the formation or have confused it with the Horn Valley Formation. The formation does not occur at Ellery Creek and Madigan did not recognize it elsewhere. It is here named Stokes Formation. (Stokes Pass is about 35 miles west of Finke Gorge).

The Stokes Formation occupies a valley between ridges of Mereenie Sandstone on the south and Stairway Greywacke on the north. This valley, which has a flat alluvium-covered floor, extends from a few miles west of Ellery Creek to the western border of the Hermannsburg Sheet. The formation also crops out in the centre of Gosses Bluff Range.

Beyond the area mapped the formation is known to occur south of Areyonga, near Tempe Downs, and along Walkers Creek.

The base of the Stokes Formation is placed at the top of the highest hard greywacke bed of the Stairway Greywacke. The top is at the change of lithology from fine-grained silty greywacke to the quartz sandstone of the Mereenie Sandstone. The formation is poorly exposed, and a continuously outcropping section was not found. The dip can rarely be obtained within the formation; so estimates of thickness are only approximate. The best exposed section seen is the type section near Stokes Pass, where it is about 2,000 feet thick. The lower half is siltstone with thin limestone beds and calcareous horizons. Many of the limestone beds are richly fossiliferous, but few fossils were found in the siltstone. This is followed by dark red and purple shale, and the uppermost part of the formation consists chiefly of fine-grained very silty greywacke. Outcrop is very poor in the upper half.

The formation is present at the Finke River, but the valley it occupies is covered by alluvium and outcrops are rare. The stratigraphic interval between the ridges of the underlying and overlying formations is about 1100 feet. East of the Finke River the valley becomes narrower and outcrop improves. Here only the lower fossiliferous part of the formation is present below the Mereenie Sandstone. Because of this and because the lithology and bedding character of the Mereenie Sandstone indicate a pronounced change of sedimentary environment, it is probable that the decrease in thickness of the formation towards the east is caused by erosion before the deposition of the Mereenie Sandstone.

Fossils have been found in the lower half of the formation. Bryozoa, crinoid (or cystoid) stems, probably three brachiopods, gastropods, trilobite fragments, at least one nautiloid, and lamellibranch casts were collected near Stokes Pass. This fauna indicates that the formation was deposited during the younger half of the Ordovician, i.e. in early Upper Ordovician or late Middle Ordovician.

The Horn Expedition collected fossils from the Stokes Formation as well as from the Horn Valley Formation, but thought they were from the same horizon. Chewings seems to have been the first to recognize the existence of two separate fossiliferous horizons and collect from each. He states this quite clearly in his paper of 1928.

Though both formations are very poorly exposed it is not difficult to distinguish one from the other. The Horn Valley Formation is richly fossiliferous in the upper part only and the Stokes Formation in the lower part only. The faunas are distinct; the younger contains bryozoa and crinoid stems absent from the other, which is much richer in nautiloids and trilobites.

DOUBTFUL ORDOVICIAN

Mereenie Sandstone

A quartz sandstone formation overlies the Larapinta Group with a regional unconformity and is succeeded, again with a regional unconformity, by the Pertnjara Formation. This unit was named Mereenie Sandstone by Madigan (1932a);".the red sandstone underlying the Pertnjara conglomerate. It forms the striking Mereenie Escarpment, which I traced back to Ellery's Creek, where the red wall on the north side of the curve in the creek just before the stream enters the conglomerate hills." As the spelling Mereenie has been officially adopted for mapping purposes, Madigan's spelling is here amended.

Where mapped the Mereenie Sandstone occurs as a single ridge quite noticeably redder than the ridges in the underlying Larapinta Group. This ridge extends from near Ellery Creek along Mereenie Range to the western boundary of the area. The formation was also mapped at Gosses Bluff Range, in Gardiner Range, and at Waterhouse Range. Madigan (1932a) believed that "the James Ranges are almost entirely built up of Mereenie Sandstone". These ranges were not mapped and only the northern edge fronting Missionary Plain was examined during the survey. However, it is clear that Madigan mapped the basal member of the Pertnjara Formation as Mereenie Sandstone in these ranges.

A section was measured through the Mereenie Sandstone about four and a half miles west from where Ellery Creek cuts through the formation. The basal 260 feet is hard to medium hard, red-brown, fine-grained quartz sandstone. It is succeeded by 640 feet of friable to medium hard, light red-brown, medium-grained sandstone. The higher member is crossbedded on a major scale with sets up to fifty feet thick and half a mile long; the lower member is not crossbedded. These two members were mapped from Ellery Creek to Goyder Pass.

The top of the Mereenie Sandstone is placed at the change from current-bedded fine-grained quartz sandstone to medium-grained feldspathic sandstone of the Pertnjara Formation.

The Mereenie Sandstone overlies the Larapinta Group. In the west it overlies Stokes Formation, apparently conformably. East of Ellery Creek it rests on Stairway Greywacke. In the Waterhouse Range it overlies Pacoota Sandstone on the north flank and Stairway Greeywacke on the south flank. The Mereenie Sandstone is thus unconformable in the eastern part of the area and apparently conformable in the western part.

The formation thickens towards the west. At Ellery Creek the thickness is 900 feet, at Finke River 1300 feet, and at Stokes Pass 2000 feet. No information is available to indicate convergence or divergence to the south.

No fossils have been found in the Mereenie Sandstone. The underlying Stokes Formation contains an early Upper Ordovician fauna, but only derived fossils have been found in the overlying Pertnjara Formation. These three formations are folded equally and as there is no evidence of erosional breaks between them in the western part of the area, large differences in age are unlikely.

The Mereenie Sandstone may be the youngest formation of the Ordovician System, or it may be younger; till more evidence is available it is regarded as possibly Ordovician (?Oum).

?SILURIAN

No Palaeozoic fossils younger than Ordovician have been found in the area. The unfossiliferous Pertnjara Formation is the youngest Palaeozoic rock unit mapped. It could possibly be Ordovician but is regarded tentatively as Silurian.

Pertnjara Formation

Tate & Watt (1896) described a post-Ordovician conglomerate which Chewings (1931) named "Pertnjara (Series) = the Post-Ordovician Conglomeratic Sandstone Formation". Madigan (1932a) used the same name. He wrote: "The Larapintine is definitely terminated above by ... conglomerate, containing derived fossils, reaching the remarkable thickness of 9,000 feet, and now named ... the Pertnjara Series". The name is here altered to Pertnjara Formation.

The Pertnjara Formation is the sequence of sandstone, quartz greywacke, and conglomerate that overlies the Mereenie Sandstone with a regional unconformity. It crops out along Ellery Creek and underlies most of Missionary Plain in a synclinal structure. Its upper limit is not known.

Along the southern front of the MacDonnell Ranges the Pertnjara Formation crops out as irregular rounded hills which contrast strongly with the linear ridges and valleys north of them. On Missionary Plain relief is reduced and outcrop is generally poor; much of the surface is covered by pebbles and boulders derived from the conglomerate. South of Missionary Plain the basal sandstone member of the Formation forms the surface of the anticlinal hills of the James Ranges.

A section was measured with chain and compass through the lower 10,500 feet of the Pertnjara Formation along Ellery Creek. The sequence and dip of the rest of the formation, about 11,000 feet thick, cropping out in the Missionary Plain Syncline were established in the field; and the thickness was calculated from outcrop width measured on air photographs.

The basal member consists of 1000 feet of dark red-brown, fine-grained to medium-grained, feldspathic quartz sandstone. Along the section line this contains scattered pebbles and pebble lenses. East of Ellery Creek it grades along the strike into a sandstone-pebble conglomerate. The sandstone pebbles are derived from the underlying Mereenie Sandstone. The sandstone matrix is similar to the Mereenie Sandstone, but contains more feldspar and silt; it is probably derived mainly from Mereenie Sandstone and partly from other rocks.

This member is succeeded by 250 feet of conglomerate containing chiefly cobbles and boulders of rocks from the Larapinta Group and including fossiliferous limestone cobbles derived from the Horn Valley Formation.

Quartz greywacke with interbedded pebble conglomerate in the upper part follows. This member is 1000 feet thick.

The first major conglomerate member succeeds these beds. It is more than 8,000 feet thick and contains pebbles, cobbles, and boulders in a sandy matrix, much of which is calcareous. Near the base, cobbles are largely of rocks from the Pertaoorrta Group and the Arumbera Greywacke. Higher in the section Upper Proterozoic rocks predominate, and toward the top most cobbles are of rocks from the Arunta Complex. In the top 1000 feet calcareous greywacke is interbedded.

Above the conglomerate lies about 3000 feet of rather soft, massive, calcareous greywacke, containing scattered pebbles and pebble bands throughout. Along the strike to the north-east this grades into coarse conglomerate (see Figure 5).

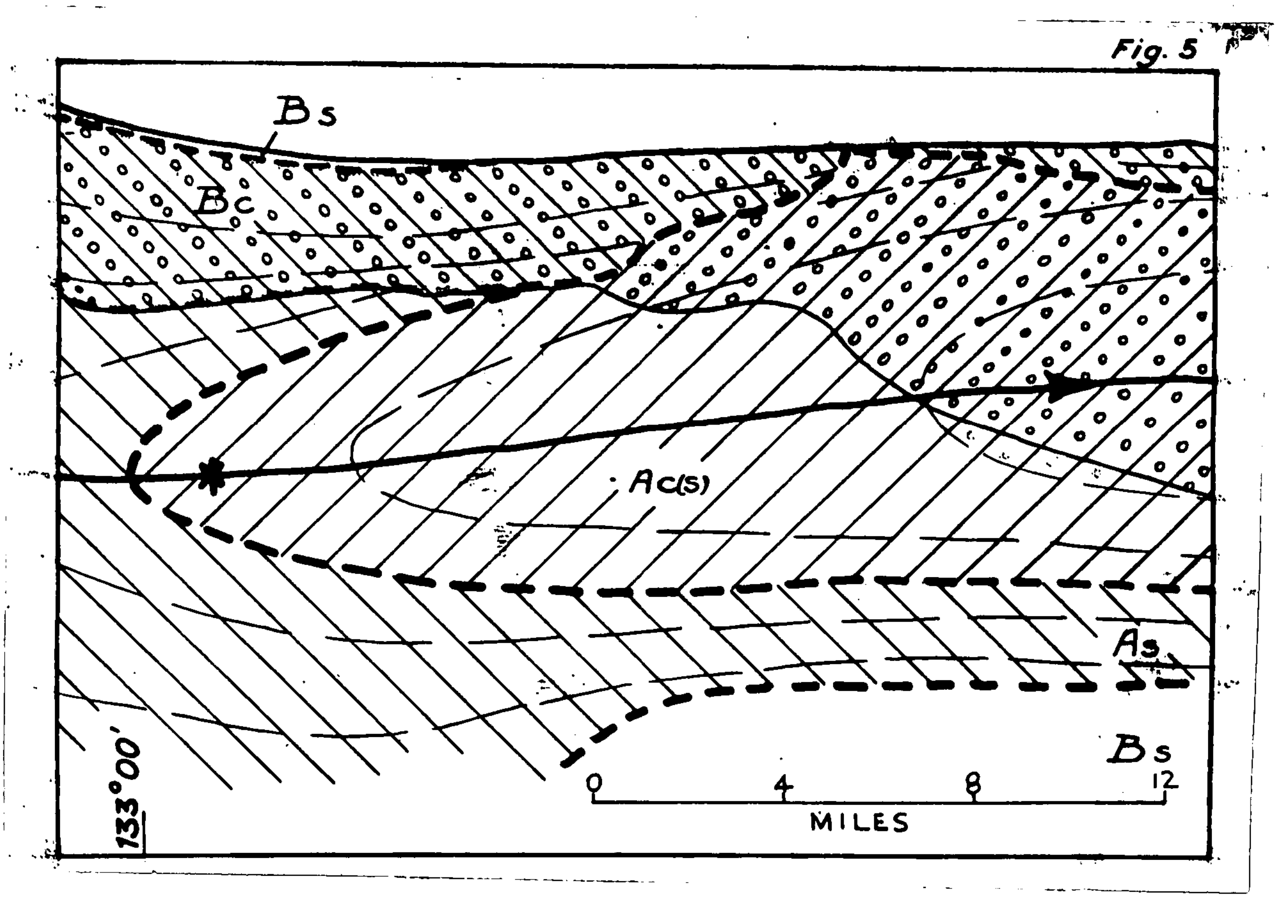

Figure 5 - Distribution of members of Pertnjara Formation.
First Cycle:

Bs-Basal sandstone, Bc - lower conglomerate
As-lower greywacke; Second Cycle:
Ac-upper conglomerate, Ac (s) - upper greywacke.

Another 8,000 feet of conglomerate crops out along the axis of the syncline before the highest beds preserved are reached. The cobbles and boulders of this upper conglomerate member are also in reverse stratigraphic order, though not as clearly as in the lower one.

The thickness of Pertnjara Formation measured from where the formation overlies the Mereenie Sandstone at Ellery Creek to the highest beds exposed in the trough of Missionary Plain Syncline is about 21,500 feet. Of this, 10,500 feet were measured by chain and compass. The section was measured from the axis of the Missionary Plain northward and along the axis to the east; it includes the thickest part of the wedge-shaped conglomerate deposits. The thickness of the Pertnjara Formation probably does not exceed 10,000 feet in the trough of the syncline.

Two main cycles of conglomerate deposition can be recognized. Of these the lower contains a complete reverse sequence from cobbles of Mereenie Sandstone at the base to cobbles and boulders of rocks of the Arunta Complex at the top.

The basal unit of the second cycle of deposition in the section is 3000 feet of pebbly greywacke along the axis of the syncline. These beds become more pebbly along the strike till on the northern flank of the syncline they are cobble and boulder conglomerates.

These relationships are shown in Figure 5. The distribution of the coarser sediments indicates a source north and east of the syncline and the sequence reflects three phases of deposition.

In the initial phase the basal sandstone member was deposited. The source area was relatively low and the Mereenie Sandstone supplied most of the material. The second phase followed further uplift of the source area. Erosion of the older sedimentary sequence accompanied deposition of the lower conglomerate member along the northern margin of the syncline and of greywacke farther from the margin. Further uplift of the source area led to deposition of the upper conglomerate member in the north-eastern part of the syncline and its accompanying greywacke farther west.

The Pertnjara Formation is conformable, or very nearly so, with the Mereenie Sandstone along its northern margin west of Ellery Creek. East of here it is unconformable and rests on an erosion surface which transected the Larapinta Group and exposed the Jay Creek Limestone. The strikes of beds in the Pertnjara Formation are roughly parallel to this surface so that successively higher beds of the formation overlap the older rocks. Probably the strandline during the first phase of Pertnjara deposition was just east of Ellery Creek and was not much farther east during deposition of the lower conglomerate member. During the third phase, the deposition of the upper conglomerate member, the strand line had moved east of the mapped area at least as far as the meridian of Alice Springs.

The Pertnjara Formation is the youngest known formation of the Palaeozoic succession; the only known overlying deposits are near horizontal Mesozoic and Tertiary beds. The only fossils found in the formation are in boulders derived from older Palaeozoic and Proterozoic beds. Thus its age can only be estimated indirectly. The Pertnjara Formation has been folded with the Larapinta Group and Mereenie Sandstone. The apparent absence of major erosional or structural unconformity in most of the mapped area suggests that it was deposited soon after those formations. The Pertnjara could possibly be Ordovician, but is more likely to be Silurian or younger.

CRETACEOUS

Siltstone, sometimes with pebbly and silty sandstone at the base, forms low mesas on the intermontane plain along Arumbera Creek and toward the Finke River. Another outcrop is mapped on Missionary Plain east of the Hugh River.

Up to forty feet of siltstone containing bands of sand up to an inch thick occurs below the leached and partly silicified cap of the mesas. The leached and silicified siltstone looks like the pallid zone of a laterite.

These beds, which are not folded, unconformably overlie Arunta rocks and units of the Proterozoic and Palaeozoic succession. No fossils have been found in them where mapped.

Apart from the outcrop on Missionary Plain these beds have been recognized only on the intramontane plain from Mt. Sonder westward along Arumbera Creek towards Burt Plain. The largest outcrops are on the divide between the Finke drainage and Arumbera Creek. Scattered outcrops continue down the valley of Arumbera Creek until, near Burt Plain, they are covered by soil and alluvium. Thus the beds appear to be continuous with the sediments which underlie Burt Plain.

Drillers logs of bores drilled on Burt Plain along Sixteen Mile Creek show that more than 500 feet of sediment is present above schist of the Arunta Complex. These beds are chiefly argillaceous, with interbeds of silty sand, and commonly, a basal conglomerate. In samples from a bore along the southern edge of Burt Plain Crespin (1948) recognized "minute spherical siliceous tests of radiolaria belonging to the group Spumellaria". She regarded the rock, a radiolarite, as Lower Cretaceous.

The beds mapped along Arumbera Creek are therefore probably also Cretaceous, and may be marine or marginal to the Cretaceous sea which deposited the radiolarite at Burt Plain.

?TERTIARY

Gravel beds occur close to high quartzite ridges near Mt. Razorback, Mt. Sonder, Mt. Giles, and south of Heavitree Range between Finke River and Jay Creek. Similar beds are also present along the northern margin of Missionary Plain.

The gravel is an unconsolidated and unlithified aggregation of pebbles, cobbles, and boulders with a matrix of soil. That on Missionary Plain derives its cobbles from the conglomerate in the Pertnjara Formation, but the others obtain cobbles and boulders directly from the adjacent ridge. The surface of the gravel beds - piedmont deposits - slopes away from the adjacent ridge.

Scarps bound the outcrops of these gravels in the ranges and they are now being dissected. They probably formed during the Tertiary* and were originally more extensive.

The gravel beds along Missionary Plain are not all bounded by scarps. Probably some areas of younger conglomeratic wash have been mapped in the unit here.

Lake Limestone

About two miles west of Hamilton Downs Homestead is an outcrop of chalcedonic limestone. About thirty feet of siliceous limestone is exposed in the scarp of a low mesa above Burt Plain. The mesa is nearly two miles long and a mile wide. No similar outcrops were mapped.

No fossils were found in the limestone, which is thought to have formed in a Tertiary lake. It is correlated with the Arltungan Beds of Madigan (1932b) because of its lithology, topographic position, and postulated lacustrine origin.

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* M.A. Condon considers that as these deposits are not deeply weathered they were most probably formed during the Pleistocene episode of strong erosion that is related to the great variations in climate which in Australia, accompanied the glaciations of the northern hemisphere.

QUATERNARY

The superficial deposits in the area have not been mapped separately. Residual soil, wash, alluvium, and sand are included in the mapping unit "Superficial Deposits".

Residual soil is not extensive in the area, though skeletal soils have developed on parts of the Arunta Complex and on a few valley floors in the ranges. Wash, as a thin veneer of sand, gravel, and silt, covers most of the gently sloping areas between scarps of ridges and main drainage channels. Alluvium is not widely distributed and occurs only along the larger streams, especially where they cross Missionary Plain.

A sand sheet with low dunes, fixed by vegetation, covers most of Missionary Plain west of the Finke River. The sand is red to yellow. The sand sheet and ridges possibly developed during the Pleistocene.

STRUCTURE

The sediment-filled depression south of the Archaean rocks has been called the Amadeus Geosyncline by Hossfeld (1954) and the Amadeus Basin by Condon et al (1958, Plate 2). The Upper Proterozoic and Lower Palaeozoic sediments which fill the trough are more than 35,000 feet thick. They occupy an area at least 300 miles long and generally between 100 and 160 miles wide.

Only a small part of this area has been mapped for this report so that only limited information about the structure of the depression and the nature of the sediments contained in it is available. The name Amadeus Geosyncline is used in this report without implying any particular depositional environment or post depositional history.

The area here mapped is about 90 miles along the length of the Geosyncline and about 30 miles from its northern margin towards the centre. The position of the area with reference to the Geosyncline is shown in Figure 1. The Geosyncline contains Upper Proterozoic and Lower Palaeozoic sediments which were deposited in shallow water and aggregate over 35,000 feet in thickness, but no igneous rocks.

In the main belt of outcrop of Upper Proterozoic to Ordovician sediments extending from Jay Creek to the western side of the area mapped the regional dip is southerly. From Jay Creek to near the Finke River it ranges from near vertical, with local overturnings, in the Heavitree Quartzite to about 60° south at the base of the Pertnjara Formation. Near the

Finke River the dip steepens in the higher beds; the lower 4,000 feet of the Pertnjara Formation is overturned and the underlying Larapinta Group is vertical. About ten miles further west about 15,000 feet of beds from the upper part of the Pertatataka Formation to the lower part of the Pertnjara Formation are overturned. To the west the dip gradually decreases, and approaching the western edge of the area mapped the strike swings towards the south-west as the dip falls below 30° south-east.

North of the Finke Gorge the Bitter Springs Limestone is irregularly and intricately folded. Two narrow west plunging anticlinal noses occur in the Heavitree Quartzite, which then continues around a larger west-plunging nose which forms the western end of Ormiston Pound. The Chewings Range meta-quartzite, which has here a dominant north dip ranging from 35° to 70°, has schist and gneiss of the Arunta Complex to both north and south. From the Finke River the Heavitree Quartzite continues to Mt. Razorback and has another west-plunging nose at Mt. Sonder. West of Mt. Razorback the quartzite occurs only as isolated shattered blocks and no Bitter Springs Limestone was found in this area though it is present near Haast Bluff (N.O. Jones, personal communication).

The only other places where Larapinta Group or older rocks were mapped are in the south-west corner of the sheet and at Gosses Bluff Range. At the former locality the complete sequence from Bitter Springs Limestone to Mereenie Sandstone occurs south-west of a large fault trending south-east, which continues beyond the area mapped towards Areyonga. The beds dip south-west at up to 40°. Gosses Bluff Range has the geometry of a diapiric structure.

The Pertnjara Formation occupies a syncline which extends from the western border of the area almost to the railway line south of Alice Springs. The deepest part of this syncline is east of the mapped area and its axis could not be mapped west of Ellery Creek.

The marked angular conformity in both dip and strike of each formation to the underlying one proves the absence of any widespread orogeny between the times of deposition of the Heavitree Quartzite and the Pertnjara Formation. It is concluded that repeated epeirogenic movements, giving rise to warping rather than faulting, gradually deepened the basin of accumulation and kept elevated the area being eroded. After the complete sequence was laid down the beds along the northern edge of Missionary Plain assumed a steeper dip. The size of the area overturned shows that major stresses operated. The absence of much severe jointing and faulting in the sediments indicates that the basement transmitted the stress.

Marshall & Narain (1954 p. 51) postulate a major crustal failure to explain an anomaly recorded on their gravity traverse through Alice Springs; both the northern and southern flanks of the postulated horst coincide with outcrops of younger sediments trending west. It may be significant that the distance between the quartzite of the Chewings Range and the Hann Range is very close to the distance of 85 kilometres calculated by Marshall & Narain for the distance between such crustal fractures.

Faults

Faulting is concentrated in the northern part of the area mapped, where the sediments dip most steeply. At Jay Creek and north of Finke Gorge the Heavitree Quartzite is offset, probably by transverse faults. The overlying Bitter Springs Limestone has acted as a "shock absorber" and has taken up all the stress by becoming intricately folded so that overlying formations have not been affected.* Two similar transverse faults slightly displace the Pacoota Sandstone near the west boundary of the area.

Between Ellery Creek and the Finke River the Heavitree Quartzite is repeated probably by strike faulting. These faults are difficult to map and are usually seen in section only where creek gaps provide suitable exposures. Several of these faults are exposed in the creek which flows through Serpentine Gorge about ten miles west of Ellery Creek. Similar strike faulting has not been recognised higher in the section, though a small bedding-plane fault occurs near the base of the Pacoota Sandstone at Finke Gorge. Mawson & Madigan (1930) reported a coarse conglomerate here, but Madigan (1932a) considered it a crush breccia and not a conglomerate. The Pacoota Sandstone dips vertically and the breccia is conformable. Lithologically, boulders of the breccia are indistinguishable from adjacent quartzite beds and the matrix of the breccia is mineralogically the same. One of the quartzite beds bounding the breccia

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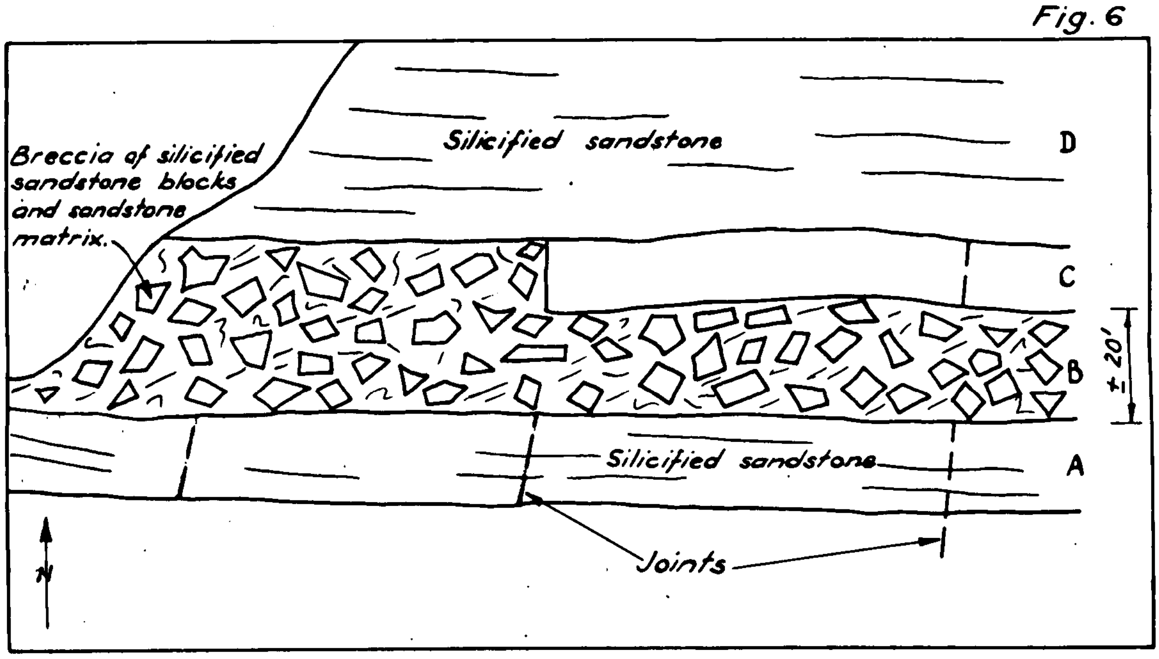
* The intricate folds of the Bitter Springs Limestone have random directions of axial surfaces which are commonly curved. The folding is not related to tangential stresses but to free movement akin to slump folding. The relation of the Bitter Springs Limestone to the diapirs (p. 43) indicates that the formation became fluid, probably because of the great thickness of sediments above, and flowed particularly into places where the vertical stress was reduced - M.A. Condon.

was seen to stop abruptly at a joint, with breccia present on the other side of the joint, as indicated in Text figure 6. One of the authors G.E. Prichard, considers that the breccia was formed by bedding-plane slip which accompanied the development of the present vertical attitude of the Larapinta Group and the overturning of the lower Pertnjara Formation. T. Quinlan is convinced that the breccia was formed by slumping before the beds were lithified.

Fig. 6



Heavitree Quartzite at Mt. Sonder. West of Mt. Razorback the Heavitree Quartzite occurs only as isolated blocks and Bitter Springs Limestone is known only at Haasts Bluff. This distribution is due to extensive faulting which affects these three units, although higher beds are not similarly dislocated; the fault system cannot be mapped for lack of outcrop.

The fault mapped in the south-western corner of the area continues south-east towards Areyonga, beyond which it dies out in an anticlinal nose. At the southern boundary of the area the stratigraphical displacement across it is approximately 15,000 feet. This fault, which A.D.M. Bell and J. Firman (Monthly Reports, Alice Springs Resident Geologist) considered a thrust, continues westward towards where Chewings (1935) shows his Deering Fault. Only a small portion of its length lies within the area mapped. It is probably a break thrust (Billings, 1942).

The Chewings Range is in very rugged country and little fieldwork could be done along it in the time available. In general the quartzite forming the range dips north at from 35° to 70°, but despite careful search at several localities no evidence of overturning was found.

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Figure 6 - Sketch plan of breccia in Pacoota Sandstone, Finke Gorge.

As the structures at Gosses Bluff Range and Goyder Pass are essentially folds, the faults mapped in those areas will be discussed with the folding later in this report.

An inlier of Arunta Complex was mapped south of the Heavitree Quartzite at Mt. Sonder. West of Mt. Razorback the Heavitree Quartzite occurs only as isolated blocks and Bitter Springs Limestone is known only at Haasts Bluff. This distribution is due to extensive faulting which affects these three units, although higher beds are not similarly dislocated; the fault system cannot be mapped for lack of outcrop.

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The Chewings Range is in very rugged country and little fieldwork could be done along it in the time available. In general the quartzite forming the range dips north at from 35° to 70°, but despite careful search at several localities no evidence of overturning was found.

From Standleys Chasm to Ellery Creek strike faults, each repeating only a few hundred feet of quartzite, are sufficiently numerous to double the width of outcrop of the quartzite of the Chewings Range. If the quartzite of the Chewings Range is part of the Arunta Complex its distribution and relationships require no structural explanation in a paper which does not discuss the structure of the Archaean rocks. We believe the Chewings Range is composed of metaquartzite equivalent to the Heavitree Quartzite: it could have formed in similar fashion to that postulated for the formation of the north-eastern limb of Mt. Sonder (Figure 7). If this is correct the southern thrust should crop out between the Chewings Range and the Heavitree Range; it has not been identified on the ground or on air photographs.

No evidence for more than one period of faulting was found. Faulting probably did not long precede the beginning of deposition of the Pertnjara Formation, and continued until vertical and overturned dips developed after the Pertnjara Formation was laid down.

<u>Folds</u>

A series of anticlinal folds each ten or more miles long and about four miles wide trends west and north-west throughout the James Ranges south of the area mapped. The only large fold structure mapped is the syncline in the Pertnjara Formation. Smaller fold structures include the diapir-like structures at Gosses Bluff Range and Goyder Pass and several west-plunging anticlinal noses of Heavitree Quartzite which occur between Ellery Creek and Mt. Sonder.

The large syncline in the Pertnjara Formation is here named the Missionary Plain Syncline; the greater part of its area has long been called Missionary Plain. From a little farther west than the western boundary of Hermannsburg Four Mile Sheet (Long. 132°00'E.) the Missionary Plain Syncline extends about 130 miles to almost due south of Alice Springs. Throughout the area mapped the plunge is eastward; from the west to Ellery Creek the plunge is very slight; from Ellery Creek to the eastern edge of the area it is about 4°. The syncline is asymmetric, with a gently dipping southern limb, whose dip rarely exceeds 15°, and a steeply dipping northern limb, where the dip is usually above 40° and the beds are overturned near the Finke River. Conglomerate beds are both thicker and coarser north of the axis. It is suggested that a renewal of the tectonic forces which initiated the sedimentation of the conglomerate caused the folding of these beds and also formed the steep dips along the northern limb.

On only one of the west-plunging anticlines does Bitter Springs Limestone occur on the north flank. This is the narrow gently-plunging structure which extends about one mile west of Ormiston Creek south of Ormiston Pound. On all other noses of Heavitree Quartzite the Bitter Springs Limestone is present on the southern limb only.

Mt. Sonder and the western margin of Ormiston Pound are the largest of the anticlinal noses developed in the Heavitree Quartzite. Smaller noses occur east of Ormiston Creek. All these plunge west.

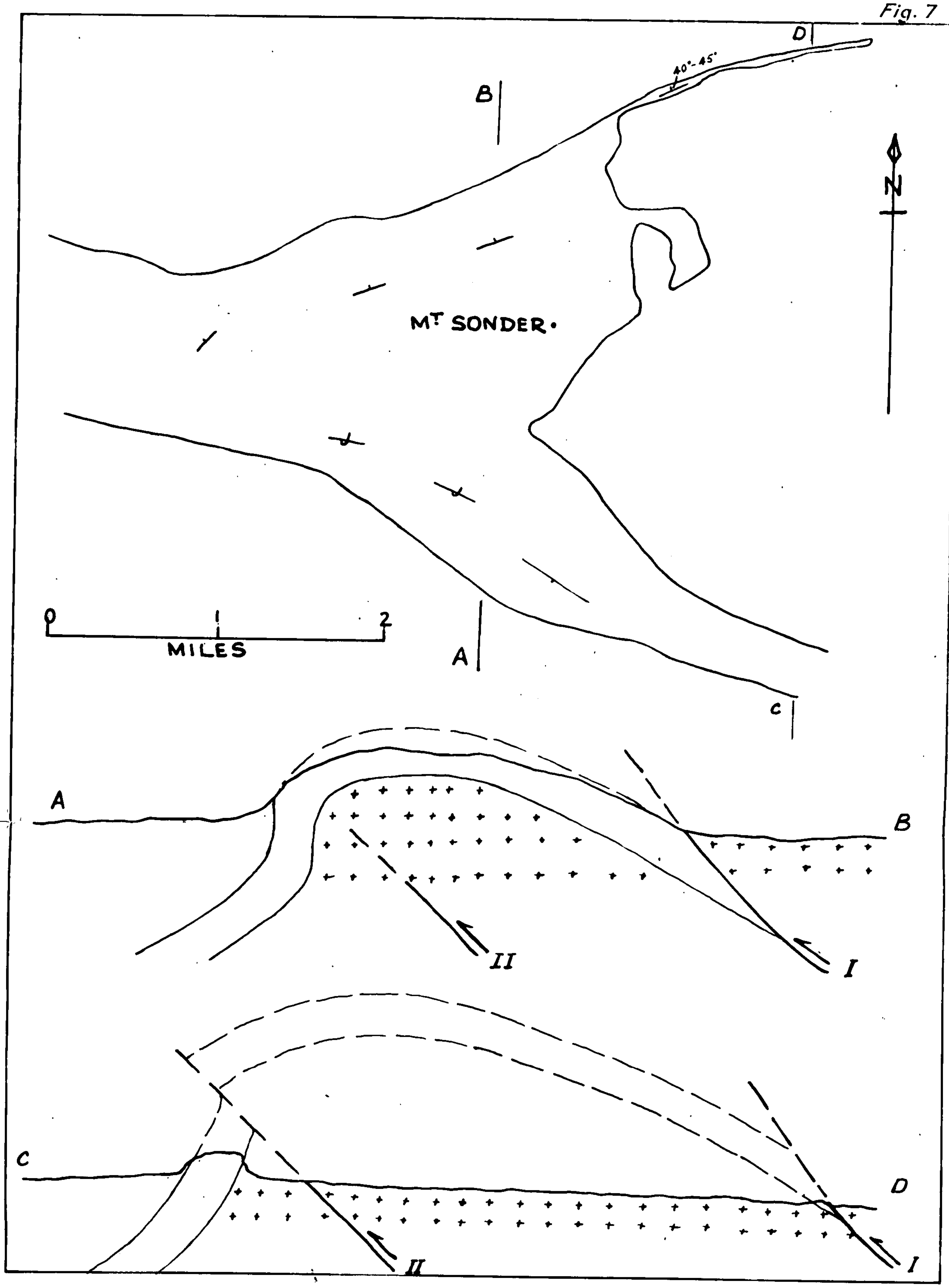
The northern limb of the Mt. Sonder anticline contains less than half the thickness of Heavitree Quartzite that is present on the southern limb. The northern limb dips north at about 40° and is approximately conformable with the foliation in the gneiss of the Arunta Complex on either side of the quartzite. The unconformity between the Heavitree Quartzite and the Arunta Complex has been folded equally with the individual beds of quartzite.

The plan of Mt. Sonder nose in Figure 7 shows the relationship of the Heavitree Quartzite to Bitter Springs Limestone on the south and to Arunta Complex on the north and in the core. The relationships shown in Section AB were seen from east of Mt. Sonder, except for the down-dip extensions of the Heavitree Quartzite on each limb and faults I and II.

These faults are postulated to explain the observed relationships. The fault marked I on the sections is a low-angle north-dipping thrust which has caused gneiss of the Arunta Complex to rest on the Heavitree Quartzite of the northern limb. The movement on the other fault, marked II on the sections, is decreasing to the west and on section AB has arched but not fractured the Heavitree Quartzite. Tilting to the south and erosion after the faulting has left the present outcrop. The faults are only postulated as a possible explanation of the Mt. Sonder structure - they were not observed in the field.

A similar explanation is suggested for the structure of the western end of Ormiston Pound, where the Heavitree Quartzite also dips north into the Arunta Complex. An increase in the throw of the southern fault, or the existence of more than one fault of this type, east of Ormiston Pound could explain the presence of north-dipping Heavitree Quartzite in the Chewings Range and, where they die out against the Heavitree Range at their western ends, the repetition and offsetting to the north of the Heavitree Quartzite between Ellery Creek and Finke River.

Fig. 7



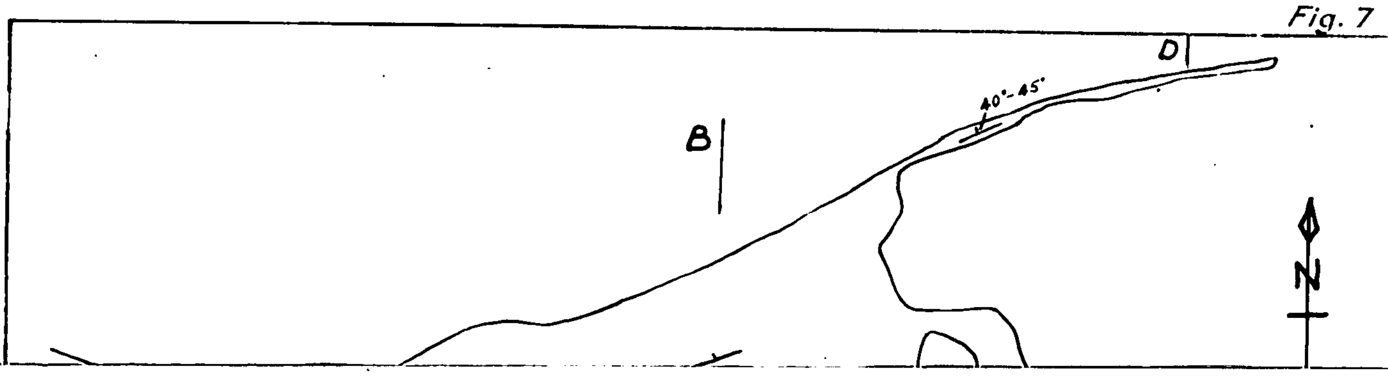


Figure 7 - Postulated structure, Mt. Sonder.

All faulting and folding in the area probably occurred during and shortly after the deposition of the Pertnjara Formation; yet, apart from the Missionary Plain Syncline and the two diapirs, no fault or fold structures were recognized in beds younger than the Bitter Springs Limestone.

The absence in these sediments of close jointing, cleavage, and similar features shows that the compressional stresses have been transmitted mainly in the basement (Arunta Complex). Dragfolding, close jointing, and occasional recrystallization along the Heavitree Range indicate that stress was also present in the Heavitree Quartzite. Text-figure 4 shows these features at Ellery Creek Big Hole.

The stresses were not transmitted through the thick incompetent Bitter Springs Limestone but were dissipated by folding within that formation. Throughout its outcrop the lower part of the formation is folded, and where the Heavitree Quartzite is folded or faulted the thickness and intensity of folding increases. Thus most of the formation is affected near Jay Creek and the whole formation is intricately folded from east of Ormiston Creek to the end of outcrop near Mt. Razorback. These are the areas of structural disturbance in the Heavitree Quartzite, but the Bitter Springs Limestone has absorbed the stresses and insulated the overlying sequence from their effects.

Gosses Bluff Range has the geometry of a diapiric structure. The Goyder Formation forms the central core and the Mereenie Sandstone and the lower member of the Pertnjara Formation constitute the rim. The siltstone and interbedded limestone of the core are irregularly folded, but the dip does not appear to exceed 20°. The hard competent arenites which encircle the core dip outwards at 60° to 70° and are transected by radial and tangential faults of small throw. The resultant structure is subcircular in plan with a rim about two miles diameter. Dip in the Pertnjara Formation decreases rapidly and is less than 20° two miles east of the centre. The regional dip near the axis of the Missionary Plain Syncline where Gosses Bluff Range occurs is very low.

Near Goyder Pass all the beds from the Bitter Springs Limestone to the lower Pertnjara Formation are approximately vertical. The outcrop here shows a section through a diapiric structure, bigger than Gosses Bluff Range and about 4 miles across, which had been formed before the beds were tilted into their present position. It shows clearly that the Bitter Springs Limestone is the mobile formation. The lensing out of the lower member of the Mereenie Sandstone against the domed Larapinta Group suggests that the dome was rising while the Mereenie Sandstone was being deposited. The marked thinning of the lower member of the Pertnjara Formation and the fact that the upper boundary of this member is not domed shows that the dome had ceased to develop when this unit was deposited.

It is concluded that both the Gosses Bluff Range and Goyder Pass structures are true diapirs, that the Bitter Springs Limestone is the mobile formation, and that these structures developed during the period of tectonism which formed the steep dips along the northern flank of the Missionary Plain Syncline. Probably the location of the structures, especially that at Goyder Pass, was controlled by earlier tectonic effects not now apparent, and the continued tectonic force caused the incompetent Bitter Springs Limestone to flow. The Gosses Bluff Range structure is somewhat younger or continued developing longer than that at Goyder Pass.

GEOLOGICAL HISTORY

In Upper Proterozoic time the Heavitree Quartzite was deposited as a broad sheet on a mature erosion surface of crystalline metamorphic rocks of the Arunta Complex. Conditions remained stable and the Bitter Springs Limestone was deposited in an extensive shallow sea which received only fine detritus from the land and in which algae flourished.

A part of these deposits was uplifted and the land surface glaciated. The Areyonga Formation was deposited. After the glaciation the basin continued to subside slowly and the Pertatataka Formation was deposited. An increase in the rate of sedimentation about the end of Upper Proterozoic time produced the Arumbera Greywacke.

The Cambrian Period was characterized by stable conditions and lutaceous and carbonate rocks were formed. Algae were again common and trilobites appeared. Relief increased before the end of this period and the lower part of the Pacoota Sandstone was deposited during the Cambrian.

The Ordovician Period succeeded the Cambrian without change in sedimentation and the upper part of the Pacoota Sandstone is Ordovician. The rest of the Larapinta Group was deposited in an area of slowly continuing subsidence. Thick arenaceous formations alternate with lutaceous deposits which are thinner in the east than in the west. Towards the end of the Ordovician Period upwarping in the east caused erosion of part of the Larapinta Group before the Mereenie Sandstone was laid down. This formation is conformable on the Larapinta Group in the west. The diapir at Goyder Pass developed during the deposition of the Mereenie Sandstone.

At the end of the Ordovician or later a renewal of uplift in the north-east caused more erosion there and deposition of the Pertnjara Formation. The major faulting and folding of the area occurred during and after the deposition of this formation. The diapir at Gosses Bluff Range is also younger than the Pertnjara Formation.

The main elements of the stratigraphy and structure were complete at the end of the orogeny. During the long period of erosion which followed the relief produced by the orogeny was planed off and south-flowing streams developed. Uplift caused entrenchment of these streams and the development of low level plains and valleys on the more easily eroded formations. The harder beds remained as ridges whose flat tops indicate the level of the surface on which the south-flowing drainage developed. The surface was then almost the same as it is today.

The great Lower Cretaceous marine transgression reached the area and covered the plains and valleys. The ridges and higher areas were probably above sealevel and a thin cover of lutaceous sediments was deposited between them.

The regression of this sea left the area dry land and it has remained subject to subaerial erosion ever since. Erosion has not been vigorous and its main result has been to remove most of the Cretaceous sediments.

ECONOMIC GEOLOGY

No important mining or quarrying has ever been carried out in the area mapped. Prospectors have investigated the igneous and metamorphic rocks of the Arunta Complex for gold, copper, and other minerals without marked success. At two localities south of the area copper deposits have been investigated: one of these is associated with the Areyonga fault, and the other is in the Waterhouse Range, where copper is present, but below ore grade, in several hundred feet of beds at the top of the Pertaoorrta Group.

Petroleum Prospects.

A sedimentary sequence well over 30,000 feet thick is exposed in the Western MacDonnell Ranges. This sequence includes possible source beds, reservoir beds, and cap rock for oil and natural gas.

Possible source beds include Bitter Springs Limestone (Upper Proterozoic), Jay Creek Limestone (Middle Cambrian), Horn Valley Formation (Lower or middle Ordovician), and Stokes Formation (Middle or Upper Ordovician).

Possible reservoir beds include part of Areyonga Formation, most of Larapinta Group, Mereenie Sandstone, and part of Pertnjara Formation. The Heavitree Quartzite, if not silicified down dip, would also be permeable, and the Bitter Springs Limestone and Jay Creek Limestone could contain appreciable quantities of oil in joint or solution openings.

Beds capable of acting as cap rock are plentiful in the Upper Proterozoic and Cambrian sequence but are poorly represented in the Ordovician. Part of the Pertnjara Formation is sufficiently impermeable to prevent the upward escape of oil or gas.

Nowhere in the area mapped were seepages of oil or gas located, nor are they reported from adjacent areas. However, in 1956 petroliferous gas was discovered during bore sinking for water near Amaroo Station. This is about 150 miles north-east of Alice Springs, that is, roughly 200 to 250 miles from the area mapped. The beds being drilled were Middle Cambrian limestone and shale.

In most of the area mapped the dips exceed 60° and accumulations of oil or gas could not be expected. However, the diapir of Gosses Bluff occurs in a gently dipping area. No indications of seepages were found here.

The chief significance of this area in the search for oil in Lower Palaeozoic rocks of Central Australia lies in the stratigraphic information so much more readily obtainable from this steeply dipping area than from the surrounding areas of lower dip and poorer outcrop.

Metallic Ores

In the metamorphic rocks of the Arunta Complex north of the Heavitree Ridge copper stainings occur on the rocks at many places. None of those examined appeared significant. No other minerals of possible economic value were noted during the mapping. No records of prospecting in this country have been found, but local residents state that prospectors have examined it at various times and, in addition to the secondary copper minerals, have located traces of gold. However, no record or report of any production of metallic ores from the area is known.

Geochemical tests for copper, nickel, and zinc were made throughout the section measured along Ellery Creek. No significant anomalies were located though the sediments contained more copper than the average for similar sediments.

Water

Most of the area mapped is used for cattle grazing at present. The number of stock which can be run is limited by the paucity of permanent water supplies. Nearly all the natural permanent water holes are deep in the rugged ranges and not near the extensive grazing country.

Bores and wells have been moderately successful in obtaining supplies of stock water from near stream channels. Several bores in the Bitter Springs Limestone have yielded reasonable supplies of fair quality stock water. Other boring in the Arunta Complex and the Pertnjara Formation on Missionary Plain have not been so successful. Recent efforts to provide supplies for stock have largely consisted of constructing earth tanks. This is the surest and most economical method of providing water on the areas of better grazing.

Building Stone

Ample supplies of building stone and stone suitable for crushing for aggregate are available.

Within recent years "chocolate sandstone" has been obtained from the Arumbera Greywacke and used as a building stone in Alice Springs. Both Bitter Springs Limestone and Heavitree Quartzite have been quarried and crushed for road and construction aggregate. These operations are sited near Alice Springs and it is unlikely that similar quarrying will commence in the area mapped as ample supplies are available nearer to Alice Springs.

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GEOLOGICAL MAP · PARTS OF HERMANNSBURG AND HENBURY 4-MILE SHEETS

GEOLOGICAL MAP · SOUTHERN HALF OF HERMANNSBURG 4-MILE SHEET

PLATE 2

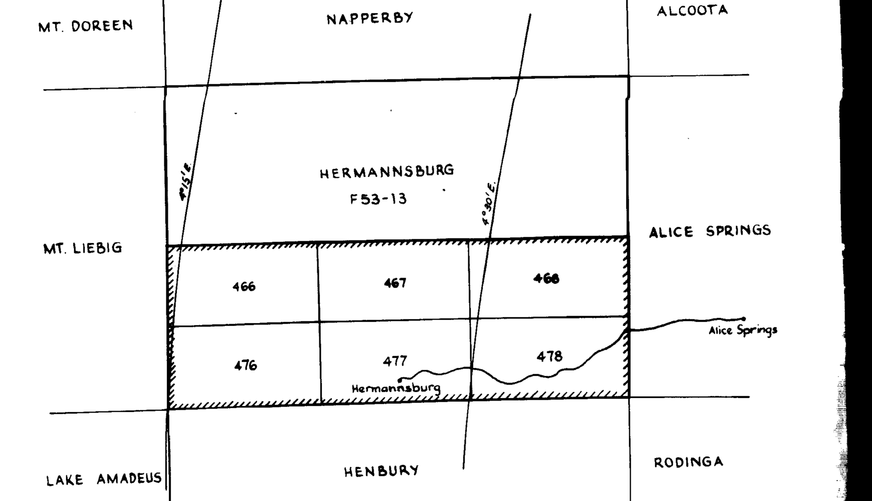
Reference

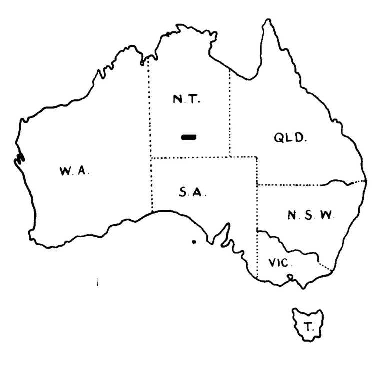
QUATERNARY		Superficial deposits, sand, alluvium.
TERTIARY		Gravel and conglomerate, and limestone
MESOZOIC		Sandstone and siltstone.
SILURIAN ?	Pertnjara Formation	Conglomerate, pebbly quartz greywacke and quartz greywacke.
SILURIAN OR ORDOVICIAN ?	Mareenie Sandstone	Quartz sandstone.
ORDOVICIAN	Larapinta Group	
	Stokes Formation	Siltstone, thin limestone beds, shale, silty fine greywacke.
	Stairway Greywacke	Quartz greywacke and quartz sandstone.
	Horn Valley Siltstone	Siltstone containing thin limestone beds and quartz greywacke.
	Pacoota Sandstone	Quartz sandstone and quartz greywacke.
CAMBRIAN	Pertaoorrta Group	
	Goyder Formation	Quartz greywacke, algal and oolitic limestone, quartz sandstone.
	Jay Creek Limestone	Dolomitic limestone with minor shale.
	Hugh River Shale	Shale with limestone and siltstone.
CAMBRIAN OR PROTEROZOIC	Arumbera Greywacke	Felspathic quartz greywacke and siltstone.
UPPER PROTEROZOIC	Pertatataka Formation	Siltstone, quartz greywacke, minor limestone.
	Areyonga Formation	Quartz greywacke, tillitic siltstone, conglomerate.
	Bitter Springs Limestone	Dolomitic limestone, shale, siltstone.
	Heavitree Quartzite	Quartzite, quartz greywacke.
ARCHAEAN	Arunta Complex	Gneiss, granite, schist.

- Geological boundary, position accurate.
- Geological boundary, position approximate.
- Geological boundary, concealed.
- Dip, measured.
- Dip, overturned.
- Dip 15° } Air photo interpretation.
- Dip, 15°-45° } Air photo interpretation.
- Dip 45° } Air photo interpretation.
- Trend lines.
- Cleavage, measured.
- Syncline, approximate position.
- Syncline, overturned, position approximate.
- Anticline, position approximate.
- Anticline, overturned, position approximate.
- Fault, position accurate.
- Fault, position approximate.
- Type section locality.
- Bore.
- Bore with windpump.
- Dam or tank
- Waterhole
- Landing ground
- Track

INDEX TO ADJOINING 4 MILE SHEETS

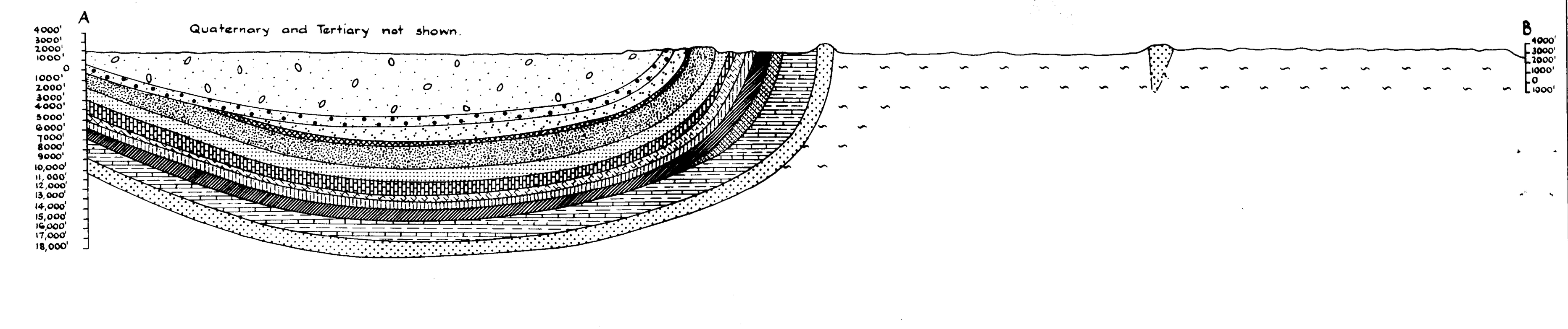
Showing Magnetic Declination

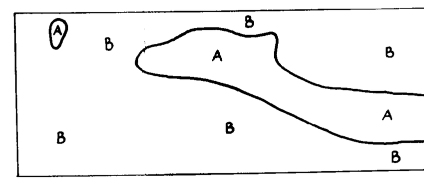




Section A-B

Natural Scale





A - Many traverses
B - Traverses and photo interpretation

GEOLOGICAL RELIABILITY DIAGRAM