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BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

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THE GEOLOGY OF THE HENBURY 1:250,000 SHEET AREA, AMADEUS BASIN, NORTHERN TERRITORY.

by

L.C. Ranford and P.J. Cook

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THE GEOLOGY OF THE HENBURY 1:250,000 SHEET AREA, AMADEUS BASIN, NORTHERN TERRITORY

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SUMMARY

During the winter of 1963 the Henbury 1:250,000 Sheet area was geologically mapped by means of reconnaissance traverses from a base camp near Tempe Downs airstrip.

The oldest rocks exposed in the area belong to the Upper Proterozoic Bitter Springs Limestone which is overlain, in the north-west corner of the area, by at least 15,000 feet of Upper Proterozoic, Cambrian, Ordovician and undifferentiated Palaeozoic sediments.

The Upper Proterozoic sediments are thickest in the south-west corner of the area and include both marine and aqueoglacial sediments. In late Upper Proterozoic times a sequence consisting largely of arenites was deposited in the south while lutites and carbonates were deposited in the north.

The Palaeozoic section is thickest in the north-west quadrant and includes marine, transitional and continental sediments. During the Cambrian there was very little sedimentation in the south-west part of the area but a thick sequence of mainly transitional sediments was laid down in the north-west quadrant and a thick sequence of marine sediments was deposited over the eastern half of the area. During the Ordovician, a thick layer of predominantly shallow water, marine arenites and lutites with minor carbonates was deposited conformably on the Upper Cambrian sediments in the northern half of the area, while in the southern half of the area, a thinner sequence of similar sediments was laid down disconformably on the Upper Cambrian sediments. The break in sedimentation in the southern area occurred during the late Upper Cambrian and early Lower Ordovician.

The undifferentiated Palaeozoic sediments rest both conformably and unconformably on the older sediments and thin from north to south.

They are mostly continental deposits but include some marine and transitional sediments.

Thin sequences of Mesozoic and Tertiary sediments were deposited unconformably on the Palaeozoic sediments after a long period of erosion. The Mesozoic sandstones and claystones are tentatively correlated with marine sediments of possible Jurassic age on the Finke Sheet area. The Tertiary sediments, include conglomerate, sandstone, shale and limestone; they contain a freshwater fauna in places.

There is evidence for six periods of folding or warping on the Henbury Sheet area but only two major orogenic episodes have been recognised. The first of these is correlated with the 'Petermann Ranges Folding' and occurred in late Upper Proterozoic or early Lower Cambrian times. The second has been called the 'Amadeus Basin Folding' and probably took place during the Upper Devonian and Lower Carboniferous. The stresses which caused both periods of folding appear to have been parallel but it is thought that the main compressional force came from the south during the 'Petermann Ranges Folding' and from the north during the 'Amadeus Basin Folding'. The folds which resulted from these stresses trend west-north-west; the earlier folds have sharper troughs and are smaller (shorter) than the later ones. The folds are probably supratenuous and have complex cores (possibly due to presence of evaporites within the Bitter Springs Limestone and Chandler Limestone Member of the Pertaoorrta Formation). It is suspected that there is a decollement between the Bitter Springs Limestone and the underlying rocks.

Seven major longitudinal thrusts and numerous smaller transverse faults have been recognised on the Henbury Sheet area; the major faults are probably 'break thrusts' associated with the folding.

Approximately 70 bores have been sunk for water in the area and the standing water level varies from about 100 feet in the north to between 200 and 300 feet in the south. The salinity of the water increases to the south.

Phosphorites have been found in the Larapinta Group sediments throughout the area and during 1963 two diamond drill holes were sunk to investigate these deposits.

A number of areas with surface showings of secondary copper mineralisation were investigated but no new deposits were located.

The Henbury Sheet area has potential source, reservoir and cap rocks and contains a few surface structures suitable for the accumulation of oil; unfortunately, most of the anticlines are breached to Upper Proterozoic level. The most promising structures are probably the Palm Valley Anticline and James Range 'C' Anticline (if closure can be demonstrated). The intersection of oil-bearing sands in a breached anticline (AP1 - Johnny Creek Anticline) on the neighbouring Lake Amadeus Sheet area during 1963 has pointed to the possibility of stratigraphic traps.

INTRODUCTION

General

During the period from 25th May to 2nd October 1963, L.C. Ranford, P.J. Cook, A.T. Wells and A.J. Stewart geologists of the Bureau of Mineral Resources, Geology and Geophysics, mapped the Henbury (G53-1) Sheet area. Ranford and Cook were responsible for mapping the northern three quarters of the Sheet area and Wells and Stewart the southern quarter. This mapping was done as part of the Bureau's programme to map the Amadeus Basin at a scale of 1:250,000. Palaeontologists J.G. Tomlinson and C.G. Gatehouse spent part of the field season in the area, collecting fossils and examining those already collected.

Location and Access.

The Henbury Sheet area lies between latitudes 24° and 25° south and between longitudes 132° and 133°30' east. Access to the area is by the main north-south road which crosses the eastern side of the area. Graded roads run from the main highway to Tempe Downs homestead, Wallera Ranch and Angas Downs homestead. As well as the roads there are numerous graded and ungraded station tracks throughout the area and the more important of these are shown on the map.

Climate

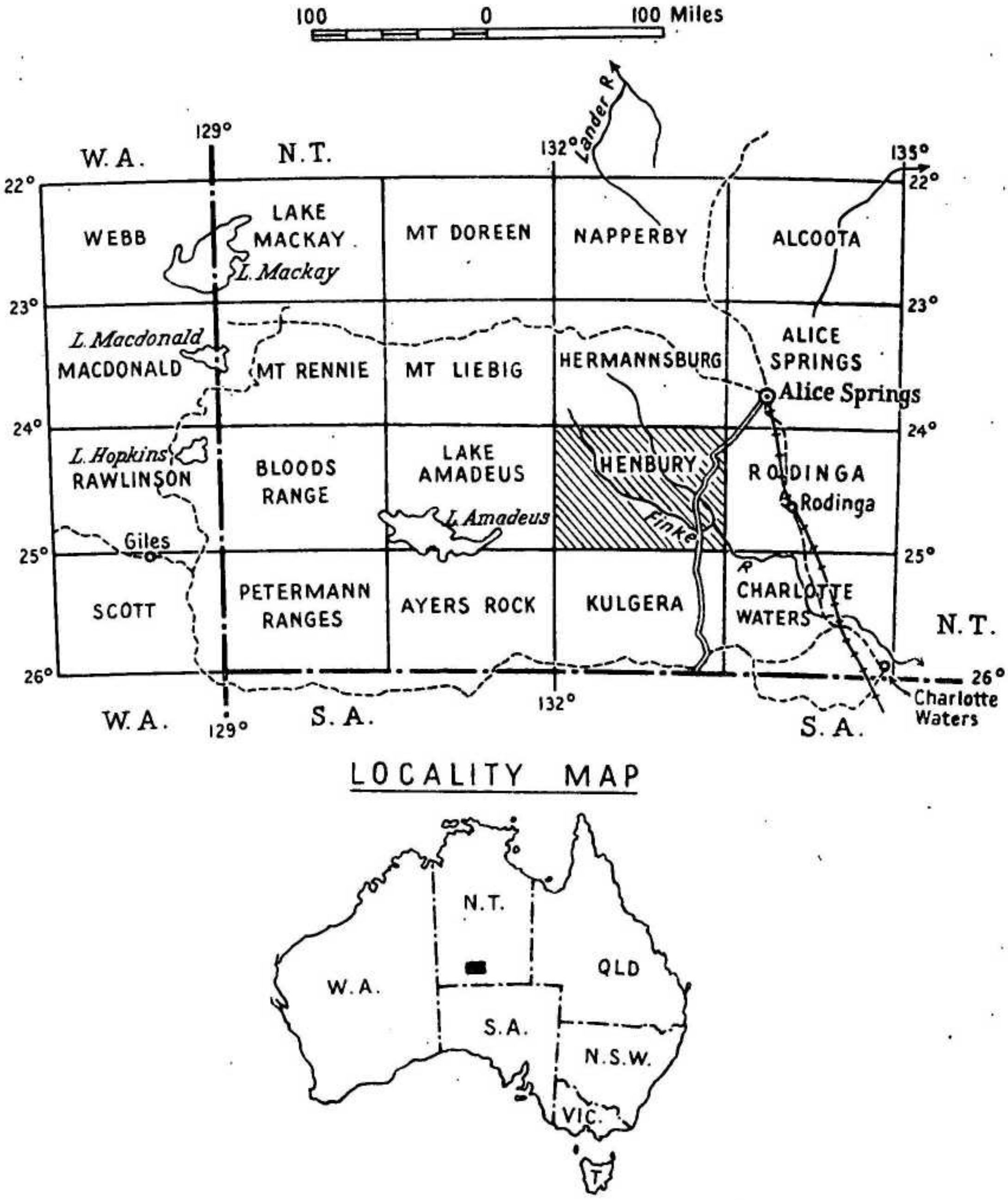
The Henbury Sheet area receives an average rainfall of less than 10" per annum. The rainfall is very irregular but it is primarily a summer rainfall. Less than one inch of rain was recorded during the winter of 1963 and the whole of the area is at present suffering from serious drought conditions.

Summer temperatures are very high, with a mean daily maximum above 100°F for many weeks. However, winter temperatures are very pleasant with a maximum temperature range of 65°F to 85°F. The winter nights are cold and frosts are quite common towards the end of June and during July.

The prevailing wind is from the south-east, but the strongest winds blew from the west and north-west during the 1963 field season.

Fig. 1

POSITION OF AREA DEALT WITH IN REPORT AND REFERENCE TO AUSTRALIAN 1:250,000 AND 1:253,440 MAP SERIES



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To accompany Record № 1964/40

Development

The only settlements in the area are the Henbury, Palmer Valley, Orange Creek and Tempe Downs homesteads, the Wallera Ranch and Palm Valley tourist camps and the Areyonga Native Settlement. There are very few fences on the western half of the area apart from stockyards and holding yards near the homesteads and some of the bores. However, on the eastern side of the area there are some boundary and other fences on the Henbury and Palmer Valley properties. There are about 70 water bores on the Henbury Sheet area.

The majority of the people living in the area are engaged in cattle raising but the tourist industry is becoming increasingly important in the winter months. The main tourist centre is Palm Valley but tourists also stay at Wallera Ranch and the roads to Ayers Rock and King Canyon pass through the area.

A number of government employees are engaged in running the school and hospital at the large Areyonga Native Settlement.

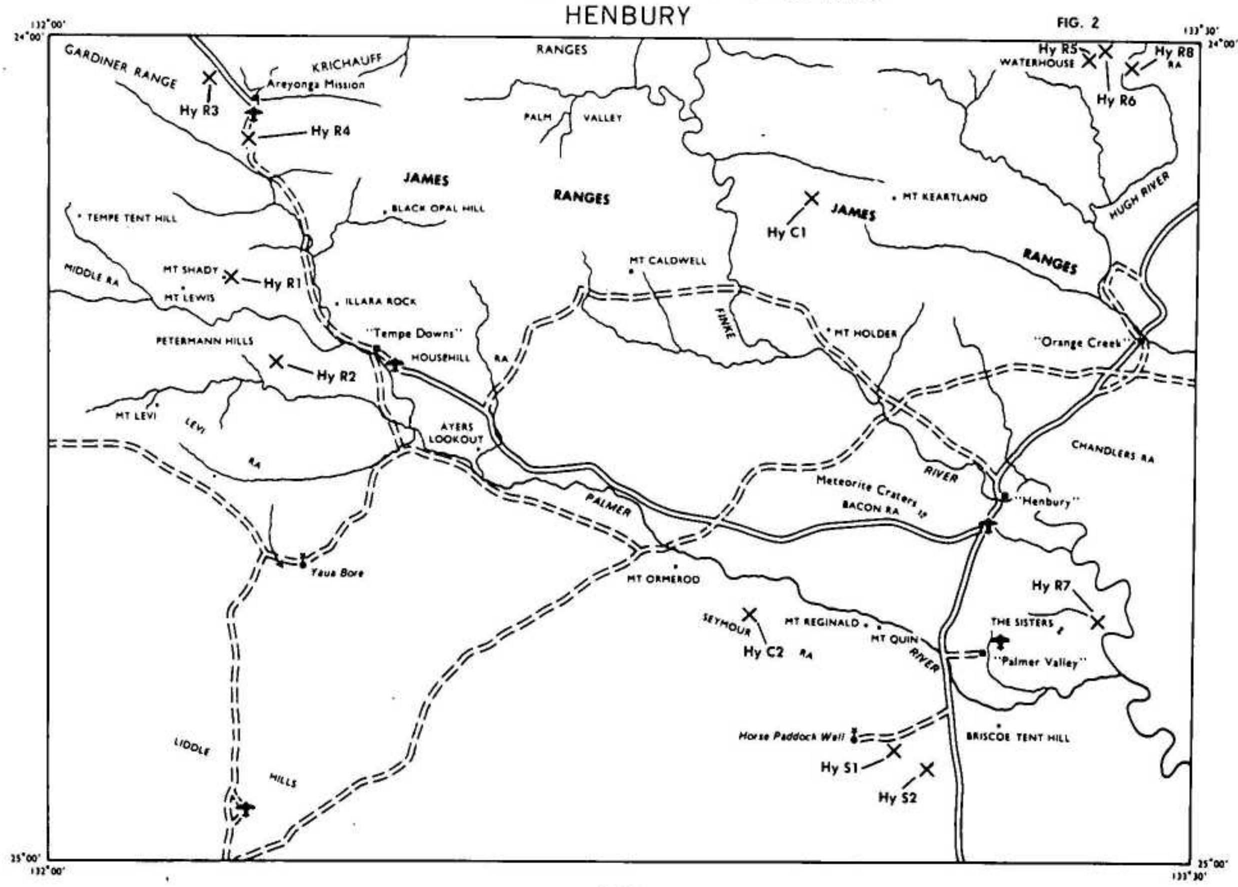
Survey Method

The mapping was done by a series of reconnaissance traverses lasting between three and six days from a base camp near the Tempe Downs airstrip. A helicopter was used for seven days to visit the more inaccessible areas and to enable quick comparison of widely separated sections. The geology was plotted on air-photographs taken by the R.A.A.F. in 1950 at a scale of 1:46,500. The geology was later transferred from the air-photographs to controlled photo-scale overlay sheets which were reduced photographically, and then redrawn at a scale of 1:250,000.

Sections were measured at selected localities using a 300 feet steel tape and an Abney Level. These measured sections have been calculated and drawn up in columnar form using standard symbols. The position of each measured section is shown approximately in Figure 2 and more exactly on the 1:250,000 scale map.

LOCATION OF MEASURED SECTIONS
HENBURY

FIG. 2



X Location of measured section

SCALE
5 0 5 10 15 MILES

Bureau of Mineral Resources, Geology and Geophysics. *April 1964* *To accompany Record No 1964/40* G53/A1/10

PREVIOUS GEOLOGICAL INVESTIGATIONS

Since 1860, the Henbury Sheet area has had a constant stream of explorers and geologists passing through it. To the early explorers, the Finke River with its numerous permanent water holes, was the highway by which they were able to enter Central Australia. The first explorer in the area was John McDouall Stuart who travelled along the Finke and Hugh Rivers in 1860 (Stuart, 1861) whilst attempting to reach the north coast of Australia. In 1864 (Stuart, 1865) he again travelled through the area on his successful journey across Australia. On both of these journeys Stuart and Waterhouse (the naturalist of the expedition) made geological observations of a very general nature. The same is also true of Giles who was in the area in 1872 (Giles, 1889) and Gosse who passed through the area in 1873 (Gosse, 1874); both of these explorers were more interested in the country which lay to the west of the Finke River.

The first geologist to visit the area was Chewings who in 1886 (Chewings, 1886) investigated the source of the Finke River. He later revisited the area several times between 1891 and 1935 and a number of papers bear reference to the geology of parts of the Henbury Sheet area (Chewings 1891, 1894, 1914, 1928, 1931, 1935). H.Y.L. Brown, the Government Geologist, also did a considerable amount of geological work in the area. It is uncertain when he made his first visit but it was probably in 1889 (Brown, 1890). He mentions the area in several other reports (Brown 1891, 1892, 1895). The work of Etheridge (identification of fossils from the Tempe Downs area) is also mentioned in several of these reports. For several years Brown and Chewings differed in their sub-divisions of the Amadeus Basin sediments, with Brown favouring a two-fold division of Primary (?Cambrian) and Secondary (those forming the flat-topped hills) whilst Chewings advocated a three-fold division into Walker Creek Series (Cambrian), Mareeno Bluff Series (lower Silurian in part) and Glen Helen Series (?Devonian). In 1892 (Tate, 1896) the Horn Expedition spent several weeks in the Henbury Sheet area and collected many fossils from the vicinity of Tempe Downs. It was from this area that many of the Larapinta Group (Larapintine of Tate, 1896) holotype fossils were collected. F.R. George led a government prospecting party through the western parts of the area in 1906 (George and Murray, 1907) whilst travelling from Ayers Rock to Alice Springs via Deering Creek. T.E. Day also led a government surveying party through the area in 1916 (Day, 1916) but neither he nor George did more than record the presence of sandstone ridges and scarps in the area. Throughout much of the early part of the 20th century the managers of Tempe Downs Station were keen amateur geologists and they added considerably to the geological knowledge of the area by sending many geological specimens to the South Australian Department of Mines.

Ward, Madigan and Mawson all worked for brief periods in the Henbury Sheet area (Ward, 1925; Mawson and Madigan, 1930; Madigan, 1931; Madigan, 1932) but most of their time was spent in the MacDonnell Ranges. It was Mawson and Madigan who pioneered the use of aeroplanes in geological work in central Australia and this method enabled them to confirm or disprove many of the correlations of earlier workers in the MacDonnell Ranges. Joklik passed through the Henbury Sheet area whilst with an expedition looking for the mythical Lasseters Reef and he made a few geological observations in the Angas Downs area (Joklik, 1952).

In 1953 the National Lead Company carried out extensive drilling of the Goyder Member of the Pertaoorrta Formation in the Waterhouse Range in the search for copper deposits. A geochemical survey was also carried out but the results of this survey and of the drilling were not encouraging and investigations were finally abandoned in 1955.

The Bureau of Mineral Resources sent its first field party into the Amadeus Basin in 1956 (Prichard and Quinlan, 1962) to map the southern part of the Hermannsburg 1:250,000 Sheet area. The work of Prichard and Quinlan has since been used as a basis for much of the later geological work in the Amadeus Basin. Both before and after 1956, the geologists of the Resident Geological Office in Alice Springs have been carrying out geological work over much of the Amadeus Basin and, whereas most of this work has been undertaken with a view to the siting of water bores, many additional geological observations have been made.

In 1957, Quinlan carried out reconnaissance geological mapping over a wide area of country in the Alice Springs district, (including parts of the Henbury 1:250,000 Sheet area) as geologist with a C.S.I.R.O. field party (Perry et al., 1962).

Brunnschweiler, in 1959, carried out reconnaissance geological trips over a wide area of Central Australia. He was especially interested in the tectonics of the area around Maryvale on the Rodinga Sheet area and Gosses Bluff on the Hermannsburg Sheet area. The Henbury Sheet area is only briefly mentioned (Brunnschweiler, 1959, 1961).

Gillespie and Leslie of Frome-Broken Hill Pty.Ltd. undertook reconnaissance geological mapping on the Henbury and surrounding Sheet areas in 1959 (Leslie, 1960) and brief palaeontological studies were carried out by Taylor (1959). Frome-Broken Hill Pty.Ltd. relinquished their oil permits in 1960. The permits were taken over by the Magellan Petroleum Corp. and associated companies and since 1960, Hopkins, Stelck, McNaughton, Banks and Haites have carried out geological mapping of the oil permit area. (Stelck and Hopkins, 1962; McNaughton, 1962; Haites, 1963; Ranneft, 1963).

The Henbury Sheet area was photo-interpreted for the Bureau of Mineral Resources in 1960 by the Institut Francais du Petrole (Scanvic, 1961) as part of a photo-interpretation programme covering the whole of the Amadeus Basin.

The first geophysical work in the Henbury Sheet area was carried out in 1960 by the Bureau of Mineral Resources when two aero-magnetic traverse lines were flown across the Sheet area (Goodeve, 1961). The only seismic work in the Sheet area was done in 1961 and was a short seismic traverse across the Palm Valley anticline on the north margin of the Sheet area. A helicopter gravity survey of the Henbury Sheet area was carried out in 1961 by the Geophysical Branch of the Bureau of Mineral Resources.

In 1960, the Bureau of Mineral Resources commenced a programme of reconnaissance geological mapping in the Amadeus Basin at a scale of 1:250,000. The Rawlinson and Macdonald Sheet areas were mapped in 1960 (Wells, Forman and Ranford, 1961), the Mount Rennie and Mount Liebig Sheet areas in 1961 (Wells, Forman and Ranford, 1962), the Lake Amadeus and Bloods Range Sheet areas in 1962 (Wells, Ranford and Cook, 1963; Forman, 1963) and the Henbury, Petermann Ranges, Ayers Rock, Kulgera and Finke Sheet areas in 1963 (Forman and Hancock, 1964; Wells, Stewart and Skwarko, 1964). In 1963, the Bureau of Mineral Resources embarked on a preliminary programme of phosphate search and diamond drilling was carried out on the Lake Amadeus and Henbury Sheet areas (Barrie, 1964).

Also during 1963 D. Milton of the Astro Division of the United States Geological Survey, became the latest in a long line of geologists investigating the Henbury Meteorite Craters, and carried out very detailed mapping of several of the craters (see section on Henbury Meteorite Craters).

PHYSIOGRAPHY

There are six main physiographic divisions in the Henbury Sheet area (see Fig. 3).

A. High mountain ranges and hills.

B. Low ranges and hills with intervening sand dunes and sand plain.

C. Sand plain with many sand dunes and some low outcrops.

D. Sand plain with dunes.

F. Gibber or alluvial plains with mesas and low hills.

G. Alluvial flood plains with some clay pans.

Division E (salt lakes) which is present on adjacent sheet areas does not occur on the Henbury Sheet area.

A. The high mountain ranges and hills are restricted to the northern parts of the sheet area. The peaks rise from 200 feet to over 1000 feet above the general level of the sand plain which has an altitude of about 1500 feet above sea level. There are three main areas belonging to this division and by far the largest of these includes the James Ranges, the Gardiner Range, the Levi Range, the Househill Range and the Mount Holder Range. The Waterhouse Range forms the second area of this division and the Chandler Range the third area.

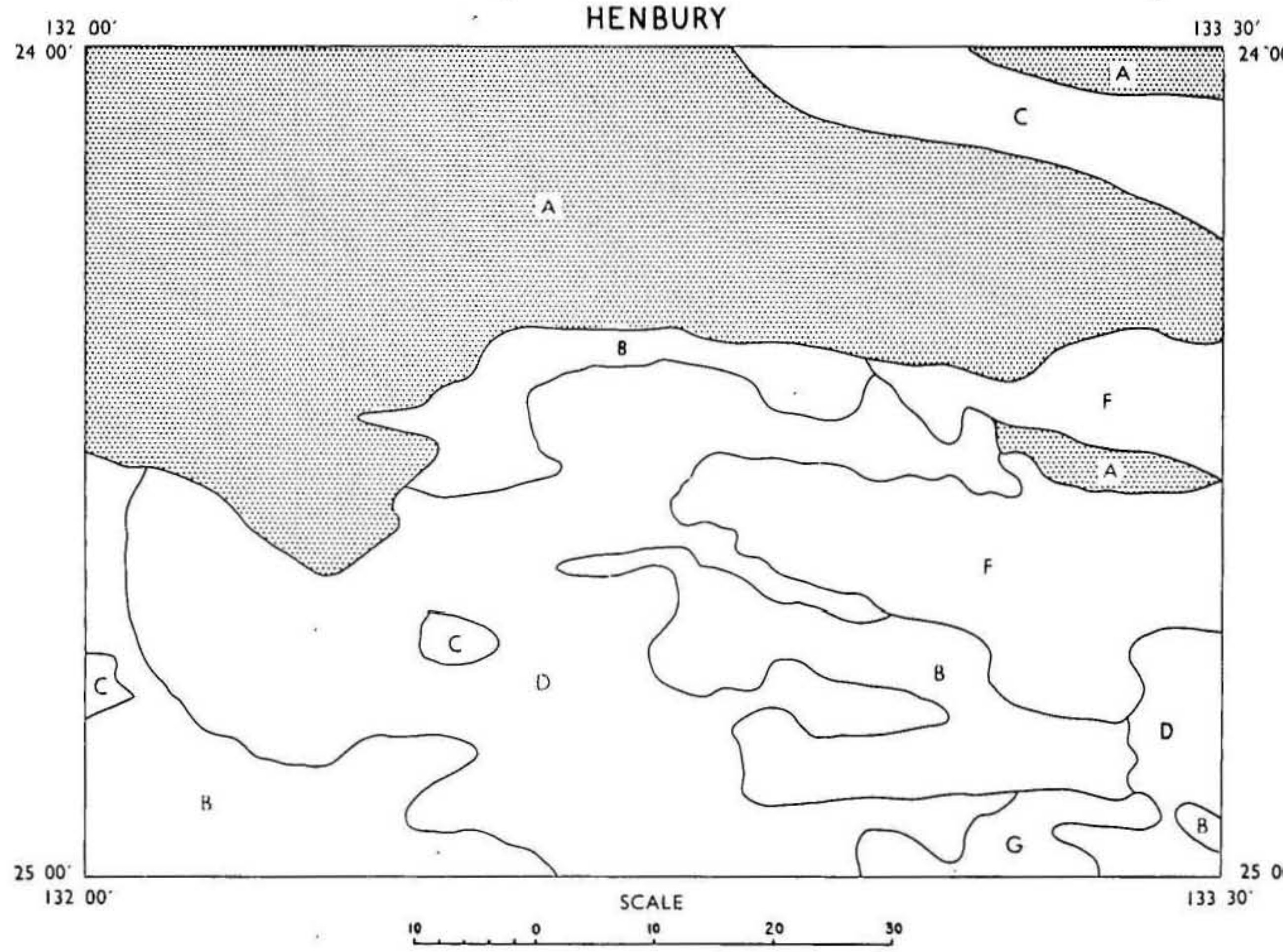
The geological units forming the greatest areas of division A are the Pertnjara Formation, the Mereenie Sandstone and to a lesser extent the Larapinta Group but in the cores of many of the anticlines there are Cambrian and Upper Proterozoic rocks exposed.

The sandstone unit of the Pertnjara Formation and the Mereenie sandstone characteristically form ranges with very steep marginal escarpments. Sand dunes are rare within division A but they do occur on top of the ranges in some places. The Larapinta Group and older geological units cropping out in the area of division A are commonly steeply dipping; where they are easily eroded there are strike valleys whereas the more resistant units form long strike ridges with a razor-back or more rarely a hog-back form.

Physiographic Divisions

Fig.3

HENBURY



A High mountain ranges and hills
B Low ranges and hills with intervening sand dunes and sand plain
C Sand plain with many sand dunes and some low outcrops
D Sand plain with dunes
F Gibber or alluvial plains with mesas and low hills
G Alluvial flood plains with some clay pans

There are three main types of drainage in the area of physiographic division A and the most important type is that which follows the strike valleys formed over the recessively weathering units. Where these strike valleys are wide, the rivers meander to a considerable degree. The second type of drainage pattern is developed on the Mereenie Sandstone and is controlled by joints and fractures or occasionally by faults and has therefore produced steep, straight, narrow valleys. The lack of any well defined joint or fracture pattern within the Pertnjara Formation has resulted in the formation of the third type of drainage which has a characteristic dendritic pattern.

B. There are three main areas of low ranges and hills with intervening sand dunes and sand plain. The hills in this division rise from 50 feet to 200 feet above the surrounding sand plain. The largest of the three main areas is situated in the extreme western and south-western parts of the Sheet area and includes the Liddle Hills. The second area includes the Seymour Range and the range to the south and the third area lies along the margin of physiographic division A and extends from the Palmer River, north and east to the Finke River. A fourth very small area occurs in the south-eastern corner of the Sheet area.

The strata within division B are frequently steeply dipping and strike ridges are a common topographic feature. The Winnall Beds form the majority of these strike ridges in the west and south-west parts of the Sheet area but in other areas of division B the strike ridges are more commonly formed by Palaeozoic rocks.

The drainage pattern within division B is only poorly defined. There is a tendency for the drainage to follow the strike valleys but the ridges are low and therefore the rivers have had little difficulty in breaking through them. The direction of drainage is either south towards the Lake Amadeus salt lake system or towards the Finke River.

C. The division of sand plains with many sand dunes and some low outcrops, covers only a relatively small part of the Henbury Sheet area. One small area of division C occurs on the extreme western margin of the Sheet area and another small area occurs in the middle of the large area of division D. The only major area of division C lies in the north-east corner of the area between the Waterhouse Range and the James Range. Here, the sand dunes are poorly defined and the average height of outcrops above the sand plain would be no more than 10 feet.

The area is thought to be underlain by the Pertnjara Formation and possible Mesozoic and Tertiary deposits.

The drainage pattern is poorly defined and, in the main area of division C, consists of small tributaries of the Hugh River in the eastern half of the area and of the Finke River in the western half.

D. The area of sand plain with dunes covers a large part of the Henbury Sheet area from the southern margin of the Sheet area to near Mount Holder and the Chandler Range. Outcrops are very rare or completely absent in most areas. The sand dunes which are mainly of the braided type, reach a maximum height of approximately 50 feet and have a poorly defined south-westerly trend.

There is no well defined drainage pattern and the only water-courses are those adjacent to the Finke and Palmer Rivers.

F. A wide area in the eastern half of the sheet area is covered by gibber plains or alluvial plains, with mesas and low hills reaching a maximum height of approximately 100 feet above the plain. The geology of this physiographic division is variable but west of the main road the rocks which crop out are mainly Upper Proterozoic and Lower Palaeozoic. East of the main road there is a thin veneer of Mesozoic and Tertiary sediments overlying fairly strongly folded Lower Palaeozoic and Upper Proterozoic strata.

Drainage is locally influenced by ridges but, in the main, is directed towards the Finke River which flows from north to south across the area and the Hugh River which flows through the extreme north-eastern corner of the area.

G. The physiographic division of alluvial flood plains with some clay pans covers only a small area at the southern margin of the Henbury Sheet area. A description of this physiographic division is to be found in the report on the Kulgera Sheet area (Wells, Stewart and Skwarko, 1964).

TABLE 1: STRATIGRAPHY OF THE HENBURY SHEET AREA

Age		Formation	Map Symbol	Maximum Thickness and Locality	Lithology	Topographic Expression	Hydrology	Remarks
Quaternary			Qa		Alluvium and river gravels.	Stream deposits, alluvial flats and scree slopes.	Good potential for high quality water.	
			Qs		Aeolian sand.	Dunes and sand plain.	Poor prospects	
			Ql		Travertine	Low areas, mounds around salt lakes.	Poor prospects	
			Qg		Gypsum	Low mounds as for travertine.	Poor prospects	
			Qc		Conglomerate (unconsolidated)	Gibber plains and scree slopes.	Poor prospects	
Tertiary			T	100'+ near Maloney Bore.	Calcareous silty sandstone, conglomerate and limestone.	Low mesas	some beds could have potential if sequence is thicker than known from outcrop.	
			Tl	100'+ near Maloney Bore.		Mesas	some beds could have potential if sequence is thicker than known from outcrop.	
			Tc	100'+ near Maloney Bore.	Conglomerate	Mesas and mounds		
			Tb		Siliceous 'Billy'	Mesa capping	No potential	
			Ta		Laterite, ferricrete.	Mesa capping or ridge capping	No potential	
Mesozoic			M	60'+ near Palmer Valley	Kaolinitic sandstone and sandy claystone.	Mesas	No great potential on Henbury Sheet area because of lack of section and amount of matrix.	Flat lying - usually has thin capping of 'Billy'.
Palaeozoic	Undifferentiated	Pertnjara Formation	Pzp(s)	1500'+ in Gardiner Range	Sandstone and silty sandstone - some scattered pebbles and cobbles.	Prominent ridges and very rugged ranges.	Some beds could supply large quantities of moderate to good quality water.	Appears to lie conformably on Pzp(a) except in N.E. quadrant of Sheet area where it unconformably overlies Pzm.
Palaeozoic	Undifferentiated	Pertnjara Formation	Pzp(a)	Approximately 1500' in Gardiner Range.	Siltstone, fine silty sandstone and some limestone.	Strike valleys.	Permeability low-prospects poor.	Poorly exposed. Not present in N.E. quadrant of Henbury Sheet area.
Palaeozoic	Undifferentiated	Mereenie Sandstone	Pzm(2)	2470' (HyR4) near Areyonga	Sandstone with large scale cross-bedding.	Prominent ridges and ranges.	Yields large quantities of excellent water.	Conformably overlies Pzm(1) on western half of Sheet area. Unconformably overlies Larapinta Group sediments in Waterhouse Range.
Palaeozoic	Undifferentiated	Mereenie Sandstone	Pzm(1)	2470' (HyR4) near Areyonga	Sandstone, silty sandstone and minor siltstone. Marine fossils.	Main escarpment of Mereenie Sandstone.	Could yield moderate quantities of good quality water.	Contains Ordovician Cruziana. Not present in Waterhouse Range.

Age		Group	Formation	Map Symbol	Maximum Thickness and Locality	Lithology	Topographic Expression	Hydrology	Remarks
Palaeozoic	Ordovician	Larapinta Group €-Ol	Stokes Formation	Ot	Approximately 1500' near Areyonga.	Siltstone, shale, limestone and silty sandstone. Marine fossils.	Strike valleys.	Impermeable sequence - prospects poor.	Generally poorly exposed. Contains some thin beds with pelletal phosphate near base.
			Stairway Sandstone	Os	880'(HyC1) southern flank of James Range 'A' Anticline.	Sandstone, silty sandstone and siltstone with minor limestone. Marine fossils.	Strike ridges.	Some porous beds but water generally saline.	Contains a number of beds of pelletal phosphate.
			Horn Valley Siltstone.	Oh	350' (HyR4) near Areyonga.	Siltstone and shale with bluey-grey or grey-green limestone. Marine fossils.	Strike valleys.	Prospects poor.	Not present in some areas on the southern half of the Sheet area.
			Pacoota Sandstone	€-Op	2053' (HyC1) -southern flank of James Range 'A' Anticline.	Sandstone and silty sandstone-partly conglomeratic. Marine fossils.	Prominent strike ridges.	Porosity and permeability highly variable - could provide large supply of good quality water in some areas.	Thins markedly to the south and is not present south of latitude 24°40' south.
	Cambrian	Pertaoorrta Formation €p	Goyder Member	€g	1181' (HyR6) in the Waterhouse Range.	Silty sandstone, siltstone, shale and limestone. Some marine fossils.	Low rounded hills in strike valley.	Upper part may provide small supply. Lower part poor prospects.	Generally poorly exposed. Contains minor copper mineralisation in some areas.
			Petermann Sst. Member	€e	637'(HyR3) near Areyonga.	Sandstone and silty sandstone with minor siltstone.	Strike ridges	Possibly some supply from cleaner sandstone beds.	Only present in north-west quadrant. Grades laterally into siltstone and shale.
			Deception Member	€d	564'(HyR3) near Areyonga.	Siltstone and shale with minor fine sandstone.	Strike valley.	Prospects poor.	Poorly exposed. Has only been mapped in north-west quadrant.
			Illara Sst. Member	€i	236'(HyR3) near Areyonga.	Sandstone and silty sandstone with minor siltstone.	Prominent strike ridges.	Possibly some supply from cleaner sandstone beds.	Has only been mapped in north-west quadrant of Henbury Sheet area.
			Jay Creek Limestone Member	€j	902'+(HyR7) four miles east of The Sisters.	Limestone, shale, siltstone and sandstone. Marine fossils and algal structures.	Low strike ridges of limestone.	Porosity and permeability probably low and prospects poor.	Only present in eastern half. Largely shallow water calcarenites and algal biolithites.
			Tempe Member	€t	764'(HyR3) near Areyonga.	Siltstone, shale, limestone and sandstone - very rich in glauconite. Some marine fossils.	Strike valley with some low strikes ridges.	Some of sandstone and limestone horizons may give small supply.	Only present in north-west quadrant. Laterally equivalent to part of Jay Creek Limestone Member.
			Chandler Limestone Member	€l	Approximately 300' near Alalgara Yard.	Limestone and dolomite with chert laminae.	Low ridges and mounds.	May have fracture porosity but suspected presence of salt would mean saline water.	Generally highly contorted and incompetently folded. Suspect presence of interbedded evaporites not seen in outcrop.
			Eninta Sst. Member	€n	310'(HyR3) near Areyonga.	Sandstone, silty sandstone and siltstone. Some conglomerate beds.	Prominent strike ridges.	Porosity generally poor and prospects not good.	Mapped only in Gardiner Range where it lies unconformably on Pertatataka Formation.
			Quandong Conglomerate Member	€q	Approximately 500' 6 miles N.E. of Tempe Downs Homestead.	Conglomeratic sandstone, conglomerate and sandstone.	Strike ridge.	Likely to have low porosity because of poor sorting. Prospects poor.	Only known from area 6 miles N.E. of Tempe Downs and core of James Range 'B' Anticline.

Age	Formation	Map Symbol	Maximum Thickness and Locality	Lithology	Topographic Expression	Hydrology	Remarks
	Winnall Beds	Ꞓuw	Approximately 3,500'+ in the Liddle Hills.	Sandstone, siltstone and shale.	Combination of prominent strike ridges and strike valleys.	The cleaner sandstone units could give good supply.	Present on southern half of area; grades laterally into Pertatataka Formation.
	Pertatataka Formation	Ꞓup	2,000'+ in Gardiner Range.	Siltstone and shale with minor sandstone and limestone.	Strike valleys with some low ridges.	Impermeable - prospects poor.	Present in Gardiner Range and near Orange Creek homestead. Was eroded during ?Lower Cambrian in some areas.
Upper Proterozoic	Areyonga Formation	Ꞓua	Approximately 1,000' near Tempe Downs.	Claystone, siltstone, sandstone, minor conglomerate and limestone.	Series of strike ridges and valleys.	Porous sands could give moderate supply.	Partly aqueoglacial sediments; present on northern half of area.
	Inindia Beds	Ꞓun	Approximately 3,000' in south-western corner of Henbury Sheet area.	Siltstone, bedded chert, chert breccia and sandstone.	Strike valleys.	Some porous beds which may give small supply.	Generally poorly exposed; present in southern half of area.
	Bitter Springs Limestone	Ꞓub	1662' Parana Hill Anticline.	Dolomite with minor siltstone, limestone and sandstone. Some chert.	Low ridges, mounds and hills.	Good supply in some areas but water generally very saline.	Contains algal stromatolites; may contain interbedded evaporites not seen in outcrop.

STRATIGRAPHY

General

The oldest rocks exposed on the Henbury Sheet area are the Upper Proterozoic sediments of the Bitter Springs Limestone. This unit is overlain by Upper Proterozoic, Cambrian, Ordovician, Devonian, Mesozoic, Tertiary and Quaternary deposits.

The Stratigraphy of the Henbury Sheet area is summarised in Table I and the thicknesses of the units from measured sections are shown in Table II. The measured sections are shown in columnar form in Plates 2, 3, 4 and 5 and generalised columnar sections from selected localities throughout the area are shown with correlation lines in Plate 1.

The relationships between the various Proterozoic and Palaeozoic units mapped on the northern half of the Henbury Sheet area are shown in Figure 4.

All new stratigraphic units defined in this report have been approved by the Territories Division of the Stratigraphic Nomenclature Committee.

UPPER PROTEROZOIC

Bitter Springs Limestone

The Bitter Springs Limestone was named by Joklik (1955) from the type locality at Bitter Springs Gorge, 40 miles east-north-east of Alice Springs.

On the Henbury Sheet area, the formation is exposed in the cores of the Gardiner Range, Walker Creek, Petermann Creek and Parana Hill Anticlines and also in the cores of unnamed anticlines immediately south of the Liddle Hills, east of Dead Bullock Plain, five miles east-south-east of Orange Creek homestead, two miles south-east of Henbury homestead and four miles north-east of Palmer Valley homestead.

The unit is best exposed in the core of the Parana Hill Anticline where a minimum thickness of 1662 feet was measured (Wells, Ranford and Cook, 1963). Good exposures are also present near Dead Bullock Plain where Leslie (1960) measured 600 feet of Bitter Springs Limestone, and in the Gardiner Range near Areyonga. The dominant lithology of the Bitter Springs Limestone is fine-grained dolomite and dolomitic limestone. It varies from fawn to pink, pale grey

POSSIBLE CORRELATION OF ROCK UNITS IN NORTHERN PART OF THE HENBURY SHEET AREA

Fig. 4.

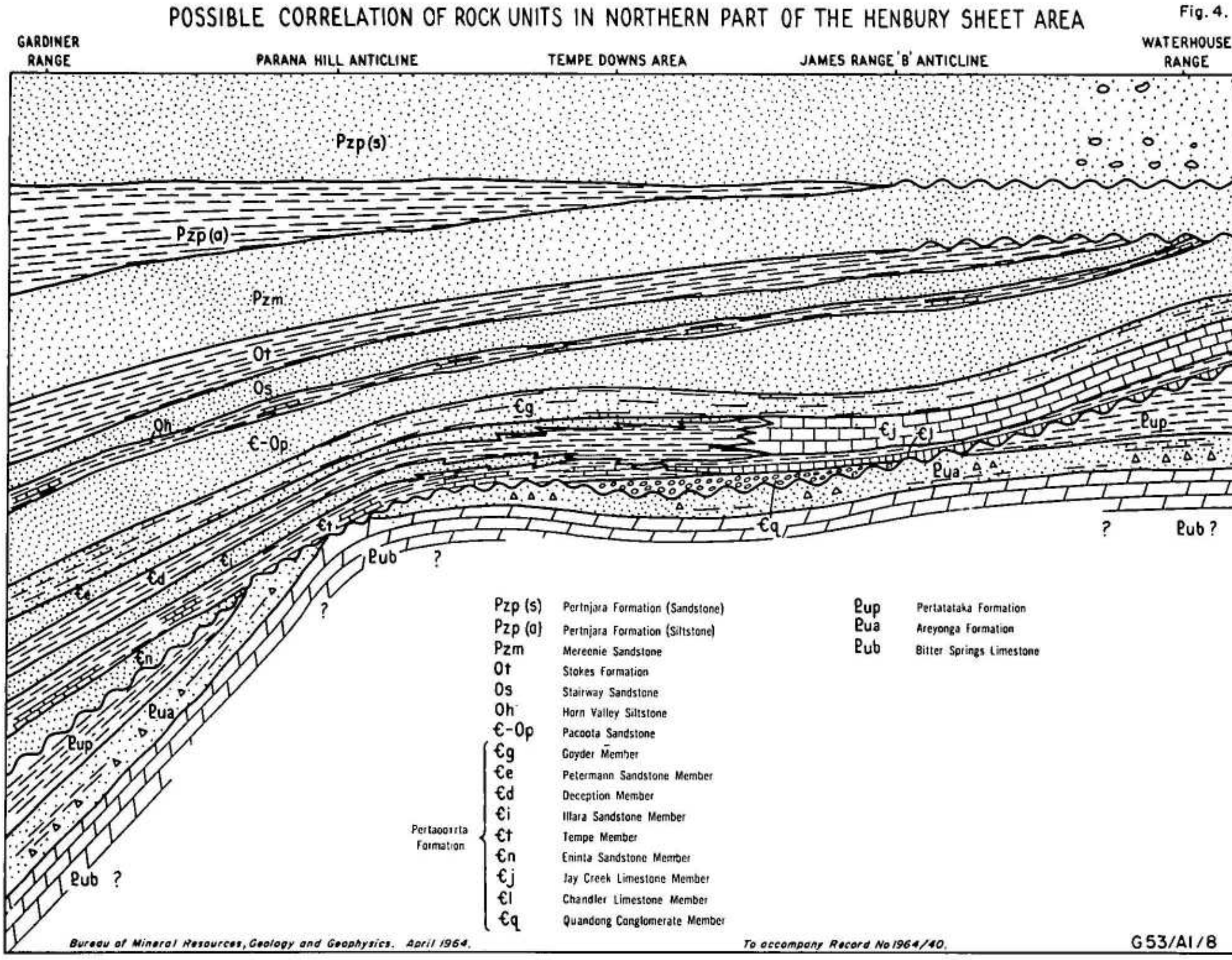


TABLE II

THICKNESSES OF UNITS ON HENBURY SHEET AREA

Formation	Map Symbol	Section Number HyR 1	HyR 2	HyR 3	HyR 4	HyR 5	HyR 6	HyR 7	HyR 8	HyC 1	HyC 2	HyS 1	HyS 2
Pertnjara Formation	Pzp(s) Pzp(a)	P	NPS	P	NM	NM	NM	NPS	NM	P	660'	P	P
Mereenie Sandstone	Pzm(2) Pzm(1)	1762'	P		2470'	See HyR 8	See HyR 8	NPS	1498'	NM	458'	700	P
Stokes Formation	Ot	1003'	P		P	A	A	NPS	A	918'	630'	322'	419'
Stairway Sandstone	Os	592'	NM	See HyR 4	825'	A	A	316'+	A	880'	440'	483'	371'
Horn Valley Siltstone	Oh	198'	NM		353'	83'+	See HyR 5	78'	See HyR 5	243'	A	A	A
Pacoota Sandstone	Є-Op	1421'	NM		1841'	1472'		65'		2053'	A	A	A
Pertaoorrta Formation	Єp	P	2173'	3586'		See HyR 6	1659'+	1017'+	See HyR 6	P	P	1390'	1050'
Goyder Member	Єg	P	786'	1075'			1181'	115		P	P	P	P
Petermann Sst Member	Єe	P	334'	637'	See HyR 3	A	A	A	A	A	A	A	A
Deception Member	Єd	P	430'	564'		A	A	A	A	A	A	A	A
Illara Sst. Member	Єi	P	178'	236'		A	A	A	A	A	A	A	A
Jay Creek Lst. Member	Єj	A	A	A	A	See HyR 6	478'+	902'+	See HyR 6	P	P	NE	NE
Tempe Member	Єt	P	445'	764'	See HyR 3	A	A	A	A	A	A	A	A
Chandler Lst. Member	Єl	A	A	A	A	NE	NE	P	NE	NE	NE	NE	NE
Eninta Sst. Member	Єn	A	A	310'	See HyR 3	NE	NE	A	NE	NE	NE	NE	NE

A – Absent from sequence
P – Poor or incomplete exposure
NE – Not exposed (may be present)
NM – Not measured (Good exposure present)
NPS – Not present due to structure

and dark grey and generally contains numerous 'biscuits', lenses and irregular masses of chert. The dolomite is partly sandy, and contains algal stromatolites some of which have been replaced by chert and stand out on weathered surfaces. In many places the dark grey dolomite is known to emit a fetid odour when freshly broken. Interbedded with the carbonates are minor amounts of red-brown and white, spotted, siltstone and mudstone which weather recessively and are not normally exposed.

The basal part of the Bitter Springs Limestone is not exposed on the Henbury Sheet area. The unit is overlain by the Areyonga Formation in the northern half of the area and by the Inindia Beds and Winnall Beds in the southern half of the area. The contact with the Areyonga Formation is apparently conformable. In some areas the boundary with the Areyonga Formation is placed at the first appearance of tillitic textured siltstone, claystone and sandstone and in other areas at the change from dolomite to interbedded siltstone and chert. Fragments derived from the Bitter Springs Limestone are common in the Areyonga Formation and therefore a disconformable relationship between these two units is presumed. In most places on the southern half of the Sheet area, the Inindia Beds overlie the Bitter Springs Limestone apparently disconformably. However, near the Liddle Hills the Winnall Beds rest on the Bitter Springs Limestone with a marked angular unconformity.

The Bitter Springs Limestone is considered to be of Upper Proterozoic age.

Inindia Beds

The Inindia Beds were defined by Wells, Ranford and Cook (1963) as 'the sequence of siltstone, sandstone, chert, chert breccia and thin beds of dolomite which disconformably overlies the Bitter Springs Limestone and is overlain, probably unconformably by the Winnall Beds'. The type area for the Inindia Beds lies 36 miles south-east of Mount Murray on the Lake Amadeus Sheet area and the name was derived from Inindia Bore in the south-east corner of the same Sheet area.

Scattered outcrops of the Inindia Beds have been mapped in the cores of anticlinal structures throughout the southern half of the Henbury Sheet area. The unit weathers recessively in most areas and is generally very poorly exposed. The best exposures occur to the east of Dead Bullock Plain where some of the softer parts of the section have been preserved beneath a capping of indurated sandstone within the formation.

No sections were measured through the Inindia Beds but the unit is estimated to be about 1000 feet thick in the middle of the Henbury Sheet area and between 2000 feet and 3000 feet thick in the south-western corner of the Sheet area.

The Inindia Beds comprise siltstone, shale, sandstone, chert and rare thin beds or lenses of limestone or dolomite, and conglomerate. The siltstone and shale are predominantly pale purple-brown and red-brown but in places mauve, white and yellow. They are laminate to massive, micaceous, moderately to poorly sorted, and in some places, tillitic textured with angular fragments of chert averaging about ¼" in diameter but measuring up to four inches in diameter. The sandstone occurs both as thin interbeds within the siltstone sequence and also as larger units which can be traced for some miles. Thin beds of medium grained, micaceous sandstone with some halite pseudomorphs occur within the siltstone near Dead Bullock Plain and thin sandstone interbeds with scattered glauconite grains occur a few miles north-west of Palmer Valley Homestead. The thicker sandstone units are generally white, medium to coarse-grained, cross-bedded, moderately to well sorted and strongly fractured and jointed. The chert occurs near the base of the Inindia Beds. It is well bedded but strongly fractured and tends to form rubble lines at the surface. The chert is mostly yellow-green, white or grey and occurs as beds up to approximately two feet thick interbedded with siltstone and shale. Some of the chert is oolitic suggesting it was formed by the replacement of oolitic carbonates.

The relationships between the Inindia Beds and the underlying Bitter Springs Limestone and overlying Winnall Beds are assumed from the attitudes of outcrops separated by concealed intervals. The Bitter Springs Limestone appears to lie conformably beneath the Inindia Beds but pebbles obviously derived from the Bitter Springs Limestone occur within the Inindia Beds and so a disconformable relationship is indicated. The relationships with the overlying Winnall Beds are more variable; in the Liddle Hills the contact is apparently unconformable and on the eastern side of the Sheet area the contact is apparently conformable. The Inindia Beds occur in the same stratigraphic position as the Areyonga Formation and some characteristic rock types are common to both units. The Inindia Beds and the Areyonga Formation are considered to interfinger about half way down the Henbury Sheet area.

The Inindia Beds are considered to be at least partly marine and contain some undoubted aqueoglacials. The sequence is considered to be Upper Proterozoic in age.

Areyonga Formation

The Areyonga Formation was defined by Prichard and Quinlan (1962) as '... the unit, consisting essentially of two members, a siltstone and a quartz greywacke, which disconformably overlies the Bitter Springs Limestone at Ellery Creek and is conformably overlain by the Pertatataka Formation'.

On the Henbury Sheet area, the Areyonga Formation crops out in the cores of the Gardiner Range, Walker Creek, Petermann Creek and Parana Hill Anticlines. The sandstone lenses stand up as prominent strike ridges but the softer, finer grained sediments are poorly exposed except where protected by the resistant sandstone ridges or where exposed in creek banks such as near Areyonga or in the Parana Hill Anticline.

Exposures were considered inadequate to justify section measuring but estimates from airphotos indicate a thickness of approximately 500 feet near Areyonga and about 1,000 feet near Tempe Downs. Associated with the apparent increase in thickness towards the south is an increase in the percentage of sandstone.

The Areyonga Formation includes many lithologies and is characterised by the lense-like nature of the lithological units. Even apparently consistent sandstone horizons appear, on closer examination, to be a series of lenses. The dominant lithology is probably tillitic textured, pebbly claystone and siltstone. This rock varies from grey-green to mauve and white and contains fragments derived from the underlying sediments as well as igneous and metamorphic basement rocks. Erratics up to 15" in diameter were seen in the claystone and many of the phenoclasts were facetted. A small percentage of the erratics were striated and at each locality the striations appeared to be restricted to boulders of one rock type. In the Parana Hill Anticline striations were only observed on boulders of grey-green, silicified sandstone whereas in the exposures nearer Tempe Downs homestead the only striations seen were on pebbles of pale yellow silicified siltstone.

The sandstone beds in the Areyonga Formation are medium to coarse grained, moderately to poorly sorted, crossbedded and generally silicified at the surface. The sandstone is mostly white but in some areas a high feldspar content gives the rock a pale pink or fawn tint. The blocky

Fig.5. 'Pipe-rock' in the Areyonga Formation of the Gardiner Range. Neg.No.g/6143.

Fig. 6. "Pipe-rock" in Areyonga Formation as seen on the bedding planes. Neg.No.M/305/A.G.

fracture, and a network of anastomosing quartz veinlets give the outcrop a characteristic appearance. In some areas a sequence of siltstone with chert interbeds is exposed towards the base of the formation. The chert is oolitic in part and varies in colour from dark red-brown to yellow-green and grey and white. The formation contains some lenses of pebble and boulder conglomerate (e.g. Parana Hill Anticline) but most of these are apparently of small lateral extent.

In the Gardiner Range, north-west of Areyonga Native Settlement, typical Areyonga Formation can be traced along strike into a sequence of limestone, dolomite, chert and sandstone. The carbonates are fawn, pink, pale grey and white; largely oolitic or pelletal and partly sandy. The dolomite is in part cross-laminated and contains some possible algal stromatolites and some chert laminae and irregular chert masses. The sandstone occurs in a bed about 20 feet thick. It is white, medium to coarse grained, well sorted, silicified and thick bedded. This sandstone contains numerous evenly spaced vertical 'tubes' or 'pipes' (see Figures 5 and 6). The 'pipes' are about ½ inch in diameter and up to three feet long. They are considered to be of organic origin .

The Areyonga Formation disconformably overlies the Bitter Springs Limestone and is conformably overlain by the Pertatataka Formation in the Western MacDonnell Ranges and in the Gardiner Range. However, at outcrops further south (e.g. in cores of Parana Hill and Walker Creek Anticlines) the Areyonga Formation is overlain unconformably by the Pertaoorrta Formation. The formation is considered to be laterally equivalent to the Inindia Beds which have been mapped on the southern half of the Henbury Sheet area. The formations occupy equivalent stratigraphic positions and have some common lithologies.

The Areyonga Formation is considered to be of Upper Proterozoic age.

Pertatataka Formation

The Pertatataka Formation was defined by Prichard and Quinlan (1962) as 'the sequence of siltstone which conformably overlies the Areyonga Formation and is conformably succeeded by the Arumbera Greywacke'. The type section lies three miles west of Ellery Creek on the Hermannsburg Sheet area.

On the Henbury Sheet area, the Pertatataka Formation crops out in the Gardiner Range and near Orange Creek Homestead. The best exposures are in the Gardiner Range about one mile south-south-west of Areyonga Native Settlement. The Pertatataka Formation is easily eroded and forms broad strike valleys with a few low ridges of the more resistant sandstone and carbonate members. Owing to the nature of the outcrops, no sections have been measured through the formation on the Henbury Sheet area.

The Pertatataka Formation comprises grey-green and purple-brown, laminated, micaceous siltstone and shale with thin interbeds of sandstone and limestone. The sandstone is grey-green or white, laminated or thin bedded, fine to coarse grained and silicified. Much of it is glauconitic and many thin beds show closely spaced, clay pellet impressions. In places, there are markings on the bedding planes and for some of these an organic origin is suspected. The limestone is white, cream pale pink-brown, sandy and oolitic. In thin section the oolites are seen to consist of both carbonate and chert and there is evidence of selective silicification of the oolites in some bands.

The Pertatataka Formation appears to lie conformably on the Areyonga Formation wherever the units have been seen together and on the Henbury Sheet area is unconformably overlain by the Pertaoorrta Formation. This unconformable relationship is well demonstrated in the Gardiner Range near Areyonga Native Settlement, The absence of the Pertatataka Formation in the Parana Hill, Petermann Creek and Walker Creek Anticlines is considered to be the result of the pre-Pertaoorrta erosion rather than lack of deposition and it is considered most likely that there is a gradual transition from Pertatataka Formation to the more sandy Winnall Beds. This increase in sand content towards the south is apparently accompanied by a corresponding increase in overall thickness.

The age of the Pertatataka Formation can only be deduced from its stratigraphic position as no fossils have been found within the formation. On the Henbury Sheet area, the Pertatataka Formation is unconformably overlain by lower Middle Cambrian sediments and lies conformably on sediments of possible Upper Proterozoic age. The formation is tentatively regarded as being of Upper Proterozoic age. However, if the correlation with the Winnall Beds is correct, a Lower Cambrian age is possible (see section on Winnall Beds).

Winnall Beds

The name 'Winnall Beds' was first used by Wells, Ranford and Cook (1963) for 'a sequence of siltstone, sandstone and pebbly sandstone which lies probably unconformably above the Inindia Beds and unconformably below the Pertaoorrta Formation, Cleland Sandstone and Larapinta Group'. These relationships were found to hold in the Henbury Sheet area with, in addition, confirmation of the unconformable contact between the Winnall Beds and the Inindia Beds. There is no Cleland Sandstone on the Henbury Sheet area.

The Winnall Beds crop out as prominent strike ridges in the southern half of the Sheet area. The formation is especially well developed in the south-western corner of the Sheet area in the vicinity of Angas Downs. Other good exposures of the Winnall Beds occur at the western ends of the Seymour Range and the range to the south. The most northerly outcrop of Winnall Beds occurs in the Bacon Range. The best section of the Winnall Beds in the Sheet area is found in the Liddle Hills where there are an estimated 3500 feet of sediments exposed. Stewart (pers. comm.) measured a minimum thickness of 1196 feet for the Winnall Beds on the northern limb of the anticline which lies to the south of the Seymour Range. The thickness of the Winnall Beds in other areas is uncertain due to incomplete exposure.

It has become apparent that there are four units within the Winnall Beds:-

(Top)	Unit 4	Sandstone
	Unit 3	Siltstone and silty sandstone
	Unit 2	Sandstone
	Unit 1	Siltstone and silty sandstone

These units are recognizable in the field and also from the air photographs. The inter-relationships of these four units are shown by Wells, Stewart and Skwarko (1964).

Unit 1, which is the basal unit of the Winnall Beds consists of thin-bedded dark siltstones and some fine, slightly calcareous, silty sandstones. It is poorly exposed in most of the Henbury Sheet area and appears to be of variable thickness; on the Ayers Rock Sheet at Mount Connor Unit 1 is 500 feet thick whereas at the Liddle Hills Unit 1 is only 20 feet thick.

Unit 2 consists of two parts. The lower part comprising massive, cross-bedded, fine grained, silicified sandstone and the upper part thin to medium-bedded, coarse grained, silicified sandstone with some conglomeratic interbeds (mainly chert fragments). Both the upper and lower parts are strongly resistant to weathering and form prominent scarps and ridges. Unit 2 is of note for its abundance of sedimentary structures such as load casts, slump rolls, scour and fill structures, possible synaeresis cracks (White, 1961), ripple marks, mud-cracks, mud-pellet markings and a large number of other structures as yet not understood. In addition to these structures there are also a large number of suspected worm tracks and trails on the bedding planes. The unit is 1800 feet thick in the Liddle Hills.

Unit 3 is a poorly exposed silty interval with varigated, thin-bedded, silty sandstone. This unit is estimated to have a thickness of 1100 feet in the Liddle Hills.

Unit 4 is a dark brown, poorly sorted, medium bedded, moderately well exposed sandstone which is silicified in some places and friable in others. This unit is thought to be the more consistent of the sandstone units and crops out over a wide area. In some places (e.g. in the Bacon Range) it has a maximum thickness of 50 feet but in the Liddle Hills has a thickness of 600 feet.

The relationship of the Winnall Beds with underlying and overlying units is obscured by poor exposure at the top and bottom of the sequence, but in the Liddle Hills, the Winnall Beds, dipping at 38°, overlie the Inindia Beds which are dipping at 72°. The Winnall Beds also overlie the Bitter Springs Limestone with a marked unconformity at the same locality. Contacts with the overlying units are visible at the Liddle Hills where flat-lying Cambrian conglomerate unconformably overlies Winnall Beds dipping at 70°and seven miles east-south-east of Briscoe Tent Hill where the Winnall Beds unconformably underlie suspected Larapinta Group sediments.

The Winnall Beds have suspected fossil tracks and trails in Unit 2 but the majority are of an indeterminate nature. Wells, Ranford and Cook (1963) record the presence of a fossil comparable to <u>Syringomorpha</u> (Northorst) and Öpik (pers. comm.) has suggested that on this basis it is possible to speculate on a Cambrian age for the Winnall Beds.

The Winnall Beds are thought to be the lateral equivalent of the Pertatataka Formation. This is supported by the known position of the Winnall Beds between the Cambrian Pertaoorrta Formation and the Inindia Beds (equivalent to the Areyonga Formation).

CAMBRIAN

Pertaoorrta Formation

The name Pertaoorrta Formation is used for a sequence of shale, siltstone, sandstone, limestone, dolomite and conglomerate which lies unconformably above the Pertatataka Formation, or its lateral equivalent the Winnall Beds and is overlain conformably by the Pacoota Sandstone on the northern half of the Henbury Sheet area and disconformably by the Horn Valley Siltstone and Stairway Sandstone over most of the southern half of the Henbury Sheet area.

The type locality of the Pertaoorrta Formation is in the Western MacDonnell Ranges near Ellery Creek and the unit includes both the 'Pertaoorrta Group' and 'Arumbera Greywacke' of Prichard and Quinlan (1962). The reasons for this usage are enumerated in Wells, Ranford and Cook (1963).

Nine members have been mapped within the Pertaoorrta Formation on the Henbury Sheet area and two of these (Chandler Limestone Member and Quandong Conglomerate Member) have been defined from outcrops within this area.

The Pertaoorrta Formation is present throughout the Henbury Sheet area but the type of exposure is dependent largely on the lithology of the members present. In the north-western quadrant of the Sheet area the sandstone members of the formation form prominent strike ridges whereas the siltstone and shale members occur in valleys and are mostly covered by alluvium and scree. In the eastern half of the Sheet area the Pertaoorrta Formation consists largely of siltstone, shale and limestone and generally forms broad valleys with low strike ridges of limestone and dolomite. In the south-western corner of the Henbury Sheet area the Pertaoorrta Formation is represented by a poorly sorted conglomerate and conglomeratic sandstone facies which forms a mesa adjacent to the Angas Downs airstrip. Outcrops are generally poor in this area and in some places the presence of the formation is only marked by lines of boulders at the surface.

Sections were measured through the Pertaoorrta Formation in the Gardiner Range about four miles north-west of Areyonga (Hy R3-3586'), in the northern flank of the Petermann Creek Anticline about 10 miles west of Tempe Downs (Hy R2-2173'), and in the northern (about 1390') and southern (about 1050') flanks of the anticlinal structure south of the eastern end of the Seymour Range. Sections were also measured through parts of the formation in the Waterhouse Range (Hy R6) and in the outcrops about four miles east-north-east of The Sisters (Hy R7). When compared with sections measured on the neighbouring Sheet areas these sections indicate a thinning to the south and to the east. This thinning is associated with a change from sandy facies to a mixture of siltstone, shale and carbonate. However, in the south-western corner of the Sheet area a relatively thin sequence of approximately 300 feet of sandstone and conglomeratic sandstone unconformably overlies the Winnall Beds and Inindia Beds. This sediment is considered to be a thin marginal development of the Pertaoorrta Formation.

The individual Members will be described separately below and therefore further remarks in this section will be limited to a discussion of the outcrops not divided into members.

South of the Liddle Hills near the Angas Downs airstrip and for about 16 miles to the east-south-east of the airstrip there are a number of outcrops of sandstone and conglomerate which lie unconformably on the Winnall Beds and are disconformably overlain by the Stairway Sandstone. This sequence has a basal unit of two to five feet of poorly sorted silty sandstone with angular chert fragments derived from the Inindia Beds. Above the basal unit is a sequence of red-brown and purple-brown, moderately to poorly sorted, silty, micaceous sandstone with some conglomeratic bands and some conglomerate. The conglomerate contains moderately rounded to well rounded pebbles, cobbles and boulders of quartzite, sandstone, vein quartz and chert. The boulders measure up to three feet in diameter and have been largely derived from the Winnall Beds. The matrix of the conglomerate is dark red-brown, coarse grained, poorly sorted, angular sandstone.

In the Seymour Range the Pertaoorrta Formation can be traced from a sequence of siltstone and sandstone with minor limestone in the west to a sequence of interbedded limestone, siltstone and shale with very minor sandstone in the east.

The interfingering of these sequences can be seen in outcrop. The Jay Creek Limestone and the Goyder Member are the only Members identified in the Seymour Range; the rest of the formation has been mapped as undifferentiated Pertaoorrta Formation. The siltstone is dark red-brown, purple-brown and green, laminated, micaceous and partly sandy. The sandstone is red-brown and fawn, laminated to thin bedded, cross bedded, ripple marked and largely silty. It contains clay pellets and some vughs filled with calcite and pseudomorphs after halite were seen on some bedding planes. The limestone is fawn, cream and pinkish brown, largely sandy and partly oolitic and pelletal. It contains some algal colonies and much of it is cross-laminated. Some thin interbeds contain angular to rounded granules and pebbles of chert and pink feldspar.

In the ranges to the south of the Seymour Range the Pertaoorrta Formation is very poorly exposed and probably comprises mainly siltstone and shale. The only exposures are of sandstone which is red-brown, purple-brown and yellow-brown, laminated and thin bedded, kaolinitic, micaceous and silty and some siltstone which is pale purple-brown, laminated, micaceous and partly sandy.

At exposures about four miles south-east of Briscoe Tent Hill the Pertaoorrta Formation comprises dolomite, siltstone, silty sandstone and one bed of arkose with pink feldspar grains.

The relationships between the various Members of the Pertaoorrta Formation are shown in Figure 4.

Fossils of Middle and Upper Cambrian age have been collected from the Pertaoorrta Formation on the Henbury Sheet area (Tomlinson, 1964) and the formation is considered to include sediments deposited in marine and transitional environments.

Quandong Conglomerate Member (New name)

The name Quandong Conglomerate Member is used for the sequence of conglomerate, conglomeratic sandstone and sandstone which forms the basal unit of the Pertaoorrta Formation unconformably above the Areyonga Formation six miles north-east of Tempe Downs homestead. The name is derived from Quandong Creek which lies about six miles east of the type locality.

The Quandong Conglomerate Member has only been mapped in the type area and the core of James Range 'B' Anticline. The Member forms a prominent strike ridge in the type area and a low ridge in the core of James Range 'B' Anticline.

No sections have been measured through this Member but it is estimated to have a maximum thickness of about 500 feet in the type area and is known to decrease to approximately 50 feet over a distance of 2 miles. Rapid changes in thickness could be expected in a basal conglomerate of this type.

Owing to the lensing nature of this unit there is a marked change in the lithology from point to point and individual beds can be traced for only a short distance along strike. The sandstone is white, red-brown or chocolate-brown, thin to thick bedded, cross bedded, moderately to poorly sorted with some silt and clay matrix. The conglomerate contains fragments up to 12 inches across but the majority are less than $\frac{3}{4}$" in diameter. The fragments are largely of chert with lesser amounts of sandstone and quartzite and many of these fragments were apparently derived from the underlying Areyonga Formation.

The Quandong Conglomerate Member is considered to be a locally developed conglomeratic unit which rests unconformably on older units and conformably beneath the Tempe Member and/or Chandler Limestone Member (Figure 4). The unit is considered to be laterally equivalent to the Eninta Sandstone Member which rests unconformably on the Pertatataka Formation and Areyonga Formation in the Gardiner Range.

The Quandong Conglomerate Member lies conformably beneath sediments of lower Middle Cambrian age and is considered most likely to be of Lower Cambrian age.

Eninta Sandstone Member

The Eninta Sandstone Member was defined by Wells, Ranford and Cook (1963) as 'the sequence of fine and medium grained, ferruginous, feldspathic, micaceous sandstone with interbedded micaceous siltstone which forms the basal unit of the Pertaoorrta Formation in the Gardiner Range. The Member lies unconformably on the Pertatataka Formation and is conformably overlain by the Tempe Member in the type locality four miles west of Katapata Gap in the Gardiner Range. The name is derived from Eninta Creek part of which lies 14 miles east-north-east of Tempe Downs Homestead on the Henbury Sheet area.'

Outcrops of the Eninta Sandstone Member are only known from the Gardiner Range Anticline in the north-western part of the Henbury Sheet area, where the unit forms a prominent strike ridge. The outcrops mapped as Eninta Sandstone Member on the Lake Amadeus Sheet area by Wells, Ranford and Cook (1963) are now considered to belong to the Tempe Member.

The only section measured through the Eninta Sandstone Member on the Henbury Sheet area gave a thickness of 310 feet (Hy R3). This indicates a rapid thinning of the unit over the distance of about 15 miles from the type locality where the unit measured about 1200 feet.

The Eninta Sandstone Member comprises sandstone with minor siltstone and conglomerate beds. The sandstone is red-brown or purple-brown, thin bedded, cross-bedded, fine to medium grained, moderately to poorly sorted, micaceous, feldspathic and largely silicified. It contains some clay pellets and the cross-bed sets are characteristically slump-folded. The siltstone is red-brown, laminated and micaceous. The conglomeratic bands were seen at two main horizons in the Member. In some areas, at the base of the unit, there were a few conglomerate beds up to one foot thick and in most places about two thirds of the way up the sequence there were some conglomeratic sandstone beds. The fragments are predominantly of chert with minor amounts of limestone and dolomite. They vary from angular to subrounded and measure up to three inches in diameter. In the upper part of the Member the phenoclasts are accompanied by very large clay pellets.

The Eninta Sandstone Member lies unconformably on the Pertatataka Formation and Areyonga Formation and conformably beneath the Tempe Member. The unit is considered to be laterally equivalent to the Quandong Conglomerate Member (Figure 4) and probably equivalent to part of the Arumbera Greywacke Member.

Fossils have not been found in this Member and it is considered to be of Lower Cambrian age from its stratigraphic position.

Chandler Limestone Member (new name)

The name Chandler Limestone Member is used for the sequence of limestone, dolomite and interlaminated chert which lies between the Tempe Member above and the Quandong Conglomerate Member below, six miles north-east of Tempe Downs homestead. The name is taken from the Chandler Range where the unit is exposed beneath the Jay Creek Limestone Member.

Outcrops of the Chandler Limestone Member are known from the type area to the eastern margin of the Henbury Sheet area and from Orange Creek Homestead in the north to Palmer Valley Homestead in the south. Fingers or lenses of the Chandler Limestone Member also occur within the lower part of the Tempe Member in the Parana Hill and Petermann Creek Anticlines. The Member is generally exposed as low isolated ridges of contorted limestone but in some places forms strike ridges and in others the only indication of the unit is the chert rubble in lines at the surface.

The contacts with the underlying and overlying units are not exposed and this together with the contorted nature of the outcrop prevents any accurate calculation of thickness for this Member. Rough estimates of thickness suggest that the Member varies from 10 feet to 300 feet in the Henbury Sheet area.

The Chandler Limestone Member comprises pale grey to dark grey, sandy limestone, dolomite and calcareous sandstone with numerous black and white chert laminae. The Member is easily distinguished from the other Pertaoorrta Formation limestones by the presence of the chert laminae, a strong fetid odour and the fact that the unit is generally strongly contorted and folded. The incompetent folding is possibly due to the presence of interbedded evaporites. Although evaporites have not been seen in outcrop they have been recorded from the lower part of the Pertaoorrta Formation in the Alice No.1 well on the Alice Springs Sheet area.

The Chandler Limestone Member lies between the Tempe Member above and Quandong Conglomerate Member below in the type area and between the Jay Creek Limestone Member above and the Pertatataka Formation below in the Chandler Range and near Orange Creek homestead. South of Henbury homestead the unit overlies the Winnall Beds and is overlain by the Jay Creek Limestone Member.

The Chandler Limestone Member is considered to be of Lower Cambrian age but a lower Middle Cambrian age is not impossible. Fossils have not been found in this unit.

Tempe Member

The Tempe Member was defined by Wells, Ranford and Cook (1963) as 'the sequence of red and green siltstone, green-brown and grey-brown, fossiliferous, glauconitic, sandy dolomite and yellow-brown, glauconitic, feldspathic sandstone which lies conformably between the Eninta Sandstone Member below and Illara Sandstone Member above in the Gardiner Range. The type locality is four miles west of Katapata Gap in the Gardiner Range.' The name is derived from Tempe Downs Station which lies on the Henbury Sheet area.

On the Henbury Sheet area the Tempe Member has been mapped in the Gardiner Range, Walker Creek, Petermann Creek and Parana Hill Anticlines. The unit has not been recognised east of longitude 132°30' or south of latitude 24°30'. The Tempe Member is not a resistant unit and normally occurs in strike valleys although the more resistant sandstone and carbonate beds tend to form low ridges.

Sections were measured through the Tempe Member in the Gardiner Range about four miles west of Areyonga (Hy R 3 - 764') and in the northern limb of the Petermann Creek Anticline (Hy R 2 - 445').

The Tempe Member comprises mainly siltstone and shale with variable amounts of sandstone, limestone and dolomite. The siltstone and shale are red-brown, purple-brown and grey-green and laminated. The sandstone varies from white to dark purple-brown. It is largely thin bedded, cross bedded, slump folded, fine to medium grained, moderately friable, micaceous and glauconitic. Some beds contain clay pellets; some beds are calcareous and some are rich in feldspar. The light coloured glauconitic beds frequently contain phosphatic brachiopods. The limestone is yellow-brown, grey and grey-green. It is usually partly glauconitic and contains trilobites, gastropods and phosphatic brachiopods. The dark grey to light grey dolomite and limestone with chert laminae and 'biscuits' occurs towards the base of the Tempe Member. This fetid carbonate sequence rests directly on the Bitter Springs Limestone and Areyonga Formation in the core of the Parana Hill Anticline and could be considered as a finger or lens of the Chandler Limestone Member which develops further to the east.

The Tempe Member lies conformably beneath the Illara Sandstone Member wherever the units have been recognised. However, the Tempe Member lies conformably on the Eninta Sandstone Member in the Gardiner Range, apparently conformably on the Chandler Limestone Member six miles north-east of Tempe Downs homestead, and unconformably on the Bitter Springs Limestone and/the Areyonga Formation in the western culmination of the Petermann Creek Anticline and in the Parana Hill Anticline. The relationships with the other members of the Pertaoorrta Formation are shown in Figure 4.

The Tempe Member contains fossils of lower Middle Cambrian age.

Jay Creek Limestone Member

The Jay Creek Limestone Member was defined as a Formation by Prichard and Quinlan(1962) who wrote, 'The Jay Creek Limestone is named after Jay Creek near the eastern edge of the area, and consists of biostromal (algal) and oolitic limestone and very minor shale beds. It conformably overlies the Hugh River Shale and is conformably succeeded by the Goyder Formation.' Wells, Ranford and Cook . (1963) suggested that these formations should be down graded to Member status and this useage is continued in this report.

The Jay Creek Limestone Member has been mapped in the middle of the Waterhouse Range Anticline, the James Range 'A' and James Range 'B' Anticlines and the eastern half of the Seymour Range Anticline. The Member also occurs to the west of the Orange Creek homestead, in the Chandler Range and in an area between Henbury and Palmer Valley homesteads from near the main north-south-road to the eastern margin of the Sheet area. Outcrops are normally poor and the unit generally forms a series of low strike ridges separated by concealed intervals. Where the exposures are more complete the section between the limestone ridges is mainly calcareous siltstone, fine grained sandstone and shale.

Incomplete sections gave a minimum thickness of 478' (Hy R6) for the Member in the middle of the Waterhouse Range Anticline and a minimum thickness of 902' (Hy R 7) for the Member about four miles east of The Sisters.

Fig.7. Algal structures in the Jay Creek Limestone Member of the Pertacorrta Formation about ten miles east of The Sisters. Neg.No.M/304/27.

Fig.8. Close-up of one of the algal structures shown above. Neg.No.M/304/26.

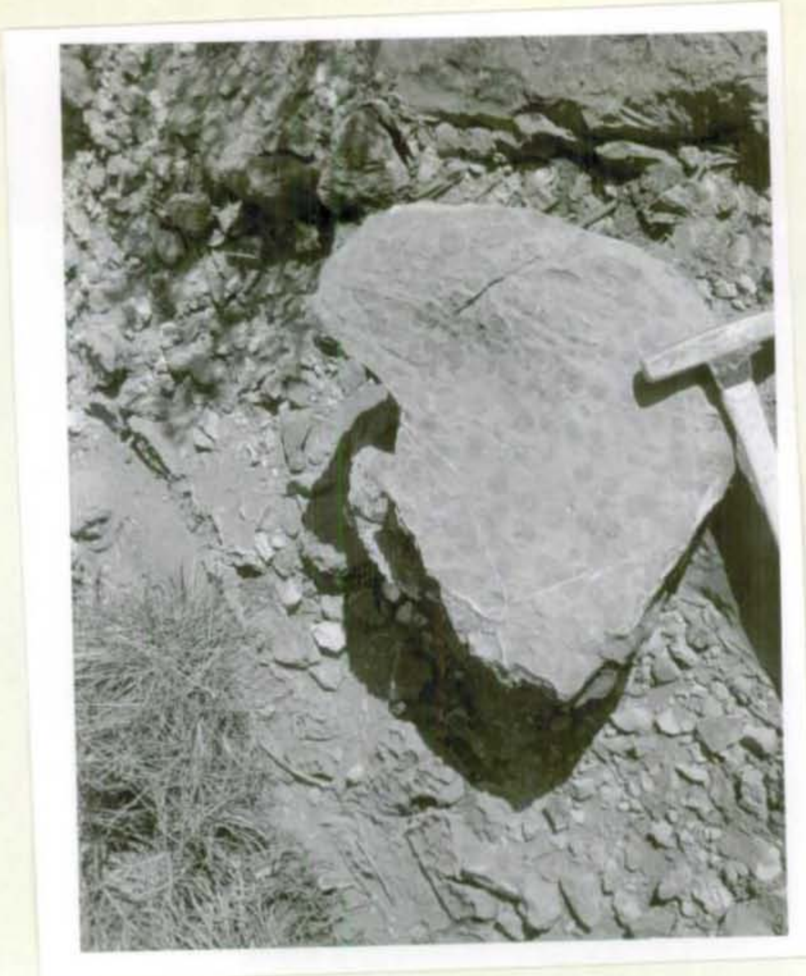


Fig. 9. *Girvanella* from the basal part of Jay Creek Limestone Member in the Waterhouse Range.
Neg.No.M/304/16

Fig.10. Algal structure in the Jay Creek Limestone Member in the Waterhouse Range. Neg.No.M/304/15.

Although there are insufficient data to prove it, it seems certain that the Jay Creek Limestone Member gradually thickens to the east after first appearing approximately half way across the Henbury Sheet area. A similar trend was noted by Prichard and Quinlan (1962) working on the Hermannsburg Sheet area to the north.

Limestone is the most obvious lithology in this Member. Assuming that most of the concealed interbeds are of siltstone and shale, the limestone probably accounts for 30 to 40 percent of the sequence, sandstone about 10 percent and siltstone and shale from 50 to 60 percent.

The siltstone and shale are pale grey, purple-brown, and grey-green, laminated, micaceous and largely calcareous.

The limestone is pale grey, fawn, cream and mid grey, thin bedded and laminated, cross-laminated, partly oolitic, partly sandy, and partly algal (see Figures 7, 8, 9 and 10). The sandstone is white, cream and pale grey, thin bedded friable, partly micaceous and commonly calcareous.

The Jay Creek Limestone Member lies conformably beneath the Goyder Member on the northern half of the Henbury Sheet area and also at some localities in the southern half of the Sheet area. However, in some places on the southern half, the Goyder Member is very thin (e.g. near The Sisters) or not present at all (e.g. in parts of the Seymour Range) and the Jay Creek Limestone Member is disconformably overlain by the Larapinta Group sediments (either Stairway Sandstone or Horn Valley Siltstone). The Jay Creek Limestone Member overlies the Chandler Limestone Member in most areas but the southernmost exposures may be underlain by undifferentiated siltstone and shale of the Pertaoorrta Formation. Tentative correlations with other Members of the Pertaoorrta Formation are shown in Figure 4.

The Jay Creek Limestone Member contains fossils of lower Middle Cambrian age (Trilobites and Girvanella) and Upper Cambrian age (Trilobites). The fossils are listed and discussed in a separate report (Tomlinson, 1964). The Member is considered to be of Middle and Upper Cambrian age and was probably deposited in a very shallow marine environment.

Illara Sandstone Member

The Illara Sandstone Member was defined by Wells, Ranford and Cook (1963) as 'the sequence of fine and medium-grained,ferruginous, micaceous sandstone with minor siltstone interbeds which lies conformably above the Tempe Member, and conformably beneath the Deception Member, within the Pertaoorrta Formation, in the Gardiner Range. The type locality is approximately 12 miles west-north-west of Katapata Gap in the Gardiner Range. The name is derived from Illara Creek which joins Walker Creek approximately two miles west-north-west of Tempe Downs homestead.'

The Illara Sandstone Member crops out forming a prominent strike ridge in the Gardiner Range, Walker Creek, Petermann Creek, and Parana Hill Anticlines.

Sections were measured through the Illara Sandstone Member in the Gardiner Range (Hy R 3) where it is 236' thick and the northern limb of the Petermann Creek Anticline (Hy R 2) where the unit is 178' thick. The Member thins to the east and is not present on the eastern half of the Henbury Sheet area.

The Illara Sandstone Member comprises sandstone and minor siltstone. The sandstone is pale red-brown, purple-brown, and white, laminated and thin bedded, cross bedded, fine to medium grained, moderately sorted, partly silicified and partly friable. It is slump folded in places, and much of it is micaceous and kaolinitic. Some beds are rich in clay pellets and some beds have a calcareous matrix. The siltstone is red-brown and purple-brown, laminated, micaceous and partly sandy.

The Illara Sandstone Member lies conformably between the Deception Member above and the Tempe Member below. The Member thins away from the north-western corner of the Henbury Sheet area and was not deposited outside the north-west quadrant. It interfingers with the siltstone Members above and below and is probably laterally equivalent to parts of the Jay Creek Limestone and Hugh River Shale Members in the Western MacDonnell Ranges and the eastern side of the Henbury Sheet area.

Fossils have not been found in this Member but it is considered to be of Middle Cambrian age from its stratigraphic position.

Deception Member

The Deception Member was described by Wells, Ranford and Cook (1963) as 'the sequence of red-brown, micaceous siltstone with minor interbeds of red-brown, fine-grained sandstone which lies conformably between the Illara Sandstone Member below and the Petermann Sandstone Member above in the Pertaoorrta Formation in the Gardiner Range. The type locality is about 12 miles west-north-west of Katapata Gap in the Gardiner Range. The name is derived from Deception Creek which passes approximately eight miles east of Tempe Downs homestead on the Henbury Sheet area.'

The Deception Member has been mapped in the Gardiner Range, Walker Creek, Petermann Creek, and Parana Hill Anticlines on the Henbury Sheet area. The unit is easily eroded and is generally concealed beneath alluvium in a strike valley; the more resistant sandstone beds form low strike ridges within the valley in some areas.

The Deception Member is 564' thick at Hy R3 in the Gardiner Range, and 430 feet thick at Hy R2 in the northern limb of the Petermann Creek Anticline. These figures show that the Member thins to the south and east from the type area but there is very little change in thickness from the Parana Hill Anticline (see Wells, Ranford and Cook, 1963) to the section at Hy R2.

The Deception Member comprises mainly siltstone and shale with minor amounts of sandstone and limestone. The siltstone and shale are red-brown, purple-brown, pale red-brown and grey-green, laminated, micaceous, partly calcareous and partly sandy. ~~The sandstone is red-brown and purple-brown, thin bedded, crossbedded, fine-grained, slump-folded, micaceous, partly calcareous and partly calcareous and partly sandy.~~ The sandstone is red-brown and purple-brown, thin bedded, cross bedded, fine-grained, slump folded, micaceous and calcareous. Some thin beds contain many clay pellets. The limestone which is fawn and cream, fine-grained, and sandy occurs as a few scattered thin beds. The Deception Member lies conformably between the overlying Petermann and underlying Illara Sandstone Members wherever it has been mapped on the Henbury Sheet area. The Member is considered to be laterally equivalent to part of the Jay Creek Limestone Member on the eastern side of the Henbury Sheet area and part of the Hugh River Shale and Jay Creek Limestone Member in the Western MacDonnell Ranges.

Fossils have not been found in the Deception Member but it is considered Middle Cambrian in age from its stratigraphic position.

Petermann Sandstone Member

The Petermann Sandstone Member was defined by Wells, Ranford and Cook, 1963 as 'the sequence of red-brown, pale purple-brown and white, fine and medium grained, micaceous sandstone which lies conformably between the Deception Member below and the Goyder Member above, within the Pertaoorrta Formation, in the Gardiner Range. The type locality is approximately 12 miles west-north-west of Katapata Gap in the Gardiner Range ..... The name is derived from the Petermann Hills .... about 12 miles west of Tempe Downs homestead.'

The Petermann Sandstone Member has been mapped in the Gardiner Range, Walker Creek, Petermann Creek, and Parana Hill Anticlines on the Henbury Sheet area. The Member thins to the east and has not been recognized east of a line south from Areyonga Native Settlement. The unit stands up as a prominent strike ridge in most places with a steep slope at the base and a more gradual slope at the top of the unit.

At HyR 3,in the Gardiner Range, the Petermann Sandstone Member is 637 feet thick and at HyR 2,in the northern limb of the Petermann Creek Anticline,the Member is 334 feet thick. These measurements indicate thinning of the Member to the east and south from the type locality. The thinning is probably associated with a gradual decrease in grain size.

The Petermann Sandstone Member comprises sandstone with minor siltstone and sandy limestone. The sandstone is pale red-brown, cream and white, banded, fine to medium grained, thin bedded, cross bedded, slump-folded, micaceous, partly calcareous and partly silty. It contains some clay pellets and some silicified beds. The siltstone is red-brown, purple-brown, laminated and micaceous. The sandy limestone is cream or pale red-brown, fine grained, thin bedded and occurs as scattered lenses only a few inches thick.

The Petermann Sandstone Member lies conformably between the underlying Deception Member and the overlying Goyder Member. Both contacts are apparently gradational. The Member thins to the east and in the Gardiner Range Anticline it can be seen to gradually disappear leaving the Goyder Member sitting conformably on the Deception Member.

The Petermann Sandstone Member is considered to be laterally equivalent to part of the Jay Creek Limestone Member on the eastern side of the Henbury Sheet area and equivalent to parts of the Hugh River Shale and Jay Creek Limestone Member in the Western MacDonnell Ranges. Only undiagnostic fossil fragments (Tomlinson, 1964) have been found in this Member but it is regarded as Middle or Upper Cambrian age from its stratigraphic position.

Goyder Member

The name Goyder Member is used in this report for the unit named by Prichard and Quinlan (1962) the Goyder Formation and defined by them 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'. The type section is half a mile west of Ellery Creek and the name was derived from Goyder Pass, which is in the Western MacDonnell Ranges 16 miles west of the Finke River Gorge. The reasons for changing the nomenclature adopted by Prichard and Quinlan (1962) are outlined in Wells, Ranford and Cook (1963).

Sediments assigned to the Goyder Member crop out in all but the south-western corner of the Henbury Sheet area. The unit is mostly poorly exposed in low strike ridges or concealed by alluvium and scree.

Sections were measured through the Goyder Member at HyR 3 (1075') in the Gardiner Range, HyR 2 (786') in the northern limb of the Petermann Creek Anticline, HyR 6 (1181'), in the southern limb of the Waterhouse Range Anticline and at HyR 7 (115'), about four miles east-north-east of The Sisters.

In the Gardiner Range the Goyder Member comprises siltstone, shale, sandstone, limestone and dolomite. The siltstone and shale are yellow, fawn, red-brown and white, micaceous and laminated. The sandstone is yellow-brown, pale red-brown, fine to medium grained, moderately sorted, laminated to thin bedded, micaceous, partly calcareous and partly silty. Some bedding planes show tracks and trails and others numerous pseudomorphs after halite. The limestone and dolomite are yellow-brown, grey, pink and fawn, thin bedded, partly sandy and partly oolitic. Some of the sandy dolomite near the base of the unit is cross laminated.

In the Waterhouse Range the carbonate beds are all placed in the underlying Jay Creek Limestone Member. The sandstone is similar to that described from the Gardiner Range but the siltstone is predominantly grey-green.

Near The Sisters the Goyder Member consists of fawn and yellow-brown, thin bedded, micaceous, calcareous sandstone and red-brown and grey-green laminated, micaceous siltstone and shale.

The Goyder Member lies apparently conformably beneath the Pacoota Sandstone in the northern half of the Henbury Sheet area but in various parts of the south-eastern quadrant of the area the unit is overlain by either the Pacoota Sandstone, the Horn Valley Siltstone or the Stairway Sandstone. In each case there is apparent conformity and no obvious indication of erosion.

In the north-western quadrant of the Henbury Sheet area, the Goyder Member is underlain by the Petermann Sandstone Member on the western side and the Deception Member on the eastern side. In the north-eastern quadrant and parts of the south-eastern quadrant of the Henbury Sheet area the Goyder Member is underlain by the Jay Creek Limestone Member. However, in some places in the south-eastern quadrant the units are too thin or the sequence is too poorly exposed to differentiate Members and in these areas it has been mapped as undifferentiated Pertaoorrta Formation.

Fossils have been collected in the Goyder Member from a number of localities (Tomlinson, 1964) and also from the underlying and overlying units. The Goyder Member is considered to be of Upper Cambrian age.

CAMBRIAN-ORDOVICIAN

LARAPINTA GROUP

The first attempts to delineate a group of rocks corresponding approximately to the Larapinta Group was made by Chewings (1894) who named the rocks the Mareeno Bluff Series. Two years later Tate (1896) gave the name Larapinta Series to what he considered to be the Ordovician rocks; the name Larapinta being derived from the aboriginal name for the middle and upper reaches of the Finke River. However, the series was not precisely defined by Tate and it was not until 1962 (Prichard and Quinlan, 1962) that the Larapinta Group was formally defined: '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 - all formations in the Larapinta Group are fossiliferous - the age of the fossils range from Upper Cambrian to Lower Ordovician in the Pacoota Sandstone to possibly Upper Ordovician in the Stokes Formation'.

Pacoota Sandstone

Mawson and Madigan (1930) were the first to use the name Pacoota Quartzite for the sandstone developed at the Finke Gorge Waterhole but some confusion arose over the use of the name. Prichard and Quinlan (1962) define the formation as follows 'The Pacoota Sandstone comprises a series of silicified quartz sandstones conformably overlying the Goyder Formation of the Pertaoorrta Group and succeeded conformably by the Horn Valley Formation'. The type section is at Ellery Creek in the Western MacDonnell Ranges.

The Pacoota Sandstone crops out sporadically over the northern half of the Henbury Sheet area but only very rarely in the southern half where it occurs in low, poorly exposed ridges. In the northern half, the Pacoota Sandstone forms very prominent strike ridges which rise up to several hundred feet above the general level of the plain.

The Pacoota Sandstone decreases in thickness from north to south across the Sheet area with the thickness ranging from 2053 feet (Hy C1) on the southern flank of James Range 'A' Anticline to 65 feet (Hy R7), four miles east of The Sisters and only five feet at a locality west-south-west of the Liddle Hills. The Pacoota Sandstone is completely absent from the Seymour Range, and the range to the south, and also is locally absent in the vicinity of Illamurta Yard due to either thinning of formations over a growing structure or to faulting or thrusting.

The Pacoota Sandstone is fine to coarse grained and generally well rounded and sorted, though in some places (e.g. near The Sisters) there is quite a high percentage of ?kaolinitic matrix and in other places (e.g. the Levi Range) pebbles of chert and silicified sandstone, up to one inch in diameter, are common. At two localities; one near Illamurta Yard and the other on the west bank of the Finke River where it cuts through the James Range 'A' Anticline there is a conglomerate apparently within and close to the base of the Pacoota Sandstone. However, it is possible that the conglomerate overlies the Pacoota Sandstone and is Tertiary in age.

Fig.11. Cruziana from the Pacoota Sandstone in the Waterhouse Range. Neg.No.M/304/10

Fig. 12. Cruziana from the Stairway Sandstone in the unnamed range south of the Seymour Range.
Neg. No.g/6135.

The bedding of the Pacoota Sandstone varies from thin to massive and such features as cross-bedding and ripple-marks are common. The formation weathers grey, white or brown; it is partly silicified but in places the rock is extremely crumbly and saccharoidal.

A few pelletal phosphatic sandstones occur within the Pacoota Sandstone. They are very similar in lithology to the Stairway Sandstone phosphorites although the pellets in the Pacoota Sandstone tend to be coarser (up to three inches in diameter). These pellet bands are thought to be of very limited lateral extent and form a negligible proportion of the total Pacoota Sandstone sequence.

Glauconitic sandstone is fairly common within the Pacoota Sandstone and occurs mainly in the upper half of the formation. Thin sections of the glauconitic sandstone reveal that there are two types of glauconite - granular and intergranular. The granular glauconite occurs as fine, well rounded discrete grains and may comprise up to 50% of the rock (e.g. Hy 136 (A)). The intergranular glauconite is interstitial to quartz grains (which may show some secondary enlargement) and only constitutes about 15% of the total rock (e.g. HY 142).

The contact between the Pacoota Sandstone and the underlying and overlying units are poorly exposed throughout the Sheet area, although in the Househill Range area and in the vicinity of The Sisters the contact between the Pacoota Sandstone and the Goyder Member is sufficiently well exposed to see that it is conformable and probably gradational. It is likely that the contact is conformable wherever the Pacoota Sandstone is present in the Sheet area. In much of the southern part of the Sheet area the Pacoota Sandstone and Horn Valley Siltstone are absent and the Stairway Sandstone rests on Cambrian and Upper Proterozoic units. The Pacoota Sandstone is locally absent in the vicinity of Illamurta Yard, and where present in this area the unit is apparently unconformably overlain by Mereenie Sandstone although due to overturning of the section it appears in the field that the Pacoota Sandstone overlies the Mereenie Sandstone.

The Pacoota Sandstone is generally poorly fossiliferous apart from Scolithus ('pipe-rock') which is very common. Other fossils found include '<u>Cruziana</u>', <u>Diplocraterion</u> , pelecypods, brachiopods, trilobites and various indeterminate tracks and trails. These fossils indicate that the Pacoota Sandstone has an age of Upper Cambrian to Lower Ordovician.

<u>Horn Valley Siltstone</u>

Madigan (1932) first proposed the name Horn Valley Beds but this name was later modified by Prichard and Quinlan (1962) to the Horn Valley Formation and defined as "the siltstone containing minor limestone beds which conformably overlies the Pacoota Sandstone and is conformably succeeded by the Stairway Greywacke". Because this unit is predominantly silty, the name is here revised to Horn Valley Siltstone. The type section is at Ellery Creek where the formation is 440 feet thick.

The Horn Valley Siltstone is very poorly exposed throughout most of the Sheet area although exposure is moderate in the Mount Levi area, near Running Waters, in the Mount Shady area, in the Househill Range near Tempe Downs homestead and near The Sisters. In these and all other areas, the formation weathers recessively, forming deep, strike valleys which contain a variable depth of superficial quaternary deposits.

The greatest thickness of Horn Valley Siltstone is recorded in the north-western part of the Sheet area: At HyR 4 (in the Areyonga area) a thickness of 353 feet is recorded for the formation; at HyC1 (in the James Range area) 243 feet and at Hy R1 (in the Mount Shady area) 198 feet. At HyR5 (on the southern flank of the Waterhouse Range) a thickness of 83 feet is recorded and near The Sisters at HyR 7 the thickness is 78 feet. West of the Liddle Hills the Horn Valley Siltstone is estimated to have a thickness of only ten feet and in the Seymour Range and the Range to the south the Horn Valley Siltstone is completely absent. It would appear fairly certain from these variations in thickness that the southern limit of Horn Valley Siltstone sedimentation, lay approximately between latitudes 24°40' and 25°00'.

The major lithology of the Horn Valley Siltstone is grey-green and greenish-brown siltstone which is laminated to thin bedded, calcareous in part, pyritic in part and soft and easily weathered. Grey, thin bedded, brittle pyritic limestone and sandy limestone is commonly interbedded with the siltstone and forms fairly prominent bands because of its greater resistance to weathering. The unit contains minor interbeds of sandstone, silty sandstone and calcareous sandstone and some pelletal phosphate bands. A prominent oolitic limonite band also crops out just below the top of the Horn Valley Siltstone at several localities in the Levi Range area and in the extreme south-western corner of the Sheet area.

This distinctive band is fully described by Wells, Ranford and Cook (1963). The same oolitic band has been intersected in diamond drill holes AP1, AP2 and AP3 and has confirmed that the limonite is due to the weathering of pyrite. Rare glauconitic sandstones and limestones have also been found within the Horn Valley Siltstone.

A thin section through a specimen of glauconitic limestone from the James Range area (Hy 137) contained both well rounded, discrete grains of glauconite and also intergranular glauconite. A thin section of a calcareous sandstone (Hy 121a) situated 10-20 feet below the top of the Horn Valley Siltstone from a locality four miles west of Mount Holder revealed a rock containing about 80% quartz which is moderately to well sorted and poorly rounded, with up to 20% intergranular calcite. Some of the calcite is fairly coarsely crystalline and there are unusual crenulated and jagged boundaries between the quartz and the calcite (this probably indicates recrystallization of both the quartz and the calcite). The only accessory minerals are rare grains of ?sphene and ?zircon and laths of crypto-crystalline apatite (probably fossil fragments).

The relationships of the Horn Valley siltstone to underlying and overlying units are always uncertain due to the extremely poor exposure. At both contacts there is a very marked change in lithology from lutaceous Horn Valley Siltstone to arenaceous Stairway Sandstone and Pacoota Sandstone. In all areas the Horn Valley Siltstone is apparently conformable with its overlying and underlying formations. However, the presence of a disconformity is indicated in the Briscoe Tent Hill area where the Horn Valley Siltstone rests on Cambrian limestones. In some other areas (e.g. parts of the Seymour Range) the Horn Valley Siltstone is completely absent and the Stairway Sandstone rests on Cambrian strata. In the Waterhouse Range area the Horn Valley Siltstone is directly overlain by the Mereenie Sandstone due to an unconformity at the base of the Mereenie Sandstone. A similar relationship may occur in the vicinity of Illamurta Yard.

The Horn Valley Siltstone contains an extremely rich and well preserved fauna and many specimens were collected. The fossils include trilobites, brachiopods, pelecypods, nautiloids, ostracods, conodonts and gastropods. This fauna indicates a Lower Ordovician age for the Horn Valley Siltstone.

Stairway Sandstone

This formation was first named the "Stairway Ridge Beds" by Chewings (1935) but the formation was later renamed the Stairway Greywacke and formally re-defined from Ellery Creek by Prichard and Quinlan (1962) as "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. It consists of about 60 percent of fine grained and medium grained quartz greywacke, usually rather silty and about 40 percent of cleaner quartz sandstone". In accord with most other reports on the Amadeus Basin this unit is here referred to as the Stairway Sandstone and not the Stairway Greywacke. In the Henbury Sheet area the Stairway Sandstone is conformably overlain by the Stokes Formation.

The Stairway Sandstone crops out over a large part of the Henbury Sheet area and commonly forms very well defined strike ridges and prominent scarps. Its best development occurs in the northern part of the Sheet area; the maximum thickness of 880 feet being recorded from HyC1 on the southern flank of James Range 'A' Anticline. A thickness of 825 feet was measured at HyR 4 near Areyonga, 760 feet at AP3 near Running Waters, 520 feet at AP2 near Mount Levi, 592 feet at HyR 1 near Mount Shady, 440 feet at HyC2 in the Seymour Range, 316 feet plus at Hy R7 near The Sisters, 483 feet at HyS1 in the middle of the range to the south of the Seymour Range, 419 feet at HyS2 at the eastern end of the same range and only 224 feet at the western end of the range. As in the other Larapinta Group units this thinning would seem to indicate that the margin of the basin of sedimentation lay to the south, though the margin for the Stairway Sandstone lay much further to the south than that for the previous Larapinta Group units.

The Stairway Sandstone consists of three main divisions; an upper and lower unit made up predominantly of sandstone, and a middle division predominantly of siltstone and mudstone with only minor sandstone. These three divisions are well defined over most of the Sheet area. However, on the southern margin there are only two divisions; a lower coarse sand and an upper fine sand.

It would appear that everywhere the lower sand tends to be coarser than the upper sand. The difference is less marked in the northern areas where the lower sand is medium to coarse grained (only rarely pebbly) and fairly well rounded and sorted and the upper sand fine to very fine grained and well rounded and sorted. In the southern parts of the Sheet area, the lower sand is coarse to very coarse grained and conglomeratic in places and poorly rounded and sorted and the upper sand is fine grained and fairly well sorted. In the south the lower coarse sand contains lenses of conglomerate with pebbles of vein quartz and quartzite up to two inches in diameter. This lower unit has a great variety of bedding plane markings, tracks and trails (Fig.12). In the south the upper unit is poorly exposed but where seen is yellow or grey in colour, and may contain abundant phosphatic material (e.g. in a small syncline nine miles north-east of Angas Downs) and may be richly fossiliferous (as in the vicinity of Briscoe Tent Hill where 'pipe-rock' is abundant and a large gastropod is extremely common).

In the more normal three-fold division of the Stairway Sandstone the lower sand is characterized by many tracks and trails which give a characteristic "ropey-texture" to the rock and also by presence of ooliths of limonite after pyrite. This lower sand is white or grey, thinly to massively bedded, rarely cross laminated, commonly silicified and strongly resistant to weathering (forming prominent scarps). The middle lutaceous division consists of black, grey and green siltstone and shaly mudstone with minor grey and brown, fine grained, fairly well rounded and sorted, thin bedded, rarely cross-laminated sandstone. Both the lutites and arenites of this middle division contain a great variety of indeterminate tracks, trails and surface markings. Pelletal phosphorites are fairly common in this middle division of the Stairway Sandstone (these are discussed more fully in the section of this report dealing with phosphorites). A few rare sandy limestone and dolomite bands are found within this middle division; they are generally yellow, grey or brown in colour, thin-bedded and recrystallized in places. A few phosphatic pellets occur in these calcareous bands. The upper division consists of sandstone which is fine grained, well rounded and sorted; it is grey or white in colour, silty in places, thinly to thickly bedded, cross-laminated in places, friable, silicified and forms prominent scarps. A few pelletal bands occur within this upper division and silty interbeds are much more common than in the lower sandy division.

A minor calcareous development occurs at the base of the Stairway Sandstone in some areas (e.g. in the Seymour Range and the range to the south, and near The Sisters). On the northern flank of the Seymour Range this lower unit consists of about 50 feet of interbedded grey and green calcareous siltstone with grey, white and varigated thin bedded limestone which appears to have a characteristic faunal assemblage of phosphatic brachiopods, gastropods and nautiloids. This sequence has been included in the Stairway Sandstone for convenience but at a later date it may become necessary to define a new unit to include these siltstones and limestones.

The Stairway Sandstone conformably overlies the Horn Valley Siltstone and it would appear, from field relationships (generally poorly exposed) and diamond drill hole AP1, that the boundary between thses two formations is very marked. A major break occurs at the base of the Stairway Sandstone in the southern part of the Sheet area where it rests disconformably on the Cambrian Pertaoorrta conglomerate in the Liddle Hills and unconformably on the Inindia Beds near Ten Mile Bore, north-west of Angas Downs homestead. The Stairway Sandstone is conformably overlain by the Stokes Formation and where exposure is sufficiently good (e.g. Parana Hill Anticline, the southern flank of the James Range 'A' Anticline) the boundary appears to be gradational. In the vicinity of Illamurta Yard, near the centre of the Sheet area, and at the western end of the Seymour Range, the Stairway Sandstone is apparently overlain by the Mereenie Sandstone.

The Stairway Sandstone is a richly fossiliferous unit and a large number of fossils were collected during the 1963 field season. The fossils include trilobites, brachiopods, gastropods, pelecypods, and nautiloids.

These fossils indicate that the age of the Stairway Sandstone is late Middle Ordovician in the Henbury Sheet area.

Stokes Formation

Chewings (1935) first called this formation the Marena Valley Shales and Mudstones but this was subsequently changed by Prichard and Quinlan (1962) to the Stokes Formation and defined from the type locality at Stokes Pass as 'The formation of siltstone and fine grained, silty greywacke which conformably overlies the Stairway Greywacke and is disconformably succeeded by the Mereenie Sandstone'. The formation is about 2000 feet thick at the type locality.

The Stokes Formation occurs throughout the Henbury Sheet area but it weathers recessively forming strike valleys and is generally poorly exposed. The formation is moderately well exposed in the Mount Shady area, at places along the southern flank of James Range 'A' Anticline and the northern flank of James Range 'B' Anticline and near Briscoe Tent Hill.

The greatest thickness of Stokes Formation on the Henbury Sheet area is thought to occur in the Areyonga area where the formation has an estimated thickness of 1500 feet. Sections were measured near Mount Shady (HyR1,1003 feet), on the southern flank of James Range 'A' Anticline (HyC1, 918 feet), on the northern flank of the Seymour Range (HyC2, 630 feet), the eastern end of therange to the south of the Seymour Range (HyS2, 419 feet) and in the middle of the same range (HyS1, 322 feet).

The Stokes Formation consists predominantly of grey, grey-green and red-brown siltstones which commonly contain halite pseudomorphs and are ripple marked. They are only rarely fossiliferous although in the Briscoe Tent Hill area the siltstones contain many pelecypods and trilobites. Limestones are common in the lower part of the Stokes Formation. They are grey, pink or yellow, slightly sandy in places, thin bedded, partly recrystallized and form prominent bands. The limestones are richly fossiliferous and many of them are coquinites. The examination of a few thin sections of these coquinites indicate that fragments of echinoderm plates are one of the major constituents. Detrital quartz makes up only a very small proportion of such limestones (five percent or less). Very minor sands and also very rare pelletal phosphorites do occur within the Stokes Formation but they are found only at the base of the unit and represent a 'carry-over' of Stairway Sandstone lithologies into the Stokes Formation because of the transitional boundary.

The boundary between the Stokes Formation and the Stairway Sandstone is conformable and gradational. The same is also thought to be true for the Stokes Formation-Mereenie Sandstone boundary over most of the Henbury Sheet area. However, in the Waterhouse Range, the Mereenie Sandstone rests unconformably on the Horn Valley Siltstone and the Pacoota Sandstone. The Stokes Formation is also locally absent in the Illamurta Spring area, at the western end of the Seymour Range and in the James Ranges about 12 miles east-south-east of Areyonga Native Settlement.

Many fossils were collected from the Stokes Formation but most of them are of a fragmentary nature. They include brachiopods, gastropods, pelecypods, trilobites, echinoderas and nautiloids.

An early Upper Ordovician age is postulated for the Stokes Formation.

UNDIFFERENTIATED PALAEOZOIC

Mereenie Sandstone

The Mereenie Sandstone was originally named by Madigan (1932) who traced the unit from Mereenie Bluff on the Mount Liebig Sheet area back to Ellery Creek on the Hermannsburg Sheet area. Prichard and Quinlan (1962) claim that the Mereenie Sandstone 'overlies the Larapinta Group with a regional unconformity and is succeeded, again with regional unconformity, by the Pertnjara Formation'.

The Mereenie Sandstone occurs throughout the Henbury Sheet area as prominent, brick-red strike ridges and ranges. The unit forms many of the most prominent topographic features on the western side of the area such as Mount Levi and the Levi Range, Tempe Tent Hill, Mount Shady and Illara Rock.

Sections were measured through the Mereenie Sandstone (Plate 2) in the Gardiner Range due south of Areyonga Native Settlement (HyR4, 2470 feet), near Mount Shady (HyR1, 1762 feet), in the Waterhouse Range (HyR8, 1498 feet), in the Seymour Range (HyC2, 458 feet), and on the northern flank of the anticline to the south of the Seymour Range (HyS1, 700 feet). There is evidence of general thinning away from the north-west corner of the Sheet area, with the most rapid change taking place towards the south.

The Mereenie Sandstone can be divided into two units in most places on the Henbury Sheet area. The basal unit is lithologically consistent and has been recognized in all major outcrop areas except the Waterhouse Range, the eastern end of the James Ranges, the Seymour Range and the southern limb of the anticline to the south of the Seymour Range. The upper unit is more variable lithologically but is always present. The two units are everywhere conformable but usually lithologically and physiographically distinct. The contact between the two units is invariably sharp and usually represented by a small strike valley or gully.

The basal unit is predominantly red-brown and pale purple-brown sandstone which is fine and medium grained, thin and medium bedded, cross-bedded and kaolinitic. This unit weathers massively forming the main escarpment and is never more than 300 feet thick. It contains '<u>Cruzianas</u>' and worm tubes in the Gardiner Range, James Ranges and near Mount Shady. '<u>Cruzianas</u>' have been found in this unit in the south-east corner of the Lake Amadeus Sheet area (Wells, Ranford and Cook, 1963) and at Stokes Pass in the Western MacDonnell Ranges. Small worm tubes also occur in the lower unit of the Mereenie Sandstone in the northern limb of the anticline south of the Seymour Range.

The upper unit of the Mereenie Sandstone is very consistent lithologically over the northern half of the Sheet area where it consists of white, fine to medium grained, well sorted, well rounded, thin bedded, ripple marked, cross-bedded sandstone. The weathered surface is a pale orange-brown and silicified. If this thin surface crust is broken much of the sandstone is so friable that it will crumble under its own weight. This unit accounts for the major part of the Mereenie Sandstone. It contains some beds which are riddled with near vertical (Fig. 15) and irregular worm burrows and on the neighbouring Lake Amadeus Sheet area the unit contains problematic markings which were first described from the Mount Rennie Sheet area (Wells, Forman and Ranford, 1962).

In the southern part of the Sheet area the upper unit of the Mereenie Sandstone is red-brown, orange-brown and white, fine to coarse grained, thin to medium bedded, cross-bedded, moderately to poorly sorted friable, porous, sandstone. It is partly kaolinitic and some beds are strongly ferruginised. This unit is quite variable and generally a dirtier sediment than its equivalent on the northern half of the Sheet area.

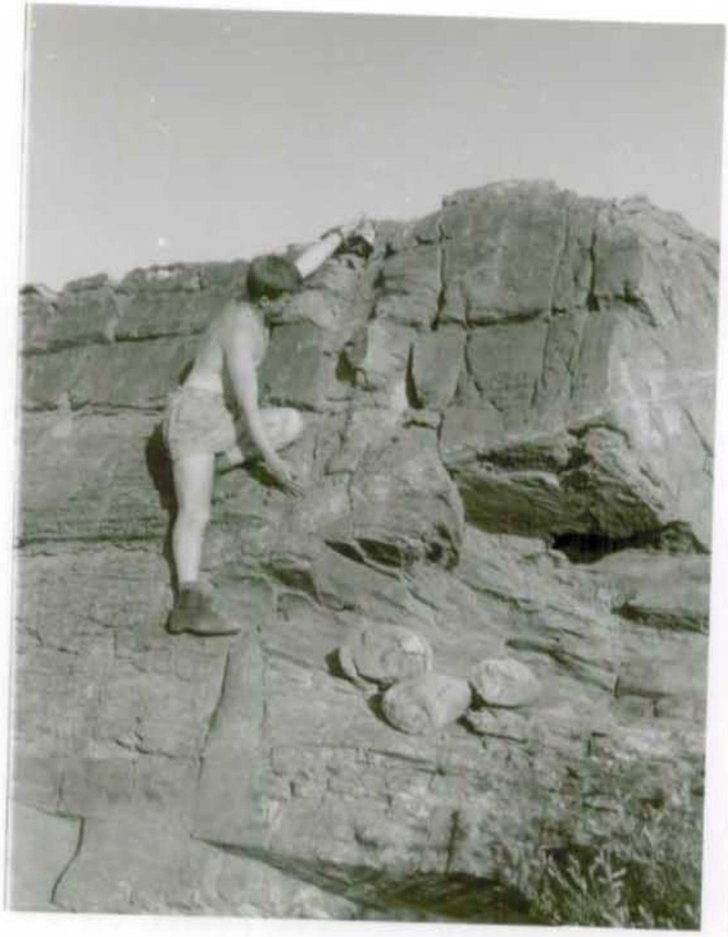


Fig.13. Large cylindrical 'rod-like' structures in the Mereenie Sandstone (Pzm(2)) about three miles west-south-west of Tempe Downs Homestead.
Neg.No.M/304/20.

Fig.14. Smaller 'rod-like' structures, as seen on the bedding planes at the same locality as the larger structures shown above. Neg.No.M/304/25.

At Hy 231 approximately three miles west-south-west of Tempe Downs homestead, the upper unit of Mereenie Sandstone contains a number of vertically standing, cylindrical rod-like structures (Figs. 13 and 14). They range in diameter from 5 to 15 inches and the largest seen was about 5 feet long. The large structures appear to taper slightly to one end and, although they all stand vertically, some taper towards the top and others towards the bottom. The structures occur in sandstone and in section they show a well developed circular structure with concentric rings of well sorted sand. The extremities of the rod-like structures are not exposed. These structures have not been seen elsewhere in the Amadeus Basin and their origin is uncertain. They are considered to be most likely of inorganic origin - possibly the feed pipes to sand volcanoes.

Over most of the Henbury Sheet area the Mereenie Sandstone has conformable and gradational contacts with the underlying Stokes Formation and the basal unit contains '<u>Cruzianas</u>' considered most likely to be of Ordivician age. However, in some areas the relationship with the underlying Larapinta Group sediments is unconformable and the basal unit of the Mereenie Sandstone is not present. In the Waterhouse Range the upper unit of the Mereenie Sandstone unconformably overlies the Pacoota Sandstone on the northern flank and the Horn Valley Siltstone on the southern flank. In the Gardiner Range, east of Areyonga, in the James Ranges near Illamurta Spring, and at the western end of the Seymour Range, the Mereenie Sandstone rests with apparent unconformity on older units. At each of these localities there is evidence of structural disturbance and it is not known whether the observed relationships are due to faulting or the original stratigraphic relationships. These three localities lie approximately along a straight line which if extended to the north, would pass through Gosses Bluff and Goyder Pass. It is possible that there was structural growth along this linear belt prior to Mereenie sedimentation.

In the north-western quadrant of the Henbury Sheet area the Mereenie Sandstone is apparently conformably overlain by siltstone and shale of the Pertnjara Formation. In the north-eastern quadrant the sandstone of the Pertnjara Formation lies unconformably or disconformably on the Mereenie Sandstone. In the Seymour Range area and in the anticlines to the south of the Syemour Range the Mereenie Sandstone is overlain by the

Fig.15. 'Pipe-rock' in the Mereenie Sandstone (Pzm(2)) near Mount Shady. Neg.No.M/304/7.

siltstone unit of the Pertnjara Formation but the contact is most probably unconformable.

The age of the Mereenie Sandstone is still uncertain. The basal unit is considered most likely to be Ordovician and as there is no evidence of any great time break within the formation it may be all of Ordovician age. The formation is partly of marine origin but probably includes some transitional and continental sediments.

Pertnjara Formation

The Pertnjara Formation was defined by Prichard and Quinlan (1962) as, 'the sequence of sandstone, quartz greywacke and conglomerate that overlies the Mereenie Sandstone with a regional unconformity ... it's upper limit is not known'. The unit was first described by Tate and Watt (1896) and was named Pertnjara (Series) by Chewing (1931), the name being derived from the aboriginal work for 'many stones' - a reference to the conglomeratic nature of the Pertnjara Formation in the MacDonnell Ranges.

The Pertnjara Formation crops out over a large portion of the northern half of the Sheet area, forming prominent scarps and ranges which rise up to 1000 feet above the surrounding plain. These scarps are well developed in the James and Gardiner Ranges and also in the Waterhouse Range. Less important developments of the Pertnjara Formation occur on the flanks of the Seymour Range and the range to the south. It is estimated from the air-photographs that the Pertnjara Formation has a thickness of at least 3000 feet in the northern parts and at least 1000 feet in the southern parts of the Sheet area.

The formation canbe divided into two lithological units in the Henbury Sheet area - a lower siltstone unit and an upper sandstone unit. These two units are described separately.

Lower Unit. This unit, sometimes informally referred to as the Pertnjara Siltstone, is poorly exposed, with only a few outcrops in isolated creek beds. It characteristically forms topographic lows and broad alluvium-covered valleys. The only place where a thickness for the lower unit was measured was in the Seymour Range and here a thickness of 660 feet was recorded. Calculations based on the air-photographs, indicate the lower unit of the Pertnjara Formation is at least 1500 feet thick in the Gardiner Range.

From the Gardiner Range, the unit thins rapidly to the east and the south. Near Mount Shady, 10 miles due south of the area of maximum thickness, the lower unit is estimated to have a thickness of only 750 feet. At the extreme western end of the James Range 'A' structure the silt unit thins to zero and it is not present over most of the north-east quadrant of the Henbury Sheet area. Local thinning (attributed to either thrusting and/or faulting or to structural growth during deposition) can be seen in the area near Illamurta Spring and near the south-west extremity of the Seymour Range.

It would appear from the limited exposure that the lower unit consists primarily of red-brown and purple-brown, micaceous (muscovite and some biotite), laminated to thin-bedded siltstones, with some thin, calcareous siltstones, grey limestones and silty sandstones.

The contact of the siltstone unit of the Pertnjara Formation with the underlying Mereenie Sandstone is obscured by Quaternary alluvium. In many places the contact is thought to be conformable but in the range south of the Seymour Range there appears to be a marked angular unconformity between the Mereenie Sandstone and the overlying siltstone of the Pertnjara Formation.

No fossils were found in the lower division of the Pertnjara Formation on the Henbury Sheet area but geologists of the Magellan Petroleum Corporation have found a fossil in a sandstone bed within the Pertnjara siltstone on the north flank of Mereenie Anticline; J.G. Tomlinson (per.comm.) has determined it to be a fragmentary fish-plate of probable Upper Devonian age. The siltstone unit of the Pertnjara Formation is tentatively regarded as being of Devonian age.

Upper Unit - This unit consists of well-exposed sandstones which form prominent scarps and ranges and wide deeply dissected plateaux. The plateaux have a characteristic dendritic drainage. It has been calculated from the air photographs that the upper unit (Pertnjara Sandstone) has a thickness of at least 1500 feet in the north-west corner of the Sheet area.

The unit consists almost entirely of red-brown, pale yellow and off-white sandstone which is fine to coarse grained, pebbly, poorly to well rounded, ferruginous in places and poorly sorted with a high percentage of silty matrix.

The bedding of the unit is medium to thick; cross-laminae, ripple marks and clay-pellet markings are common. This sandstone unit is commonly silicified, and consequently is more resistant to weathering.

The contact between the sandstone (upper unit) of the Pertnjara Formation and the siltstone (lower unit) is poorly exposed in most places but where it is visible (e.g. near Tempe Tent Hill and in the range to the south of the Seymour Range) the contact appears to be conformable. Near Tempe Tent Hill the boundary appears to be gradational but in the southern part of the sheet area the contact appears to be very sharp. The presence of a regional unconformity or disconformity at the base of the sandstone unit can be demonstrated by following the Pertnjara Formation east across the area where it can be seen to gradually transgress the Mereenie Sandstone. Erosion has removed the upper part of the sandstone unit of the Pertnjara Formation over the entire Henbury Sheet area.

No fossils were found in the sandstone unit of the Pertnjara Formation during this field season but Leslie (1960) reports the finding of 'a plant fossil (aff. Sigillaria) about 1500 feet above the base of the formation in the Tempe Downs area'. This fossil from the sandstone unit of the Pertnjara Formation is considered to be of Upper Devonian or Lower Carboniferous age.

?MESOZOIC

Sediments of possible Mesozoic age have been mapped at localities scattered throughout the southern three-quarters of the Henbury Sheet area. The sediments are flat-lying and in many places exposed in mesas capped with siliceous billy.

No sections have been measured but approximately 60 feet of sediment has been estimated in some of the mesas. The sediments comprise sandstone with interbeds of claystone and siltstone and rarely grit and conglomerate. The sandstone is white or cream, fine to coarse grained, moderately to poorly sorted, laminated to massively bedded, partly crossbedded and has a kaolinitic matrix. It contains scattered fragments of claystone and in some places the sequence is stained yellow and red as in the mottled zone of a laterite profile. The claystone and siltstone are white and generally sandy. The grit and conglomerate beds are considered to be local deposits derived from the underlying Palaeozoic and Proterozoic sediments.

Fossils have not been found in these sediments and they are tentatively regarded as having a Mesozoic age because of a possible correlation with the De Souza Sandstone.

The possible Mesozoic sediments of the Henbury Sheet area are similar in places to the type of De Souza Sandstone and are considered to represent a marginal facies laid down during the period of deposition of the De Souza Sandstone.

?TERTIARY

Deposits considered to be Tertiary occur sporadically over much of the Henbury Sheet area but are found mainly in the northern parts. A total of five Tertiary units were distinguished within the area mapped.

Undifferentiated Tertiary

Undifferentiated Tertiary sediments are of limited extent and have been mapped only in the Waterhouse Range (first recorded by Madigan(1932))and north of Dead Bullock Dam (Hy 95c & d). At both of these localities the mode of outcrop is as low mesas with a maximum height of 25 feet. This undifferentiated unit consists of a mixture of the other units. It comprises interbedded calcareous sandstones and conglomerates, calcareous sandy claystone and siltstone and some sandy limestone. The conglomerates, which in the Waterhouse Range form the upper part of the ?Tertiary section, are very coarse in places (with boulders up to two feet in diameter), and are composed mainly of silicified sandstone, some metamorphic quartzite and minor amounts of vein quartz; the cement is commonly calcareous. The sandstones are light brown in colour, coarse grained, poorly rounded and sorted, poorly bedded, and cross laminated in places. The finer sediments are grey in colour and are poorly exposed except where the limestone forms a capping.

The only fossils which have so far been found in this unit are silicified wood and tree roots which Madigan (1932) and J.G. Tomlinson (pers. comm.) have found in the Waterhouse Range. These fossils are of no great value in determining the age of the deposit.

Fig.16. Tertiary limestone with interbeds of sandy siltstone and calcareous sandstone near Maloney Bore.
Neg.No.M/306/31.

Fig.17. Tertiary conglomerate near No.5 Bore on Big Stone Plain.
Neg. No.M/305/3.

?Tertiary Conglomerate

This unit covers a considerable portion of the Henbury Sheet area but appears to be especially associated with areas adjacent to the Finke River and in some places, the ranges. The conglomerate is well exposed in the banks of the Finke River but is also well exposed in other areas such as Big Stone Plain near No. 5 Bore (Fig. 17), and also east of the main road, where rounded hills of ?Tertiary conglomerate rise up to 50 feet above the surrounding plain. In many places the ?Tertiary conglomerate has been redistributed by Quaternary erosion and drainage (e.g. in the vicinity of the Henbury Meteorite Craters) and in such areas the conglomerate is mapped as being of Quaternary age. In all areas the main criterion for distinguishing between Tertiary and Quaternary conglomerates is that those of the Tertiary are consolidated whereas those of the Quaternary are not.

The lithology of the ?Tertiary conglomerate is similar to that described in the previous section dealing with the undifferentiated Tertiary. The pebbles, cobbles and boulders are mainly of sandstone (many cobbles and boulders are recognised as having been derived from the Larapinta Group). The matrix is calcareous or sandy, with the sand poorly sorted and rounded. The cobbles etc. are poorly sorted but moderately well rounded.

No fossils have been found in the ?Tertiary conglomerate. At some localities (e.g. in the vicinity of Maloney Bore and Boomerang Bore) the ?Tertiary conglomerate appears to 'rim' the ?Tertiary limestone and it is suggested that in some places the ?Tertiary conglomerates formed on the strand lines and margins of fresh-water lakes whilst the limestones formed penecontemporaneously in the deeper parts of the lakes.

?Tertiary Limestone

On the Henbury Sheet area, limestones of possible Tertiary age are best developed between Maloney Bore and Boomerang Bore and in the Chandler Range area. There are also minor developments five miles west of Running Waters, eight miles west of Middleton Ponds homestead (abandoned) and near McRaes Yard.

This unit consists of white, grey and pale yellow limestones and chalcedonized limestone with interbeds of purple and green, sandy siltstones and siltstones and red-brown, coarse grained, poorly sorted, (pebbly in places) calcareous sandstone. The limestone beds attain a thickness of up to six feet and in places form prominent scarps and the cappings of mesas (Fig. 16). The maximum known thickness of this ?Tertiary limestone unit is 100 feet near Maloney Bore. In other places it appears to be considerably thinner and in the Chandler Range it has a maximum thickness of about 30 feet.

The ?Tertiary limestones of the Chandler Range area and those near Running Waters are fossiliferous, containing ostracods, planorbid gastropods and ?algae. The age of this limestone sequence cannot be dated with certainty from the fossils but it is suspected they are Tertiary. From the fossil assemblage it would seem fairly certain that this unit was laid down in fresh-water lakes.

?Tertiary 'Billy' (silicified sandstone)

'Billy' is the name given to a hard, siliceous sandstone (Dunstan 1900) developed as part of the lateritic profile. It is most strongly developed on ?Mesozoic sediments but is found in places, on pre-Mesozoic sediments. The best developments of 'billy' are found in the eastern half of the Sheet area where it commonly forms the resistant cappings of mesas. The 'billy' has a maximum known thickness of only 3 feet. It is white, grey or pale brown in colour, fine to coarse grained and partly banded. 'Billy' acquires many of the lithological features of the 'host rock' but the silicification, in many cases, obscures a sufficient number of the original lithological features for it to be impossible to establish the identity of the original rock unit.

The exact age of the ?Tertiary 'billy' is uncertain for relationships are obscure in the field, but it is known to be post-Mesozoic and is probably older than the main Tertiary weathering profile.

?Tertiary Laterite

The only part of the Tertiary laterite weathering profile which is at all common in the sheet area is the ferruginized zone. In addition, a mottled zone was found developed on the Goyder Member of the Pertaoorrta Formation at some localities.

The main area of ferruginization occurs along the southern front of the James Range between Enintatatara Rock Hole and Mount Holder, where ferruginized Mesozoic sediments unconformably overlie Pertnjara Formation, Mereenie Sandstone and Stokes Formation. The ferruginized rock commonly forms prominent scarps and bastion topography. As with ?Tertiary 'billy', the laterite assumes the lithological characteristics of the host rock which, in most areas, is a kaolinitic, medium to thick bedded sandstone. A specimen of ferruginized Goyder Member from the Yaua Bore area of the Levi Range contained 59% Fe and a specimen of ferruginized Mesozoic sediments from the Illamurta Spring area contained 43% Fe. The age of the laterite is difficult to establish with certainty but it was almost certainly formed after the laying down of the Tertiary sediments.

QUATERNARY

Aeolian Sand

Considerable areas of the Henbury Sheet area are covered by aeolian sand, especially within the area of physiographic division D (see Fig. 3) where there are wide sand plains with braided sand-dunes. The dunes, have a consistent trend locally but the trend varies considerably throughout the Sheet area. They are usually fixed by spinifex, desert oaks and eucalypts; the only migrating dunes are those which occur on clay-rich alluvium and have a hard base and no vegetation to check their movement.

Alluvium

The largest deposits of alluvium occur in the eastern half of the Sheet area and especially within the areas of physiographic divisions 'B' and 'F' and 'G' (see Fig.3). In all areas, local developments of alluvium are found adjacent to water-courses. The deposits are orange-brown to light brown sand, silt, clay and gravel and in some areas may attain a thickness of greater than 100 feet. In places the alluvium is covered by a dense growth of mulga (this is especially true adjacent to the ranges).

Conglomerate

Deposits of recent conglomerate cover only a relatively minor portion of the Sheet area and are to be found mainly adjacent to creeks and water courses and on the flanks of the ranges and scarps. Within the area of physiographic division 'F' (see Fig. 3) wide areas are covered with unconsolidated conglomerate which has resulted from the re-distribution of ?Tertiary conglomerate.

Travertine

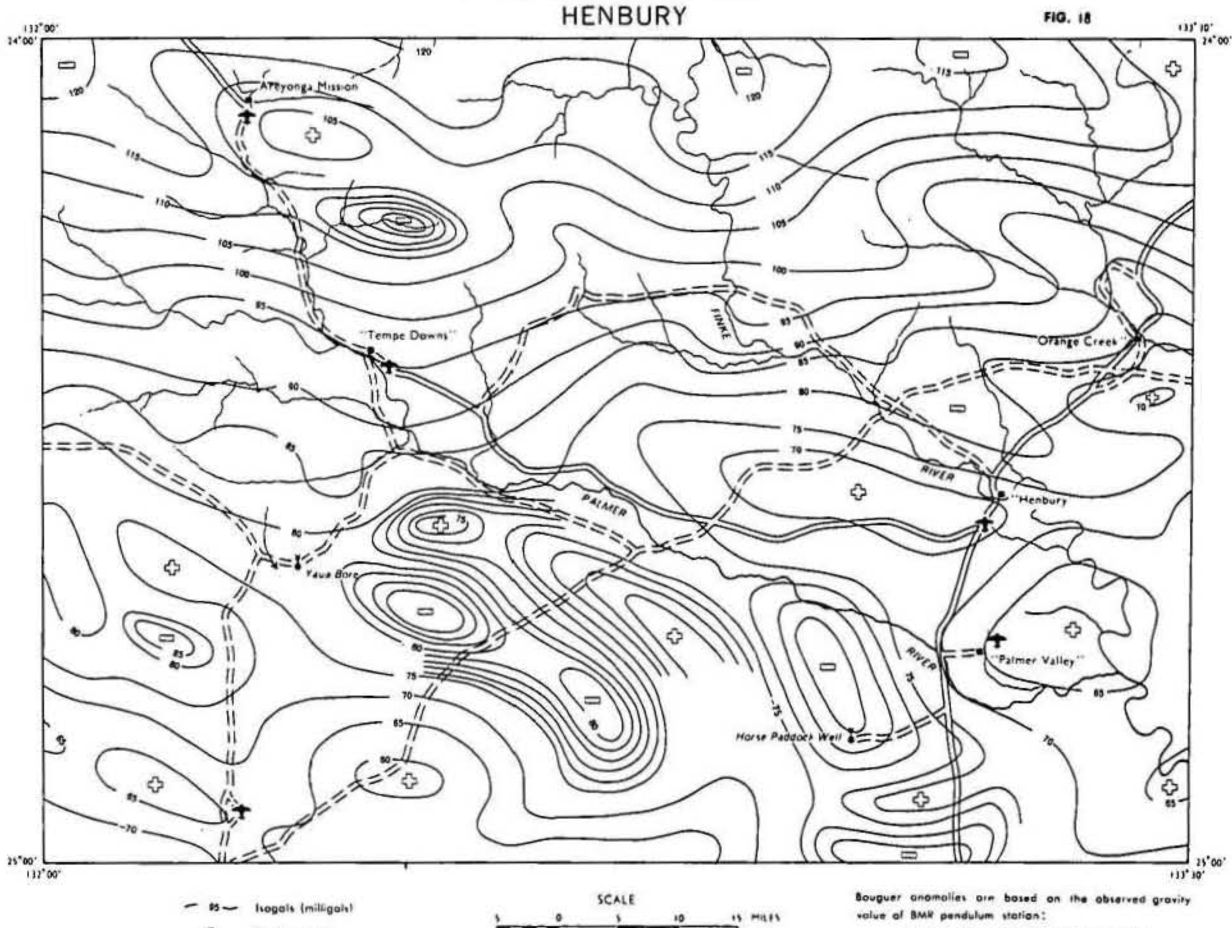
Small deposits of travertine occur adjacent to and overlying calcareous sediments. The deposits consist of grey or white, concretionary masses which commonly have a very vuggy texture; they result from the precipitation of carbonate from carbonate-rich ground-waters in superficial Quaternary sediments.

Gypsum

Small areas of superficial gypsiferous deposits occur in the south-western corner of the Sheet area, where masses of amorphous gypsum occur in low mounds. Such deposits are commonly associated with caliche or travertine and may be formed by a similar mechanism.

BOUGUER ANOMOLIES
HENBURY

FIG. 18



— 85 — Isogals (milligals)

High anomaly

Low anomaly

SCALE 5 0 5 10 15 MILES

Bouguer anomolies are based on the observed gravity value of BMR pendulum station:

No. 35 Alice Springs 978,653.6 milligals

For the calculation of Bouguer anomalies 2.2 g/cm^3 has been adopted as an average rock density

Geophysical field data from BMR gravity and microbarometer surveys

Bureau of Mineral Resources, Geology and Geophysics. April 1964. To accompany Record No 1964/4C.

G53/A1/12

STRUCTURE

The Henbury Sheet area lies in the central part of the Amadeus Basin and no igneous or metamorphic basement rocks are exposed in the area. Sections measured through the sediments indicate that the sedimentary pile decreases in thickness from north to south.

Only two reconnaissance aeromagnetic traverses have been flown across the area and these have been interpreted to indicate a thickness of greater than 10,000 feet of sediments along the flight lines (Goodeve, 1961).

The regional gravity contours (Fig. 18) correspond fairly closely to the known geological and structural trends and also indicate a thinning of the sediments to the south. In general, the cores of major anticlinal structures correspond to gravity maxima and the synclines to gravity minima. The -80 isogal divides the Henbury Sheet area into two distinct provinces. These provinces have different outcrop patterns, structural elements and possibly different sedimentational histories. The -80 isogal corresponds approximately to the southern limit of Pacoota Sandstone outcrop and probably marks the southern margin or hinge line of the basin during the early part of the Lower Ordovician.

Folding

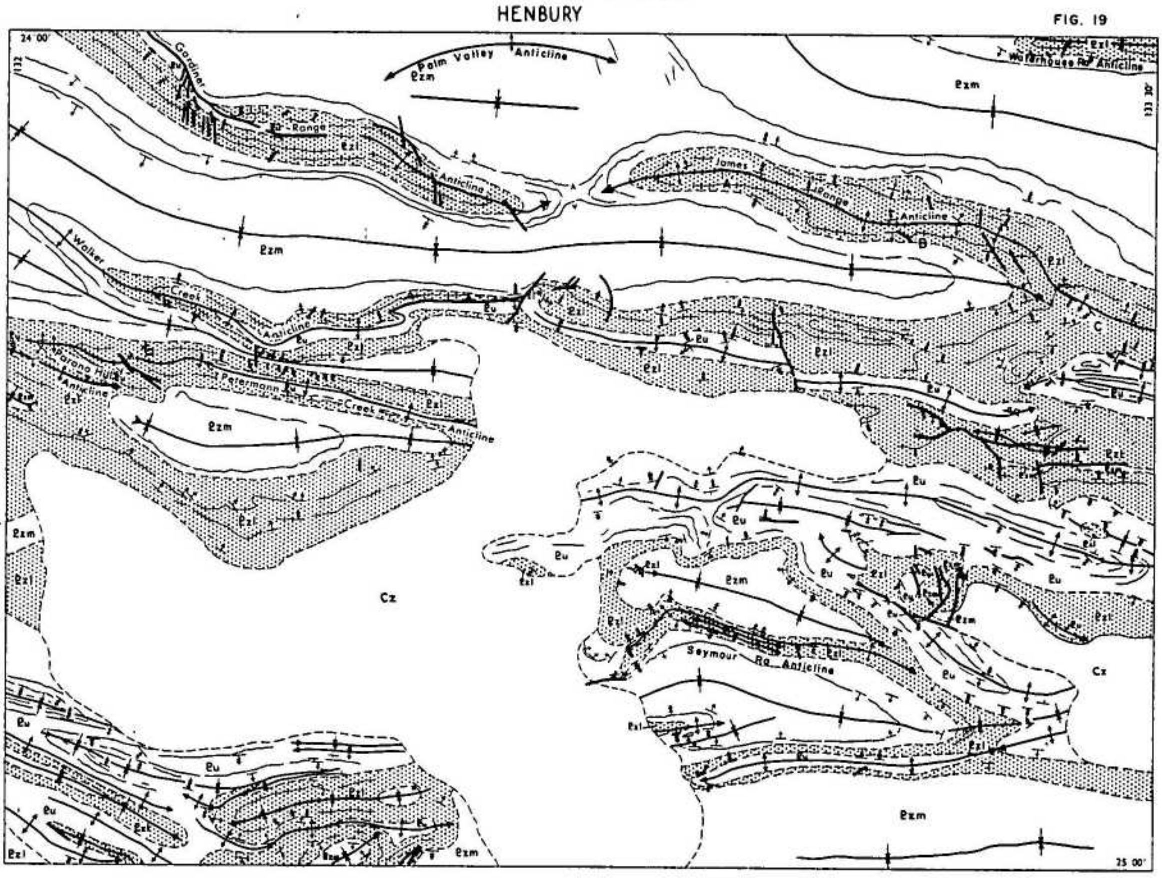
The sediments of the Henbury Sheet area were folded or warped on at least six occasions between the Upper Proterozoic and Mesozoic times but only two major orogenic episodes have been recognised.

The first orogeny occurred in late Upper Proterozoic or early Lower Cambrian times, and resulted in the tight folds seen in the Liddle Hills in the south-west corner of the Sheet area (Fig. 19). This folding was most intense in the southern part of the Amadeus Basin (Wells, Ranford and Cook, 1963) and is correlated with the Petermann Ranges Folding of Forman and Hancock (1964).

The second period of folding probably began during the Upper Devonian and the final pulse of this orogeny folded the Pertnjara Formation during the Carboniferous Period. This second period of folding resulted in the long, narrow, structures which trend in a west-north-westerly direction, and which are now characteristic of the northern half of the Amadeus Basin.

STRUCTURAL INTERPRETATION
HENBURY

FIG. 19



SCALE
5 0 5 10 15 MILES

Bureau of Mineral Resources, Geology and Geophysics. April 1964 To accompany Record No 1964/40 G53/A1/11

The axes of the folds formed during the two orogenies are subparellel but the stresses were probably directed from the south during the earlier folding and from the north during the later folding. The folds formed by the earlier orogeny have sharp anticlinal crests and broad synclinal troughs.

The complexity of the major structures on the Henbury Sheet area appears to increase with depth so that relatively simple anticlinal or domal structures in the Pertnjara Formation or Mereenie Sandstone may be complexly folded and faulted in the Upper Proterozoic and Cambrian strata. Many of the anticlines are thought to be supratenuous folds formed by contemporaneous growth and sedimentation. Such features as supratenuous folding and the increasing complexity with depth in the cores of the folds are considered to be due to the presence of evaporites in the sequence. Evaporites and diapiric structures have not been recognised in outcrop on the Henbury Sheet area. However, probable diapirs are known from the neighbouring Lake Amadeus and Hermannsburg Sheet areas and evaporites have been intersected in wells (Ooraminna No.1 and Alice No.1) drilled for oil on the Alice Springs and Rodinga Sheet areas. Considering these facts together with the disturbed and contorted nature of some of the outcrops on the Henbury Sheet area, it seems probable that evaporites occur within the Upper Proterozoic Bitter Springs Limestone and the Cambrian Chandler Limestone Member of the Pertaoorrta Formation.

Faulting

The faults recognised on the Henbury Sheet area are of two main types. The largest and most prominent faults are longitudinal thrust faults which occur in the Gardiner, Chandler, Seymour and Bacon Ranges and in the Illamurta Spring area. These faults could be termed 'break thrusts' after Billings (1942).

The main longitudinal fault in the Gardiner Range has been referred to by previous workers as the 'Gardiner Fault' and the ' reyonga Fault'. It extends for about 50 miles in a west-north-west to north-westerly direction and has an estimated throw of about 14,000 feet. At the surface the fault plane dips between 55° and 90° to the south-west. The greatest amount of movement has taken place about mid-way along its length where the Bitter Springs Limestone rests against the Pertnjara Formation. The movement along the fault appears to decrease gradually towards its extremities.

The longitudinal thrusts in the Chandler Range dip steeply to the north and trend between west and north-west. The thrust zone extends for about 20 miles and the maximum throw is probably about 5,000 feet. There is local overturning of the younger units near the fault plane and in some places the Mereenie Sandstone rests against the Chandler Limestone Member. A notable feature of the thrusts in the Chandler Range is the almost ubiquitous occurrence of the highly incompetent Chandler Limestone Member in the hanging wall at the fault line.

About 16 miles east-north-east of Tempe Downs Homestead, near Illamurta Spring, the Areyonga Formation has been thrust over the Mereenie Sandstone. The thrust plane dips steeply to the south and the throw is calculated to be about 8,000 feet, assuming the relationships are purely the result of faulting. It is possible that there has been structural growth during deposition at this locality and if this is so then the movement may have been much less than 8,000 feet.

At the south-western extrêmity of the Seymour Range the Inindia Beds have been thrust over the Mereenie Sandstone. The thrust plane dips steeply to the north and the throw could be up to 5,000 feet. However, as is the case with the thrust near Illamurta Spring, there is a possibility of a reduced section due to structural growth during deposition at this locality, and therefore the movement may be much less than 5,000 feet.

A similar structure to those seen near Illamurta Spring and the south-western part of the Seymour Range occurs about 15 miles east of Areyonga Native Settlement. At this locality the Pacoota Sandstone appears to have been thrust against the Mereenie Sandstone. This structure dips steeply to the south, has a lateral extent of about five miles and a possible throw of about 2,500 feet.

In the Bacon Range, and in an area about 10 miles to the south, there are a number of steeply dipping thrusts which can be traced for up to 15 miles. These thrusts trend between west and west-north-west and the larger ones have a south-block-up movement.

The second group offaults on the Henbury Sheet area are the transverse faults. This group is the largest numerically but most of them are of small lateral extent and show very little displacement. A large number of these transverse faults radiate from the large longitudinal fault in the core of the Gardiner Range Anticline. The transverse faults all trend between north-north-west and north-north-east.

GEOLOGICAL HISTORY

The oldest unit exposed on the Henbury 1:250,000 Sheet area is the Bitter Springs Limestone which was deposited in a widespread Upper Proterozoic sea during a period of tectonic stability. The presence of algal stromatolites and evaporites within the unit indicates a very shallow water environment. The deposition of the Bitter Springs Limestone was interrupted by epeirogenic movements which resulted in some blocks being eroded.

The overlying Areyonga Formation (in the north) and Inindia Beds (in the south) were deposited disconformably on the Bitter Springs Limestone and contain fragments of the Bitter Springs Limestone as well as other pre-Cambrian sedimentary, igneous and metamorphic rocks. The Areyonga Formation and Inindia Beds are considered to be partly aqueoglacial in origin; it seems probable that some of the erratics within them have been transported (possibly icerafted) up to 100 miles.

The Areyonga Formation is thinner, coarser grained and more variable than the Inindia Beds and probably represents a landward facies. The sediments are partly marine and contain some oolitic and algal limestone beds which may have been deposited during warmer interglacial periods.

After the deposition of the Inindia Beds the sediments in the south-western part of the basin were folded but there is no evidence of any disturbance in the north where the Pertatataka Formation lies conformably on the Areyonga Formation. The source of the sediments probably lay to the south during the deposition of the Winnall Beds and Pertatataka Formation. The Winnall Beds are considerably thicker and coarser than the Pertatataka Formation which was apparently deposited in a quiet marine environment and contains some minor, shallow water, carbonate facies.

In late Upper Proterozoic or early Lower Cambrian times sedimentation was interrupted in the south by an orogenic period which resulted in isoclinal folding and uplift of much of the Winnall Beds and less intense folding of the Pertatataka Formation in some areas. These movements drove the sea from the area and, although sedimentation may have continued along the northern margin of the present basin, it is possible that much of the Henbury Sheet area remained above sea level for much of the Lower Cambrian.

As the basin gradually subsided the seas of Pertaoorrta Formation times spread to the south and the west leaving some lenses of locally derived conglomerate on and near the unconformity surface. Migration of the shoreline resulted in a corresponding shift in the sedimentary facies so that the carbonates which first appeared in the Lower Cambrian in the north-east part of the basin had reached the eastern half of the Henbury Sheet area by the early Middle Cambrian. Due to minor fluctuations of sea level some thin marine beds and lenses were deposited as far west as longitude 131°31' but the typical Jay Creek Limestone facies is not known west of 132°50' on the Henbury Sheet area. Subsidence continued into the Upper Cambrian and both the marine carbonates in the east and the continental and transitional red sandstones in the west were followed by a widespread marine sandstone, siltstone and sandy limestone sequence (Goyder Member). This sequence was followed in late Upper Cambrian times, with no obvious breaks in the northern parts of the Sheet area, by the basal sandstone of the Larapinta Group (Pacoota Sandstone). During the period from the late Upper Cambrian until at least the early part of the Upper Ordovician stable shelf, marine sediments were deposited over much of the Henbury Sheet area although the sea may not have encroached on the southern quarter of the area until late in the Lower Ordovician. The Larapinta Group sediments represent two major cycles of sedimentation from arenite to carbonate and lutite; the greatest thickness of sediments was laid down along the northern margin of the area. Most of the sediments are of shallow water origin but part of the Horn Valley Siltstone may have been deposited in deeper water.

In Upper Ordovician times epeirogenic movements resulted in some sediments in the north-eastern corner of the Henbury Sheet area being lifted above wave-base and eroded, but marine sedimentation continued into Mereenie Sandstone times over much of the Sheet area. A gradual regression of the sea and a change to transitional and continental environments occurred during the deposition of the Mereenie Sandstone. These conditions may have continued until the Upper Devonian (i.e. until the deposition of the silts of the Pertnjara Formation) when orogenic movements in the northern and eastern parts of the basin resulted in erosion in some areas and the deposition of a thick sequence of coarse clastic sediments adjacent to the uplifted area along the northern margin of the present basin. Away from the disturbed zones finer grained sands were deposited on the silts. The final pulse of the orogeny caused folding of the Pertnjara Formation and also most of the major faults throughout the basin. Some of this folding and faulting probably took place along pre-existing lines of weakness. Erosion of the folded, faulted and uplifted sediments continued until either the Jurassic or Cretaceous period when a marine incursion from the east resulted in the deposition of a thin sequence of sediments between the ranges on the Henbury Sheet area. No marine fossils have been found in these sediments on the Henbury Sheet area and they most likely represent transitional and continental facies deposited around the margins of the extensive Mesozoic seas.

Following the deposition of Mesozoic sediments the area was uplifted and eroded. During the Tertiary a wetter period resulted in the formation of an extensive series of lakes which were probably fed by the present drainage system. Thin beds of conglomerate, sandstone, siltstone, shale and carbonate were deposited in and around these lakes.

The deposition of the Tertiary lacustrine sediments was followed by further dissection and erosion.

The sand dunes were formed during an arid phase in the Quaternary and now, as a result of a more recent amelioration of the climate, the dunes have been fixed by a sparse vegetational cover, and thin alluvial sequences have been deposited in the river courses, on the flood plains, and adjacent to the ranges.

ECONOMIC GEOLOGY

Phosphate Deposits

Introduction

The presence of phosphorites in the Amadeus Basin was first mentioned briefly by Wells, Forman and Ranford (1962), who found isolated examples of phosphate-rich rock in the Stairway Sandstone of the Mount Liebig Sheet area. During 1962 a closer study of these phosphorites was made in the Lake Amadeus Sheet area and especially in the vicinity of Johnny Creek (Wells, Ranford and Cook, 1963; Cook, 1963). As a result of this work, diamond drilling of the Stairway Sandstone was carried out by the Bureau of Mineral Resources in 1963 at two localities (AP1, AP4) on the Lake Amadeus Sheet area and two (AP2, AP3) on the Henbury Sheet area (Barrie, 1964). During 1963, the authors continued reconnaissance surface studies of the Stairway Sandstone phosphorites of the Henbury Sheet area. This work confirmed that pelletal phosphorites are confined to the Cambro-Ordovician Larapinta Group (apart from very minor developments in the Tempe Member of the Pertaoorrta Formation) and indicate that only the Stairway Sandstone has a sufficient concentration of phosphate for there to be any likelihood of it having an economic potential.

It is not proposed at this stage to discuss the Amadeus Basin phosphorites in detail as this will be the subject of reports by Barrie (1964) and Crook and Cook (1964), but some observations made specifically within the Henbury Sheet area are discussed briefly.

Phosphorite occurrences

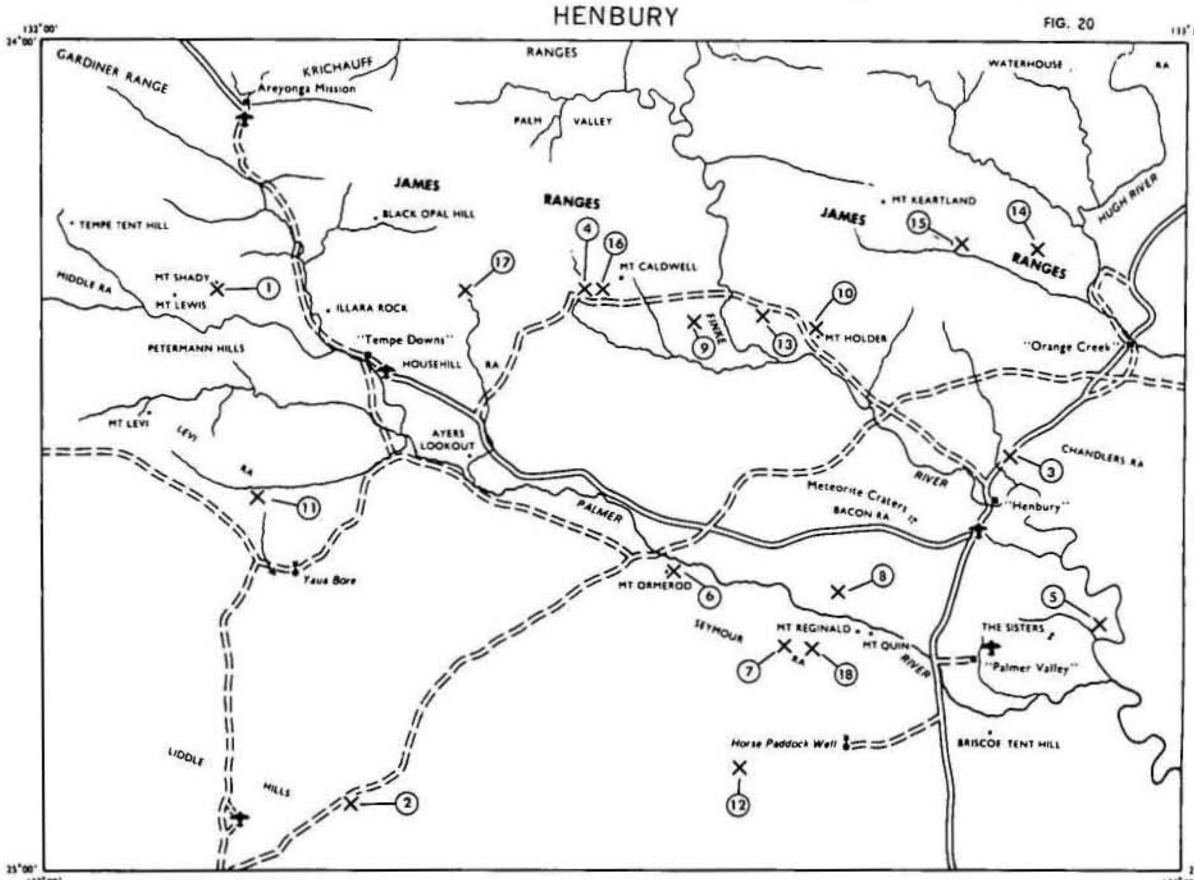
Stokes Formation: This formation is apparently poorly phosphatic because pelletal phosphorite was found at only one locality (in Walker Creek Anticline on the western side of the Sheet area). The phosphorite occurred just above the base of the formation and probably represents a continuation of Stairway Sandstone conditions into the Stokes Formation.

Stairway Sandstone: This is the most phosphatic formation of the Larapinta Group, with a maximum P_2O_5 content of 19% recorded from a sample of pelletal phosphorite from Walker Creek Anticline (locality 1, see Fig. 20).

LOCATION OF SPECIMENS ANALYSED FOR P_2O_5 CONTENT

HENBURY

FIG. 20



× Location of analysed specimen

SCALE 5 0 5 10 15 MILES

Bureau of Mineral Resources, Geology and Geophysics. April 1964. To accompany Record No 1964/40. G53/A1/13

TABLE III QUANTITATIVE PHOSPHATE ANALYSES

Map Reference No. (See Fig.20)	Field Reference No.	Formation	Lithology	Percentage of P_2O_5
1	Hy53	Stairway Sandstone	Sandstone with medium, phosphatic pellets.	19.0
2	Hy705(B)	Stairway Sandstone	Coarse sandstone with large pellets.	18.0
3	Hy189(B)	Stairway Sandstone	Sandstone with fine pellets.	17.0
1	Hy55	Stairway San stone	Sandstone with pellets.	16.9
4	Hy129	Stairway Sandstone	Pelletal sandstone.	16.5
1	Hy40	Pacoota Sandstone	Fossiliferous sandstone with pellets.	16.0
5	Hy90(B)	Stairway Sandstone	Pelletal silty sandstone.	16.0
1	Hy54	Stairway Sandstone	Calcareous sandstone with phosphatic pellets.	14.2
I	Hg10	Stairway Sandstone	Sandstone with small pellets.	14.2
6	Hy154	Stairway Sandstone	Sandstone with pellets.	14.1
7	Hy149	Stairway Sandstone	Sandstone with fine pellets.	14.0
1	Hy59	Stairway Sandstone	Sandstone with medium, phosphatic pellets.	14.0
8	Hy155	Stairway Sandstone	Sandstone with pellets (from scree).	13.2
9	Hy120(A)	Stairway Sandstone	White, pelletal, silty sandstone.	13.0
10	Hy123(C)	Stairway Sandstone	Fine, pelletal sandstone.	12.5
1	Hy51	Stairway Sandstone	Sandstone with pellets.	12.2
11	Hy107(5)	Stairway Sandstone	Sandstone with small, phosphatic pellets (from scree).	11.2
7	Hy148	Stairway Sandstone	Coarse, pelletal sandstone (from scree).	10.8
9	Hy120(B)	Stairway Sandstone	Sandstone with fine, white, silty pellets.	10.8
3	Hy189(A)	Stairway Sandstone	Pelletal sandstone (silicified in part).	10.0
11	Hy107(2)	Stairway Sandstone	Sandstone with grey, phosphatic pellets (from scree).	8.8
1	Hy57	Stairway Sandstone	Sandstone with phosphatic pellets.	8.8
5	Hy90	Stairway Sandstone	Calcareous sandstone with pellets.	8.0
12	Hy62(a)	Stairway Sandstone	Green and white, silty sandstone with pellets.	8.0
12	Hy62(b)	Stairway Sandstone	Green and white, silty sandstone with pellets.	8.0
11	Hy107(4)	Stairway Sandstone	Coarse sandstone with pellets (from scree).	7.5
13	Hy121(d)	Horn Valley Siltstone	Calcareous sandstone with fine pellets.	7.0
11	Hy107(3)	Stairway Sandstone	Ferruginized, phosphatic sandstone (from scree).	6.7
3	Hy189(c)	Stairway Sandstone	Pelletal sandstone (silicified in part).	6.0
14	Hy171	Pacoota Sandstone	Coarse sandstone with large phosphatic nodules (from river gravel)	5.2

Map Reference No. (See Fig.20)	Field Reference No.	Formation	Lithology	Percentage of P_2O_5
.0	Hy123(a)	Stairway Sandstone	Silty, calcareous sandstone with pellets.	4.5
10	Hy123(b)	Stairway Sandstone	Silicified sandstone with pellets.	4.5
10	Hy123(d)	Stairway Sandstone	Pelletal siltstone.	2.5
9	Hy119(A)	Stairway Sandstone	Silicified sandstone with silty ooliths.	2.0
13	Hy121(b)	Horn Valley Siltstone	Limestone with fine pellets.	1.7
15	Hy172	Stairway Sandstone	Sandstone with silty oolites.	1.6
13	Hy121(c)	Horn Valley Siltstone	Fossiliferous limestone.	1.2
13	Hy121(a)	Horn Valley Siltstone	Sandy limestone with a lustrous appearance.	1.0
11	Hy107(6)	Stairway Sandstone	Fossiliferous sandstone (from scree).	<0.5
11	Hy107(1)	Stairway Sandstone	White, silty sandstone.	<0.5
16	Hy132	Boundary of Stairway Sandstone and Horn Valley Siltstone	Sandstone with silty ooliths.	<0.5
4	Hy130	Stairway Sandstone	Silty sandstone which has been strongly sheared.	<0.5
17	Hy125	?Horn Valley Siltstone	Brown, sandy limestone.	<0.5
9	Hy119(B)	Stairway Sandstone	Silicified sandstone with pellet casts.	<0.5
18	Hy146	Stairway Sandstone	Partially silicified, very coarse grained sandstone.	<0.5
5	Hy90(c)	Stairway Sandstone	Pelletal sandstone (strongly ferruginized)	<0.5

Ⅱ Indicates that the specimen was collected from Gosses Bluff and not from a locality within the Henbury Sheet area.

This formation is discussed in greater detail below.

Horn Valley Siltstone: The maximum P_2O_5 content recorded from this unit was 7%. The sample, which was a calcareous sandstone with fine phosphatic pellets, was obtained from locality 13 (see Fig. 20) and represents a 12 inch band which lies about 20 feet below the top of the Horn Valley Siltstone. The majority of the lithologies within the formation are only slightly phosphatic, with a P_2O_5 content of about 1% or less. Phosphatic pellets are rare but the P_2O_5 content is added to slightly by the presence of phosphatic shelly fragments of fossils (trilobites and brachiopods).

Pacoota Sandstone: This formation is generally poorly phosphatic. This is concluded from the results of analyses carried out on samples of the Pacoota Sandstone of the Lake Amadeus Sheet area (Wells, Ranford and Cook, 1963), but the two samples of Pacoota Sandstone from the Henbury Sheet area, submitted for P_2O_5 analyses gave results of 16% and 5.2%. Both of these samples were sandstones with phosphatic pellets and may be regarded as exceptional lithologies within the Pacoota Sandstone. The normal sandstone of the formation would probably have a P_2O_5 content of less than 1%.

Stairway Sandstone Phosphorites.

As a result of fairly extensive sampling of the Stairway Sandstone during 1962 and 1963 it can now be concluded that the only lithology with any potential for economic deposits is the pelletal material of the formation. This is a fairly distinctive lithology which may occur anywhere within the Stairway Sandstone. The pelletal bands are especially well exposed in the Mount Shady area; in the vicinity of Mount Holder; in the Chandler Range near the main road; and nine miles north-east of Angas Downs homestead. Pelletal bands are also found at many other localities but are only poorly exposed.

The percentage of pellets is highly variable within the formation with only rare pellets in some beds and up to 50% of pellets in others. There is some correlation between the percentage of pellets and the percentage of P_2O_5 in a sample but the correlation is only very approximate for the pellets may contain variable amounts of detrital quartz (see Table V, Wells, Ranford and Cook (1963) for details of P_2O_5 content of individual pellets). As in the Lake Amadeus Sheet area there appeared to be two types of pellets; a brown, well rounded pellet with a fairly high degree of sphericity and a grey or black poorly rounded pèllet with a low degree of sphericity. Phosphatic ooliths are generally rare but a few have been seen in thin section (see Fig. 30, Wells, Ranford and Cook, 1963). Oolitic pyrite is common towards the base of the Stairway Sandstone and also in the upper part of the Horn Valley Siltstone and it is suggested that this oolitic material may have originally been phosphatic ooliths which were pyritized shortly after deposition. In the southern part of the Sheet area a peculiar green pelletal band up to one foot in thickness was found. It is especially well developed at the western end of the range to the south of the Seymour Range. An identical band has been found in the Inindia Bore area and a sample from this area submitted for X-ray analysis indicated that the green mineral was corkite (a lead phosphate complex, not previously recorded in Australia). It is not known as yet whether the mineral is primary or is a secondary weathering product. The fact that corkite is not recorded in the diamond drill hole AP4, which was drilled through the Stairway Sandstone near to the corkite locality in the Inindia Bore area (Barrie, 1964) suggests that corkite is a secondary weathering product.

The pellet bands have a minimum thickness of less than one inch and a maximum thickness of one foot but their average thickness appears to be only about two inches.

In thin section, the phosphorites consist predominantly of medium to very fine grained detrital quartz with areas of intergranular cryptocrystalline apatite. These areas of intergranular apatite generally correspond to pellets but it would appear also that some of the apatite has moved into other parts of the sandstone. It is suggested from some thin sections that the quartz grains within the pellets are of a slightly different grain size to the surrounding quartz grains (generally the latter is coarser grained - see Figs. 25 and 30; Wells, Ranford and Cook 1963), but this is not supported by all the thin sections of phosphorites. A thin section of a phosphatic pelletal sandstone (Hy705C) from locality 2 (see Fig. 20), containing 17.8% P_2O_5 (equivalent to 42.3% Apatite), has been described as follows by the Australian Mineral Development Laboratories, South Australia (in lit): "This rock has been classified as a <u>phosphatic protoquartzite</u> or subgreywacke. It consists of fragmental grains of quartz cemented by slightly iron-stained, crypto-crystalline <u>apatite</u>. The quartz grains are poorly sorted, ranging in grain size from fine to medium grained; they are generally angular or subangular in shape but occasional subrounded grains are seen. In part there appears to be a tendency towards graded bedding but this is rather obscure. A few grains are reworked as they show remnants of secondary quartz overgrowths. Extinction on the grains is undulatory. Rock fragments are a minor constituent; they are rounded in outline and of a similar nature to the host rock. Occasional flakes of muscovite occur but show no preferred orientation. Rounded zircon is a rather common accessory while rounded opaques and green tourmaline are less abundant. The cryptocrystalline apatite cement is not evenly distributed through the rock and some indication of brecciation are seen. Iron oxide occurs as a stain and, in part, cements grains as well". This should not be regarded as a description of a typcial Stairway Sandstone phosphorite but merely as a description of one of the phosphorite lithologies.

Origin of the Stairway Sandstone Phosphorites

The origin of the phosphorites has already been discussed briefly in previous reports (Wells, Ranford and Cook 1963, Cook 1963). There is little to be added to these discussions at present from the work exclusively within the Henbury Sheet area. It can be pointed out that the phosphorites have their major concentration (in both thickness and grade) in the middle part of the Stairway Sandstone which is the silty part of the formation. However, within this silty portion of the formation it is found that the phosphatic pellets accompany the sandy beds and are only very rarely found in the silt. This is also the case in the Lake Amadeus Sheet area and Cook (1963) has postulated an autochthonous origin of the phosphate to account for this and other relationships. It would also appear that some of the phosphatic material is allochthonous and it may be that, within the Amadeus Basin in Stairway Sandstone times, several mechanisms were operating contemporaneously and resulted in very similar end-products.

Water Supply

Surface Water

There is abundant surface water in the northern and eastern parts of the Sheet area, with large waterholes occurring in many of the creeks and rivers. Waterholes are especially abundant along the Finke River and are permanent and contain fresh water. Downstream along the Finke River, the number of waterholes gradually diminishes and a high percentage of them become saline. Permanent waterholes also occur in the Hugh and Palmer Rivers and in the Petermann, Walker, Illara and Palm Creeks.

Permanent rockholes are found at many places in the ranges and are especially common in the Mereenie Sandstone and to a lesser extent in the sandstones of the Pertnjara Formation. The waterholes tend to be concentrated in specific areas and along certain scarps. The main concentrations occur south of Areyonga Mission; along the southern side of Nineteen Mile Plain; east and west of Illamurta Spring and in Palm Valley. In addition, isolated permanent rockholes occur in the Levi Range (Antaia Rockhole) and the Chandler Range (Antiarra Rockhole).

Semi-permanent waterholes and rockholes are found throughout the area and these may retain water for up to several months after rain, but they cannot be relied upon. The life of such semi-permanent waterholes and rockholes could be considerably extended by deepening or damming them. There are, in addition, many places in the ranges where the creeks could be dammed and even with the low rainfall and high rate of evaporation a large body of water could be retained for a considerable length of time. In places, "turkeys nest" type dams have been constructed for the storage of surface waters and have been found successful. At present up to 90% of the Tempe Downs cattle and up to 40% of the Henbury cattle are being watered on natural surface waters.

Underground Water

The water potential of the various formations is summarized in Table I. The formation with the greatest potential is undoubtedly the Mereenie Sandstone. However, its tendency to form high relief makes it difficult to intersect below the water table. The same is also true for the sandstone of the Pertnjara Formation. In many areas, the most accessible aquifers are located within the quaternary alluvium and this is probably the most widely used source of underground water in the Henbury Sheet area. Some of

TABLE IV BORE DATA

Bore name	Ref. No. G53/1-	Lease	Location	Total Depth	Depth to first aquifer	Standing water level	Supply (galls. per hour)	Total dissolv. SALTS (parts per million)	Strata	Remarks
No.2 Drought Relief	2	Angas Downs	10 miles N.E. of Angas Downs H.S.	-	-	-	-	1999	Sandstone	Mainly in the Winnall Beds.
No.3 Drought Relief	4	Angas Downs	3 mls W. of old Angas Downs H.S.	345'	315'	318'	very small	4567	15' alluvium then clays & sands	Mainly in sandstones, sandy clays & calcareous sandstones. Bottomed in impermeable shales.
Mt. Gloaming	5	Henbury	4 mls S.E. of Mt. Gloaming.	362'	340'	90'	900	7743	0'-50' sand, 50'-230' clay 230'-362' white sandstone.	The sandstone is a fine-grained kaolinitic & glauconitic. It possibly has fracture porosity.
White Hill	6	Henbury	-	175'	-	-	dry	-	Interbedded sands and clays.	The sands were silty & probably lacked porosity.
Settlement No. 1	7	Areyonga	200 yds N.E. of Settlement .	183'	160'	-	700	764	Sandstones clays and gravels.	
Settlement No. 2	8	Areyonga	600 yds N. of Settlement	115'	35'		1000	3049	0'-85' shales 83'-115' siltstone	Silts & shales of the Pertnjara Formation.
Settlement No.3	9	Areyonga	500 yds N. of Settlement.	450'	18'	18'	800	464	Mainly sandstones.	Sandstones of the Pertnjara Formation.
Stock Well	10	Orange Crk.	Close to Orange Crk. H.S.		-	-	-	-	-	No further information available.
Homestead Well	11	Angas Downs	At old Angas Downs H.S.	20'	-	12'	small	4603	-	-
Titra Well	12	Palmer Valley	6 mls S.S.W. of H.S.	26'	-	14'	very good	7527	-	-
Homestead Well	13	Tempe Downs	60 yds S.W. of H.S.	60'	-	-		1507	-	-
Whitewood Gap	14	Henbury	12 mls E.N.E. of H.S.	272'	210'-230'	230'	small	13,838	0'-5' sand, 5'-30' sandstone, 30'-267' red shale & grey lst. 267'-272' shale & siltstone.	Sited in Stokes Formation
Boomerang	15	Henbury	12 mls N.E. of H.S.	-	-	-	-	-	-	No further information available.
No.1 Homestead	16	Palmer	300 yds S.E. of H.S.	110'	-	100'	-	4852	-	Unsuitable for human consumption.
No.2 Homestead	17	Palmer Valley	300 yds E. of H.S.	100'	-	-	-	8034	-	Unsuitable for human consumption.
No. 3 Homestead	18	Palmer Valley	1 ml. N.N.E. of H.S.	140'	116'	116'	800	3438	0'-130' interbedded sands and clays 130'-140' gravel.	Unsuitable for human consumption.
No. 5	19	Palmer Valley	18 mls S.S.W. of H.S.	240'	215'	70'	700	9614	Mainly sandstones with some clay interbeds.	Unsuitable for human consumption.
Depot Well	20	Areyonga	Upstream from Settlement.	-	-	-	Soakage	764	-	

Bore name	Ref. No. G53/1-	Lease	Location	Total Depth	Depth to first aquifer	Standing Water Level	Supply (galls. per hour)	Total dissolv. SALTS (parts per million)	Strata	Remarks
West No.1	21	Owen Springs	20 mls S.W. of H.S.	31'	-	-	600	-		
Dud	22	Palmer Valley	15 mls S.S.W. of H.S.	-	-	-	-	-	-	
No.7	23	Palmer Valley	400 yds N. of No.6 Bore.	110'	100'	-	-	-	Clays & gravels.	
No.5	24	Hugh River Stock Route		176'	-	-	-	-	Mainly clays with ironstone.	
No.4	25	Hugh River Stock Route	6 mls W. of main road.	181'	-	65'	1000	2050	Sandstone then limestone.	
Eastern	26	Palmer Valley	14 mls S.S.E. of H.S.	300'	-	250'	-	5068	-	
No.6 Dud	27	Palmer Valley	400 yds E. of H.S.	120'	109'	-	-	-	Interbedded sands & clays.	
Turner	28	Palmer Valley	12 mls S.S.W. of H.S.				1000	3052	0'-20' loam & gravel, 20'-310' sandstone.	
West No.2	29	Owen Springs	20 mls S.W. of H.S.		67'		very small		0'-30' alluvium, 30'-110' red sandstone.	
West No.3	30	Owen Springs	20 mls S.W. of H.S.	150'	46'	39'	600		0'-20' alluvium, 20'-50' pebbly sandstone, 50'-150' red sandstone.	
No.3	31	Hugh River Stock Route	-	500'	-	280'	500	7270		
	32	Henbury		330'	-	200'			Sands, clays & silts.	
No.1	33	Angas Downs	10 mls S.E. of old H.S.	475'		100'				
No.2	34	Angas Downs	4 mls W. of H.S.	412'		220'		very saline	Blue clay.	
Mt. Quinn No.1	35	Henbury	-	141'		110'		very saline	0'- 5' surface soil, 5'-141' red clay.	
Mt. Quinn	36	-	-	-	-	-	dry	-	0'- 26' limestone, 26'-63' blue & white clay, 63'-75' sandstone, 75'-498' red clay.	
No.1	37	Palmer Valley	20 mls S. of Henbury H.S.	74'	-	-	-	-	0'-55' clay, 55'-74' limestone.	
Areyonga No.1	38	Areyonga	-	400'	-	-	145	-	0'-15' alluvium 15'-400' sandstone.	
Mordicadatta	40	Henbury	20 mls W.S.W. of H.S.	127'	-	90'	-	1216	-	
Mt. Quinn H.S.	41	Henbury	20 mls W.S.W. of Henbury H.S. H.S.	34'	-	30'	350	7340	-	
Cotton Bush	42	Henbury	8 mls N.E. of H.S.	160'	-	100'	-	6090	-	

Bore name	Ref. No. G53/1-	Lease	Location	Total Depth	Depth to first aquifer	Standing water level	Supply (galls. per hour)	Total dissolv. SALTS (parts per million)	Strata	Remarks
Bowra	43	Henbury	E.N.E. of No.5 Bore	-	-	-	very good	4698	-	
Homestead	45	Orange Ck.		82'	-	-	400	1914	-	
Stuart Well	47	Orange Ck.	7 mls N.N.W. of H.S.	-	-	-	-	-	-	No further information available.
Nallysnum	50	Henbury	8 mls S.W. of H.S.	150'	-	-	-	8611	-	
Maloney	52	Henbury	11 mls N. of H.S.	-	-	-	-	-	-	No further information available.
Crows Nest	53	Henbury	8 mls S.S.E. of	-	-	-	-	6654	-	
No.5	55	Hugh River Stock Route	25 mls W. of Henbury H.S.	218'	-	155'	-	960	0'- 14' soil, 14'- 190' sandstone and clay, 190'- 218' dark sandstone.	
No.1.1959/1	67	Areyonga	1¼ mls E. of Settlement	490'	150'	150'	-	795	0'- 175' clay with some gravels 175'-370' siltstone, 370'-490' fine quartz sandstone.	Sited to intersect Mereenie Sandstone
Palmer	68	Palmer Valley	3 mls W.S.W. of H.S.	80'	-	-	600	-	-	
Horse Paddock Well	69	Palmer Valley	9 mls S.W. of H.S.	-	-	-	-	-	-	No further information available.
1961/1	70	Areyonga	½ ml N. of Settlement	463	3'	3'	2500	651	0'- 40' fine, white sandstone, 40'- 72' sandy and clayey siltstone 72'-225' silty sandstone, 225'-265' chocolate sandy siltstone 265'-340' clean sandstone, 340'-400' fine silty sandstone, 400'-425' chocolate shales, 425'-463' sandy siltstone.	Sited to intersect aquifers within the Pertnjara Sandstone.
Pioneer Tuits	71	Palm Valley Lodge	60 yds S. of lodge.	180'	-	-	1000	692	-	Sited within the Pertnjara Formation.
No.22	73	Palmer Valley	8 mls S. of H.S.	140'	-	70'	small supply		0'- 20' loam, 20'-140' yellow clay.	
Salt Creek	74	Palmer Valley	2 mls N.E. of Birthday Bore.	295'	-	-	-	2938	0'- 20' loam, 20'-295' brown sandstone.	
No.4	75	Palmer Valley	1½ mls E. of Mopoke Dam.	400'	-	-	dry	-	0'- 20' limestone, 20'- 30' gypsum & clay, 30'-39' clay & gravel, 39'-400' sandstone.	
No.5	76	Palmer Valley	½ ml. E. of Mopoke Dam.	250'	-	-	dry	-	0'- 20' loam & clays, 20'-250' red sandstone & mudstone.	
No.18	77	Palmer Valley	5 mls S.E. of Turkey Bore.	226'	-	-	dry	-	0'- 6' topsoil, 6'-226' interbedded clays & sands.	
No.23	79	Palmer Valley	5 mls W. of Stevenson Dam.	250'	-	-	200'	-	-	
Olunga Well	80	Angas Downs	14 mls N. of old H.S.	14'	-	11'	-	3037	-	
Yaua	81	Angas Downs	22 mls N. of old H.S.	-	-	-	-	1013	-	

Bore name	Ref. No. G53/1-	Lease	Location	Total Depth	Depth to first aquifer	Standing water level	Supply (galls. per hour)	Total dissolv. SALTS (parts per million)	Strata	Remarks
Well	82	Angas Downs	½ ml.S. of old H.S.	14'	-	9'	-	4682	-	
South Block	84	Angas Downs	4 mls.N. of old H.S.	-	-	23'	-	11,009	-	
Well	85	Angas Downs	4 mls.N. of old H.S.	27'	-	-	-	4355	-	
No.2	86	Tempe Downs	Approx. 20 mls.S. of H.S.	70'	45'	35'	-	-	-	
No.1	87	Tempe Downs	In H.S. yard.	45'	-	-	1200+	817	-	
Salt	88	Henbury	7 mls. S.W. of Nallysum Bore.	154'	150'	-	good small supply	20,285		Sited to intersect Stairway Sandstone.
Dud	89	Henbury	34 mls. S.S.W. of H.S.	255'	-	-		6688	0'-10' grey lst.(?travertine), 10' -21' calcareous sandstone, 21' -157' fn,med& coarse sandstones, 157' -167' clay, 167' -177' dark grey shale, 177' -198' blue-grey limestone, 198' -255' calcareous shales.	
Dud	90	Henbury	34 mls. S.S.W. of H.S.	180'	-	-	-	5882	0' - 3' loam, 3' -107' silty sandstone, 107' -180' clean sandstone.	
-	94	Angas Downs	-	347'	-	-	-	-	-	No further information available.
1961/2	95	Areyonga	10 mls. E. of 1961/1 Bore.	80'	-	30'	700	-	0' -10' kunkar 10' -80' sandstone.	
1962/1	97	Areyonga	½ ml. S. of Amulda Gap.	285'	130'	126'	900	2140	0' - 2' soil 2' -83' clay & boulders, 83' -130' sandstone, 130' -223' grey & red shales, 223' -285' clays & sands.	
1961/3	98	Areyonga	Close to the Settlement.	360'	-	-	-	700	0' - 72' -? 72' - 357' light brown, silty sand, 357' - 360' brown siltstone.	Sited in the Pertnjara Formation.

the other formations such as parts of the Pertaoorrta Formation, the Winnall Beds, the Areyonga Formation and the Bitter Springs Limestone are possible sources of moderate to poor quality water. The remainder of the formations have extremely poor water prospects.

There are a large number of bores and wells in the Sheet area (see Table IV) but unfortunately much of the information about them is incomplete. The deepest bore in the Sheet area is the Hugh River Stock Route No.3 Bore (Ref. No.G53/1-31. See Table IV) which reached a total depth of 500 feet. The average depth of the bores is about 200 feet. The standing water level varies considerably within a small area but the regional variation is from about 100 feet in the northern part of the Sheet area to 2-300 feet in the southern part of the Sheet area. Salinities are also very variable but again, there is a tendency for salinities to increase from north to south, the maximum salinity of 20,285 parts per million of dissolved salts being recorded from a bore (Ref.No. G53/1-88 See Table IV) in the Stairway Sandstone.

Petroleum Prospects

Prior to 1963, many geologists considered the petroleum prospects of the Amadeus Basin to be poor. However, in 1963 three wells were drilled in the Amadeus Basin by a combine of several oil companies and all the wells encountered hydrocarbons. Ooraminna No.1, which was drilled to a total depth of 6107, encountered methane gas in the Areyonga Formation over the interval 3761 to 3906 feet and the flow of gas was measured at 12,000 cubic feet per day. Alice No.1, which was drilled to a total depth of 7504 feet, found traces of oil in Cambrian strata at 3505 to 3555 feet, 3635 to 3360 feet, 6110 to 6170 feet and at 6860 feet. A third well, Mereenie No.1 was drilled to 3983 feet and produced more than 10 million cubic feet of wet gas per day from the Larapinta Group sediments. In addition to these three wells, four holes were drilled during 1963 in the Amadeus Basin to search for phosphate. One of these holes - A.P.1, situated on the south flank of Johnny Creek Anticline (Lake Amadeus Sheet area), intersected nine feet of oil saturated and patchy oil saturated core between 652 and 661 feet in the Stairway Sandstone. Oil was also seen in numerous fractures and vughs below 661 feet in both the Stairway Sandstone and the Horn Valley Siltstone. In addition, the eleven feet of Pacoota Sandstone penetrated showed slight fluorescence. The

Petroleum Technology ~~Branch~~ Section of the Bureau of Mineral Resources carried out core analysis and established that the oil-bearing core had an effective porosity of 9%, an absolute horizontal permeability of 21 Millidarcys and that the oil saturation in the pore space was 40%. The extracted oil, which was a highly mobile black fluid with a strong napthenic odour, had a density of 0.95 gms/cc.. The core was exposed to the atmosphere for several days before core analysis and therefore some of the more volatile fractions of oil are likely to have been lost.

In addition to finding oil, the diamond drill holes proved that unweathered Stairway Sandstone and Horn Valley Siltstone contain abundant black, carbonaceous, pyritic shales which have the appearance of source beds. Other possible source beds in the Henbury Sheet area are the limestones and dolomites of the Pertaoorrta Formation, the Pertatataka Formation and the Bitter Springs Limestone, (all of which produce a strong petroliferous odour on freshly broken surfaces), and the shales of the Pertaoorrta and Pertatataka Formation.

Reservoir rocks occur throughout the stratigraphic sequence. These include thin sands near the top of the Bitter Springs Limestone in some areas; some of the Areyonga Formation sandstones; the more porous sands of the Pertaoorrta Formation; some of the Cambrian limestones and dolomites which have fracture and "vugh" porosity; and the sands of the Pacoota Sandstone, the Stairway Sandstone, and the Mereenie Sandstone.

Suitable caprocks consist mainly of siltstone and shale intervals such as those in the Areyonga, Pertatataka and Pertaoorrta Formations, the Horn Valley Siltstone, the Stokes Formation and the siltstone of the Pertnjara Formation. In addition, the Bitter Springs Limestone and the Chandler Limestone Member of the Pertaoorrta Formation are known to contain interbedded evaporites which could act as suitable caprocks.

There are many surface antclinal structures in the Henbury Sheet area but some of these are not closed at the surface (e.g. the Seymour Range Anticline, the anticline to the south of the Seymour Range and the James Range 'C' Anticline). Others are breached too deep in the stratigraphic column to have any petroleum potential (e.g. the Parana Hill, Walker Creek, Petermann Creek and Gardiner Range Anticlines all of which have been breached down to the Bitter Springs Limestone).

However, the James Range 'A' and Waterhouse Range Anticlines are closed in the Jay Creek Limestone Member of the Pertaoorrta Formation, the James Range 'B' Anticline is closed in the Quandong Conglomerate Member of the Pertaoorrta Formation and the Palm Valley Anticline is probably closed in the Pertnjara Formation.

Oil accumulation in fault traps is possible in some areas, especially in the Chandler Range where a major reverse fault places the Chandler Limestone Member with interbedded evaporites against porous sands of the Larapinta Group and Pertaoorrta Formation.

Possibly the best chances for oil accumulation in the Henbury Sheet area occur in the Palm Valley Anticline and James Range 'C' Anticline and in stratigraphic traps due to the pinchout of porous sands. Pinchouts are especially common in the Pertaoorrta Formation and the Larapinta Group. The oil found at Johnny Creek Anticline is possibly the result of accumulation in a stratigraphic trap. There are likely to be many other such possibilities for oil or gas accumulations in the Amadeus Basin.

Copper

Copper mineralization is known from four localities on the Henbury Sheet area. No new mineralised areas were located during the 1963 field season and some of the information mentioned below comes from an unpublished report on 'Amadeus Copper Deposits' by A.D.M. Bell (1953).

1. Waterhouse Range (Owen Springs Prospect)

Copper mineralisation in the form of malachite and cuprite occurs in the Goyder Member of the Pertaoorrta Formation on the northern flank of the Waterhouse Range Anticline. Some nickel is also present. The copper appears to be stratigraphically controlled and as no veins or intrusives of any type are known from this area, it is thought most likely to be of syngenetio origin. Five diamond drill holes were drilled by the Titanium Alloy Manufacturing Company during 1954 to investigate this deposit but the results were disappointing and the project was abandoned.

2. Areyonga (Namatjira's Prospect)

Copper mineralisation in the form of malachite, azurite, chalcocite, digenite, chrysocolla and covellite occurs in a 'crush zone' or 'fault breccia' in the Eninta Sandstone Member of the Pertaoorrta Formation about 10 miles east-south-east of the Areyonga Native Settlement. This prospect was worked by Albert Namatjira at one stage. There is evidence of possible syngenetic copper in the Eninta Sandstone nearby and it is considered probable that this has been concentrated in the fault breccia.

One mineralised specimen from the fault breccia (Hy 402) was submitted for mineral identification and contains the minerals listed above plus some possible enargite and gold. The major constituent of the ore sample submitted was a fine grained, steel grey admixture of chalcocite and digenite.

3. Alalgara Yard (Lalgra Prospect)

Copper showings have been reported from the Pertaoorrta Formation near Alalgara Yard about 22 miles north-west of Henbury homestead. The copper occurs as pellets of malachite in micaceous sandstone of the Goyder Member of the Pertaoorrta Formation.

4. Boggy Hole

Malachite has been reported from a 'ferruginous oolite grit' exposed in the banks of the Finke River about 42 miles north-north-west of Henbury homestead. Bell (1953) reports that 'the oolite grit band is variable in character and from five to ten feet in thickness.' Unlike the other copper showings this one occurs within the Larapinta Group sediments.

Miscellaneous

Evaporites occur in the Bitter Springs Limestone Ooraminna No.1 Well, in the Chandler Limestone Member from Alice No.1 Well and also from a locality on the Henbury Sheet area (Hy 198). These deposits are so far removed from major centres of population that it is unlikely that they will constitute economic deposits unless a valuable evaporitic mineral such as potash is found.

Thick limestone and dolomite sequences occur in the Upper Proterozoic and Cambrian but are of no commercial interest because of the high cost of freight. This also applies to building stone which would be readily obtainable from some of the fissile sandstones in the Upper Proterozoic and Palaeozoic; there is, however, a very limited local market in and around Alice Springs.

The jasper found in the Areyonga Formation and the Inindia Beds has some economic potential because it polishes into attractive stones which are used in jewelry. However, most of the outcrops where jasper is available in sufficient quantities (e.g. Parana Hill Anticline) are highly inaccessible.

In the vicinity of Running Waters, approximately 20 square miles of strongly ferruginized sediments crop out as flat-lying deposits. A specimen of the ferruginized sediment contains 43.5% Fe and 10% Si. Ferruginous and manganiferous deposits, in the form of surface encrustations, are found above the Goyder Member of the Pertaoorrta Formation and up to 84.1% F_2O_3 has been recorded from a selected sample from the Levi Range (Hy 106).

HENBURY METEORITE CRATERS

The Henbury Meteorite craters are seven miles west-south-west of Henbury homestead and just north of the Bacon Range. They were first reported by Alderman (1933) and have since been investigated by Rayner (1939) who carried out a geophysical survey of the craters, and by many other geologists. During 1963, Dr. D.J. Milton of the U.S.G.S. carried out detailed structural investigations of some of the larger craters.

There are at least 12 craters in the area north of the Bacon Range and Alderman (1933) reported thirteen. The largest crater (Fig.21) is about 600 feet in diameter and 40-50 feet deep. The craters are partially filled by alluvium and, as they have a tendency to act as a catchment for water, they now contain a thicker growth of trees than is found on the surrounding plains. The craters occur in the Winnall Beds and an unconsolidated conglomerate (of suspected Quaternary age) which overlies the Winnall Beds north of the Bacon Range.

Meteoric material, including iron fragments up to 170½ pounds in weight, meteoric "glass" and fused rock fragments, were very common when the area was first visited but collecting by subsequent investigators has now almost completely denuded the area of this material.

The age of the Henbury meteorite craters is uncertain but they are known to be younger than the unconsolidated conglomerate and older than the fully grown Acacia and Mulga trees in and around the craters. Unfortunately, it has not yet been possible to locate any charcoal (as the result of the burning of trees ignited by the impact of the meteorite) for radio-active carbon age dating. There are no records of the meteorites in the aboriginal lore of the area. The fact that the form of the meteorite craters is still so well preserved would suggest that the craters are fairly young. Alderman (1933) has suggested the age should be reckoned in terms of thousands of years but Milton (pers. comm.) has suggested that the impact may have occurred several hundred years ago.

Fig.21. View from the air of the largest of the Henbury Meteorite Craters. Neg.No.g/6140

Fig. 22. Margin of the main crater showing some siltstone and shale from the Winnall Beds which was forced out and over Quaternary scree by the impact.
Neg.No.g/6139

Dr. D.J. Milton has made the following brief resume of his recent structural work on the Henbury craters:-

'A geologically Recent meteorite shower at Henbury, Northern Territory, Australia formed twelve craters in shale and sandstone dipping homoclinally about 35^{o} and in overlying alluvium. The largest crater, formed by the impact of two objects, is an oval 660 feet long, 500 feet wide, with the floor 30 feet below and the crest 5 to 20 feet above the surrounding surface. Bedrock units in the walls are markedly displaced outward. Folds formed in both the lower and upper portions of the wall.. Many are overturned outward and break thrusts are associated with some anticlines. One such "nappe" overrides the pre-crater surface for sixty feet or more. Elsewhere on the rim are overturned flaps of the Meteor Crater type, some thrust outward as well as overturned. In some segments of the lower wall outward displacement increases downward, so that these segments appear as if they had been hinged at the top. Structural blocks separated by faults characteristically are interlocking, even where the displacement between them is considerable. Apparently dilation accompanied impact, so that structural blocks moved more or less independently of their neighbours.

At two of the smaller craters ejected fragments from thin sandstone beds lie in straight lines radial to the crater. One pair of such rays emanating from the two intersections of a bed with the rim have their outer ends connected by a loop, in a pattern similar to that of rays and ray loops around some lunar craters.'

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REFERENCES

ALDERMAN, A.R., 1933 - The meteorite craters at Henbury, central Australia, with addendum by L.H.Spencer. Mineralog.Mag., 23, 19-32; Smithsonian Rep. for 1932, pages 223-234.

BARRIE, J., 1964 - Phosphate Drilling, Amadeus Basin, Bur.Min.Resour.Aust.Rec. (in prep.)

BELL, A.D.M., 1953 - Amadeus Copper Deposits. Unpub. report by Resident Geologist, Mines Branch, Alice Springs.

BILLINGS, M.P., 1942 - Structural Geology. Prentice-Hall. New York.

BROWN, H.Y.L., 1890 - Report on the Geological examination of the country in the neighbourhood of Alice Springs. S.Aust. Parl.Pap. 189.

BROWN, H.Y.L., 1891 - Reports on coal-bearing areas in the neighbourhood of Leigh Creek. S.Aust.Parl.Pap. 50.

BROWN, H.Y.L., 1892 - Further geological examinations of the Leigh Creek and Hergott Districts. S.Aust.Parl.Pap. 23.

BROWN, H.Y.L., 1895 - Government Geologist's Report on Exploration in the Northern Territory. S.Aust.Parl.Pap. 82.

BRUNNSCHWEILER, R.O., 1959 - Part 1 - The geology of Gosses Bluff, (N.T.), and vicinity and Part II - A geological reconnaissance in the area between Hugh River and Centralian Railway, Deep Well Siding and Maryvale Homestead, N.T. Unpubl.Rep. to Enterprise Exploration Co.Pty.Ltd.

BRUNNSCHWEILER, R.O., 1961 - Jung protorozoiche (Assyntische) Gebingsbildung in Australien. Ecl.Geol.Helv., 54, 335-351.

CHEWINGS, C., 1886 - The Sources of the Finke River (reprinted from the Adelaide Observer), Adelaide.
*

CHEWINGS, C., 1894 - Notes on the Sedimentary Rocks of the Macdonnell and James Ranges. Trans.Roy.Soc.S.Aust., 18, 197-198.

CHEWINGS, C., 1914 - Notes on the Stratigraphy of Central Australia. Trans.Roy.Soc.S.Aust., 38, 41-52.

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

CHEWINGS, C., 1931 - A delineation of the Pre-Cambrian plateau in Central and North Australia with notes on the impingent sedimentary formations. Trans.Roy.Soc.S.Aust. 55, 1-11.

CHEWINGS, C., 1935 - The Pertatataka Series ub Central Australia, with notes on the Amadeus Sunkland. Trans.Roy.Soc. S.Aust., 59, 141-163.

* CHEWINGS, C., 1891 - Geological notes on the Upper Finke Basin. Trans.Roy.Soc.S.Aust., 14, 247 - 255.

COOK, P.J., 1963 - Phosphorites in the Amadeus Basin of Central Australia. Aust.Jour.Sci. 26, 55-56.

CROOK, K.A.W., and COOK, P.J., 1964 - A Sedimentilogical Study of the Ordovician Stairway Sandstone, Amadeus Basin. N.T., Bur.Min.Resour.Aust.Rec. (in prep.)

DAY, T.E., 1916 - Report and plans of exploration in Central Australia. Bull.N.Terr.Aust., 20.

DUNSTAN, B., 1900 - The Permo-Carboniferous Coal Measures of Clermont. Geol.Surv.Qld Pub. 148

FORMAN, D.J., 1963 - Regional Geology of the Bloods Range Sheet south-west Amadeus Basin. Bur.Min.Resour.Aust.Rec. 1963/47. (unpubl.)

FORMAN, D.J., and HANCOCK, P.M., 1964 - Regional geology of the southern margin, Amadeus Basin, Rawlinson Range to Mulga Park Station. Bur.Min.Resour.Aust.Rec. 1964/41 (unpubl.)

GEORGE, F.R., and MURRAY, W.R., 1907 - Journal of the Government Prospecting Expedition to the south-western portions of the Northern Territory; prepared by W.R.Murray. S.Aust.Parl.Pap. 50.

GILES, E., 1889 - Australia Twice Traversed. Sampson Low, Marston Searle and Rivington, London.

GOODEVE, P.E., 1961 - Rawlinson Range - Young Range Aeromagnetic Survey, W.A. 1960 (unpub.) Bur.Min.Resour.Aust.Rec., 1961/137.

GOSSE, W.C., 1874 - Exploration in 1873. S.Aust.Parl.Pap., 48.

HAITES, B., 1963 - Stratigraphy of the Ordovician Larapinta Group in the Western Amadeus Basin, N.T. Unpubl.Rep. for United Canso Oil and Gas Co.

JOKLIK, G.F., 1955 - The geology and mica fields of the Harts Range, Central Australia. Bur.Min.Resour.Aust.Bull., 26.

LESLIE, R.B., 1960 - The geology of the southern part of the Amadeus Basin, Northern Territory. Unpubl.Rep.for Frome - Broken Hill Co.Pty.Ltd. No.4300 - G - 28.

MADIGAN, C.T., 1931 - The Physiography of the Western MacDonnell Ranges. Geogr.J., 88, 417 - 433.

MADIGAN, C.T., 1932 - The geology of the Western MacDonnell Ranges. Quart.J.geol.Soc.Lond., 88, 672-711.

MAWSON, D., and MADIGAN, C.T., 1930 - Pre-Ordovician Rocks of the MacDonnell Ranges (Central Australia). Quart.J.geol.Soc.Lond., 86, 415 - 429.

McNAUGHTON, D.A., 1962 - Petroleum prospects Oil Permits 43 and 46, Northern Territory, Australia. Unpubl.Rep.for Magellan Petroleum Corporation.

MURRAY, W.R., 1904 - Exploration by R.T.Maurice - Fowlers Bay to Cambridge Gulf. S.Aust.Parl.Pap. 43.

PRICHARD, C.E., and QUINLAN, T., 1962 - The Geology of the southern part of the Hermannsburg 1:250,000 Sheet. Bur.Min.Resour. Aust.Rep., 61.

PERRY, R.A., MABBUT, J.A., LITCHFIELD, W.H., QUINLAN, T., LAZARIDES, M., JONES, N.O., SLATER, R.O., STEWART, G.A., BATEMEN, W., and RYAN, G.R., 1962 - Lands of the Alice Springs Area, Northern Territory, 1956-57. C.S.I.R.O. Aust.Land Res.Ser., No.6.

RANNEFT, T.S.M., 1963 - Amadeus Basin Petroleum Prospects. Jour.Aust.Pet. Expl.Assoc. 1963.

RAYNER, J.M., 1939 - Examination of the Henbury meteorite craters by the methods of applied geophysics. Aust.and N.Z. Assoc. Adv.Sci., 24, 72-78.

SCANVIC, J.Y., 1961 - Report on photo-interpretation of the Amadeus Basin. Unpub.Rep. Bur.Min.Resour.Aust.

STELCK, C.R., and HOPKINS, R.M., 1962 - Early Sequence of interesting Shelf Deposits, Central Australia. J.Alberta.Soc.Pet.Geol. 10, 1-13.

STUART, J.M., 1861 - Journal of his Expedition across the centre of Australia from Spencer's Gulf in the south to latitude 18°47' in the north. Jour.Roy.Geog.Soc., S.Aust. 31.

STUART, J.M., 1865 - Explorations in Australia; the Journals of John McDouall Stuart during the years 1858 - 1862 etc. Saunder Oxley and Co., London.

TATE, R., 1896 - Report on the work of the Horn Scientific Expedition to Central Australia. Part 3, London.

TATE, R., and WATT, J.A., 1896 - General Geology in Report on the work of the Horn Scientific Expedition to Central Australia, Part III.

TOMLINSON, J. Gilbert. 1964 - Palaeozoic fossils from the Amadeus Basin, 1963. Bur.Min.Resour.Aust.Rec. (unpub.)(in prep.)

WARD, L.K., 1925 - Notes on the geological structure of Central Australia. Trans.Roy.Soc.S.Aust. 49, 61-84.

* WELLS, A.T., RANFORD, L.C., and COOK, P.J., 1963 - The Geology of the Lake Amadeus 1:250,000 Sheet area. Bur.Min.Resour.Aust. Rec. 1963/51 (Unpubl.)

WELLS, A.T., FORMAN, D.J., and RANFORD, L.C., 1961 - Geological Reconnnissance of the Rawlinson - Macdonald area, Western Australia. Bur.Min.Resour.Aust.Rec., 1961/59. (unpubl.)

WELLS, A.T., FORMAN, D.J., and RANFORD, L.C., 1962 - Geological Reconnaissance of the North-west Amadeus Basin, Unpub. Bur.Min. Resour.Aust.Rec., 1962/63. (unpubl.)

* WELLS, A.T., STEWART, A.J., and SKWARKO, S., 1964 - Geology of the south-eastern part of the Amadeus Basin. Bur.Min.Resour. Aust.Rec. 1964/35. (Unpubl.)

WHITE, W.A., 1961 - Colloid phenomena in the sedimentation of Argillaceous Rock. J.Sed.Pet., 31, 560-570.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

THE GEOLOGY OF THE HENBURY 1:250,000 SHEET AREA, AMADEUS BASIN, NORTHERN TERRITORY.

BY

L. C. RANFORD and P. J. COOK

RECORDS 1964/40

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ENCLOSURES

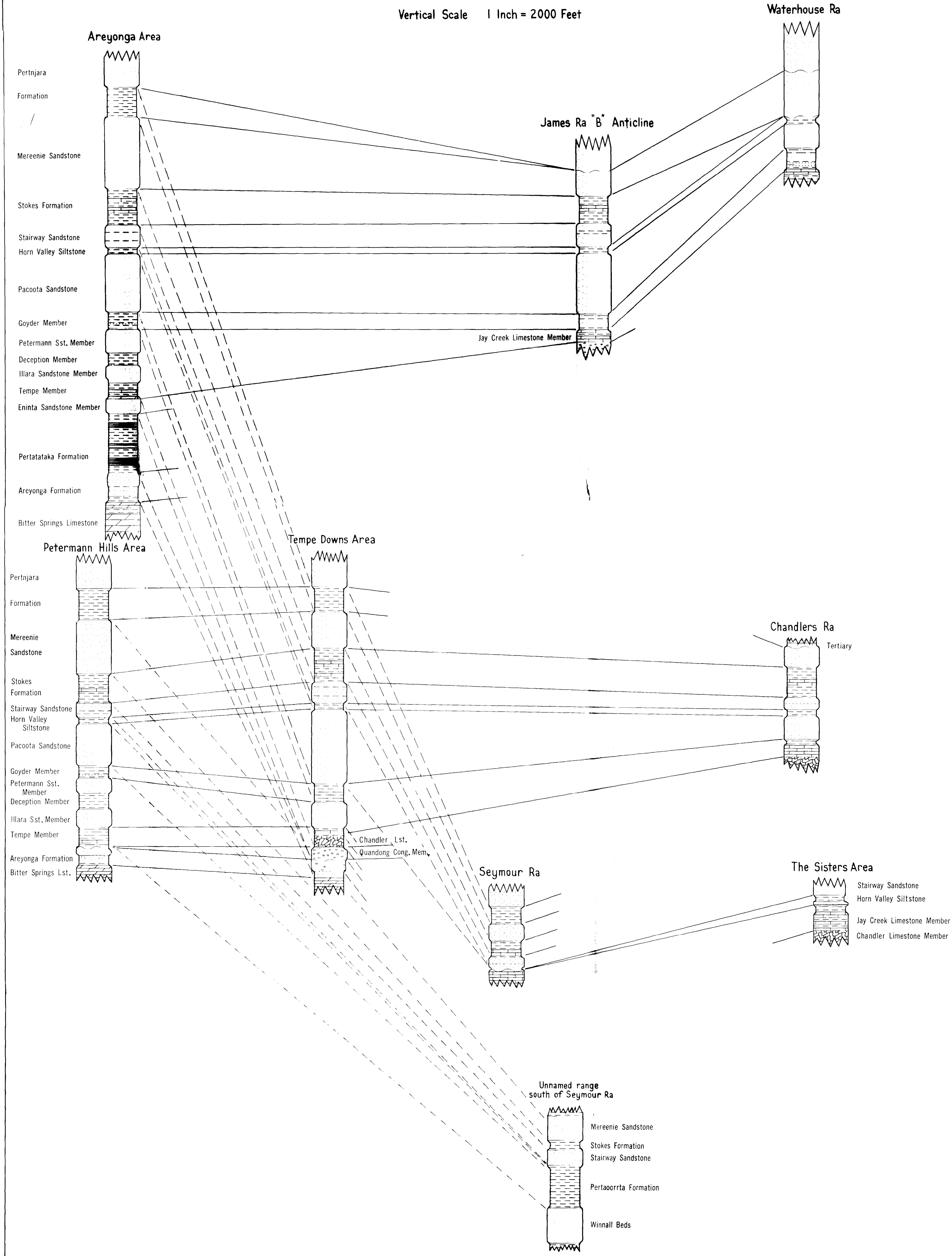
Plates:

1. Stratigraphic Columns of Selected Localities on the Henbury Sheet Area.
2. Measured Sections of Mereenie Sandstone.
3. Measured Sections of Larapinta Group Units, Northern Half of the Henbury Sheet Area.
4. Measured Sections of Larapinta Group Units, Southern Half of the Henbury Sheet Area.
5. Measured Sections of Pertaoorrta Formation.
6. Reference for Columnar Sections.
7. Geological Map of the Henbury 1 : 250,000 Sheet Area.

STRATIGRAPHIC COLUMNS AT SELECTED LOCALITIES ON THE HENBURY SHEET AREA

PLATE 1.

Vertical Scale 1 Inch = 2000 Feet



Bureau of Mineral Resources, Geology and Geophysics. April 1964. To accompany Record No 1964/40

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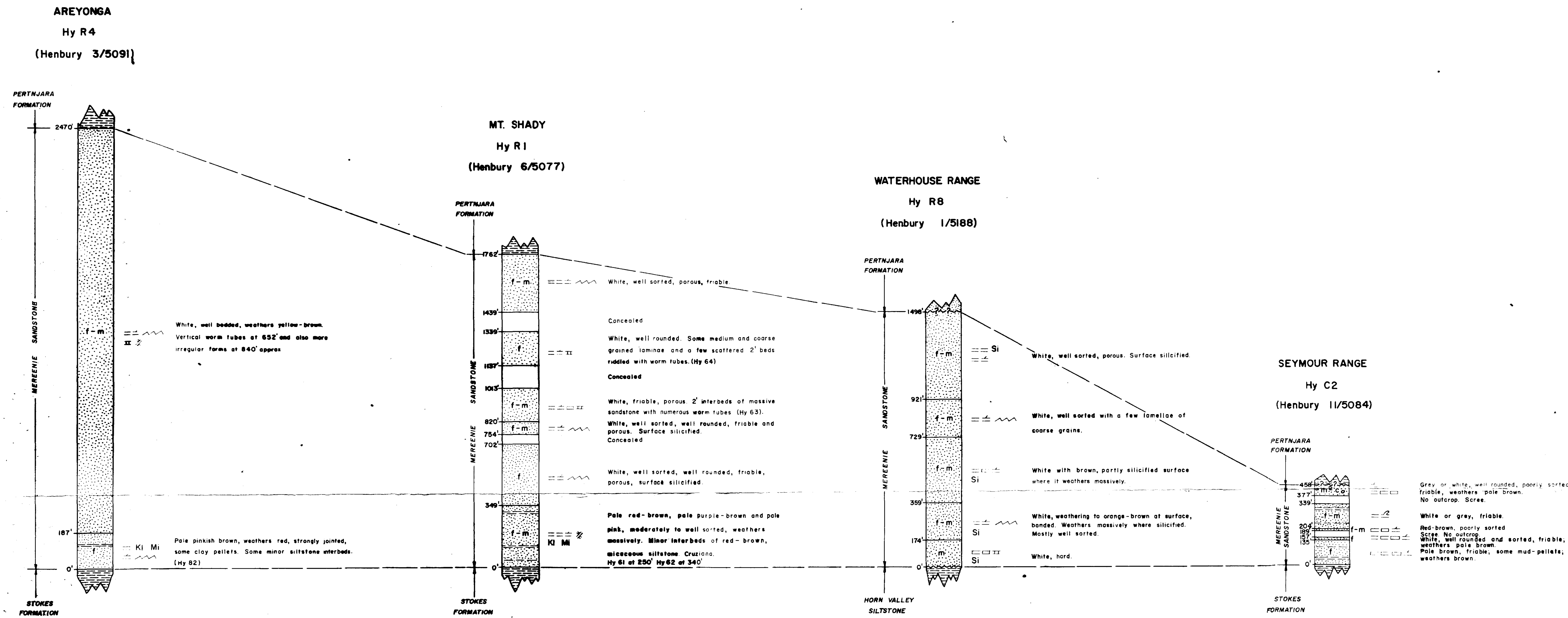
MEASURED SECTIONS OF MEREENIE SANDSTONE

Plate 2

HENBURY SHEET AREA

Scale: 1" = 400 Feet



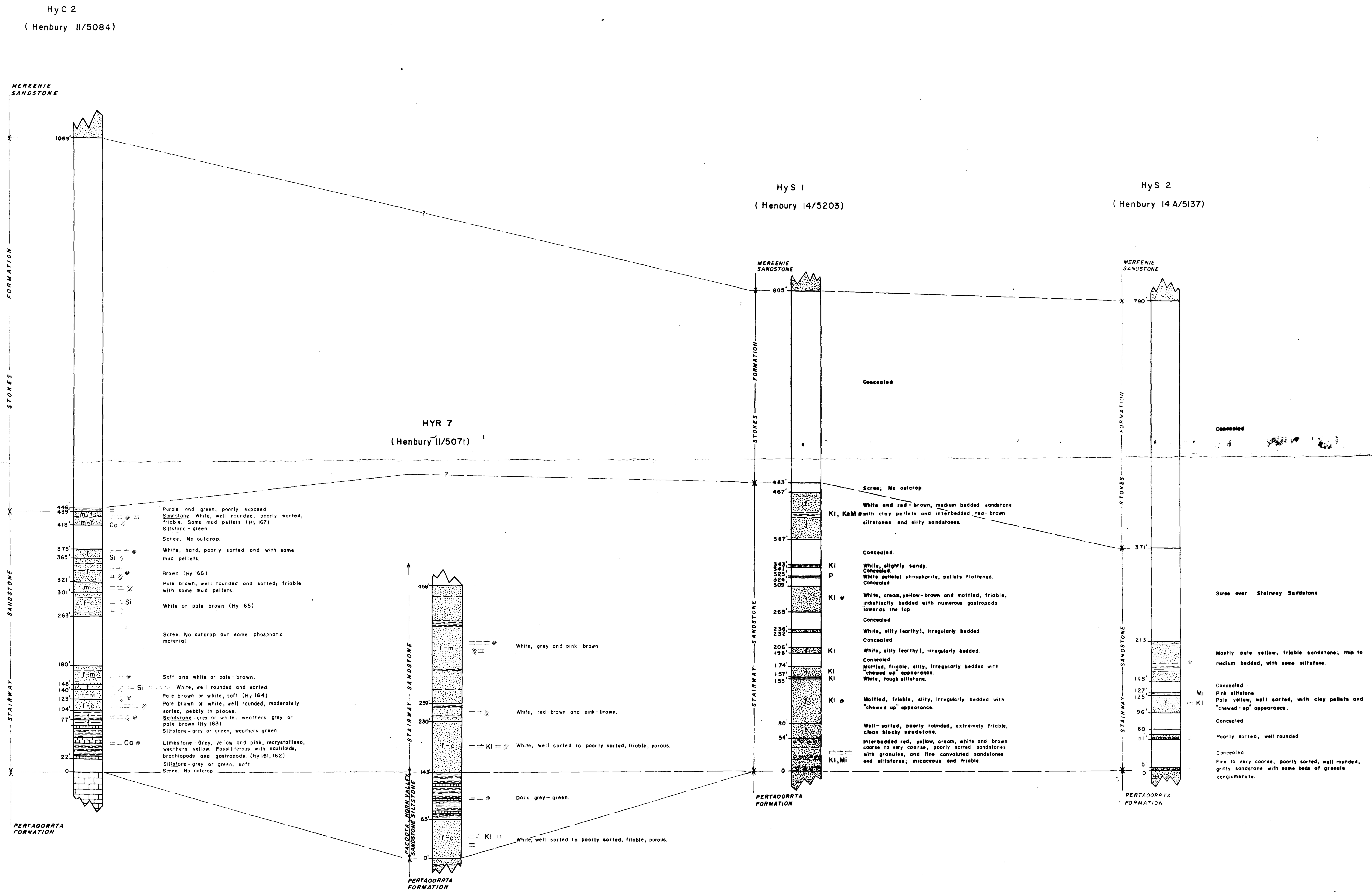
MEASURED SECTIONS OF LARAPINTA GROUP UNITS
ON NORTHERN HALF OF HENBURY SHEET AREA.
Scale: 1" = 100 Feet

Plate 4

MEASURED SECTIONS OF LARAPINTA GROUP UNITS

SOUTHERN HALF OF HENBURY SHEET AREA

Scale 1" = 100 Feet



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G53/A1/5

G53/A1/5

MEASURED SECTIONS OF PERTAOORRTA FORMATION

HENBURY SHEET AREA

Scale 1" = 100 Feet

Plate 5

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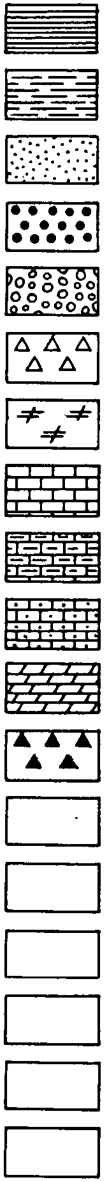
G53/A1/14

PLATE 6.

REFERENCE FOR COLUMNAR SECTIONS



Shale

Siltstone

Sandstone

Coarse sandstone - Fine conglomerate

Conglomerate

Erratics

Chert

Limestone

Silty limestone

Sandy limestone

Dolomite

Breccia

Grain Size

f	- *fine*	*0·12 - 0·25 mm.*
m	- *medium*	*0·25 - 1·0 mm.*
c	- *coarse*	*1·0 - 2·0 mm.*
v.c.	- *very coarse*	*2·0 - 4·0 mm.*
Fine conglomerate		*4·0 - 16·0 mm.*
Pebble conglomerate		*3/4 - 2 1/2 inches*
Cobble conglomerate		*2 1/2 - 10 inches*
Boulder conglomerate		*> 10 inches*

Si	*Silicified*	Gl	*Glauconitic*
Fe	*Ferruginous*	Fl	*Feldspathic*
Mi	*Micaceous*	Ha	*Pseudomorphs of halite*
Ca	*Calcareous*		
Kl	*Kaolinitic*	P	*Phosphatic*
G	*Gypsum*		

Bedding

Very thick	*> 40 inches*
Thick	*12 - 40 inches*
Medium	*4 - 12 inches*
Thin	*0·4 - 4 inches*
Laminate	*< 0·4 inches*

Cross bedded

Cross laminated

Graded bedding

Undulate

Slumped

Ripple marks - wave

Ripple marks - current

Tracks and trails

"Pipe rock"

Scattered vertical worm tubes

Oolites

Macrofossil

(Henbury 6/5556) Sheet, run and photo number

Gaps in columnar sections are concealed areas

To accompany Record 1964/40

Bureau of Mineral Resources, Geology & Geophysics. April, 1964.

G53-A1-3 G.M.

PRELIMINARY EDITION, 1964

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NORTHERN TERRITORY

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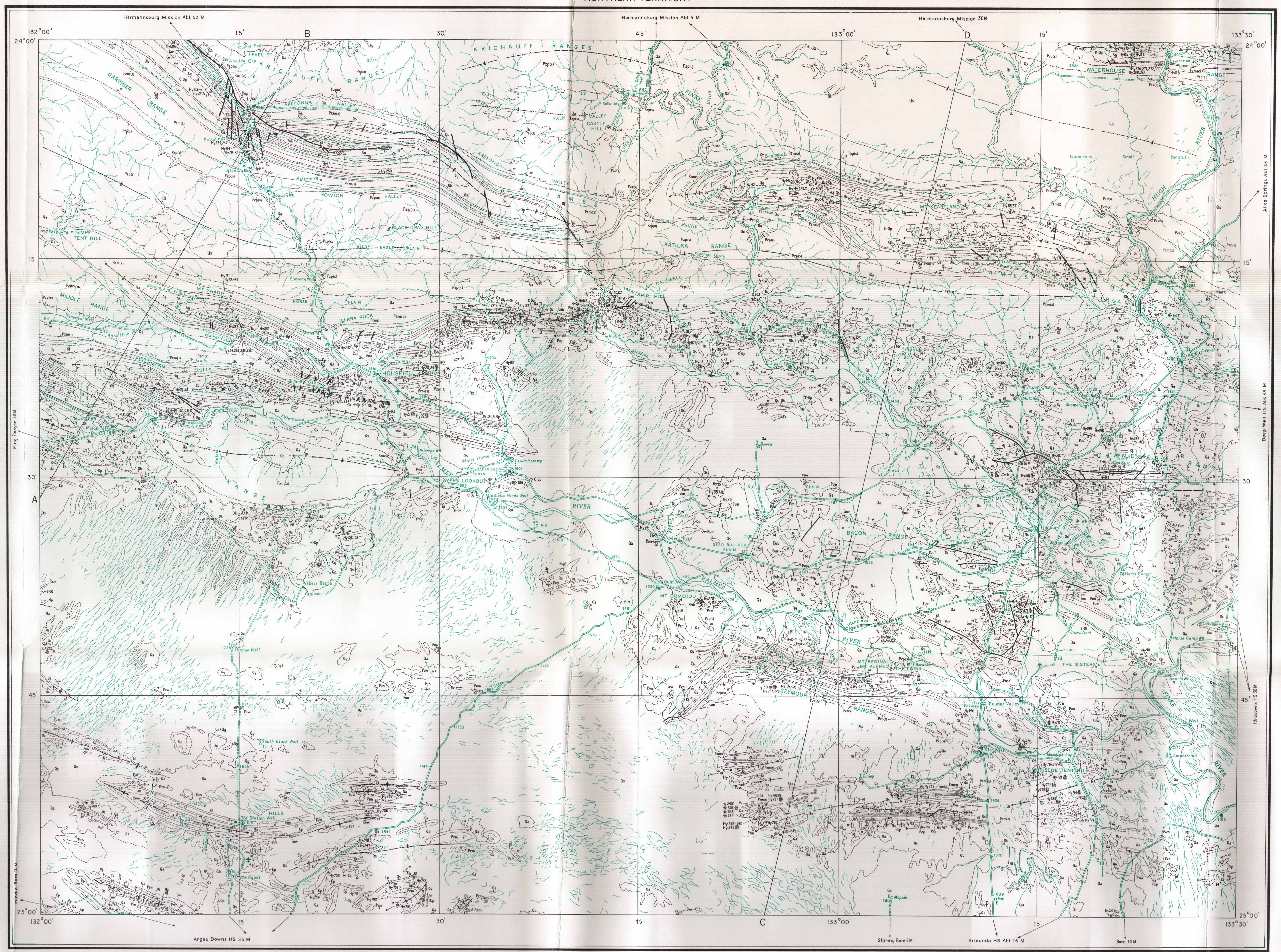

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Transverse Mercator Projection.

Geology and compilation, 1963, by: L.C. Ranford, P.J. Cook, A. T. Wells, A.J. Stewart and A.S. Mikolajczak
Drawn, 1964, by: A.S. Mikolajczak

Reference

CAINOZOIC	QUATERNARY		Q	Alluvium, sand, travertine, gypsum, conglomerate (section only)
			Qa	Alluvium, river gravel
			Qs	Aeolian sand
			Ql	Travertine
			Qg	Gypsum
			Qc	Conglomerate
	(?)TERTIARY	Undifferentiated	T	Calcareous, silty sandstone, conglomerate, limestone
			Tl	Limestone containing freshwater gastropods
			Tc	Conglomerate
			Tb	"Grey Billy"
			Ta	Laterite, ferricrete
(?)MESOZOIC			M	Kaolinitic sandstone, sandy claystone
PALAEOZOIC	UNDIFFERENTIATED	Pertnjara Formation	Pzp	Sandstone, pebbly sandstone, siltstone
			Pzp(s)	Sandstone, pebbly sandstone
			Pzp(a)	Siltstone, fine silty sandstone
		Mereenie Sandstone	Pzm	Red-brown and white, cross-bedded sandstone
			Pzm(2)	White, cross-bedded sandstone
			Pzm(1)	Red-brown, silty sandstone
	ORDOVICIAN TO CAMBRIAN	Larapinta Group: Undifferentiated	€-Ol	Fossiliferous sandstone, siltstone and limestone
		Stokes Formation	Ot	Siltstone, shale, fossiliferous limestone
		Stairway Sandstone	Os	Fossiliferous sandstone, silty sandstone, siltstone, limestone
		Horn Valley Siltstone	Oh	Fossiliferous siltstone, limestone
		Pacoota Sandstone	€-Op	Fossiliferous sandstone, silty sandstone
	CAMBRIAN	Pertaoorrta Formation	€p	Sandstone, siltstone, shale, limestone
		Goyder Member	€g	Silty sandstone, sandstone, siltstone, limestone
		Petermann Sandstone Member	€e	Red-brown sandstone, silty sandstone
		Deception Member	€d	Red-brown siltstone, shale
		Illara Sandstone Member	€i	Red-brown sandstone, silty sandstone
		Jay Creek Limestone Member	€j	Limestone, shale, dolomite
		Tempe Member	€t	Siltstone, calcareous sandstone, fossiliferous, glauconitic limestone
		Chandler Limestone Member	€l	Limestone and dolomite with chert laminae
		Eninta Sandstone Member	€n	Red-brown sandstone, silty sandstone, siltstone
		Quandong Conglomerate Member	€q	Conglomerate, conglomeratic sandstone
PRECAMBRIAN	UPPER PROTEROZOIC	Winnall Beds	Puw	Sandstone, siltstone
		Pertatataka Formation	Pup	Siltstone, shale, sandstone, limestone
		Areyonga Formation	Pua	Sandstone, claystone, siltstone, minor conglomerate and limestone
		Inindia Beds	Pun	Siltstone, bedded chert, chert breccia, sandstone
		Bitter Springs Limestone	Pub	Dolomite, dolomitic limestone, limestone, siltstone

- Geological boundary
- Anticline, showing plunge
- Syncline, showing plunge
- Fault

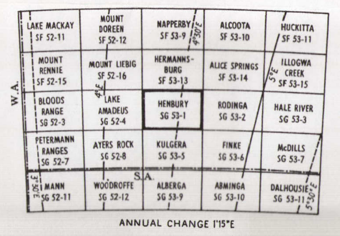
Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes.

- Strike and dip of strata
- Strike and dip of strata, facing not known
- Vertical strata
- Horizontal strata
- Overturned strata
- Top of bed
- Dip < 15° (air-photo interpretation)
- Dip 15° — 45° (air-photo interpretation)
- Dip > 45° (air-photo interpretation)
- Trend lines (air-photo interpretation)
- Joint pattern (air-photo interpretation)
- Macrofossil locality
- x Hy23 Text reference to specimen locality
- HyR-2 Measured section
- DD APZ 388'8" Diamond drill hole; showing depth
- •Cu Minor mineral occurrence (Cu copper, Pb lead)

- Bore with windpump
- Abandoned bore
- Well
- Spring
- T Tank
- E Earth tank
- WH Waterhole
- RH Rockhole
- Swamp
- Sand dunes
- Road
- Vehicle track
- Fence
- Henbury Homestead
- Landing ground
- Yd Yard
- Astronomical station
- •1193 Height in feet, instrument levelled. Datum, mean sea level Port Augusta

INDEX TO ADJOINING SHEETS

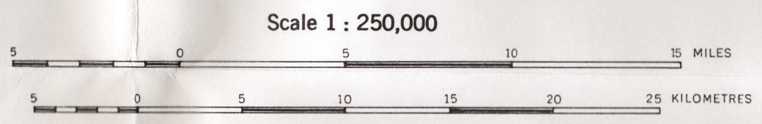
Showing Magnetic Declination



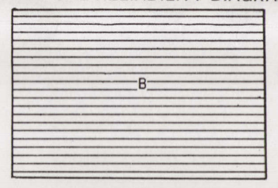
LAKE MACKAY SF 52-11	MOUNT DOREEN SF 52-12	NAPPERBY SF 53-9	ALCOOTA SF 53-10	HUCKITTA SF 53-11
MOUNT RENNIE SF 52-15	MOUNT LIEBIG SF 52-16	HERMANNSBURG SF 53-13	ALICE SPRINGS SF 53-14	ILLOGWA CREEK SF 53-15
BLOODS RANGE SG 52-3	LAKE AMADEUS SG 52-4	HENBURY SG 53-1	RODINGA SG 53-2	HALE RIVER SG 53-3
PETERMANN RANGES SG 52-7	AYERS ROCK SG 52-8	KULGERA SG 53-5	FINKE SG 53-6	McDILLS SG 53-7
MANN SG 52-11	WOODROFFE SG 52-12	ALBERGA SG 53-9	ABMINGA SG 53-10	DALHOUSIE SG 53-11

ANNUAL CHANGE 1'15"E

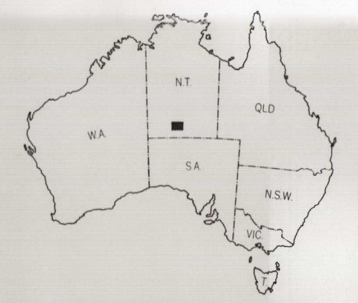
Scale 1 : 250,000

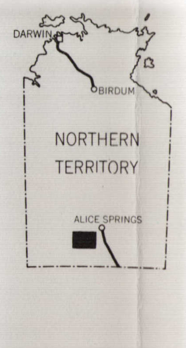


GEOLOGICAL RELIABILITY DIAGRAM



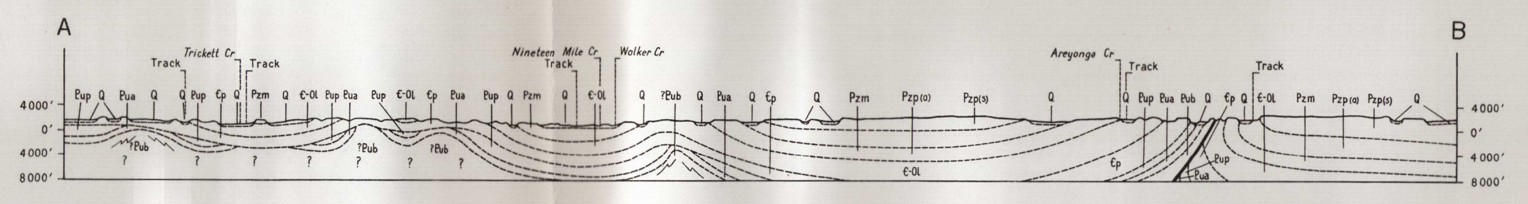
B Detailed reconnaissance - numerous traverses with air-photo interpretation

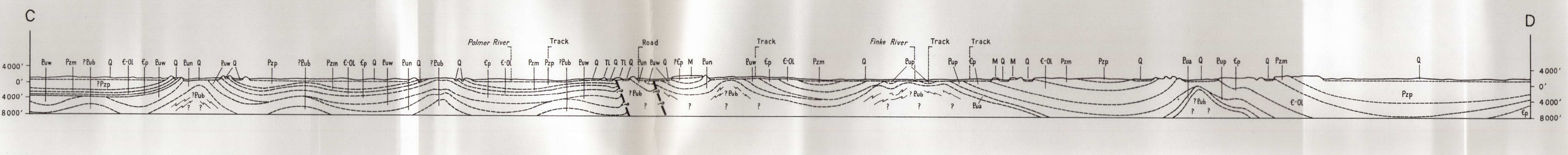




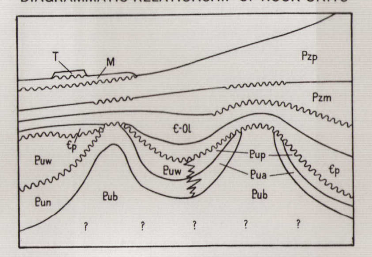
Sections

Scale: V/H = 1





DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Unconformity

HENBURY

SHEET SG 53-1