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1964/41

REGIONAL GEOLOGY OF THE SOUTHERN MARGIN, AMADEUS BASIN, RAWLINSON RANGE TO MULGA PARK STATION

by

D.J.Forman and P.M. Hancock

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REGIONAL GEOLOGY OF THE SOUTHERN MARGIN, AMADEUS BASIN. RAWLINSON RANGE TO MULGA PARK STATION.

SUMMARY.

The south-west margin of the Amadeus Basin lies in the south-west corner of the Northern Territory and continues westerly for at least 60 miles into Western Australia.

The oldest known rocks in the area, named the Mount Harris Basalt and Bloods Range Beds, are a sequence of Precambrian basic and acid volcanics with interbedded sediments. These are overlain with regional unconformity by 14,000 feet of Upper Proterozoic sediments - the Dean Quartzite, Pinyinna Beds, Inindia Beds and Winnall Beds.

The Dean Quartzite is the basal unit of the Amadeus Basin sediments along the southern margin of the basin. It is correlated with the Heavitree Quartzite which forms the basal unit of the Amadeus Basin sediments along the northern margin of the basin. Both the Dean Quartzite and the Heavitree Quartzite are succeeded by a sequence of carbonate sediments, shale and siltstone called the Pinyinna Beds in the southern margin of the basin and the Bitter Springs Limestone along the northern margin, and within the Amadeus Basin.

The Inindia Beds and Winnall Beds are correlated with the Areyonga Formation and Pertataka Formation of the northern Amadeus Basin. An angular unconformity separates them but this disappears to the north. The formations comprise siltstone, sandstone and thin limestone and dolomite.

A major orogeny late in the Upper Proterozoic folded the Upper Proterozoic sediments adjacent to the southern margin of the basin, and thus provided a source for the Cambrian sediments within the basin. This orogeny has been named the Petermann Ranges Folding. During the Petermann Ranges Folding the Mount Harris Basalt, Bloods Range Beds and Dean Quartzite beneath the Pinyinna Beds were regionally folded into a recumbent fold which extends at least 200 miles in an east-west direction, and is overturned for a distance of about 35 miles across the strike. Granite, gneiss and schist were formed from the Bloods Range Beds and Mount Harris Basalt during the regional overturning, but the Dean Quartzite formed a metamorphic barrier largely protecting itself and the Pinyinna Beds from conversion to gneiss and granite. Radioactive age determination on a specimen from one of the largest granite bodies has given an age of 600 million years.

About 10,000 feet of sediment, the Inindia Beds and Winnall Beds, were overlying the Pinyinna Beds during this deformation. They were squeezed northwards out of the core of the recumbent fold and slid northwards on a decollement surface in the Pinyinna Beds and Bitter Springs Limestone. The tight and isoclinal folding of these formations dies out to the north away from the orogenic area.

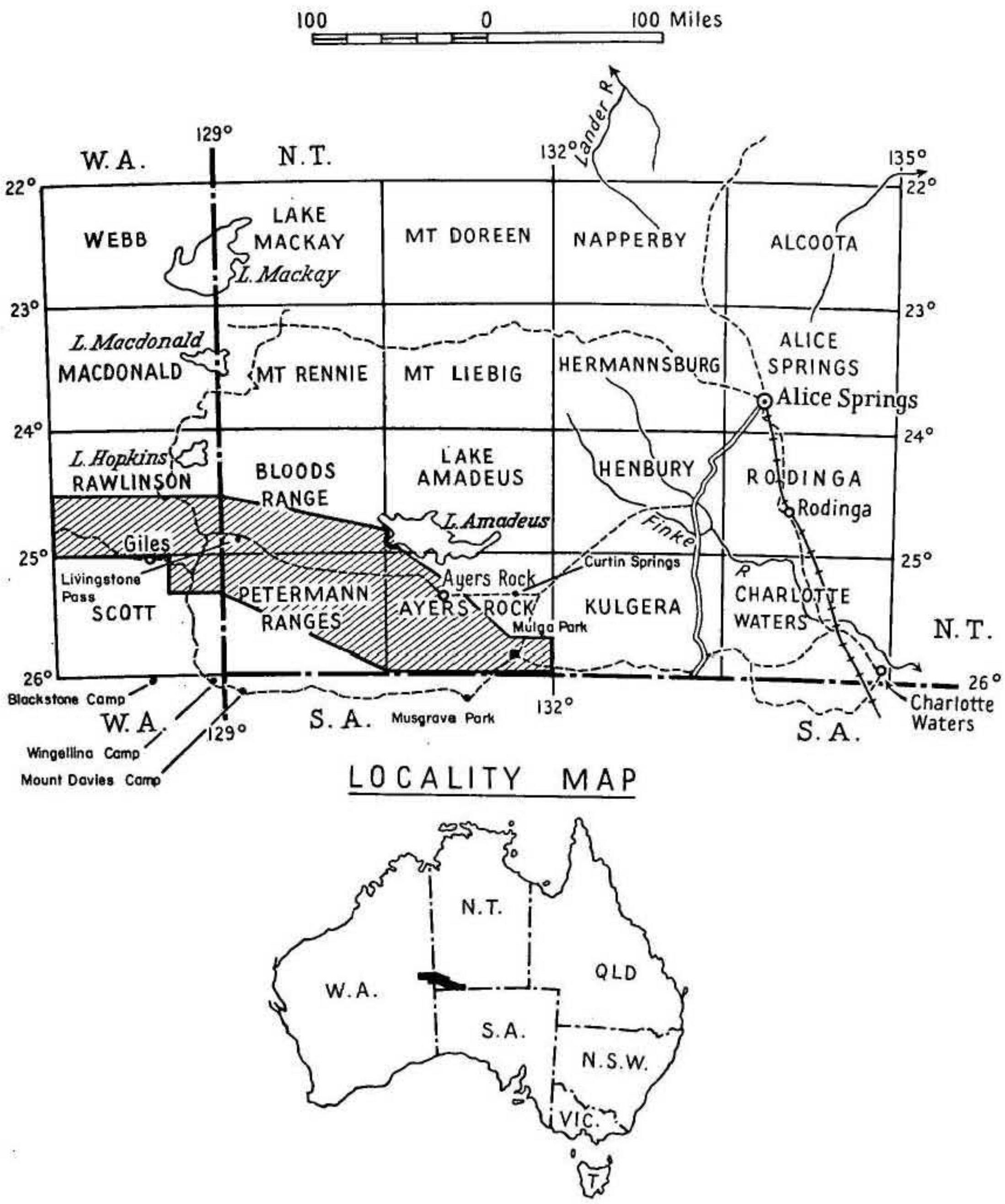
Formation of the regional recumbent fold raised the southern margin of the Amadeus Basin above sea level, probably as a mountain chain, and this elevated area was rapidly eroded. Adjacent to the northern flank of the fold, thick wedges of conglomerate and arkose were deposited unconformable upon the Upper Proterozoic sediments. These sediments, the Mount Currie Conglomerate and Ayers Rock arkose, are probably Lower Cambrian in age. Farther north the Cleland Sandstone was deposited in a fluviatile environment, marginal to the marine Cambrian facies of the Amadeus Basin.

During a marine transgression, in the Ordovician, a thin sequence of sandstone, limestone, siltstone, shale and conglomerate was deposited on the southern half of the Bloods Range Sheet area and sandstone was deposited on the north-east quadrant of the Petermann Ranges Sheet area. These deposits are flat lying and demonstrate the lack of tectonic activity since the Ordovician and probably since the Petermann Ranges Folding.

Subsequent slow weathering has produced superficial deposits of Tertiary sandstone and conglomerate and Quaternary travertine, evaporites, alluvium and aeolian sand.

Fig. 1

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



Bureau of Mineral Resources, Geology and Geophysics. March, 1964.
GD 155

NT/A/71
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To accompany. Record Nº 1964/41

INTRODUCTION

General

The southern margin of the Amadeus Basin was mapped by the Bureau of Mineral Resources in the years 1960, 1962 and 1963. In 1960, Wells, Forman and Ranford spent 6 weeks mapping the southern half of the Rawlinson Sheet area. From 12th July 1962 to 19th September, 1962, Forman and Stewart mapped the southern half of the Bloods Range Sheet area. In May to September, 1963, Forman and Hancock remapped the south-east corner of the Rawlinson Sheet area, and mapped the north-east corner of Scott, the Petermann Ranges Sheet area, except 5 one-mile sheets in the south, and the Ayers Rock Sheet area, except 3 one-mile sheets on the eastern side. Dr. W. Oldershaw, petrologist, joined this party for 2 weeks and collected granite samples for age determination. During 1963 Wells, Stewart and Skwarko mapped outcrops of granite and gneiss on the southern part of the Kulgera and Finke 1:250,000 Sheet areas but the results of their investigation are not included in this report.

Location and Access

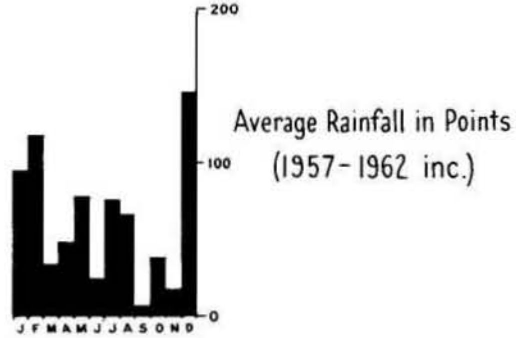
Fig. 1 shows the position of the area covered in this report and access to it. The area is accessible by graded roads from the main Alice Springs-Adelaide road to Ayers Rock and Giles. Access to Giles is also possible from the west by a graded road from Carnegie Station. The track shown westerly from Ayers Rock to Giles is an ungraded vehicle track unsuited to two wheel drive vehicles.

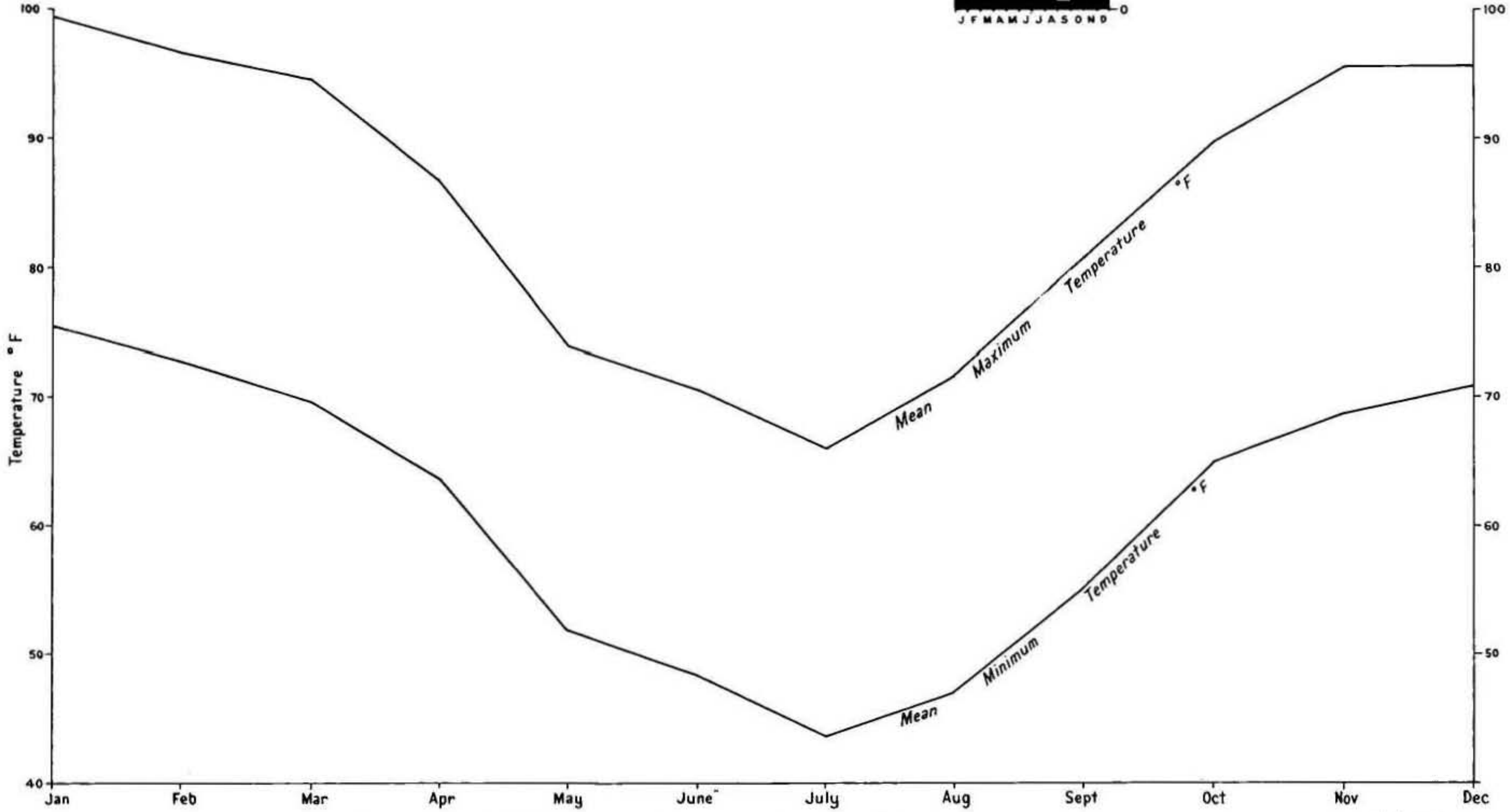
Bloods Range and Petermann Ranges Sheet areas and part of the Ayers Rock Sheet area lie within a Northern Territory aboriginal reserve and permission to enter must be obtained from the Welfare Branch of the Northern Territory Administration. The Rawlinson and Scott Sheet areas lie within a Western Australian aboriginal reserve and permission to enter is required from the Western Australian Department of Native Welfare. The road to Giles passes through a South Australian aboriginal reserve and permission to enter must be obtained from the Department of Aboriginal Affairs of South Australia.

Giles Meteorological Station is operated by the Bureau of Meteorology but administered and maintained by the Weapons Research Establishment. Permission to visit Giles is required from the Controller Weapons Research Establishment, and is conditional on the applicants having

FIG 2

METEOROLOGICAL DATA
GILES WEATHER STATION
(Average 1957 - 1962 inc.)





Bureau of Mineral Resources, Geology and Geophysics. April 1964. *To accompany Record 1964/41.* W/A/20 conformed with the medical and character requirements for permission to enter the Western Ausstralian and South Australian native reserves.

Climate

Fig. 2 shows the mean maximum and mean minimum temperatures and average monthly rainfall for Giles for the period 1957-1963 inclusive. During a fortnight in May-June 1963 there was a rainfall of about 3 inches making cross country travel almost impossible for several days after the rain.

Development

The area is undeveloped except at Giles, Livingstone Pass, Ayers Rock, Curtin Springs Station and Store and Mulga Park Station.

Good water has been obtained from a few bores south of the Pass of Abencerrages near Giles Weather Station. Good water was obtained from several bores in the Livingstone Pass area in 1963. These bores were sunk by the Water Resources Board of the Northern Territory Administration on behalf of the Welfare Branch with a view to establishing a native settlement in the area. At the same time in 1963 the Animal Industries Branch of the Northern Territory Administration reported on the grazing prospects of the Petermann Ranges area for the Welfare Branch.

Ayers Rock is well established as a tourist resort with two good water bores and tourist accommodation provided by three companies. A Ranger is permanently employed at the "Rock". Good graded roads provide access to and around Mount Olga for tourists.

Ayers Rock is connected to Curtin Springs Station by a first class graded road. The Station maintains a general store and petrol station for the public and provides morning and afternoon teas. Curtin Springs Station is connected to Mulga Park station by a graded road and this area in the south-east corner of the Ayers Rock Sheet area has been developed for grazing.

Other places of interest south of the area are the abandonned nickel prospecting camps: Blackstone camp and Wingellina camp in Western Australia and Mount Davies camp in South Australia. The South Australian Department of Aboriginal Affairs maintains a Native Mission at Musgrave Park in the Musgrave Ranges on the road between Mulga Park and Giles.

Within a native reserve no watering places whether sheds, tanks, catchments, bores or wells may be established without the permission of the Aborigines Protection Board and only then in such positions as are agreed by the board. No aboriginal watering places, whether rock holes or soaks, may be used, except in cases of dire necessity.

Survey Method

Mapping was carried out by three, four and five day Landrover traverses from base camps at Giles and the Robert Range in 1960, at the Hull River in 1962 and at Giles Creek, Chirnside Creek and Feltham Hill in 1963. Two one-day helicopter traverses were made from Giles in 1962, seven from Mount Olga and five from Chirnside Creek in 1963.

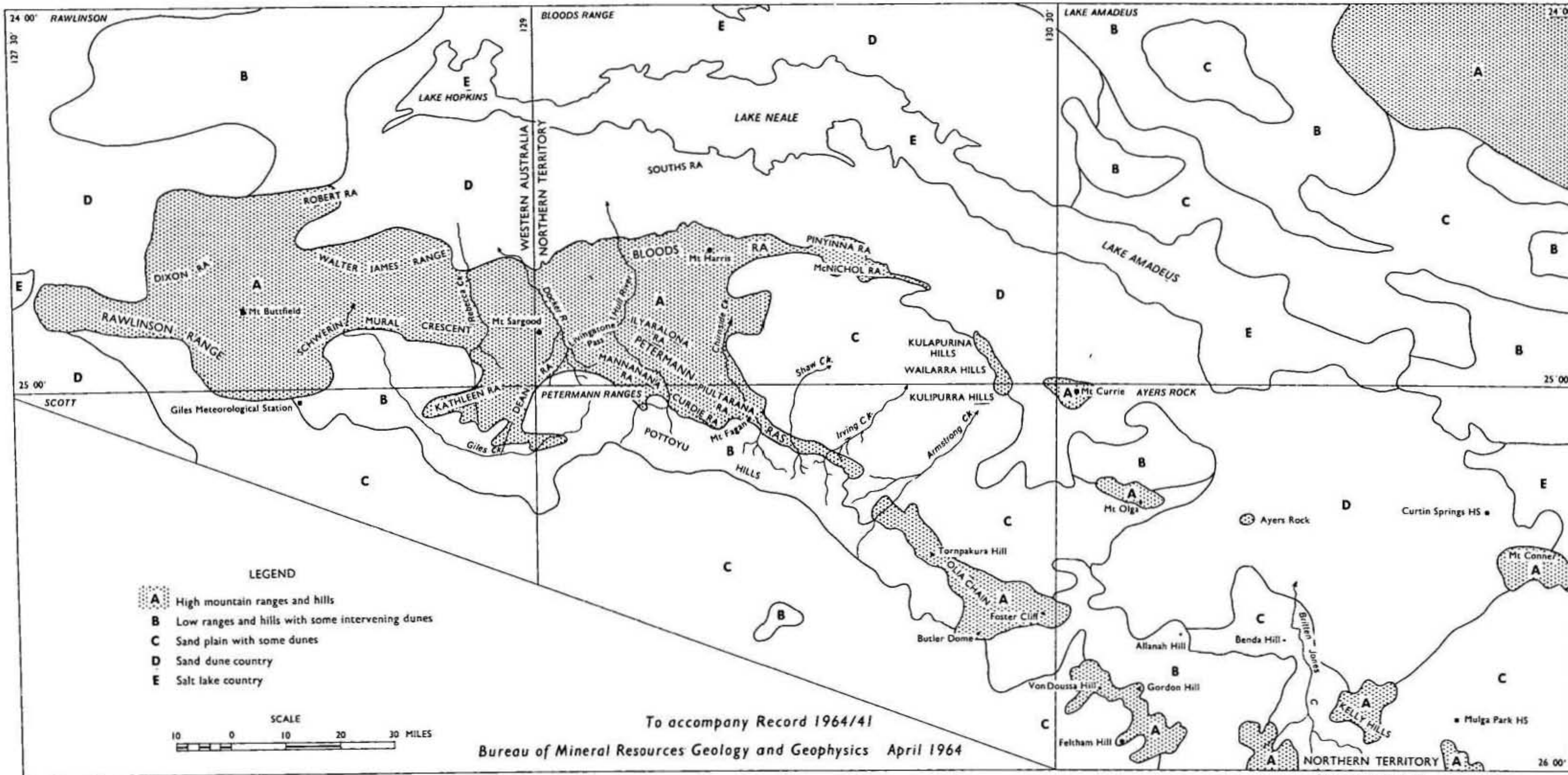
The geology was plotted on aerial photographs at a scale of approximately 1:46,500 in the Northern Territory part of the area, and 1:36,500 in the Western Australian part and then transferred to transparent controlled ~~mosaics~~ slotted template assemblies at photo-scale. The ~~mosaics~~ assemblies were reduced photographically to a scale of 1:250,000 and the final map was drafted at this scale.

PREVIOUS INVESTIGATIONS

The south-west margin of the Amadeus Basin was first explored by Giles in 1872-1874 and 1876 (Giles,1889). The first scientific investigations in the area were made by the Central Australian Exploring Expedition in 1889 (Tietkens,1891) followed by the Horn Scientific Expedition in 1896 (Tate and Watt,1896). In 1901 two South Australian Government prospecting expeditions investigated the Musgrave, Mann and Rawlinson Ranges (Wells,1904) and a further expedition investigated the Musgrave, Mann and Tomkinson Ranges in 1903 (Wells and George,1904). H. Basedow led a prospecting and geological expedition to the area in 1903 and recorded geological observations in the Musgrave Ranges, Mount Olga, Mount Conner, and Ayers Rock (Basedow,1905). In 1905 F.R. George led a South Australian Government prospecting expedition to the Petermann Ranges and Bloods Range, and produced a geological sketch map but found no mineralisation apart from a trace of gold in a floater of quartz at Foster Cliff (George,1907). During 1926, Basedow and Mackay examined the geology of the Bloods Range and Petermann Ranges and produced a geological report on the latter, (Basedow,1929). This was followed by Mackay's

PHYSIOGRAPHIC DIVISIONS

FIG. 3



NT/A/68

aerial survey of the Petermann Ranges in 1930 (Mackay,1934).

In the 1930's Lasseter's report of a rich gold reef in the area gave rise to many expeditions to find the reef which is now considered to be non existent. In 1935 the Border Gold Reef Expedition traversed along the Olia Chain and the Petermann Ranges into Western Australia in search of the reef. H.A. Ellis was attached as geologist to a further search in 1936 (Ellis,1937). Faith in the possible existence of Lasseter's Reef was still strong enough in certain quarters for a further expedition to be financed in 1951. G.F. Joklik of the Bureau of Mineral Resources accompanied this expedition and recorded his geological observations (Joklik,1952). Frome-Broken Hill Co. Pty. Ltd. carried out an extensive survey in the area in 1958 (Gillespie,1959).

During October 1960 the Bureau of Mineral Resources flew an aeromagnetic traverse from Alice Springs to Giles (Goodeve,1961) and in 1962 a helicopter gravity party covered the southern margin of the Amadeus Basin as part of a larger reconnaissance gravity survey (Lonsdale and Flavelle,1963).

The geological mapping of the southern margin of the Amadeus Basin has been undertaken by the Bureau of Mineral Resources in the following stages. Rawlinson and Macdonald Sheet areas in 1960 (Wells, Forman and Ranford, 1961); Bloods Range Sheet area in 1962 (Forman,1963), the Petermann Ranges Sheet area apart from the southern margin, the Ayers Rock Sheet area apart from the north-east portion and parts of the Rawlinson and Scott Sheet areas by the authors in 1963. The north-east portion of the Ayers Rock Sheet area and the Kulgera Sheet area were mapped in 1963 (Wells, Stewart and Skwarko,1964).

PHYSIOGRAPHY

Fig. 3 illustrates the main physiographic divisions adjacent to the southern margin of the Amadeus Basin. The divisions are:

A. High Mountain Ranges and Hills:

The high mountain ranges and hills are up to 3,500 feet above sea level and 1,500 feet above the surrounding plain. They form an outstanding feature extending in an easterly direction from the Rawlinson Range and Schwerin Mural Crescent in Western Australia to the Petermann Ranges and Olia Chain in the Northern Territory, a distance of over 200 miles. A second chain of mountain ranges and hills occurs farther north and extends from the

Robert Range and Walter James Ranges, in Western Australia to Bloods Range, Pinyinna Range, McNichol Range, Kulapurina Hills, Wailarra Hills and Kulipurra Hills in the Northern Territory. These ranges and hills are composed mainly of the tough Dean Quartzite. The ranges are elongate, rugged and generally have steep scarp slopes and moderate dip slopes. A deeply incised drainage cuts the ranges and at the base of most of the ranges there are alluvial fans and plains which support mulga scrub.

The ranges are cut by the Giles, Rebecca, Chirnside, Shaw, Irving and Armstrong Creeks and the Docker and Hull Rivers, all of which drain northerly towards Lakes Hopkins, Neale and Amadeus.

Three remarkable inselbergs, Ayers Rock, Mount Olga and Mount Connor form prominent features to the north of the ranges on the Ayers Rock Sheet area. All three rise to over 1,000 feet above the surrounding plain. They are described in detail by Ollier and Tuddenham (1961).

B. Low Ranges and Hills with some Intervening Dunes.

Low ranges and hills with intervening dunes and alluvial plains cover large portions of the area on the flanks of the Petermann Ranges and Olia Chain and north of the Robert Range. The ranges and hills stand from 50 to 300 feet above the plain and commonly have an incised drainage pattern.

C. Sand Plain with some Dunes.

Sand plain with widely spaced sand dunes and a few low outcrops occurs north and south of the high mountain ranges and hills. Spinifex, desert oaks and light scrub grow on the plain where the sand is of aeolian origin, and mulga grows on the alluvium.

D. Sand Dune Country.

The sand dune country is characterized by closely spaced longitudinal dunes which are branching and generally trend easterly, and areas containing an interlocking network of dunes. The dunes are of unconsolidated sand fixed by spinnifex. They are up to forty feet high.

E. Salt Lake Country.

Most of the salt lakes occur in a west-northwest trending belt north of the ranges and include Lakes Amadeus, Neale and Hopkins. The salt lakes have islands and fringes of sand and travertine. They lie about 1,500 feet above sea level.

TABLE 1.

AGE	UNIT	MAP SYMBOL	LITHOLOGY	CORRELATED WITH	REMARKS
Quaternary		Qs Qa Ql	Sand. Alluvium. Travertine.		
Tertiary		Tc T	Conglomerate. Sandstone.		
PALAEOZOIC – Ordovician		O	Sandstone, dolomite, limestone, siltstone, shale and conglomerate	Larapinta Group	Shallow marine outliers from the Amadeus Basin. Unconformably overlie gneiss
PALAEOZOIC – Cambrian	Ayers Rock arkose. Mount Currie Conglomerate Dolerite	- Pzc - d	Arkose, siltstone. Conglomerate, sandstone. Dolerite	Pertaoorrta Formation, Sir Frederick Conglomerate, Ellis Sandstone, Maurice Formation.	The arkose and conglomerate were deposited as thick wedges in front of the regional recumbent fold. They contain fragments of dolerite.
ANGULAR UNCONFORMITY					
PRECAMBRIAN – Upper Proterozoic	Winnall Beds	PuW	Siltstone, sandstone, pebbly sandstone.	Pertatataka Formation, Carnegie Formation.	May be 8000 feet thick. Where the two units could not be differentiated they have been mapped as undifferentiated Upper Proterozoic. Pu.
	UNCONFORMITY				
	Inindia Beds	Pun	Siltstone, sandstone, chert, chert breccia, dolomite.	Areyonga Formation, Boord Formation and basal Carnegie Formation.	May be 2000 feet thick.
	Pinyinna Beds	Pui	Crystalline dolomite, limestone, siltstone, slate, phyllite, lineated and schistose carbonate.	Bitter Springs Limestone	May be 2000 feet thick. The unit has been plastic during deformation and probably contains evaporites. Intruded by dolerite.
	Dean Quartzite	Pud	Quartzite, sandstone, pebbly quartzite and sandstone, conglomerate, greywacke, silty sandstone, sericitic quartzite, sericite-quartz schist.	Heavitree Quartzite	3900 feet measured in the Robert Range but thickness probably averages one to two thousand feet. It has gradational contacts with granite and gneiss and is intruded by granite.
REGIONAL UNCONFORMITY WITH BLOODS RANGE BEDS AND MOUNT HARRIS BASALT					
PRECAMBRIAN – Undifferentiated	Unnamed granite	pЄg	Granite, gneiss, schist, amphibolite, quartz-epidote rock, quartzite, porphyroblastic schist.		Age determination work on a specimen of the Pottoyu Granite Complex has given an age of 600 million years. Hence granite probably formed during folding of Winnall Beds. Gradational into Olia Gneiss.
	Pottoyu Granite Complex	pЄo	Granite, gneiss, schist, amphibolite, quartz-epidote rock and quartzite.		
	Olia Gneiss	pЄn	Gneiss, migmatite, porphyroblastic schist, amphibolite, slate, chert, quartzite, sericite-quartz schist, granite.		Gneiss probably formed from older rocks during the regional folding. Is gradational into porphyroblastic schist, Bloods Range Beds and Dean Quartzite.
	"Porphyroblastic Schist"	pЄm	Porphyroblastic schist, amphibolite schist, quartz-epidote rock, biotite-quartz schist, quartzite, porphyroblastic gneiss, gneiss.	Bloods Range Beds and possibly part of Mount Harris Basalt.	The porphyroblastic schist is gradational into Bloods Range Beds, Olia Gneiss and granite and is intruded by granite.
	"Porphyry"	pЄp	Porphyry		Igneous sediments within the Bloods Range Beds and Mount Harris Basalt.
	Bloods Range Beds	pЄb	Sandstone and quartzite, sericite-feldspar-quartz schist, quartz-sericite schist, sericite-quartz schist, slate, acid and basic volcanics.	Dixon Range Beds of the Rawlinson Sheet area	Gradational into porphyroblastic schist and gneiss.
	Mount Harris Basalt	pЄh	Amygdaloidal basalt, green schist, possible tuff and agglomerate, quartzite, porphyry, quartz-epidote rock quartz-amphibolite, conglomerate.	Basalt beneath Mount Leisler on Mount Rennie Sheet area.	Degree of metamorphism is variable. Gradational contact with granite.

No rocks in the area have been definitely identified as older than the Mount Harris Basalt, but parts of the Olia Gneiss, particularly on the northern front of the Musgrave Ranges may have formed from older sediments, gneiss or granite.

STRATIGRAPHY

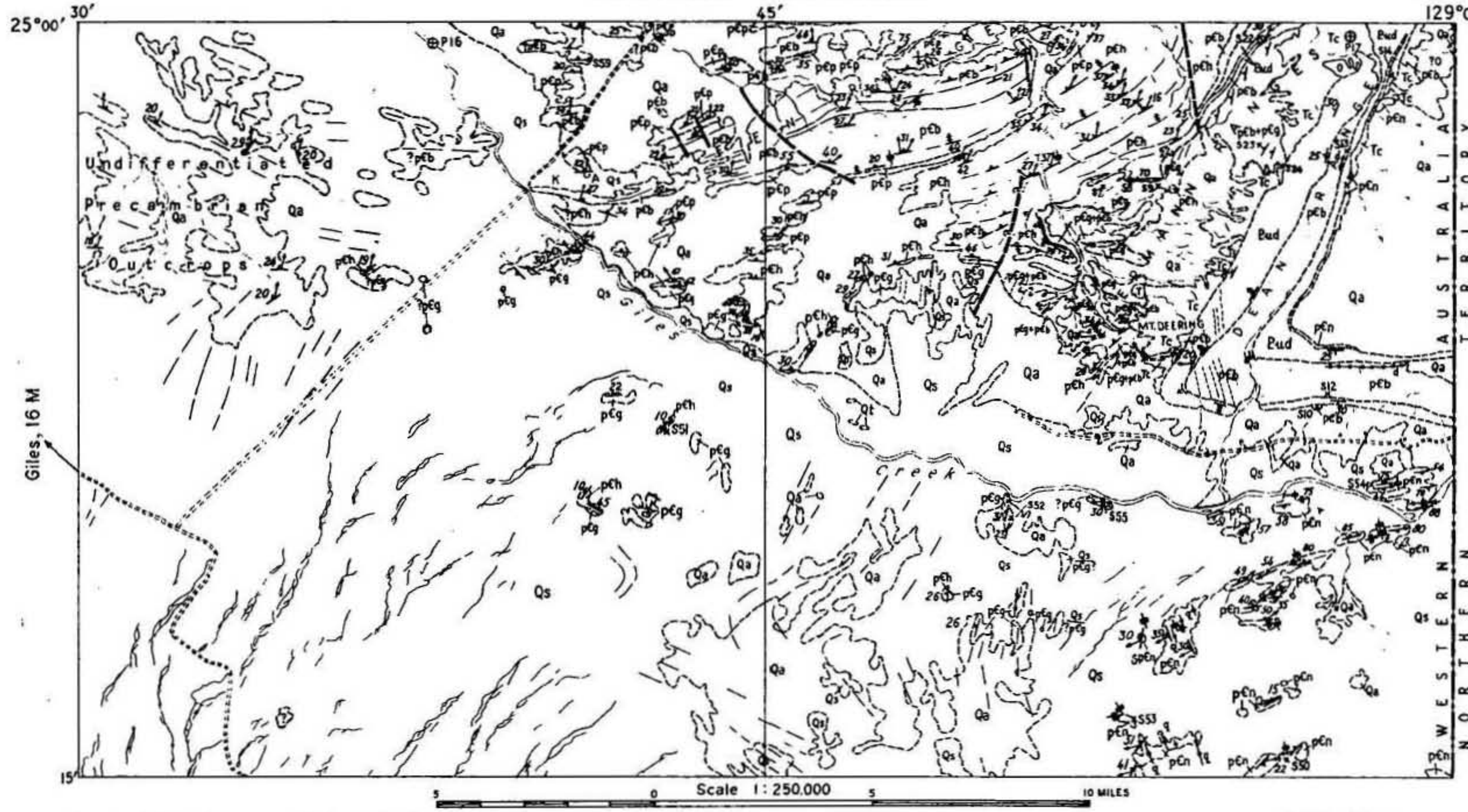
General

This report is concerned mainly with those rocks which lie south of the main body of sediment in the Amadeus Basin. The sediments within the Amadeus Basin are defined from the northern margin of the basin where the Upper Proterozoic Heavitree Quartzite and younger formations rest unconformably on the eroded surface of the Arunta Complex gneiss, granite and schist. The southern margin of the Amadeus Basin is not marked by this abrupt unconformity between an igneous and metamorphic basement and a basal quartzite. At the southern margin the Dean Quartzite which is believed to be equivalent to the Heavitree Quartzite lies with regional unconformity on a sequence of Precambrian volcanic and sedimentary rock named the Bloods Range Beds and the Mount Harris Basalt. During regional folding the Bloods Range Beds and Mount Harris Basalt were metamorphosed to schist, amphibolite, gneiss and granite and the Dean Quartzite and overlying Pinyinna Beds were recumbently infolded. Hence the gneiss, granite, schist and amphibolite, beneath the Dean Quartzite was formed after the Dean Quartzite and a considerable thickness of Upper Proterozoic sediments had been deposited along the southern margin of the Amadeus Basin. The probability of older sediment, gneiss and granite occurring beneath the Mount Harris Basalt is admitted but these rocks, if they occur in the area, could not be separated. Overlying the Pinyinna Beds, Dean Quartzite, Bloods Range Beds and Mount Harris Basalt during the regional recumbent folding were Upper Proterozoic sediments, Inindia Beds and Winnall Beds, of the Amadeus Basin possibly totalling 10,000 feet in thickness. These relatively competent sediments do not appear to be infolded with the underlying less competent strata and their tectonic style of deformation suggests Jura-type folding with a decollement in the Pinyinna Beds and equivalent Bitter Springs Limestone. The probable relationship of these sediments to the Mount Harris Basalt, Bloods Range Beds, Dean Quartzite, Pinyinna Beds, schist, gneiss, granite and porphyry is shown in Figure 21. The Mount Currie Conglomerate and the arkose at Ayers Rock are thought to be wedge-like bodies of sediment deposited in front of a mountain chain produced by recumbent folding.

The stratigraphy of the southern margin is summarized in Table 1.

GEOLOGY OF THE NORTH-EAST CORNER OF THE SCOTT 1:250.000 SHEET AREA
WESTERN AUSTRALIA

Fig. 4



Bureau of Mineral Resources, Geology & Geophysics. April, 1964.
To accompany Record 1964/41

G 52-A6-1 G.M.

Figure 5: Oscillation ripple marks in the basal quartzite of the Mount Harris Basalt. The quartzite in the photo is overturned. Massive granite overlies the quartzite to the right of the photo and the Mount Harris Basalt underlies the quartzite to the left of the photo.
Neg.No.G/6095

UNDIFFERENTIATED PRECAMBRIAN

Mount Harris Basalt

The name Mount Harris Basalt was first proposed by Forman (1963) for the thick sequence of amygdaloidal basalt, green schist, and possible tuff and agglomerate with minor quartzite which has a gradational contact with granite and is overlain by the Bloods Range Beds. The basalt is intruded by granite and porphyry and is associated with brown, feldspar porphyry which may be intrusive or extrusive.

The type area for the sequence is near Mount Harris in Bloods Range. The unit crops out between Bloods Range and Ilyaralona Range on the Bloods Range Sheet, the north-east corner of the Scott Sheet area (Fig. 4), and the south-east corner of the Rawlinson Sheet area. Metamorphosed remnants of the Mount Harris Basalt within areas of granite and gneiss are believed to be represented by lenses of quartz-epidote rock, quartz-amphibolite and thin quartzite.

The base of the formation crops out in many places as a low quartzite ridge with abundant cross-bedding. Oscillation ripple marks were seen in the Scott Sheet area (Fig. 5). The cross beds are well enough preserved to give reliable facings and these invariably show that the basalt succession is stratigraphically upwards from the quartzite and that the granite is occupying a position stratigraphically below the quartzite.

The nature of the contact between the Mount Harris Basalt and the granite suggests two possibilities. (1) That the granite was emplaced metasomatically beneath the Mount Harris Basalt. (2) That the Mount Harris Basalt was deposited over the granite and later deformed with it.

The gradational contact between quartzite and granite is similar on both the Scott Sheet area and the Bloods Range Sheet area. The schistose, coarse-grained, gritty, cross-bedded sandstone is underlain by a pale green-grey, coarse, quartz-sericite schist with veinlets and irregular patches containing quartz-feldspar pegmatite. Rare feldspars up to 2 inches appear to have grown in the schist after the schistosity developed. Sericite-feldspar-quartz schist occurs beneath the sericite-quartz schist and this appears to grade downwards into very coarsely porphyritic, rapakivi granite with a fine to medium-grained matrix. The feldspars in the granite have a rough orientation but the granite has been subjected to only minor post crystallization stress. The sericite-feldspar-quartz schist may be interpreted as a metamorphosed arkose overlying the granite, as a feldspathized zone of schists, marginal to a metasomatically emplaced granite, or as a zone of sheared granite. If the sericite-feldspar-quartz schist was a metamorphosed arkose, some granite boulders could be expected near its contact with the granite. No granite boulders have been found in the schist. Some of the schist may be sheared granite but it is clear from the gradation between metasediment and schist that in many places the schist has resulted from alteration of an original sediment. In the Kathleen Range - Dean Range area, the contact between granite and Mount Harris Basalt is not marked by quartzite at every locality but instead the granite is in contact with schist or basalt stratigraphically higher than the quartzite. At two localities west of the Dean Range, quartzite occurs within the granite.

Probably the strongest evidence for the late emplacement of the granite lies in the fact that the granite is unsheared within ten or twenty feet of the isoclinally folded quartzite at the base of the Mount Harris Basalt and that at one locality, where the quartzite is overturned in a downward facing anticline and syncline, the overlying granite is massive. The abundance of quartz and pegmatite veins in the Mount Harris Basalt and Bloods Range Beds supports the hypothesis for a late origin of the granite. In the type area between the Ilyaralona Range and Bloods Range the basal quartzite is overlain by a sequence of green and green-grey, amygdaloidal, epidotized basalt with lesser amounts of green chlorite schist and possible metamorphosed tuff, tuffaceous sandstone and sandstone. At many localities the basalt is brecciated. The brecciation may be secondary but could be primary as in an agglomerate. There is a considerable area of poor outcrop in which fragments of green, epidotized, amygdaloidal basalt occur as scree amongst fragments of green, chlorite schist.

Five miles south-west of Mount Harris the basalt is intruded by a boss of coarse, even-grained, biotite granite and dykes of pink, aplitic granite, porphyritic aplite and rhyolite porphyry. On the northern margin of this intrusion the basalt appears to be little altered although thin section examination shows that the basalt has been extensively sericitized. South of the intrusion the basalt has been locally altered to medium and coarse-grained, green-grey, amphibolite and chlorite schist. A quartz vein intruding this rock contains secondary lead and copper minerals, galena and a trace of silver and gold (specimen No. BR 99).

Between the Dean Range and the Kathleen Range there is a thick sequence of alternating green epidotized, amygdaloidal basalt, brecciated, green, epidotized amygdaloidal basalt, quartz-epidote rock with amygdaloidal texture and green schist (chlorite-actinolite-quartz-sericite-epidote-schist). These green rocks are interbedded with white, lineated quartzite, lineated quartz-sericite schist and quartz-sericite schist with lineated porphyroblastic or blastoporphyritic quartz and feldspar. The sequence is intruded by quartz veins,feldspar-quartz veins and iron ore-feldspar-quartz veins. A boulder bed approximately fifteen feet thick within the sequence contains stretched boulders of sericitic quartzite and granite gneiss in a matrix of sericite schist. Malachite occurs in grey schist about 25 yards north of the boulder bed. A grab sample of the best looking rock assayed 2% copper. Traces of copper occur at other localities, within the Mount Harris Basalt, but none are considered to be economically important.

South of the Kathleen Range (Fig. 4) the green schists and epidotized amygdaloidal basalt with interbedded porphyroblastic or blastoporphyritic schist pass upwards into the Bloods Range Beds with an increase in the proportion of porphyroblastic or blastoporphyritic schist and quartzite, quartz-sericite schist and sericite-quartz schist. The contact appears gradational and there is no evidence for an unconformity.

North of the Ilyaralona Range the Bloods Range Beds overlie the Mount Harris Basalt at one locality and one mile farther along strike they overlie granite. This relationship may be explained if an unconformity is assumed at the base of the Bloods Range Beds or alternatively if the granite is younger than the Mount Harris Basalt and Bloods Range Beds. This second alternative is preferred because of the conformable relationship in the Kathleen Range area and because the granite is known to be younger in other areas.

The sequence beneath the Mount Harris Basalt is probably replaced by granite. The existence of older rocks is proved by the granite gneiss boulders within the Mount Harris Basalt sequence.

The age of the Mount Harris Basalt is unknown except that it is older than the Dean Quartzite of Upper Proterozoic age and the Bloods Range Beds. The near conformity of the Dean Quartzite, Bloods Range Beds and Mount Harris Basalt suggests that the age may be Lower Proterozoic.

Bloods Range Beds

The name Bloods Range Beds was proposed by Forman (1963) for a sequence of sandstone and quartzite, sericite-feldspar-quartz schist, quartz-sericite schist, sericite-quartz schist, porphyry and slate with interbedded schistose basic extrusive rocks. Some schists with a relict fragmental texture and abundant lithic fragments may have been derived from tuff and agglomerate, and some schists containing sand-sized grains of quartz may have been derived from tuffaceous sandstone.

The sequence overlies the Mount Harris Basalt and is overlain apparently conformably and unconformably by the Dean Quartzite.

The type area for the Bloods Range Beds is south of Bloods Range. The Beds also crop out between the Schwerin Mural Crescent and the Dean Range. In addition the porphyroblastic schists south of the Dean and Mannanana Ranges are believed to be derived in part from the Bloods Range Beds. The Beds have been altered along strike to gneiss, granite, amphibolite and porphyroblastic schist.

Isoclinal folding and metamorphism make thickness estimations unreliable but the formation is probably at least several thousands of feet thick.

The Bloods Range Beds are correlated with the Dixon Range Beds (Wells, Forman and Ranford, 1961) of the Rawlinson Sheet area. The Dixon Range Beds are a sequence of sandstone, siltstone, shale, arkose and fine conglomerate which crops out apparently conformable beneath the Dean Quartzite in the Dixon Range, Walter James Range and Robert Range area. About 4,500 feet of this sediment crops out in a west plunging syncline in the Dixon Range. The dominant lithology is sandstone with interbedded micaceous siltstone and shale, arkose, arkosic grit, pebble conglomerate and probable greywacke. Cross-stratification and both current and wave ripple markings are common. Farther to the east, in the area south of the Walter James Range, the Dixon Range Beds are better sorted and finer-grained.

The Bloods Range Beds crop out extensively in the area between the Schwerin Mural Crescent on the Rawlinson Sheet area and the Dean Range on the Scott Sheet area. The Beds appear to be conformable on the Mount Harris Basalt and to be overlain conformably by the Dean Quartzite.

Between the contact with the Mount Harris Basalt and the Kathleen Range on the Scott Sheet area, (Fig. 4), the Bloods Range Beds consist of a north dipping succession of schistose and lineated, brown, quartz-feldspar porphyry in layers up to 50 feet thick interbedded with greenish-pink iron oxide - chlorite - feldspar - sericite - quartz schist which may be a sheared tuff, a porphyroblastic schist or a more highly sheared porphyry. Within this succession are at least two beds both containing green, epidotized, amygdaloidal basalt, brecciated, green, epidotized, amygaloidal basalt and green schist. These basal beds are overlain by a considerable thickness of lineated schists which may originally have been acid porphyry, tuff, tuffaceous sandstone and sandstone but are now represented by schistose brown and grey, quartz-feldspar porphyry, feldspar-sericite-quartz schist, quartz-sericite schist, sericite-quartz schist and quartzite. Original layering in these rocks is isoclinally folded wherever visible and the schistosity is parallel to the axial planes of these folds and in most places to the bedding. Micaceous malachite occurs as thin laminae in some of the schistose quartzite.

One of the major problems in this area is to determine whether the abundant greenish-pink or silvery-grey, fine to medium-grained, feldspar-sericite-quartz schist is schistose acid porphyry, schistose tuff or porphyroblastic schist.

The remainder of the Bloods Range Beds succession is exposed in a broad synclinal structure between the Kathleen Range and the Schwerin Mural Crescent (Rawlinson and Scott Sheet areas).

In this area at least two, thick quartz - feldspar porphyries are interbedded with green, quartz-epidote rock, a dark grey brecciated rock with epidote cement, amphibolite, green schists, sericite-quartz schist, quartz sericite schist, grey slate, phyllite and minor epidotized amygdaloidal basalt. On the southern slopes of the Schwerin Mural Crescent the contact between the Bloods Range Beds and the Dean Quartzite is poorly exposed. Beneath the contact the Bloods Range Beds are made up of silvery-grey, sericite - quartz schist, feldspar-sericite-quartz schist, grey, brown and black slate and minor foliated quartz-feldspar porphyry. Traces of malachite occur in the slate beneath the Dean Quartzite. Near the south-east corner of the Rawlinson Sheet area, near the top of the section, the

Bloods Range Beds consist of dark greenish-grey slate and pebbly and bouldery, quartz-sericite schist and sericite schist. The Dean Quartzite contains some pebbles near its base.

The sequence is intruded by numerous calcite veins, calcite-chlorite - quartz veins, feldspar-quartz veins and iron oxide - feldspar-quartz veins. In places augen-like clots of quartz and feldspar occur within the schist.

West of the Dean Range on the Scott Sheet area the Bloods Range Beds are associated with porphyroblastic schist, pegmatite, granite and porphyroblastic gneiss. The granite is of two types: One contains abundant, large ovoid feldspar crystals in a fine to medium-grained matrix of quartz, feldspar and biotite; the other is a pink, leucocratic, fine to medium-grained granite. The granite with large ovoid feldspar is gradational into schist with large ovoid feldspars, black and dark grey, fine to medium-grained mica schist and quartz-epidote rock. The pink leucocratic fine to medium-grained granite occurs as relatively thin dyke or sill-like bodies within the ovoid feldspar granite. The pegmatites are coarse-grained and contain pink feldspar up to one foot in size. A core of quartz and hematite is common. The zones of granite and porphyroblastic schist are about one hundred feet wide and occur parallel to the schistosity and at a slight angle to the regional strike of the bedding. The granite and schists may be traced up to the base of the Dean Quartzite in the ridge 4 miles west of the Dean Range on the Scott Sheet area. The granite and schist with ovoid feldspar is clearly of metasomatic origin but the pink, fine to medium-grained, granite may be intrusive.

West and north-west of Mount Deering in the Dean Range (Fig. 4) the schist and porphyroblastic schist grade into the granite which crops out at the base of the Mount Harris Basalt. In this area it was not possible to distinguish schist derived from the Bloods Range Beds from schist derived from the Mount Harris Basalt.

A gradation from schist to gneiss is visible in the Bloods Range Beds beneath the lowermost ridges of Dean Quartzite in the anticlinal section of the Dean Range. Pale grey, fine to medium-grained, biotite-quartz-feldspar, porphyroblastic augen-gneiss crops out beneath the Dean Quartzite. The gneiss passes down into grey, fine to medium-grained biotite-quartz-feldspar gneiss, sericite-quartz schist and epidote-quartz-sericite schist. These rocks are intruded by discordant iron-oxide - quartz - feldspar pegmatite. Proceeding farther down the section the gradation from schist to gneiss by progressive feldspathization is visible. The transition is from sericite-quartz schist to fine to medium-grained sericite-quartz-feldspar schistose gneiss with rare large porphyroblasts of feldspar. As feldspathization increases in density the rock becomes a porphyroblastic, biotite-sericite-quartz-feldspar schistose gneiss and as schistosity gives way to gneissosity the final product is a sericite-biotite-quartz feldspar porphyroblastic augen gneiss.

The Bloods Range Beds are believed to occur beneath the Dean Quartzite in the Dean, Mannanana and Curdie Ranges but are now extensively altered to schist, amphibolite, porphyroblastic schist, gneiss and granite.

Remnants of schist, amphibolite, slate and quartzite are common within the granite and gneiss of the area. These metamorphic rocks were probably derived from the Bloods Range Beds, the Mount Harris Basalt or an older sequence of sediments.

The description of the porphyroblastic schist which crops out south of the Dean, Mannanana and Curdie Ranges is largely a description of the metamorphic products of the Bloods Range Beds in this area.

The Bloods Range Beds may be of Lower or Upper Proterozoic age as they are overlain with regional unconformity by the Dean Quartzite of Upper Proterozoic age.

Porphyry

Porphyry occurs within the Bloods Range Beds and the Mount Harris Basalt and outcrops south of the Kathleen Range, between the Kathleen Range and the Schwerin Mural Crescent, south of Bloods Range, and within the porphyroblastic schist to the south of the Mannanana Range. North of the Kathleen Range the porphyries were mapped and described in 1960 (Wells, Forman and Ranford, 1961). For the purpose of description the porphyries are divided into three groups: those to the north and south of the Kathleen Range, that is the porphyries west of the Dean Range, and those south of Bloods Range on either side of the Hull River. The porphyry south of the Mannanana Range and east of the Dean Range is described within the porphyroblastic schist.

Porphyry west of the Dean Range

The porphyry occurs in bands from a few feet to several hundred feet thick, and is schistose and interbedded with schistose tuff, green schist, amygdaloidal epidotized basalt, sericite-schist, sericite-quartz schist, quartz-sericite schist, slate and occasional quartzite towards the top of the Bloods Range Beds. The porphyries are grey or brown and contain phenocrysts and possibly porphyroblasts in a fine-grained matrix. The phenocrysts are of quartz and feldspar. Veins of quartz and pegmatite cut the porphyries. The porphyry occurs conformably in the sediments or basalts suggesting that these are extrusive porphyries. They probably form part of a suite of volcanic rocks which range with time from basic to acidic. The suite commenced with flows of vesicular basalt, and acid porphyry and tuff deposits, then as deposition continued the acid volcanics became more abundant and the basalt flows less abundant. Towards the top of the Bloods Range Beds porphyries and tuffs are the main volcanic rocks.

In thin section the phenocrysts are of subhedral quartz up to 4 mm diameter, and subhedral to euhedral albite-oligoclase feldspar up to 6 mm in length. The groundmass is a fine-grained, schistose aggregate of quartz, biotite, sericite, iron oxide, and epidote in variable percentages. The quartz phenocrysts have irregular margins where groundmass minerals have grown into them and the quartz shows undulose extinction under crossed nicols due to post crystallization strain. The feldspar phenocrysts are broken, extensively altered and rolled. The texture of the rock is blastoporphyritic.

B. Porphyry south of Bloods Range

The porphyry outcrops south of Bloods Range are up to six miles long and two miles wide. They have been described in Forman (1963). The porphyries are associated with the Bloods Range Beds and Mount Harris Basalt. In some places the porphyries have a schistosity which parallels their margins and the schistosity of the associated beds. The porphyry contains phenocrysts of pink subhedral to euhedral albite-oligoclase feldspar up to 6 mm long and subhedral to euhedral quartz up to 3 mm long set in a fine-grained, decussate, brown, matrix of quartz and feldspar with minor iron ore and chlorite.

Porphyroblastic Schist

The porphyroblastic schist occurs on the Bloods Range and Petermann Ranges Sheet areas as an arcuate outcrop between the Pottoyu Granite Complex and the Dean Quartzite in the Dean and Mannanana Ranges. A small area of porphyroblastic schist occurs west of the Dean Range and there is a moderate percentage of porphyroblastic schist within most of the area mapped as Olia Gneiss. The porphyroblastic schist is associated with amphibolite schist, quartz-epidote rock, biotite-quartz schist, quartzite, porphyroblastic gneiss, gneiss and granite. The schists are gradational with gneiss and granite and are also intruded by granite.

Typically the porphyroblastic schist is comprised of large microcline microperthite, albite crystals and quartz crystals set in a fine-grained matrix containing variable amounts of quartz, feldspar, sericite, epidote, biotite and iron ore.

The large feldspar crystals occur in two sizes. The large size is ovoid in shape and is up to two inches in length. These are the true porphyroblasts in the porphyroblastic schist. The smaller size is up to half an inch long and probably formed part of the original porphyry or tuff from which the schist developed. The large feldspar crystals are of microcline microperthite and albite and all gradations from microcline microperthite to albite are visible in thin section. In the majority of crystals it is not clear whether the soda feldspar has replaced the potash feldspar or vice versa. In a few crystals the potash-soda feldspar appears to have been replaced by a soda feldspar with a "chessboard" twinning pattern; the centre of some sodic plagioclase crystals is occupied by microcline microperthite; in some of the crystals a core of microperthite is mantled by a zone of interlocking plagioclase crystals; the large crystals appears as interlocking aggregates of plagioclase crystals or as aggregates of plagioclase and microcline microperthite.

It appears that the large quartz and feldspar crystals in the schist were present before crystallization of the fine-grained groundmass and the development of the schistosity for the following reasons:- The feldspar crystals are extensively sericitized and have ragged, irregular margins where the fresher unaltered groundmass material has eaten into them; some crystals are fractured and the fractures contain sericite, biotite and quartz oriented parallel to the schistosity, and the coarse crystals of quartz show undulose extinction due to post-crystallization strain, whereas the matrix quartz is unstrained.

It is concluded that the large feldspar crystals in the schist have two origins. The smaller crystals are similar to the phenocrysts developed in the porphyries of the Bloods Range Beds and Mount Harris Basalt and the rock probably developed from a schistose porphyry or tuff. The larger ovoid crystals are similar to the porphyroblasts in the porphyroblastic gneiss and the Pottoyu Granite Complex and these have developed as porphyroblasts as a result of granitization. This relationship is clear west of the Dean Range and has been described in the section on the Bloods Range Beds.

The groundmass of the schist contains oriented acicular crystals of sericite and biotite and a granular, micrographic to myrmekitic intergrowth of quartz and feldspar.

The porphyroblastic schists are gradational to porphyroblastic gneiss, the major change from one rock-type to the other being an increase in grain size of the groundmass and an increased segregation of the mineral components.

Two lineations and schistosities are evident in the schist. The older schistosity, on which the older lineation occurs, is refolded about the second schistosity; the second lineation is a b - lineation associated with this folding. It is probable that the porphyroblasts grew during the first folding and that the groundmass recrystallization took place during the second folding.

The position of the schists and porphyroblastic schist beneath the Dean Quartzite, the similarity of the schists with schists of the Bloods Range Beds and the presence of abundant schistose porphyry or tuff, which also occurs in the Bloods Range Beds, suggests that the porphyroblastic schists have been derived at least in part from the Bloods Range Beds.

The schists are believed to have developed during the Petermann Ranges Folding late in the Upper Proterzoic.

Olia Gneiss (new name, approved)

The name Olia Gneiss is proposed for the gneiss which crops out in the area mapped between Giles in Western Australia and Mulga Park in the Northern Territory. The gneiss has intrusive and gradational contacts with granite and is gradational into the Dean Quartzite, Bloods Range Beds and probably the Mount Harris Basalt. It crops out extensively in the following areas; south of Giles Creek on the Scott sheet; the Pottoyu Hills; the Olia Chain; the southern half of the Ayers Rock Sheet area; the Petermann Ranges between the Shaw and Armstrong Creeks; and ten miles south of Mount Harris on the Bloods Range Sheet area. The gneiss is intruded by small pegmatite and quartz veins.

The gneiss to the south of Giles Creek is fine-grained leucocratic, pale pink, and quartz rich with a strong lineation. The gneiss has strong north-south, east-west vertical joints and a weak foliation at 70° E. of N. It contains 40-50% anhedral quartz orientated parallel to the lineation, subhedral to anhedral microcline, subhedral oligoclase, subparallel streaks of biotite, apatite and accessory magnetite. To the south mafic, biotite amphibolite gneiss up to 100 feet thick is interbanded with the leucocratic gneiss. The mafic gneiss contains 40-50% quartz, orthoclase, oligoclase, up to 15% hornblende, and up to 15% biotite. The rock contains several percent of apatite.

The gneiss of the Pottoyu Hills and Olia Chain, consists of well foliated, strongly jointed and folded coarse porphyroblastic and fine-grained varieties. North-west and north-north-east lineations, parallel to the b - axes of isoclinal folds, occur on foliation surfaces. In some areas, e.g. south of Tornpakura Hill, where there is strong cross folding, two foliation planes occur in the gneiss with corresponding lineations. The bands of coarse porphyroblastic and fine-grained gneiss are from a few feet to several hundred feet thick.

The coarse porphyroblastic gneiss is well foliated, grey or pink and augen textured. The foliation is caused by a mineral segregation into alternating layers of quartz-feldspathic and micaceous minerals. The micaceous layers are up to a ¼" thick and form augens around the felspar porphyroblasts in the quartzo-feldspathic layers which are up to 2" thick. Typical specimens of the coarse porphyroblastic gneiss contain 50-60% microcline, as anhedral twinned grains up to 6 mm. long in the matrix, and up to 5 cms long as porphyroblasts; 20-30% anhedral quartz as minute rounded inclusions to grains 1.0 mm. in diameter often showing strain effects and an amoeboid texture suggesting shearing and recrystallisation; 5-20% plagioclase as partially sericitised anhedral grains of albite-oligoclase composition and up to 1.5 mm. in diameter; 10-20% biotite as pleochroic, greyish-yellow to olive brown, sub-parallel, elongate, streaky patches in the plane of schistosity, and direction of lineation with individual flakes up to 2.5 mm. Biotite occurs in bands and as augen around feldspar porphyroblasts. Epidote occupies up to 10% of the gneiss and occurs in association with biotite and garnet, as discreet rounded grains up to 0.5 mm., and accumulations of these grains. Muscovite occurs as small

Figure 6: Twelve miles E.N.E. of Feltham Hill. Recumbent folding in lineated, recrystallized and partly feldspathized cherty rock from within the Olia Gneiss. The structure of the hand specimen is similar to the structure of the southern margin of the Amadeus Basin. Half natural size.
Neg.No. G/6035

flakes up to 1.0 mm. across in small quantities in association with biotite. Accessory garnet occurs as poorly developed minute, anhedral, intergranular grains. Accessory magnetite occurs as subhedral and euhedral grains up to 1.5 mm. together with accessory zircon and apatite. Lobate grains of myrmekite up to 0.5 mm. occur in some specimens. Microcline occurs in the quartzo-feldspathic layers in augen as individual porphyroblasts and as compound porphyroblasts of clusters of anhedral grains. The microcline porphyroblasts contain minute rounded inclusions of quartz and plagioclase. The gneiss grades along and across the foliation into gneissic granite, and may be classified as amphibolite facies.

Interbanded with the coarse porphyroblastic augen gneiss are bands of foliated, fine to medium, even-grained, leucocratic, microcline-albite-quartz gneiss, containing minor biotite, garnet and accessory magnetite.

On the southern flanks of the Pottoyu Hills the gneiss is a fine, even-grained, well foliated, lineated, leucocratic microcline-albite-quartz gneiss with bands of quartz-epidote rock, and mafic, medium-grained, biotite amphibolite gneiss up to 20 feet thick. The mafic bands grade laterally into the Bloods Range Beds and Mount Harris Basalt. The gneiss is folded into isoclinal folds with north-west - south-east axes paralleled by a lineation.

On the southern part of the Ayers Rock Sheet area, east of Feltham Hill and north of the Musgrave Ranges, the coarse-porphyroblastic augen gneiss and magnetite is interlayered with fine-grained, well foliated, lineated, leucocratic and mafic gneiss, amphibolite, slate, chert, quartzite and sericite-quartz schist. The gneiss and the interlayered rocks are folded into near recumbent isoclinal folds with north-west trending axes which are commonly refolded isoclinally on north - north-east axes (Fig. 6). Strong lineations parallel the axes of both fold directions.

The fine-grained mafic gneiss is blue-grey to black with ovoid feldspar porphyroblasts randomly orientated and up to 1½" diameter, smaller ovoid feldspar porphyroblasts up to ½" diameter, with their long axes in the plane of the foliation, and a fine-grained matrix of feldspar, quartz, biotite and amphibole. The gneiss has a fine foliation caused by very fine alternating bands of quartzo-feldspathic and pelitic minerals. This gneiss resembles a sheared mafic porphyry in hand specimen but is considered to be a feldspathised, porphyroblastic, schistose gneiss. The fine-grained leucocratic gneiss consists of quartzo-feldspathic layers up to $\frac{1}{4}$" thick interbanded with very thin discontinuous, biotite rich bands of pelitic minerals ~~(see Fig.No.)~~. The quartzo-feldspathic bands contain quartz and feldspar porphyroblasts up to $\frac{1}{4}$" diameter.

Doleritic dykes up to 6' thick and striking approximately east-west and north-south cut the gneisses in this area. Occasional lenses of dolerite, approximately conformable with the foliation, are up to $\frac{1}{2}$ mile long and 200 yards wide with east-west striking dykes as offshoots.

The gneiss of the Kelly Hills in the southern half of the Ayers Rock Sheet area is quartz rich and grey coloured. It occurs as banded biotite-quartz gneiss, biotite quartzite, biotite-feldspar-quartz gneiss, and biotite-quartz-feldspar gneiss. The gneiss is shattered and intricately intruded by a network of dolerite dykes and veinlets.

Aplite and pegmatite dykes and veins of random orientation cut the Olia Gneiss and granite of the area. The pegmatites contain quartz, feldspar, iron oxide and occasionally muscovite and biotite.

The gneiss is considered to have formed by metamorphism of sediments underlying the Dean Quartzite during the regional folding. These sediments are probably equivalent to the Mount Harris Basalt and the Bloods Range Beds in the western part of the Bloods Range Sheet area and on the Scott and Rawlinson Sheet areas. Quartz-epidote rock, with possible relict amygdales and the pelitic members of the gneiss are considered to be gneissic equivalents of the basaltic and argillaceous members of the Mount Harris Basalt and Bloods Range Beds. A transition from schist of the Bloods Range Beds to gneiss has been described in the section on the Bloods Range Beds.

Hence most of the gneiss is considered to be formed by granitization and metamorphism of the Bloods Range Beds and Mount Harris Basalt. Some of it, however particularly that in the northern foothills of the Musgrave Ranges, may be an original gneissic basement or a gneissified sedimentary sequence older than the Mount Harris Basalt.

The gneiss is believed to be late Upper Proterozoic in age. The pegmatite veins which cut the Bloods Range Beds and the Mount Harris Basalt, as well as their metamorphic lateral equivalents, are considered to be a late stage expression of the feldspathization of those sediments and the granitization of the gneiss.

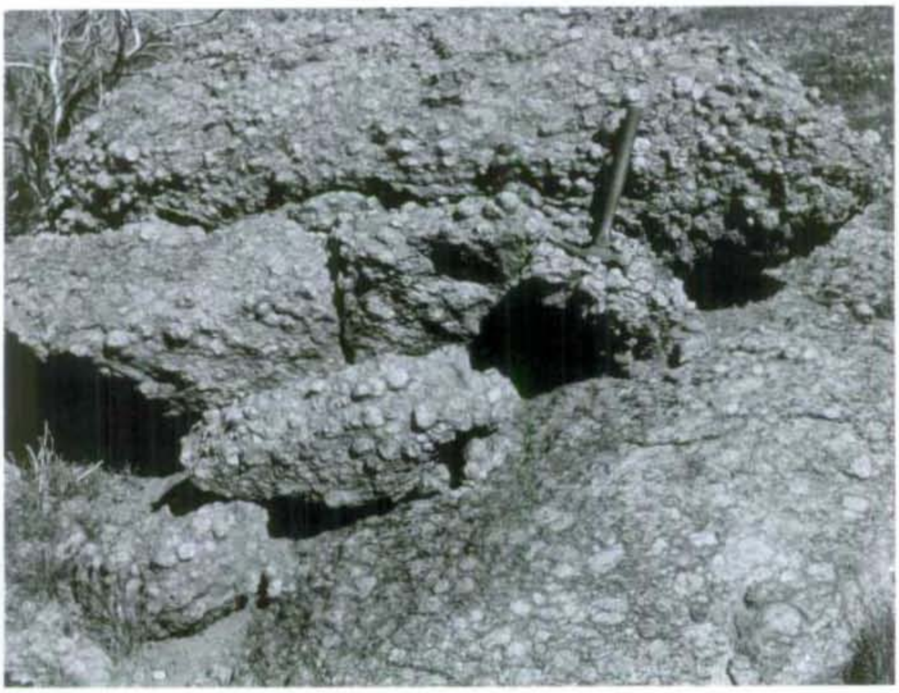


Figure 7: Coarsely porphyritic, gneissic, biotite granite from the Petteyu Granite Complex, Petteyu Hills. Note ovoid shape of feldspars.
Neg.No. G/6032

Figure 8: Porphyroblastic augen gneiss ten miles north of Feltham Hill on Ayers Rock Sheet area. The pre-existing foliation has been nearly lost by granitization.
Neg.No. G/6081.

Granite

Granite crops out in a discontinuous belt which extends from Giles Creek west of the Dean Range, through the Pottoyu Hills, Butler Dome and south of Foster Cliff to Mulga Park Station. The largest single body of granite outcrops in the Pottoyu Hills and this body is named the Pottoyu Granite Complex. Granite also crops out in the Bloods Range Sheet area between Bloods Range and the Petermann Ranges.

The granite is both gradational and intrusive into the Dean Quartzite, Olia Gneiss, Mount Harris Basalt and Bloods Range Beds and is commonly interbanded with gneiss, schist, amphibolite, quartz-epidote rock, quartzite and porphyroblastic schist.

Pottoyu Granite Complex. (new name, approved)

The Pottoyu Granite Complex is defined as the body of granite with up to 50% of interlayered, gneiss, schist, amphibolite, quartz-epidote rock and quartzite which crops out in the Pottoyu Hills south of the Petermann Ranges.

The Complex is enclosed by Bloods Range Beds, porphyroblastic schist and Olia Gneiss in the north-western half and by Olia Gneiss and Dean Quartzite in the south-eastern half.

The granite is typically a very coarsely porphyritic, gneissic, biotite granite (Fig. 7). The phenocrysts are ovoid, microcline microperthite, from one to two inches long, and these are commonly oriented with their long axes in the plane of gneissosity. Some crystals have a rim of anhedral albite-oligoclase. The groundmass is of quartz, microcline, albite-oligoclase and biotite with accessory amounts of iron oxide, muscovite and zircon. Secondary epidote occurs in veins and in some places replaces plagioclase feldspar.

The northern margin of the Complex has a border phase of pink, medium-grained granite and medium-grained, porphyritic granite which is intrusive into the porphyroblastic schist, Olia Gneiss, and coarsely porphyritic biotite granite. This granite is massive to weakly foliated. West of Mount Phillips the two granite types occur together with biotite schist, quartzite, quartz-epidote rock and possible schistose porphyry. Adjacent to the Dean Quartzite the contact is transitional except in a few places where it is clearly intrusive. The main mass of the Pottoyu Granite Complex is composed of the grey, coarse-grained, coarsely porphyritic, biotite-quartz-feldspar gneissic rapakivi granite with up to 50% of grey, fine to medium-grained, sparsely porphyroblastic, biotite-quartz-feldspar gneiss, grey, medium-grained porphyroblastic biotite-quartz-feldspar, augen gneiss, biotite schist, amphibolite, quartz-epidote rock and quartzite. All the rocks are intruded by concordant and discordant veinlets of iron-ore-feldspar-quartz pegmatite and vein quartz.

A specimen of coarse, porphyritic gneissic granite from the Pottoyu Hills 4 miles north-west of Tornpakura Hill was submitted to Dr. P. Leggo of the Bureau of Mineral Resources for age determination at the Australian National University. Age determination by the Rubidium - Strontium method on biotite, microcline feldspar and total rock gave an age of 600 m.y. $\pm$ 10 m.y. using $\lambda = 1.39 \times 10^{-11}$ / years.

Granite west of the Dean Range:

Granite crops out west of the Dean Range where it underlies the Mount Harris Basalt and the Dean Quartzite. The granite is coarse-grained, massive to weakly foliated, pink-brown, poorly-jointed and in most localities contains abundant, large, ovoid feldspar up to two inches in diameter.

In thin-section the granite consists of anhedral microcline microperthite up to 4 cms. in diameter, anhedral quartz up to 1 cm. in diameter, anhedral albite-oligoclase up to 5 mm. in length, biotite, muscovite and iron oxides. The ovoid feldspar has a core of microcline microperthite with anhedral quartz included in the crystal cleavage planes and in some specimens albite appears to have replaced the rims. Some of the groundmass microcline is also replaced.

Veins of quartz, pegmatite and pink, medium-grained granite occur within the granite.

To the east the granite grades into coarse porphyroblastic gneiss and then through porphyroblastic schist to schist which is similar to the Bloods Range Beds. This gradation has been described previously in the section on the Bloods Range Beds. To the north the granite is in contact with the Mount Harris Basalt and the nature of this contact has been discussed in the description of the Mount Harris Basalt.

The nature of these contacts, the folding of the contacts and the relatively slight shearing of the adjacent granite, the presence of apparently xenolithic Mount Harris Basalt in the granite, the presence of pegmatite and quartz veins in the Bloods Range Beds and Mount Harris Basalt and the age of the granite all support the hypothesis that the granite was emplaced metasomatically at a late stage of the regional folding.

Granite at Butler Dome:

Granite crops out at Butler Dome, south-east of the Pottoyu Hills, over an area of six by four miles. It is overlain by the Dean Quartzite to the east and is in contact with the Olia Gneiss to the west. The predominant lithology is a lineated, coarsely porphyritic, coarse-grained, biotite-quartz-feldspar gneissic granite. The contact with the augen gneiss of the Olia Gneiss is gradational. The lineation in the granite is due to the trace of an earlier relict gneissosity on the foliation of the granite. Within the granite are narrow, northerly trending, bands of amphibolite which probably represent original amphibolitic intercalations in the gneiss. The contact with the Dean Quartzite is gradational through porphyroblastic, augen, biotite granite gneiss to biotite-sericite-quartz schist, sericite-quartz schist and quartzite.

Granite, 10 miles south of Foster Cliff (12 miles east of Butler Dome)

The granite body crops out over an area of ten by six miles. It is a coarsely porphyritic biotite-quartz-feldspar gneissic granite similar to the granite of Butler Dome. Contact with the wall rock gneiss is both gradational and intrusive. Adjacent to the granite the Olia Gneiss is coarsely porphyroblastic but further away it is medium-grained.

Granite on the southern half of the Ayers Rock Sheet:

Small bodies of granite, up to four square miles in area, crop out on the southern half of the Ayers Rock Sheet. The granite is both very coarsely porphyritic, medium to coarse-grained, biotite-quartz-feldspar gneissic granite with gneissic schlieren and basic xenoliths and massive, coarse, even-grained, biotite-quartz-feldspar granite. Some areas of gneiss are partially granitized: the gneissosity has been blurred by granitization (Fig. 3) and migmatite has developed.

Granite outcrops on the Bloods Range Sheet area:

These outcrops are described in Forman (1963). In the Ilyaralona - Piultarana Range area the granite is typically very coarse, porphyritic and schistose in part. The contact with the Dean Quartzite and Mount Harris Basalt appears gradational. Granite intrudes the Mount Harris

Basalt six miles south-west of Mount Harris. At other localities the granite occurs as coarse-grained, biotite granite and very coarsely porphyritic granite.

UPPER PROTEROZOIC

Dean Quartzite

The name Dean Quartzite was applied by Forman (1963) to the sequence of tough, varicoloured, cross-bedded quartzite, which overlies porphyroblastic schist, the Mount Harris Basalt, Bloods Range Beds and granite and is conformably overlain by the Pinyinna Beds.

The Quartzite extends over 250 miles in an east-west direction from near Mulga Park in the Northern Territory to Rawlinson Range in Western Australia and occurs in nearly all the high hills and ranges within the area (Rawlinson Range, Schwerin Mural Crescent, Walter James Range, Robert Range, Bloods Range, Pinyinna Range, McNichol Range, Petermann Ranges, Olia Chain, Von Doussa Hill, Gordon Hill, Allanah Hill, Benda Hill, and others).

The Dean Quartzite forms a unique marker bed in the succession and its distribution and structure provided the evidence for the recumbent fold hypothesis advanced in 1963 and for the retention of this hypothesis following further mapping later in 1963. The Dean Quartzite is also of considerable stratigraphic importance local and regional. Regionally it is correlated with the Upper Proterozoic Heavitree Quartzite of the northern margin of the Amadeus Basin and possibly with the Townsend Quartzite of the Officer Basin in South Australia and Western Australia. Age determination work carried out in the A.N.U. by Dr. P. Leggo of the Bureau of Mineral Resources has shown that the gneiss and granite which formed during the regional deformation of the Dean Quartzite are 600 million years old and therefore an Upper Proterozoic age for the Dean Quartzite is probable.

In Bloods Range the Quartzite overlies both the Mount Harris Basalt and the Bloods Range Beds. The basal beds of the Dean Quartzite contain small subangular fragments of brown, amygdaloidal basalt and vein quartz and hence an unconformity is deduced. In the Schwerin Mural Crescent the Dean Quartzite overlies slate and schist of the Bloods Range Beds apparently conformably and in the Walter James Range the Dean Quartzite is apparently conformable on the Dixon Range Beds. In the Dean and Mannanana Ranges, Mount Sargood and farther north in Bloods Range the base of the Dean Quartzite contains local thin conglomerate, conglomeratic sandstone, greywacke and sandy siltstone beds. It appears therefore that the Dean Quartzite is conformable on older sediments in the western side of the area but may be unconformable on the eastern side of the area. The original sedimentary relationship of the Dean Quartzite to older rocks in the Petermann Ranges and Olia Chain, and on the southern half of the Ayers Rock Sheet area, is not visible as the older rocks have been largely converted to gneiss and granite during metamorphism. The present contact is a metamorphic-gradational contact from granite or gneiss to quartzite. In the area between Mulga Park and Feltham Hill the gneiss underlying the quartzite contains large areas of schist, slate and amphibolite which are gradational into the gneiss. Therefore it appears probable that sedimentary or volcanic rocks originally occurred beneath the Dean Quartzite before they were converted to gneiss, schist and amphibolite during the regional folding.

The Quartzite has been described in the Bloods Range Sheet area (Forman, 1963) and the Rawlinson Sheet area (Wells, Forman and Ranford, 1961). The least altered Dean Quartzite is predominantly medium to coarse-grained, moderately sorted, moderately rounded, white and brown, quartzite and sandstone with thin bedding, laminae and cross laminae. It includes intervals of very coarse-grained, brown sandstone and pebbly sandstone. This little altered sediment occurs in the Robert Range, Walter James Range, Mount Buttfield, Bloods Range, Pinyinna Range and McNichol Range. In other outcrops throughout the area the Dean Quartzite has been metamorphosed by deep infolding to fine to medium-grained quartzite, sericitic quartzite and sericite-quartz schist which is commonly schistose and lineated. The infolded and metamorphosed quartzite occurs in the Rawlinson Range and Schwerin Mural Crescent where the metamorphism varies from relatively slight to moderate and in the Dean Range, Petermann Ranges, Olia Chain, Kulipurra Hills and southern half of the Ayers Rock Sheet area where the metamorphism varies from moderate to relatively strong and schistosity and lineation are well developed. The origin of these features is explained in the chapter on structure.

The stratigraphic thickness of the Dean Quartzite is impossible to determine in most places because the quartzite is metamorphosed, partly converted to gneiss and granite, isoclinally folded and thrust faulted. About 3900 feet of section was measured in the Robert Range and between 1000 to 1500 feet was estimated in the Piultarana Range. From outcrop width and dip on air photographs there may be 2000 feet in the Pinyinna Range. The Schwerin Mural Crescent contains recumbently folded Dean Quartzite which may not be more than an estimated 1000 feet thick.

The Quartzite is overlain directly by the siltstone and dolomite of the Pinyinna Beds.

The Dean Quartzite is correlated with the Heavitree Quartzite of Upper Proterozoic age. The correlation is based on the similarity between the Dean Quartzite - Pinyinna Beds and the Heavitree Quartzite - Bitter Springs Limestone sequences. Both the Heavitree Quartzite and the Dean Quartzite occur at the base of the sediments in the Amadeus Basin, on the northern and southern margins respectively.

Pinyinna Beds

The Pinyinna Beds were defined (Forman, 1963) as a poorly exposed sequence of crystalline dolomite, limestone (with a few poorly preserved stromatolites) and siltstone which conformably overlies the Dean Quartzite. The Beds have been recrystallized to medium-grained lineated schist and slate or only slightly recrystallized in the Petermann Ranges, Dean Range, Olia Chain and southern half of Ayers Rock Sheet area. They are slightly recrystallized or unaltered in Bloods Range, Pinyinna Range, and near Mount Harris. At the type locality in the Pinyinna Range the basal beds are composed of at least 700 feet of grey, brown and white, laminated, micaceous siltstone. These are overlain by grey and pink, fine-grained and fine to medium-grained, laminated dolomite and foetid dolomite, grey dolomite with stromatolites and pale grey, fine-grained limestone.

The Pinyinna Beds are overlain unconformably by the Mount Currie Conglomerate at Pinyinna Range but have not been found overlain by any other unit. The Beds are correlated with the Upper Proterozoic Bitter Springs Limestone which has its nearest outcrop 14 miles north-north-east of Pinyinna Range. The two names, Bitter Springs Limestone and Pinyinna Beds, are considered to be synonymous but the Pinyinna Beds are the infolded and generally altered portion of the Bitter Springs Limestone within, or immediately adjacent to, the regional recumbent fold.

Carbonates, or their lineated and schistose equivalents, are only known from a few localities. These are:

Figure 9: Recumbent folding in the basal unit of the Pinyinna Beds, Foster Cliff. Schistosity in the phyllite is parallel to the axial planes of the folds and lineation is parallel to the axial line of the folds. The photo was taken in the core of a larger recumbent fold. (See Fig.18.)
Neg.No. G/6033

Pinyinna Range and Mount Harris adjacent to the most southerly outcrops of the Dean Quartzite (Forman, 1963); Dean Range on the Scott Sheet area; Puiltarana Range on the Bloods Range Sheet area (Forman, 1963), and the Petermann Ranges between the Chirnside and Armstrong Creeks on the Petermann Ranges Sheet area. The basal siltstone, immediately overlying the Dean Quartzite, is more widely distributed through the area within the cores of many isoclinal and recumbent folds.

The Pinyinna Beds crop out west of the Dean Range on the Scott Sheet area where they are overlain and underlain by schistone, and lineated Dean Quartzite. The Beds are white weathering, grey phyllite containing folded quartz veins and red-brown, yellow-brown and pink, laminated, medium-grained recrystallized lineated dolomite showing small scale recumbent folds with axial lines trending 75°. The dolomite is interbedded with yellow-brown sericite schist.

Between the Petermann Ranges, in the area south-east of Chirnside Creek, the Pinyinna Beds crop out as low hills of coarse-grained, recrystallized, lineated, black, brown, grey, yellow-brown and pink dolomite associated with well cleaved black slate and micaceous slate with incipient spotting and knotting. The slate has tiny holes from which hematite cubes or low carbon silicates may have weathered. Intersection of cleavage and bedding was visible in several erratic specimens. The lineation in the dolomite is parallel to the regional lineation.

The metamorphosed basal unit of the Pinyinna Beds is poorly exposed in the core of flat lying isoclinal folds in Tornpakura Hill, Stevenson Peak, Butler Dome and Foster Cliff (Fig. 9) of the Olia Chain, and in the Gordon Hill area of the Ayers Rock Sheet. The lithology is grey schistose slate, grey phyllite and grey, fine-grained, quartz-sericite schist. The schistosity is parallel to the axial planes of tight isoclinal folds and the lineation developed is parallel to the axial lines of the folds. The sequence is intruded by quartz veinlets and, at several localities, by veinlets of quartz and feldspar.

The Pinyinna Beds have not been mapped on the Rawlinson Sheet area but the siltstone has been observed north of the Schwerin Mural Crescent (see Fig. 11). Gillespie (1959) reported the occurrence of brown weathering, shaly, calcareous mudstone and light grey, laminated shale about 8 miles south-east of Bungabiddy Rock Hole, Walter James Range.

Inindia Beds

The name Inindia Beds was introduced by Wells, Ranford and Cook (1963) for "the sequence of siltstone, sandstone, chert, chert breccia and thin interbeds of dolomite which conformably overlies the Bitter Springs Limestone and is overlain, probably unconformably, by the Winnall Beds". The reference area lies 36 miles south-east of Mount Murray on the Lake Amadeus Sheet area.

Outcrops of Inindia Beds on the Ayers Rock Sheet area are described in Wells, Stewart and Skwarko (1964) and outcrops on the Bloods Range Sheet area are described in Forman (1963).

Winnall Beds

The name Winnall Beds was used by Wells, Ranford and Cook (1963) for "the sequence of siltstone, sandstone and pebbly sandstone which lies probably unconformably above the Inindia Beds and unconformably below the Pertaoorta Formation, Cleland Sandstone and Larapinta Group".

The Winnall Beds crop out on the Bloods Range, Lake Amadeus and Ayers Rock Sheet areas as strike ridges. Farther north-east the unit is believed to interfinger with the Pertatataka Formation.

The Beds crop out in the Ayers Rock, Mount Currie, Mount Olga area as long, low, strike ridges and as small isolated outcrops. The unit appears to be unconform ably overlain by the Mount Currie Conglomerate. The sequence cropping out between Ayers Rock and Mount Currie is estimated, by photo-measurements and measured dips, to be at least 5000 feet thick assuming that there is no repetition by strike faults.

The ridges are comprised of sandstone with poorly outcropping interbeds of siltstone. The gaps between the ridges are covered by alluvium. The sandstone is white medium-grained and medium to coarse-grained. It contains laminae and thin beds of moderately sorted and subrounded quartz grains with interstitial kaolin and silica. The sandstone is tough and jointed, breaking into flags and blocks. Ripple marking and cross lamination are commonly developed. The interbeds of siltstone are poorly exposed and include yellow-brown and red-brown laminated micaceous varieties. One hand specimen collected exhibits isoclinal folding and a possible faint fracture cleavage. The Winnall Beds are considered to be Upper Proterzoic or possibly Lower Cambrian in age (Wells, Ranford & Cook, 1963).

Undifferentiated

Outcrops of sandstone and siltstone on the north-eastern corner of the Petermann Ranges Sheet area may belong to either the Winnall Beds or Inindia Beds. The outcrop has not been conclusively identified.

PALAEOZOIC

The undifferentiated Precambrian and Upper Proterozoic rocks were folded and metamorphosed during the Petermann Ranges Folding. Dolerite was intruded into the Pinyinna Beds and Olia Gneiss shortly after the folding probably early in the Cambrian. The land mass so formed cropped out near the present position of the southern margin of the Amadeus Basin and contributed sediment northwards into the basin. Adjacent to the upraised mountains of the land mass wedges of arkose and conglomerate were deposited uncomformably over the Upper Proterozoic sediments while farther north the Cleland Sandstone was deposited, in a fluviatile environment. During the Ordovician the sea transgressed southwards and deposited marine sandstone, siltstone and limestone on the southern part of the Bloods Range Sheet area and marine sandstone on the northern part of the Petermann Ranges Sheet area.

Dolerite

Sills and dykes of quartz-dolerite crop out in the southern part of the Ayers Rock Sheet area and rarely on the Petermann Ranges Sheet area. One uralitized dolerite body occurs within the Pinyinna Beds east of Chirnside Creek but all the other bodies occur in coarse porphyroblastic, augen gneiss or medium-grained gneiss. The dolerite is typically unaltered and occurs as dykes up to 15 feet thick but average two to four feet. The sills are commonly up to 100 feet thick and occasional domal or laccolithic sill-like bodies may be considerably thicker. The lack of alteration shows that the dykes were injected after the last major orogeny in the area but the occurrence as domal or laccolithic sills in the gneiss suggests they may have been deposited shortly after the last folding while the gneiss was less plastic but was still subjected to stress.

The dolerite contains xenoliths of gneiss and is intruded by thin acid igneous dykes. Although the acid igneous dykes have been traced across the dolerite bodies there is no clear proof that they intrude the adjacent gneiss and they could be igneous intrusives associated with the dolerite as final stage differentiates. Adjacent to the margin of the largest sill-like bodies of dolerite the gneiss is altered to a dark grey, porphyroblastic schist which resembles a schistose acid porphyry within the sequence.

In the Kelly Hills south of Mulga Park and on the Ayers Rock Sheet area the gneiss and biotite quartzite is intruded by dykes, thin veinlets and wedges of criss-crossing basalt.

The quartz dolerite contains phenocrysts of plagioclase up to 2 mm. long and glomero-phenocrysts of plagioclase and augite set in a matrix of euhedral plagioclase laths 0.5 mm. long and iron ore with up to 10% of interstitial quartz and potash feldspar in a myrmekitic intergrowth.

The Mount Currie Conglomerate contains phenoclasts which may have been derived from the dolerite dykes and sills.

The age of the dolerite is probably late Upper Proterozoic or early Cambrian because the dolerite appears to have intruded the Olia Gneiss soon after the Petermann Ranges Folding which took place 600 million years ago.

<u>Mount Currie Conglomerate</u>

The name Mount Currie Conglomerate was used by Forman (1963) for a sequence of pebble, cobble and boulder conglomerate unconformably overlying undifferentiated Upper Proterozoic sediments at Mount Currie. The top of the formation is eroded. Outcrops of the conglomerate occur between Pinyinna Range on the Bloods Range Sheet area and Mount Olga on the Ayers Rock Sheet area. Wells, Ranford and Cook (1963) include a petrological description of a sample of Mount Currie Conglomerate from Mount Olga in their description of the unit. The description by W. Oldershaw (B.M.R.) shows that the phenoclasts are "set in a granular matrix of angular fragments 0.2-2 mm. across of quartz-albite intergrowths, devitrified glass, fresh microcline orthoclase perthite, plagioclase, quartz and augite. The interstices are filled with fine-grained epidote. This epidote cement could be due to regional metamorphism affecting only the fine-grained cement of the rock or it could be of hydrothermal or volcanic origin. However, the surrounding feldspars show very little alteration."

The thickness of the Mount Currie Conglomerate is unknown but the sequence dips south at a moderate angle, over a distance between ten and sixteen miles, before older rocks are encountered again. A possible explanation for this is given in one of the cross sections on the Ayers Rock Sheet. This section suggests 20,000 feet of conglomerate overlapping against a near vertical cliff face to the south. At Mount Olga about 2000 feet of conglomerate is exposed showing that the conglomerate is not less than 2000 feet thick.

The contact of the sequence with older rocks is not exposed on the Ayers Rock Sheet area but an unconformity may be assumed for three reasons: There is an angular discordance visible between the conglomerate and the underlying Winnall Beds; fragments in the conglomerate have been derived from the underlying rock units; an unconformity is visible at Pinyinna Range on the Bloods Range Sheet area between the Pinyinna Beds and the Mount Currie Conglomerate.

The basal beds exposed at Pinyinna Range, Mount Currie and in the outcrops between Mount Currie and Ayers Rock are conglomerate with silicified sandstone phenoclasts up to 2 feet across. The matrix is sandy at Pinyinna Range and in the two outcrops farther east, but is not exposed on the Ayers Rock Sheet area. The sandstone phenoclasts appear to have been derived from the Dean Quartzite at Pinyinna Range and from the Winnall Beds in outcrops on the Ayers Rock Sheet area. At specimen locality AR 100 the basal boulder bed is succeeded by a strongly outcropping ridge of white and pale purple-brown quartz sandstone which is medium-grained and consists of thin and medium beds and cross laminae. Angular to rounded pebbles of chert and silicified sandstone are poorly distributed amongst the poorly sorted, subrounded and subangular sand grains. The interval overlying this ridge is concealed but about ½ mile farther south there is outcrop of pebble, cobble and boulder conglomerate with a matrix and thin interbeds and lenses of epidotized arkose similar to that described by W. Oldershaw. The phenoclasts are brown, weathered, amygdaloidal basalt with amygdales of chert rimmed by epidote, brown weathering porphyritic dolerite, banded porphyritic basalt, pink-brown, medium and coarse-grained, epidotized, biotite granite, pink iron ore-biotite microgranite, rare lineated quartzite and rare kaolinitic and feldspathic, medium-grained sandstone.

At Mount Currie the basal beds, containing dominant phenoclasts of quartz sandstone, are overlain by conglomerate with phenoclasts of brown feldspar porphyry, greenish-grey basalt, green epidotized amygdaloidal basalt and grey quartz sandstone and rare vein quartz. The pebbles, cobbles and boulders are well rounded and ellipsoidal, up to about 14 inches in length, and are set in a matrix of medium-grained quartz-feldspar and epidote.

Higher in the section towards Mount Olga the conglomerate contains numerous phenoclasts of fine-grained acid and basic igneous rock, granite and gneiss in the epidote rich matrix. The granite is typically fine to medium-grained but coarse-grained granite does occur. Coarse porphyritic granite and granite with ovoid feldspars were not seen. The granite phenoclasts are more abundant than the other varieties.

Although stratigraphic control is poor it appears probable that the phenoclasts are composed mostly of sandstone at the base, fine-grained acid and basic igneous rocks in the centre and granite and gneiss towards the top of the section. The rounded inselberg type relief of Mount Currie and Mount Olga occurs only in the middle and upper sections of the Mount Currie Conglomerate. The basal section does not appear to have an epidote cement and forms a more subdued, low ridge relief. The age of the Mount Currie Conglomerate is probably Cambrian for the following reasons: The conglomerate overlies the Bitter Springs Limestone, and Winnall Beds probably unconformably; the conglomerate was deposited after the folding of these sediments and probably before the folding of the Cleland Sandstone and the Larapinta Group; a thin conglomerate at the base of the Cleland Sandstone is probably the basinwards equivalent of the Mount Currie Conglomerate.

The thin interbeds and matrix of epidotized arkose within the conglomerate suggest the possibility that the arkose with epidotized laminae at Ayers Rock is a lithological variant of the Mount Currie Conglomerate.

Ayers Rock arkose

An estimated 8000 feet of steeply dipping arkose crops out at Ayers Rock. Neither the base nor the top of the unit is exposed. One further outcrop of similar lithology lies about 2½ miles south-west of Ayers Rock. This outcrop has the same attitude and south-west facing as the arkose at Ayers Rock and probably represents the same unit. Provided there are no structural complications the total thickness of the arkose unit may be over 20,000 feet. Both outcrops are isolated and there is no direct evidence on their stratigraphic position in the sequence except that they occur along strike from the Mount Currie Conglomerate, 9 miles to the north-west. The unit is lithologically distinct from other units in the Amadeus Basin and the best correlation seems to be with the arkosic matrix of the Mount Currie Conglomerate.

The arkose at Ayers Rock is pale grey, dark grey, pink-grey and green-grey. It is coarse-grained with some medium-grained laminae, and is almost continuously cross-laminated on a small scale. Darker laminae appear to have higher concentrations of heavy minerals and some green-grey zones up to 2 inches thick are probably epidotized. Epidotization appears to have occurred parallel to the bedding at the junction of the cross-beds. Some of the feldspar fragments within the arkose are between ½ and 1 inch in length and this arkose may be termed pebbly.

The outcrop 2½ miles to the south-east of Ayers Rock exposes a few hundred feet of purple-brown, medium-grained, poorly sorted, subangular arkose with angular mud pellets interbedded with purple-brown arkosic siltstone. This outcrop is similar to some outcrops of the Maurice Formation in the Wallace Hills of the Rawlinson Sheet area.

The Ayers Rock arkose is probably a wedge of sediment deposited adjacent to the tectonically active area to the south. As the Mount Currie Conglomerate is a similar wedge it is possible that both units were deposited at the same time. Hence the arkose is tentatively placed in the Cambrian as a lithological variant of the Mount Currie Conglomerate.

<u>Ordovician</u>

Ordovician sediments occur on the Petermann Ranges and Bloods Range Sheet areas as outliers of the Larapinta Group of the Amadeus Basin. The sediments are flat-lying unaltered sandstone, dolomite, limestone, siltstone, shale and conglomerate unconformably overlying the metamorphosed and intensely folded Precambrian rocks. Aggregate thickness is probably not more than 60-70 feet. Fragmentary molluscs and trilobites from the Bloods Range Sheet area were not generally identifiable but indicate an Ordovician age (J. Gilbert - Tomlinson, B.M.R. pers. comm.).

Ordovician sediments crop out on the north-eastern corner of the Petermann Ranges Sheet area. At specimen locality PR25, 43 feet of flat-lying Ordovician sandstone uncomformably overlies coarsely porphyroblastic, fine to medium-grained, quartz-biotite-feldspar schist which is intruded by quartz-feldspar and feldspar-quartz veins. At the base is a thin bed of pebbly, poorly sorted sandstone. This is succeeded by silicified yellow-brown sandstone and gritty sandstone which is medium-grained and part coarse-grained, well sorted and part poorly sorted, well rounded and part angular. The sandstone is thin and medium-bedded and contains poorly outcropping interbeds which are probably siltstone. Higher in the sequence the sandstone is better sorted and rounded and thin beds with bedding-plane markings and vertical worm tubes appear. The hill is capped by a pale yellow-brown, medium-grained sandstone which is laminated, hard, silicified and moderately sorted and rounded. It contains abundant diplocraterion.

Pipe-rock and white bimodal sandstone occurs adjacent to many of the ranges in the area. These deposits have no stratigraphic control except they are underlain by the metamorphic rocks of the region and are overlain by conglomerate of probable Tertiary age. The discovery in 1964 of silicified wood and casts of vascular plants several feet above poorly preserved Scolithus tubes in a similar deposit north of the Petermann Ranges has demonstrated that some of these deposits are younger than Ordovician.

? TERTIARY

Sandstone

An outcrop of subhorizontal, coarse-grained sandstone, about 20' thick, occurs at PR78 near the Shaw River north of the Petermann Ranges. The sandstone has a grey-brown colour and is indistinctly bedded. It consists of uneven, coarse, angular fragments of quartz in a fine-grained secondary siliceous matrix. Angular quartz fragments are up to ½" long. The surface silicified portion breaks with a conchoidal fracture and the planes of fracture pass through the included particles. Portions of the sandstone which have not undergone surface silicification are friable and break down into individual quartz grains. Casts of vascular plants were found in the sandstone and some silicified wood with vascular bundles are included. Traces of vertical worm tubes occur at the same outcrop in a bed just below that of the fossil wood. The vascular plants indicate the age is late Palaeozoic to Recent and show that not all the pipe rock of this area is Ordovician.

Flat-lying deposits of sandstone occur beneath the Tertiary conglomerate adjacent to the Dean Range, Foster Cliff and Gordon Hill. The deposit near Foster Cliff contains organic markings which resemble worm burrows but are considered indeterminate. The conglomerate was deposited on top of the scoured surface of the sandstone without any angular discordance. Similar deposits also occur on the Bloods Range and Rawlinson Sheet area. Some of these deposits contain abundant pipe rock and for this reason have been mapped as Ordovician.

Conglomerate

Lithified piedmont deposits occur on the flanks of the high ranges. They dip at angles up to 15° away from the ranges and beneath the Quaternary sand and alluvium. They are often partly covered by recent scree, and adjacent to Foster Cliff, Gordon Hill and the Dean Range they are underlain conformably and disconformably by sandstone. Many small creeks dissect the deposits.

The phenoclasts of these deposits are angular to subrounded and poorly sorted with the largest, boulder-sized fragments nearest the ranges or hills. The components are derived from the adjacent ranges and consist mainly of quartzite with smaller amounts of sericite schist and vein quartz. The phenoclasts vary from less than an inch to two feet in diameter. Similar sediments are recorded from the northern margin of the Amadeus Basin (Prichard & Quinlan, 1962), but these are unlithified.

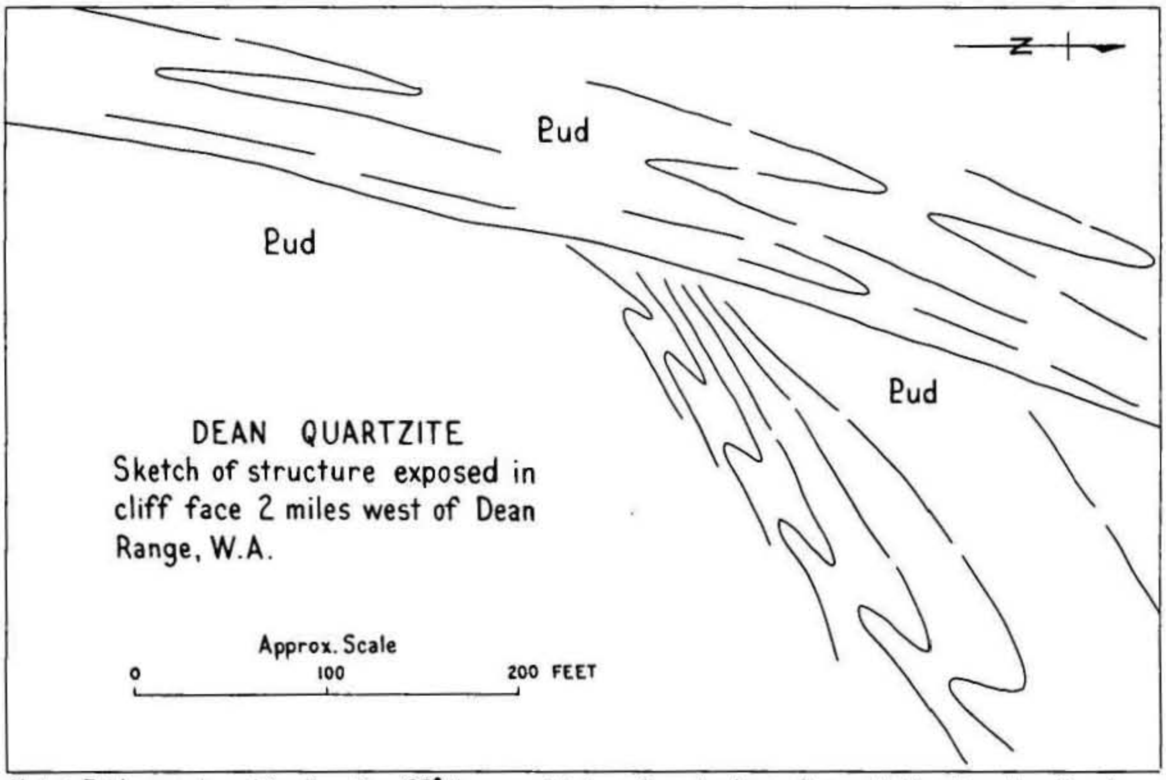
The conglomerates are considered by Prichard and Quinlan to be Tertiary but Condon (in Prichard & Quinlan, 1962) considers that as the deposits are not deeply weathered they were most probably formed during the Pleistocene episode of strong erosion.

QUATERNARY

Deposits of aeolian sand, alluvium and travertine cover the greater part of the area and their age is assumed to be Quaternary. The orange-brown aeolian sand occurs as flat plains and dunes. The dunes which are rarely over twelve miles long are unconsolidated, branching, strongly braided in some areas, and are up to 60 feet high but average 20 to 30 feet above the plain level. The trend of the dunes is generally east to north-east but adjacent to the ranges deflections of the prevailing winds have caused variations.

The alluvium occurs in flood plains fringing the ranges and around the larger creeks. An extensive alluvial plain occurs along the northern flanks of the Musgrave Ranges at Mulga Park. The alluvial plains consist of a red-brown alluvium which commonly contains pebbles.

FIG 10



Note: Fold axes trend in direction 90° above and below thrust plane. Recrystallization lineation in direction 0°

Bureau of Mineral Resources, Geology and Geophysics. To accompany Record 1964/41.
April 1964.

W/A/19

RECUMBENT FOLDING - SCHWERIN MURAL CRESCENT

FIG. 11

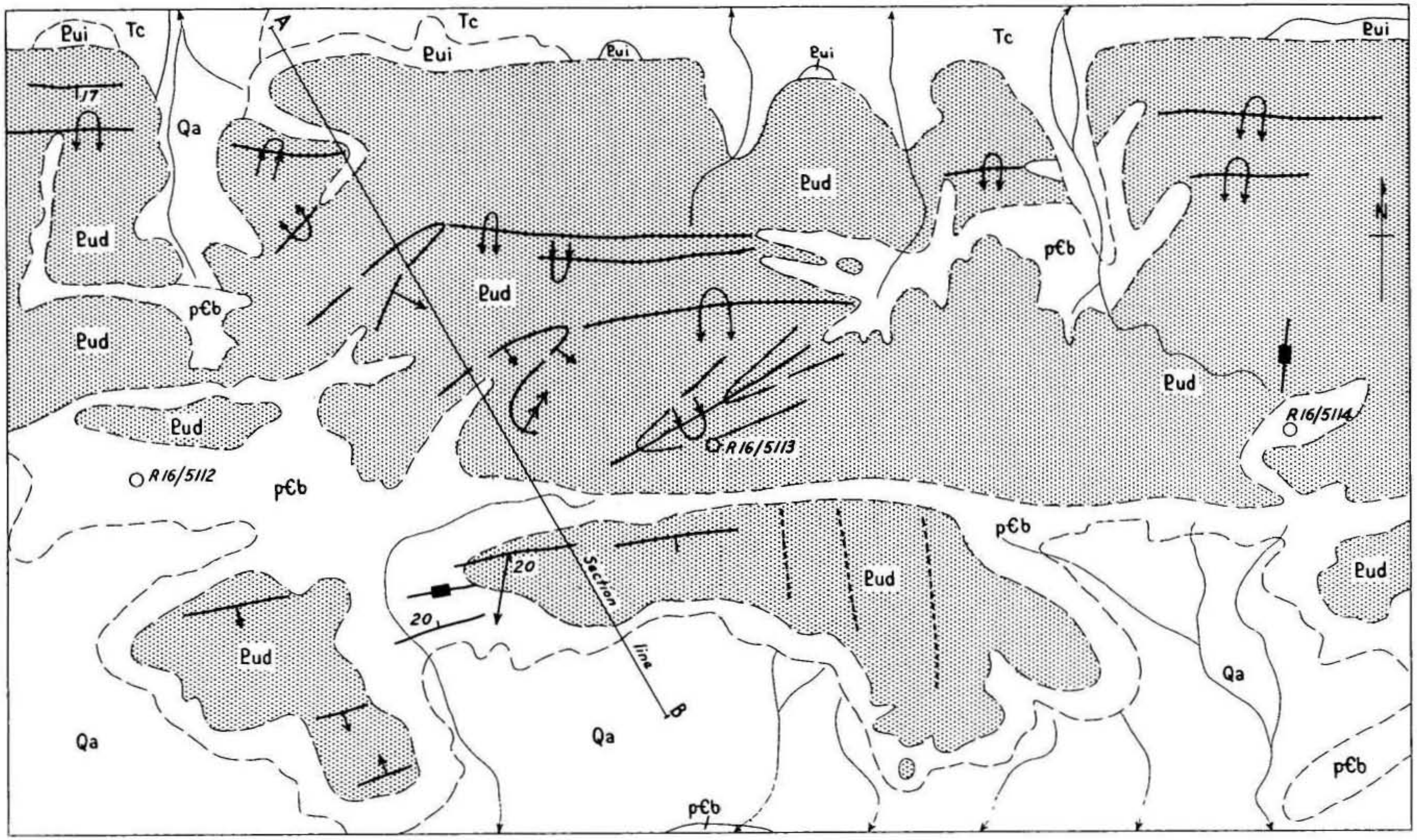
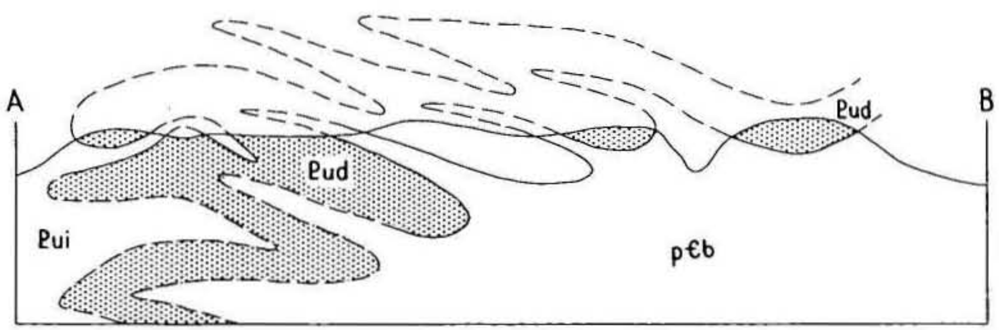


Photo scale 1:36,000



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

To accompany Record 1964/41.

NT/A/70

Figure 12: F^2 folding in the Dean Quartzite 3 miles north of Mount Phillips (Petermann Ranges). Vertical schistosity S^2 is parallel to the axial planes of the fold and the lineation pitches at 90° parallel to axes of the folds.

Figure 13: Vertical schistosity and lineation in the Dean Quartzite 3 miles north of Mount Phillips. Quartz rods have developed parallel to the lineation.

Neg. No.G/6223

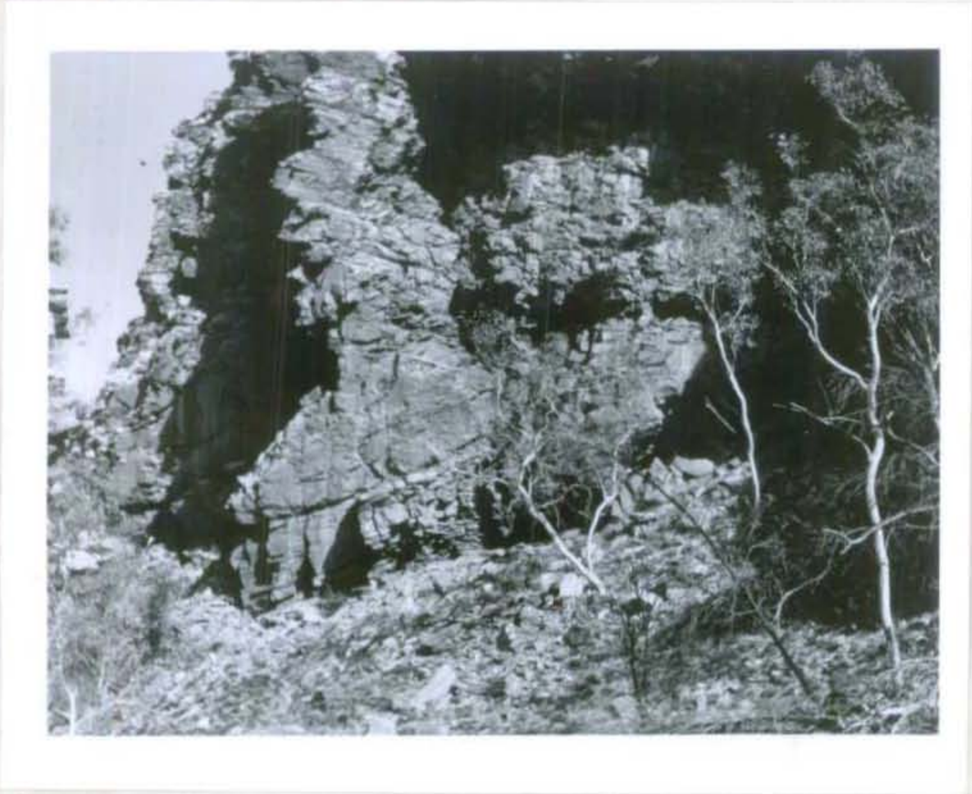


Figure 14: Recumbent folding in the Dean Quartzite at Glen Cumming, near Mount Russel in the Rawlinson Range, Western Australia.
Neg.No. G/6022.

Figure 15: Isoclinal folding and middle limb shear in the Dean Quartzite three miles west-south-west of Foster Cliff, Northern Territory. Note the schistosity is parallel to the axial plane of the fold.
Neg.No. G/6019

Figure 16: Isoclinally folded Dean Quartzite and porphyroblastic augen gneiss at Butler Dome, Northern Territory. The quartzite is the white bedded rock on the left side of the photo and the gneiss is the darker rock on the right side of the photo. Neg.No.G/6015.

Figure 17: Photo taken close up to the contact between Dean Quartzite and gneiss in Fig.16. Dean quartzite at left grades into sericitic quartzite, quartz sericitic schist, biotite-quartz-sericite schist, feldspar-sericite-biotite-quartz-schist, and porphyroblastic, medium-grained, biotite-quartz-feldspar, augen gneiss. Neg.No.G/6017

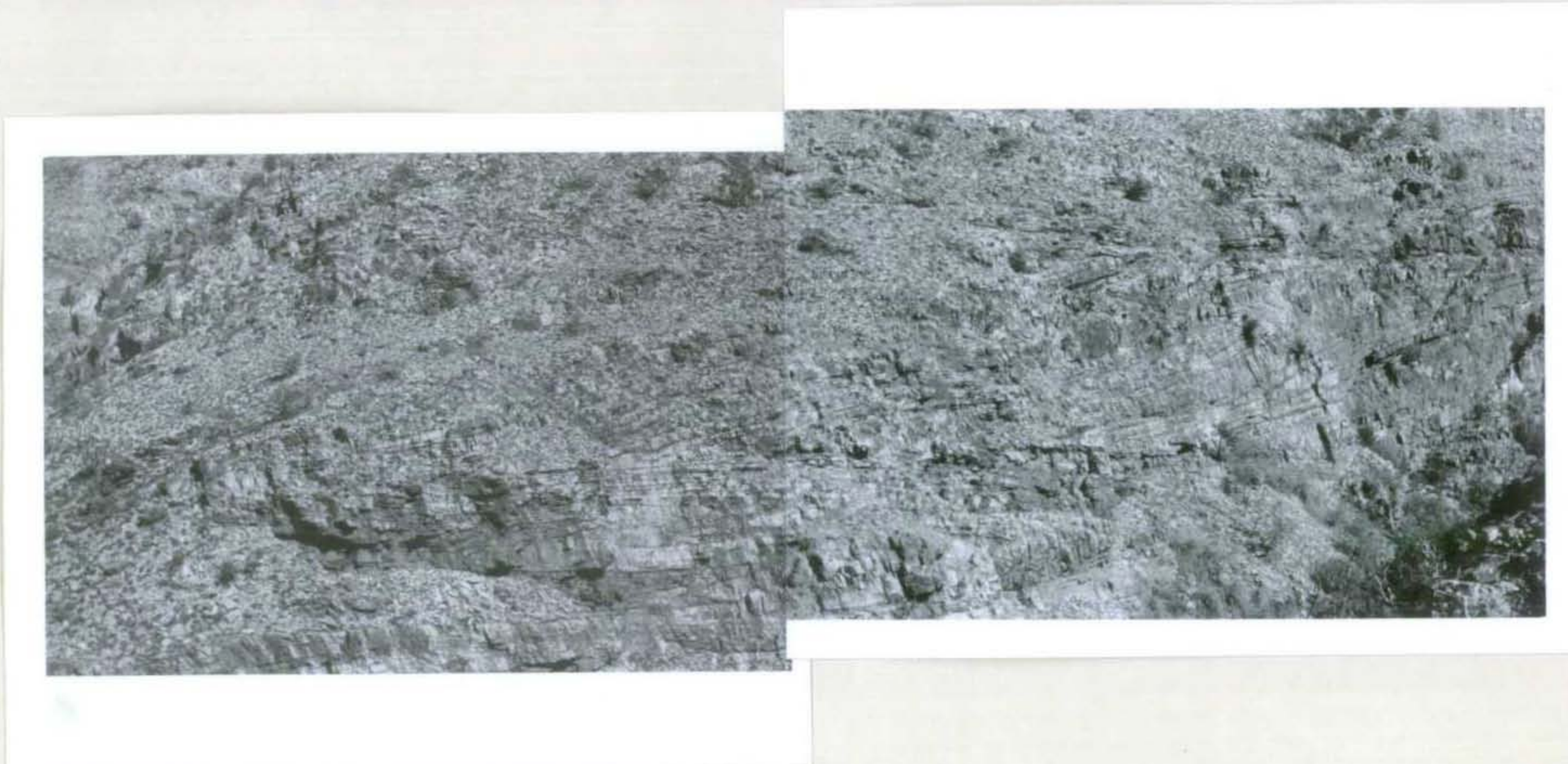


Figure 18: Recumbent fold in the Dean Quartzite and Pinyinna Beds at Foster Cliff, N.T. The quartzite along the top of the photo is overturned. The Pinyinna Beds form the poor outcrop in the core of the fold on the centre left of the photos. (See Fig.7.)

Neg.Nos.G/5995-6.

Travertine (or caliche) occurs as a thin white to grey crust, and forms small low outcrops in minor depressions in the desert plain. The travertine probably formed by precipitation from lime-rich waters of dessicating lakes or by precipitation from groundwater in low lying areas.

STRUCTURE

The discussion of the structure of the southern margin of the Amadeus Basin is restricted to the area in which the Dean Quartzite crops out from the Rawlinson Sheet area in the west to the Ayers Rock Sheet area in the east. The structure of the remainder of the southern margin is not discussed here but has been treated in Wells, Stewart and Skwarko (1964).

The hypothesis of a regional recumbent fold was advanced by Forman (1963), following mapping of the Bloods Range Sheet area. The hypothesis was further substantiated during the mapping of Petermann Ranges and Ayers Rock Sheet areas and mapping of part of Scott and Rawlinson Sheet areas.

It is now known that a uniform structural pattern and sequence exists in the ranges between Giles in Western Australia and Mulga Park in the Northern Territory. The pattern is consistent with that described from the Scottish Highlands by many workers. A description of this pattern and sequence will form the first part of this chapter. It is also known that rocks which were previously at no greater depth than about 14,000 feet have been metamorphosed and in some places converted to gneiss and granite. The implication that these rocks have been buried to much greater depths by overfolding seems inescapable. The final evidence in favour of a recumbent fold is that the regional distribution of the Dean Quartzite can be satisfactorily explained only if a recumbent fold is assumed.

The Style of Deformation

The style of deformation may be seen by reference to Figs. 10 - 18 incl. These show the small scale isoclinal and recumbent folding of the Dean Quartzite in the Schwerin Mural Crescent, west of the Dean Range in Western Australia, the Petermann Ranges, Rawlinson Range, Olia Chain and southern half of the Ayers Rock Sheet area. The same style of folding occurs at Bloods Range and has been described in Forman (1963, Figs. 15 and 16). Figures 9, 12, 13 and 15 show that in areas where schistosity has

FIG. 19

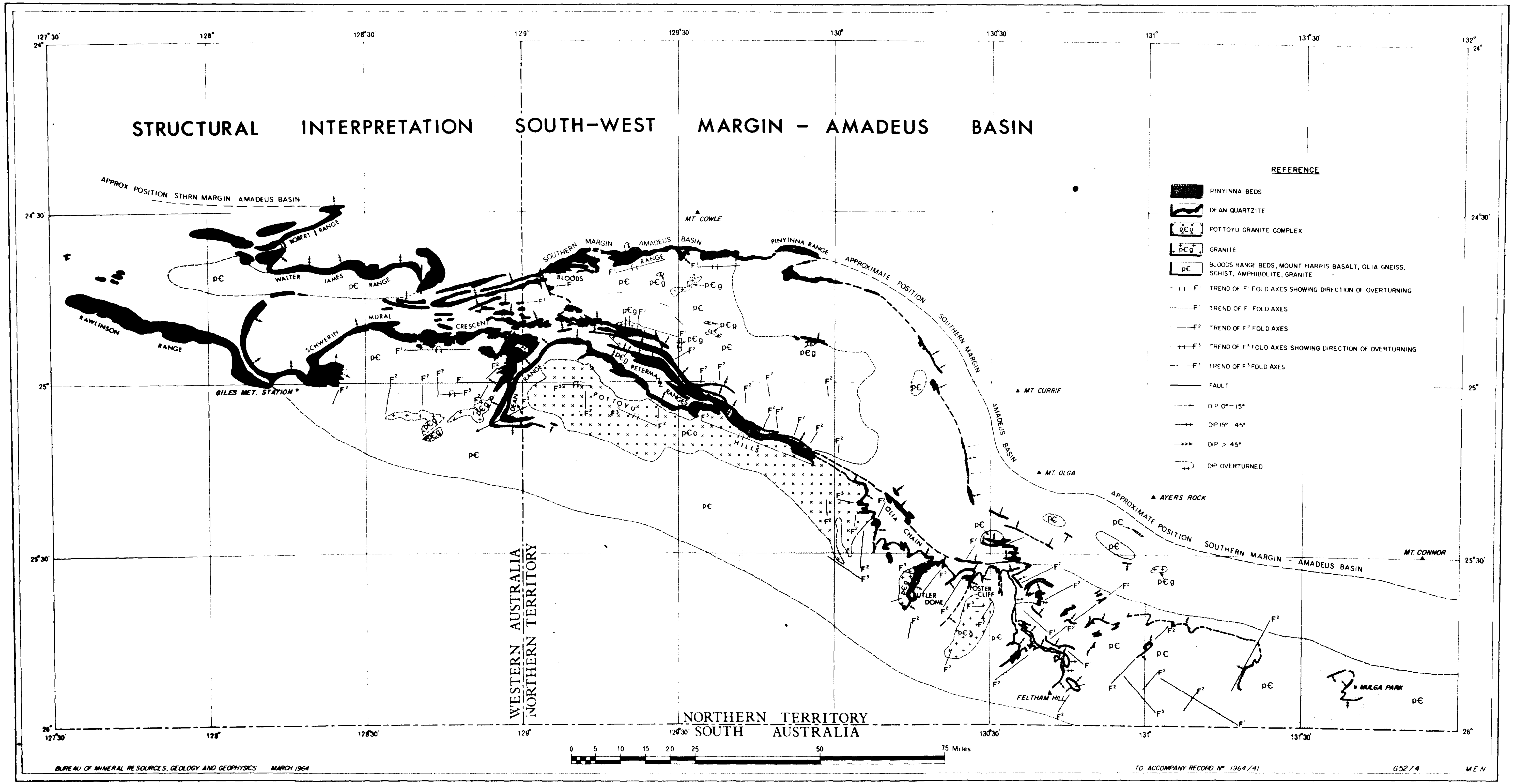

STRUCTURAL INTERPRETATION SOUTH-WEST MARGIN - AMADEUS BASIN
REFERENCE
PINYINNA BEDS
DEAN QUARTZITE
POTTOYU GRANITE COMPLEX
GRANITE
BLOODS RANGE BEDS, MOUNT HARRIS BASALT, OLIA GNEISS, SCHIST, AMPHIBOLITE, GRANITE
TREND OF F¹ FOLD AXES SHOWING DIRECTION OF OVERTURNING
TREND OF F¹ FOLD AXES
TREND OF F² FOLD AXES
TREND OF F³ FOLD AXES SHOWING DIRECTION OF OVERTURNING
TREND OF F³ FOLD AXES
FAULT
DIP 0°-15°
DIP 15°-45°
DIP > 45°
DIP OVERTURNED
APPROX POSITION STHRN MARGIN AMADEUS BASIN
ROBERT RANGE
WALTER JAMES RANGE
RAWLINSON RANGE
SCHWERIN MURAL CRESCENT
GILES MET. STATION
DEAN RANGE
BLOODS RANGE
SOUTHERN MARGIN AMADEUS BASIN
MT. COWLE
PINYINNA RANGE
APPROXIMATE POSITION SOUTHERN MARGIN AMADEUS BASIN
PETERMANN RANGES
POTTOYU HILLS
OLIA CHAIN
MT CURRIE
MT OLGA
AYERS ROCK
MT. CONNOR
BUTLER DOME
FOSTER CLIFF
FELTHAM HILL
MULGA PARK
WESTERN AUSTRALIA
NORTHERN TERRITORY
SOUTH AUSTRALIA
75 Miles
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS MARCH 1964
TO ACCOMPANY RECORD Nº 1964/41
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Figure 20: Olia Gneiss two miles south of Giles Creek. The lithology is gneissic schist with medium-grained, thin quartzo-feldspathic bands alternating with thin pelitic bands. The subhorizontal schistosity (S_1 or S_2) is refolded by F_3 beneath the band. The axial plane of this later folding is S_3.

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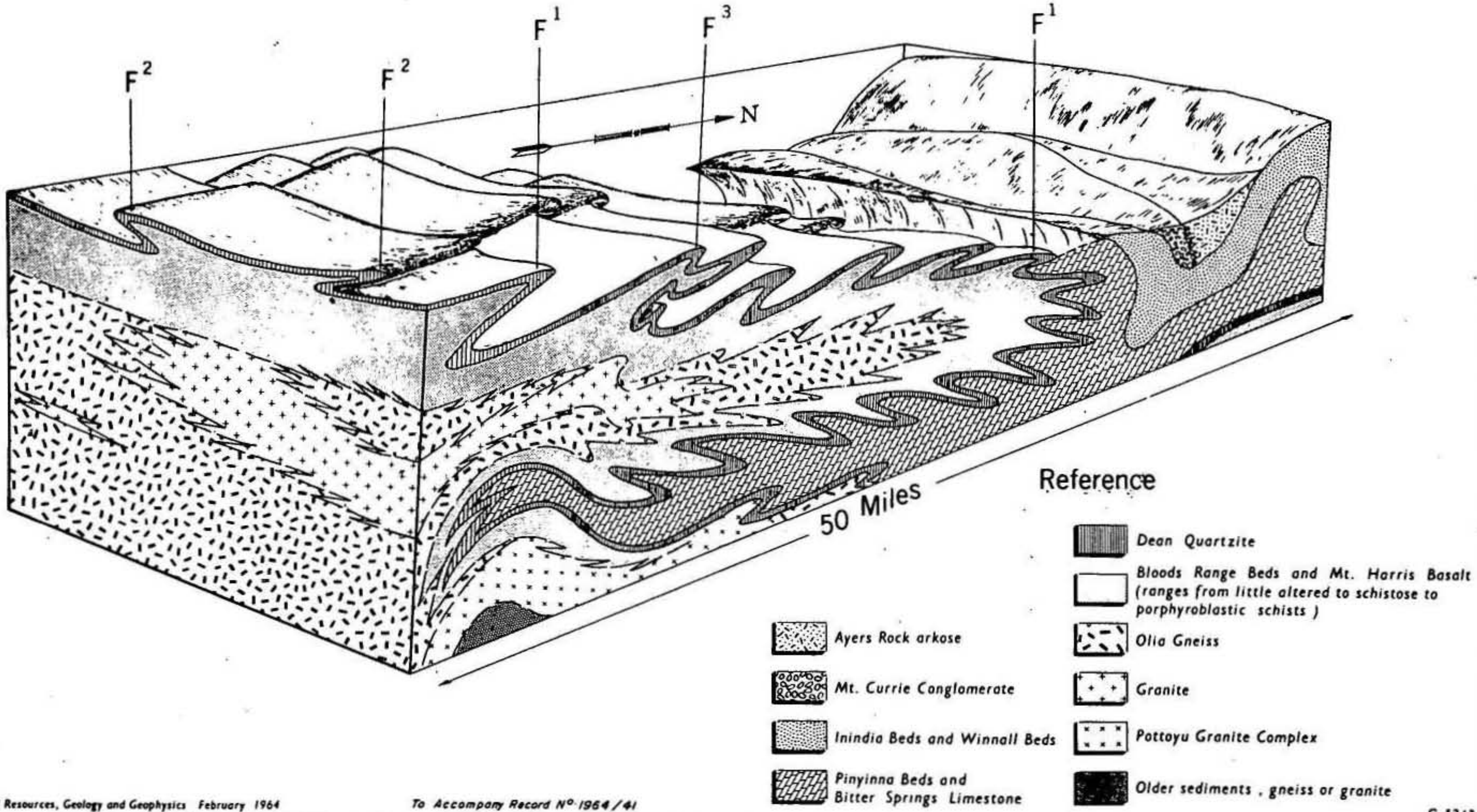
RELATIONSHIP OF METAMORPHISM AND MINOR STRUCTURES TO REGIONAL STRUCTURE, SOUTH-WEST MARGIN, AMADEUS BASIN



Bureau of Mineral Resources, Geology and Geophysics February 1964

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FIG. 21

developed it is parallel to the axial plane of the fold and that a lineation is parallel to the axial line of the fold. Figures 10 and 11 show that in some areas at least a lineation occurs at right angles to the predominant fold direction. In both these figures the folds trend east-west and the lineation northerly. The northerly lineation is the predominant lineation in the area and at other localities is parallel to the axial lines of folds (Figures 9, 12 and 13).

It is therefore deduced that there are two directions of recumbent and isoclinal folding, one roughly east-west parallel to the main trend of the ranges, the other northerly and at right angles to the east-west folding. The east-west isoclinal folding is referred to here as F^1 folding with F^1 folds and the northerly isoclinal folds are referred to as F^2 folds. The folds are represented on Figure 19 which shows the regional trend and distribution of the fold structures. F^1 folds are known from the Schwerin Mural Crescent, the Dean Quartzite Range west of the Dean Range, Bloods Range and the southern half of the Ayers Rock Sheet area where they are clearly refolded by F^2 folds. The F^2 fold axes plunge and trend parallel to the dominant lineation of the region. Folds associated with the lineation have been recognized in the Petermann Ranges, Olia Chain and southern half of Ayers Rock Sheet area. It has not been proved in all areas whether the F^1 folds have been folded by the F^2 folds or vice versa.

Another folding, apparently later than F^1 or F^2 occurs throughout the region. This is designated F^3 on Figure 19. The F^3 folds are well developed in the Mannanana Range, Curdie Range, Mount Fagan, Mount Miller and Mount Phillips and the axial planes strike east-south-east parallel to the trend of these ranges. The folds are typically tight with overturned axes dipping southerly at moderate to steep angles. The northern limbs of anticlines and the southern limbs of synclines are overturned. The folding has produced a schistosity parallel to the axial plane and a lineation parallel to the b - axis. Schistosity and lineation associated with F^2 are refolded by F^3 (Fig. 20). F^3 folds also occur in the Kathleen Range area in Western Australia and on the southern half of the Ayers Rock Sheet area.

Figure 21 is a block diagram showing F^1, F^2 and F^3 folds in their relation to the regional recumbent fold.

The fold structures and associated schistosity and lineation are not restricted to the Dean Quartzite, but occur in the Bloods Range Beds, Mount Harris Basalt, schist, Olia Gneiss, Pottoyu Granite Complex and the other granite bodies.

The following section demonstrates the correlation between degree of metamorphism and position in the structure and describes the metamorphic structures within the rocks.

Metamorphism in the Recumbent Fold

Figure 21 summarizes the position of the various metamorphic rock types in the recumbent fold. The least altered volcanic and clastic sedimentary rocks beneath the Dean Quartzite occur adjacent to the upper normal limb where depth of burial and subsequent degree of deformation are at a minimum. As these sediments are traced around the fold past the northern nose area of the recumbent fold on to the inverted middle limb the degree of metamorphism increases and the volcanic and clastic sediments have been converted to schist and amphibolite. Tracing along the inverted middle limb towards the recumbent synclinal closure to the south the schists grade into fine-grained gneiss, porphyroblastic schist and porphyroblastic gneiss both above and below the core of the inverted middle limb and the normal bottom limb. The gneiss is gradational with granite which varies from foliated to massive.

The schistosity S^1 and S^2 in the schists is parallel to the axial planes of F^1 and F^2 folds. The axial planes of F^1 and F^2, and therefore S^1 and S^2, appear to be parallel. Where schist grades into fine-grained gneiss, or porphyroblastic gneiss the gneissosity is parallel to the schistosity. It has been noted in the Petermann Ranges, Dean Range, and Butler Dome in particular, that the gneissosity in coarsely porphyroblastic augen gneiss is parallel to the axes of F^2 folds in the Dean Quartzite and to the schistosity in the Dean Quartzite. The strong lineation L^2 which occurs in the plane of gneissosity is parallel to the plunge and trend of the F^2 folds in the adjacent Dean Quartzite and to the lineation L^2 on bedding surfaces (S^0) in the Dean Quartzite (as in Figs. 12 and 13). F^1 and S^1 have not been proved in these structures but it is reasonable to assume that S^1 has been isoclinally folded parallel to S^2 and is now indistinguishable from it.

In areas where F^3 and S^3 are developed the S^1 - S^2 surfaces are folded into F^3 folds which have a schistosity S^3 parallel to the axial plane. F^3 folds occur in the

Dean Quartzite in the Mannanna,, and Gurdie ranges and at Mount Fagan and Mount Phillips. They are prominently developed in the schists to the south of these ranges where they have refolded $S^1 - S^2$ schistosity and L^2 lineation and are most strongly developed farther south in the Pottoyu Granite Complex. The schists which lie between the Dean Quartzite and the Pottoyu Granite Complex are porphyroblastic in part and grade into fine to medium-grained biotite-quartz-feldspar gneiss and porphyroblastic gneiss in which the gneissosity is the same as $S^1 - S^2$ in the schists. The gneissosity in the gneiss is also refolded by F^3 and the development of S^3 in gneiss is visible in Figure 20. The gneiss is gradational into granite in the Pottoyu Granite Complex. The S^2 surface in the gneiss and L^2 (lineation) are folded by F^3. As the gneiss grades into the granite the folding becomes tighter and more isoclinal so that the S^2 becomes parallel to S^3. In some of these outcrops L^2 is still visible though L^3 is dominant. The final stage of conversion of gneiss to granite is seen as a blurring of S^2 to the stage where it is no longer recognizable and F^3 folding is not visible. The resultant granite preserves a weak to absent foliation, which is S^3, and a lineation L^3. In the rapakivi granite the growth of abundant egg-sized, ovoid feldspars has largely destroyed the original gneissosity (S^2) but the old lineation L^2 is still prominently visible in many outcrops . In the majority of outcrops S^2 and L^2 are destroyed and only S^3 and L^3 are visible.

The preservation of S^2 and L^2 in the granite as a foliation and the gradual transition from dominant S^2 and L^2 to dominant S^3 and L^3 are strong evidence in favour of a metasomatic replacement origin in situ for the granite in the Pottoyu Granite Complex. The same sort of structural gradation is visible traversing the gneiss west of Butler Dome into the granite west of Butler Dome. It is therefore concluded that much of the granite in the region was formed at a late stage during the F^3 folding. Some mobilization of the granite has also occurred as sharp intrusive contacts are visible in places with gneiss and schist.

Lineation is of various types. The most readily recognisable lineation is intersection of bedding and schistosity in the Dean Quartzite. In most outcrops, however, bedding and schistosity are parallel and the lineation is best described as a mineral lineation due either to an alignment and streaking of quartz and musco-

Figure 22: Folded gneiss south of Giles Creek on the Petermann Ranges Sheet area. The gneiss is pinkish-grey, medium-grained and contains biotite, quartz and feldspar. The isoclinal folds axes trend easterly parallel to the lineation in the gneiss.

Neg. No. G/6080.

vite down the bedding plane or due to microscopic folds and undulations on the bedding plane. Figure 13 shows quartz rods which parallel the lineation in quartz-sericite schist. In a few places it was possible to measure the direction of maximum elongation of pebbles and this direction was parallel to the adjacent mineral lineation.

The lineation measured was not always parallel or at right angles to the direction of minor fold axes in the quartzite. In many outcrops a spread of lineation was measured which in places converged on the direction of minor fold axes. At other localities a range of up to 40 or 80 degrees was measured in the direction of the fold axes themselves without any indication that they belonged to two periods of folding. At these localities the relationships of bedding, schistosity, fold axes and lineation was obscure. However, in most outcrops of strongly lineated and recrystallized schistose quartzite the relationships were clear and conform to those described in this section.

Within the gneiss the most common lineation is a crude banding, streaking and orientation of dark and light minerals on the plane of gneissosity. The lineation is quite distinct. Some amphibolite interlayered with the gneiss contains oriented amphibole with long axes parallel to the lineation in the adjacent gneiss. In several localities the lineation parallels minor folds in the gneiss (as in Fig. 22). At other localities, particularly in the coarsely porphyroblastic augen gneiss, no isoclinal folding of gneissosity can be seen, but it is quite possible that an earlier gneissosity has been folded parallel to the late gneissosity and that the lineation represents the outcrop of the relict gneissosity on the later gneissosity surface. This hypothesis is supported by two field observations.

1. The coarse porphyroblastic gneiss is transitional into the fine to medium-grained gneiss and appears to have been developed from it.
2. Folding of the gneissosity is visible only in the fine-to-medium-grained varieties of gneiss. In the southern half of the Ayers Rock Sheet area the fine-to-medium-grained gneiss contains the lineation (L^1) (associated with F^1) folded about F^2 fold axes, whereas the coarse porphyroblastic gneiss contains only the F^2 lineation (L^2). It appears therefore that the coarse porphyroblastic gneiss has developed during F^2 whereas the fine-to-medium-grained gneiss developed during F^1.

Conclusions

1. A uniform structural style and sequence persists between Giles in Western Australia and Mulga Park in the Northern Territory.

2. The style consists of isoclinal and recumbent folding and cross folding with a later tight to isoclinal folding superimposed upon it.

3. The metamorphism of the quartzite and the development of gneiss and granite from the underlying rocks took place during the same orogenic period and the same metamorphic structures are preserved in schist, gneiss, granite and quartzite.

4. After deposition of the Winnall Beds the Dean Quartzite was probably under a load of about 12,000 feet of sediment. To account for the metamorphism which took place later it is necessary to infold the Dean Quartzite to a much greater depth.

5. The distribution of the Dean Quartzite is the final consideration which suggests that the regional infold is a recumbent fold (i.e. close to horizontal). If the fold were a vertical or steeply inclined infold, its core would lie beneath Bloods Range and would not appear in the Petermann Ranges and Dean Range.

The folding on the southern margin of the Amadeus Basin has been named the "Petermann Ranges Folding" by Forman (1963). This folding is believed to have taken place after deposition of the Winnall Beds and Inindia Beds although these formations are not known to have been infolded. Forman (1963) has outlined the evidence which suggests that the Bitter Springs Limestone and equivalent Pinyinna Beds are incompetent members of the sequence and that there is a disharmonic relationship between the structure above and below the Bitter Springs Limestone. The Winnall Beds and Inindia Beds may have been squeezed out of the recumbent fold by the plastic Pinyinna Beds and appear to have slid northwards on a decollement surface in the Bitter Springs Limestone. This relationship is shown diagrammatically in Figure 21 which also shows the wedges of conglomerate and arkose which were deposited in front of the fold.

GEOLOGICAL HISTORY

The order of geological events may be summarized thus:

(1) Volcanic activity including the extrusion of Precambrian basic and acid lavas and sedimentation of the Mount Harris Basalt and Bloods Range Beds.

(2) Upworping and erosion near Bloods Range.

(3) Deposition of about 4000 feet of the Upper Proterozoic Dean Quartzite and Pinyinna Beds in a relatively stable, epicontinental, shallow marine environment.

(4) Instability farther south in the Upper Proterozoic caused a change from carbonate to clastic sedimentation evidenced by the Inindia Beds (about 2000 feet) and an increase in instability and uplift evidenced by the Winnall Beds (about 8000 feet).

(5) Petermann Ranges Folding late in the Upper Proterozoic accompanied by metamorphism of the Mount Harris Basalt, Bloods Range Beds, Dean Quartzite and Pinyinna Beds, and formation of schist, porphyroblastic schist, gneiss and granite. The orogeny caused recumbent and isoclinal folding of the sediments beneath the Pinyinna Beds and Bitter Springs Limestone while the sediments overlying probably slid northwards on a decollement surface. Intrusion of dolerite. Area rises above sea and erosion commences.

(6) Deposition of a tectonic wedge of Mount Currie Conglomerate and Ayers Rock arkose against the northern front of the main recumbent fold mountain probably early in the Cambrian.

(7) Erosion of newly raised land surface during the Cambrian and deposition of the post-orogenic Cambrian strata in deltaic and paralic environments along its northern edge.

(8) Marine transgression. A shallow Ordovician sea spread southwards over parts of the Bloods Range and Petermann Ranges Sheet areas. Deposition took place in a stable, shallow, marine environment.

(9) Slow weathering and erosion. Some conglomerate and sandstone may have been deposited adjacent to the ranges in the Mesozoic.

(10) Tertiary pluvial period when conglomerates were deposited near ranges and the water-table may have emerged over the low-lying areas now occupied by Lake Neale and Lake Amadeus.

(11) Deposition of travertine in low-lying areas.

(12) A period of aridity when the water-table dropped. Alluvial sand reworked by wind into sand dunes.

(13) Sand dunes became stable.

ECONOMIC GEOLOGY

No economic mineral deposits are known on the southern margin of the Amadeus Basin.

Copper

Occurrences of copper on the Bloods Range Sheet area were reported by Forman (1963). Deposits of malachite occur in the Kathleen Range area of the Scott Sheet. The deposits occur in the Mount Harris Basalt and Bloods Range Beds in sericite schist, sericitic quartzite and epidotized amygdaloidal basalt. In some deposits the malachite is micaceous and is oriented parallel to the metamorphic sericite in the same rock. In other deposits the malachite is secondary. None of these deposits is of economic size at the surface, and none has been tested at depth because the surface showings have not been considered sufficiently encouraging to warrant drilling.

Lead, silver and gold

Secondary lead minerals, galena, silver and gold were found with secondary copper minerals in vein quartz intruding the Mount Harris Basalt on the Bloods Range Sheet area (Forman, 1963). None of these minerals occurred in economic quantities and the outcrop of mineralized vein quartz was very small.

Phosphate

Phosphate has been reported from the Bloods Range Sheet area (Forman, 1963) but the deposit is not of economic interest.

Underground Water

Supplies of underground water have been obtained at Giles, Livingstone Pass, Ayers Rock and Mulga Park Station. Two bores for water have been drilled at Mount Olga without success. Bore data for the Livingstone Pass area are indicated below. Wells et al, (1961) give bore data for the Giles area and Wells et al (1964), give bore data for the Ayers Rock Sheet area. The following summary outlines the type of occurrence of water at Giles, Livingstone Pass, Ayers Rock and Mulga Park.

(1) Giles

The water is obtained from bores south of the Rawlinson Range near Giles. These bores are sited along the creek which flows from near Giles through the Pass of the Abencerrages. It is probable that the water is obtained from alluvium which overlies porphyroblastic schist and gneiss.

(2) Livingstone Pass

The catchment area is in Learmonth Park and the Dean Range - Schwerin Mural Crescent area to the west. It has not been proved that water flows underground from the east to the Docker River in the valley between the Petermann Ranges.

One bore was sited in Livingstone Pass to test the flow through the pass from the Learmonth Park, catchment area. Several other bores were sited to the west of Livingstone Pass to test the underground flow from the Dean Range - Schwerin Mural Crescent catchment area; one of these obtained a good supply of potable water. The remainder of the bores were sited farther north across the Docker River to test the underground flow of water through the northern gap in the Petermann Ranges. The water from these bores was mostly salty.

All the water was obtained from unconsolidated sediments over-lying the Dean Quartzite, Pinyinna Beds or Precambrian metamorphics. The results of the drilling programme, which was carried out by the Water Resources Branch, Northern Territory Administration, Alice Springs, between May and August, 1963 are summarized in the following table (Youles, 1964).

TABLE 2.

Bore No.	Depth	T.D.S.	Yield	Drawdown	Remarks
G52/3-1	208ft.	525ppm.	1200gph.	4.85ft.	
G52/3-2	130ft.	3860ppm.	1440gph.	12.1ft.	
G52/3-3	130ft.	5160ppm.	Not tested		
G52/3-4	130ft.	1528ppm.	600gph.	14ft.	
G52/3-5	205ft.	546ppm.	Not tested		100' N.E. of bore 3 - 10
G52/3-6	117ft.	2832ppm.	1000gph.	18.15ft.	
G52/3-7	115ft.	1167ppm.	Not tested		
G52/3-8	105ft.	-	Not tested		100' S of bore 3 - 1
G52/3-9	105ft.	-	Not tested		100' N of bore 3 - 1
G52/3-10	120ft.	318ppm.	1750gph.	22.5ft.	Probable production bore.

(3) Ayers Rock

Good water has been obtained near Ayers Rock by drilling the surrounding alluvial deposits. Seven bores have been sunk to depths of between 50 and 400 feet through clay, sand, silt and travertine. The 400-foot bore appears to have penetrated bed-rock and was unsuccessful. Only two of these bores, Reserve No. 2 try and Tuits No. 2 try, struck water in excess of 600 gallons per hour.

(4) Mulga Park

Bore records for Mulga Park Station are particularly poor. All the bores were commenced in alluvium and many were carried to bedrock gneiss, schist, amphibolite, dolerite and granite in most cases. No information is available as to whether the water was obtained in the alluvium or in the bedrock. The area east of Britten Jones Creek is largely an alluvial flat with little indication of subsurface basement contours on which to base a drilling programme. Water has been found by a process of trial and error and in the process many unsuccessful bores have been drilled.

Petroleum Prospects

The southern margin of the Amadeus Basin offers no petroleum prospects owing to the age, structure and metamorphism of the rocks. However oil could accumulate north of the southern margin within the Amadeus Basin. Close to the southern margin, the Bitter Springs Limestone and Pinyinna Beds and Inindia Beds of Upper Proterzoic age, offer potential source rocks and porosity could be obtained in the Inindia Beds or the Winnall Beds. No suitable structural traps are known at the present time from surface outcrop adjacent to the southern margin.

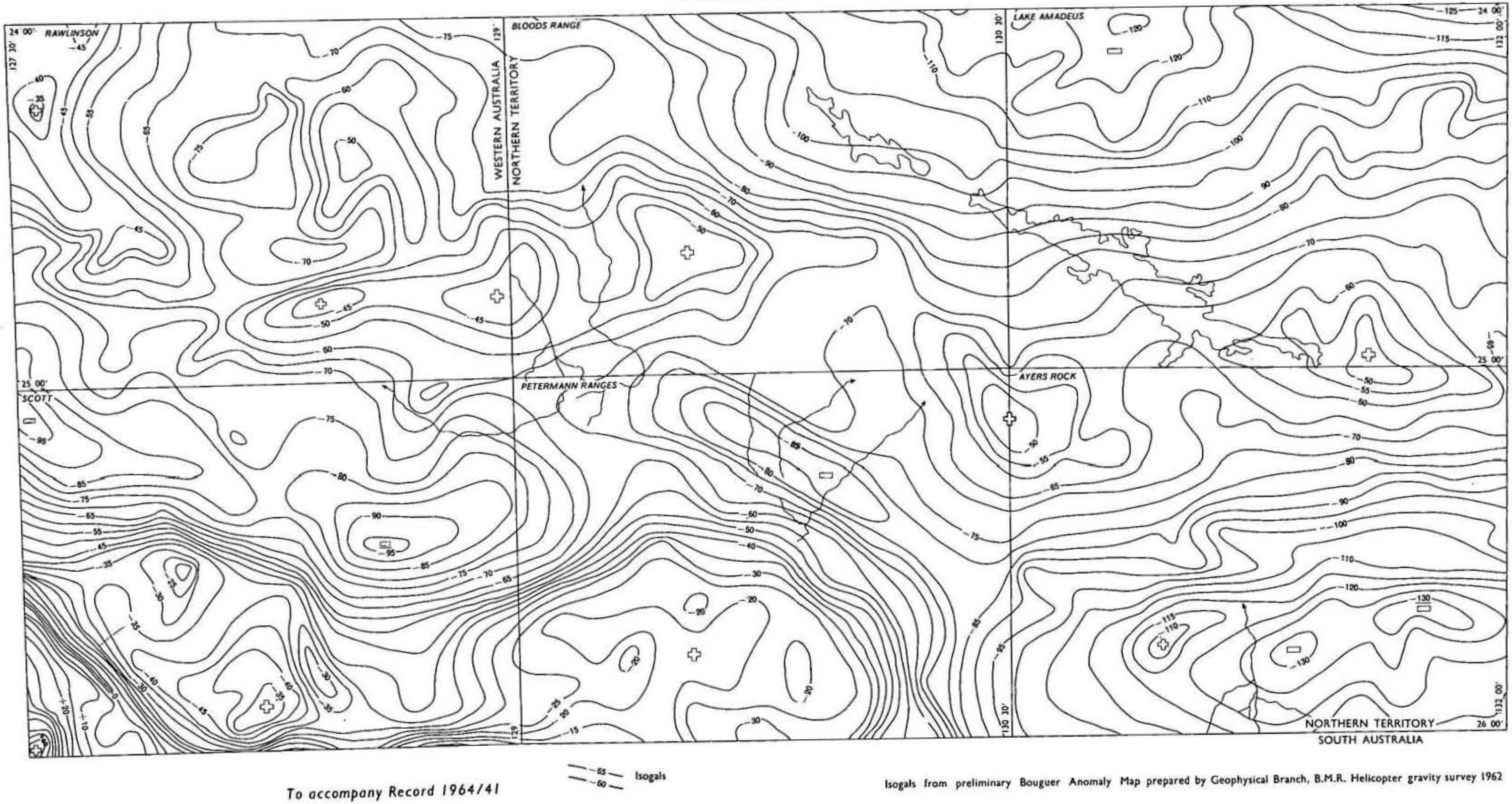
GEOPHYSICAL DATA

Reconnaissance aeromagnetic and regional gravity data have been obtained by the Geophysical Branch of the Bureau of Mineral Resources.

Between 21st October and 26th October 1960 the Geophysical Branch flew aeromagnetic traverses from Alice Springs to Giles and other flights from Giles. Another flight was made from Mount Davies in South Australia to Alice Springs (Goodeve, 1961). The flights west of Giles indicated shallow basement within the area described in this report. On the traverse from Alice Springs to Giles over the Amadeus Basin the smooth magnetic profile indicated that any fluctuations in magnetic intensity of the basement rocks were obscured by over 10,000 feet of sediments. The smooth profile changed to a profile of moderate magnetic variation, as the plane flew over the Bloods Range Sheet area, at a point several miles north-east of Pinyinna and McNichol Ranges. From this point to Giles the magnetic

BOUGUER ANOMALIES

FIG. 2.3



To accompany Record 1964/41

Isogals from preliminary Bouguer Anomaly Map prepared by Geophysical Branch, B.M.R. Helicopter gravity survey 1962

SCALE

10 0 10 20 30 MILES

NT/A/69

Bureau of Mineral Resources Geology and Geophysics April 1964 basement is interpreted at depths of 0-2000 feet and agrees with the area of outcrop of the Dean Quartzite, Bloods Range Beds, Mount Harris Basalt and some granite and gneiss. The flight from Mount Davies to Alice Springs was made over Foster Cliff and Ayers Rock. Between Mount Davies, Foster Cliff and Ayers Rock the magnetic profile indicates basement is at shallow depth. This result agrees with the abundance of outcrop of quartzite, granite and gneiss from Mount Davies to within 10 miles of Ayers Rock and suggests that the Ayers Rock arkose may contain bodies of different magnetic intensity.

Between Ayers Rock and Alice Springs the smooth profile indicated magnetic basement to be at least 10,000 feet below ground surface.

The nature of the magnetic basement is known from outcrop geology along the southern margin of the basin but cannot be assumed to be the same farther north beneath the sediments of the Amadeus Basin. The reason for this is that the Bloods Range Beds or equivalents, which have been partially granitized and metamorphosed along the southern margin, may be unaltered if they occur beneath the Dean Quartzite or Heavitree Quartzite in the Amadeus Basin. In this case magnetic basement would not occur at the base of the Dean Quartzite or Heavitree Quartzite but perhaps some thousands of feet deeper where the Bloods Range Beds may be in contact with the Mount Harris Basalt or with older igneous and metamorphic rocks. Hence the regional unconformity beneath the Dean Quartzite and the difference in intensity of metamorphism of the sediments beneath the Dean Quartzite make it impossible to be certain of the position of the magnetic basement below the deeper parts of the Amadeus Basin. However it is unlikely that magnetic basement will occur above the Dean Quartzite or Heavitree Quartzite.

Economic basement may be taken as the base of the Heavitree Quartzite/Dean Quartzite, and this may or may not coincide with magnetic basement. The thickness of sediments above economic basement may aggregate 14,000 feet to the top of the Winnall Beds and hence a depth of over 10,000 feet to magnetic basement is reasonable.

In 1962 the Geophysical Branch made a regional gravity reconnaissance in the areas as part of a larger programme, in the Amadeus and Canning Basins (Lonsdale & Flavelle, 1963). Figure 23 shows the preliminary bouguer anomaly map of the area. The most noteable features of this map are (1) a gravity minimum which extends from the

Kelly Hills on the Ayers Rock Sheet area through the northern half of the Petermann Ranges Sheet area to the Scott Sheet area twenty to thirty miles south of Giles. (2) A gravity ridge extending along Bloods Range and the northern part of the Ayers Rock Sheet area. (3) A gravity minimum to the north of the gravity ridge.

It may be possible to explain part of the northern gravity minimum by the thickness of Amadeus Basin sediments in that area, but the southern gravity minimum overlies Olia Gneiss, Dean Quartzite and granite. To explain the southern minimum, the gravity ridge to the north, and a maximum farther south, it is necessary to postulate a density contrast in the "basement" rocks and an increased thickness of low density rocks along the gravity minimum. It seems probable that the disposition of the high and low density rocks in the "basement" has been controlled by orogenic processes which also caused the folding of the sediments within the Amadeus Basin.

A strong maximum anomaly in the southern part of the Scott Sheet area may be explained by the presence of high density, basic and ultrabasic igneous rocks.

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64/41
C.4

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REGIONAL GEOLOGY OF THE SOUTHERN MARGIN, AMADEUS BASIN, RAWLINSON RANGE TO MULGA PARK STATION.

BY

D. J. FORMAN and P. M. HANCOCK

RECORDS 1964/41

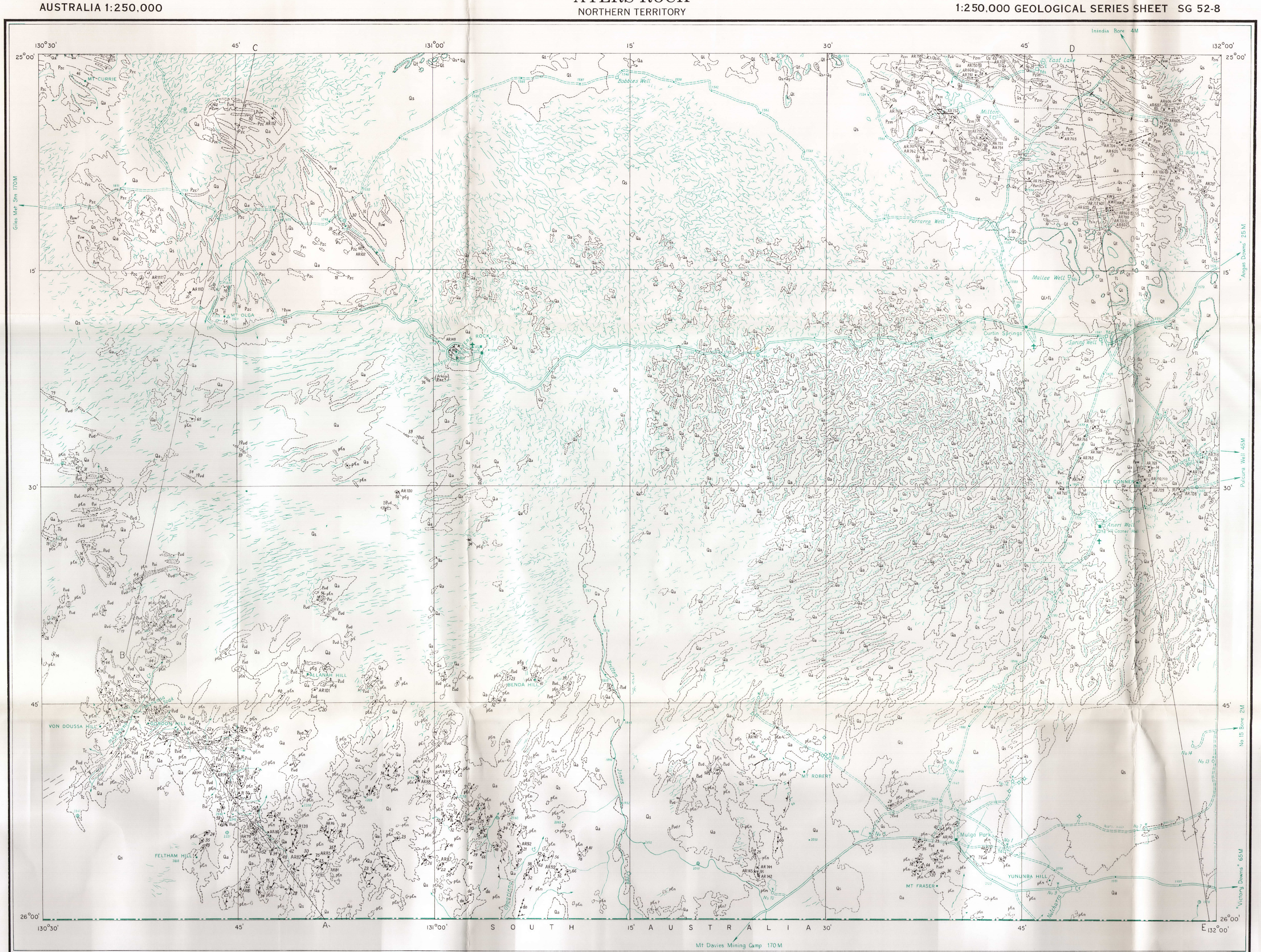
1 : 250,000 MAPS OF AYERS ROCK, PETERMANN RANGES, BLOODS RANGE AND RAWLINSON

AUSTRALIA 1:250,000

AYERS ROCK
NORTHERN TERRITORY

1:250,000 GEOLOGICAL SERIES SHEET SG 52-8

PRELIMINARY EDITION, 1964
SUBJECT TO AMENDMENT



Reference

CAINOZOIC	QUATERNARY		Qa	Alluvium
			Qs	Sand
			Qt	Evaporites
			Ql	Travertine
			Qg	Gypsum
	TERTIARY		Tc	Conglomerate
			Tl	Limestone
PALAEOZOIC	UNDIFFERENTIATED	Mereenie Sandstone	Pzm	Red-brown silty sandstone and white cross-bedded sandstone
	ORDOVICIAN	Stokes Formation	Ot	Shale and siltstone, some fossiliferous dolomite at base
		Stairway Sandstone	Os	White fine sandstone and kaolinitic sandstone, minor siltstone
	CAMBRIAN	Pertaoorrta Formation	Єp	Pebbly conglomerate
	UNDIFFERENTIATED		Pzc	Conglomerate; arkose at Ayers Rock possible lithological variant
PRECAMBRIAN	UPPER PROTEROZOIC	Winnall Beds	Puw	Fine siliceous sandstone and dark brown siltstone, minor conglomerate
		Inindia Beds	Pun	Red-brown and white siltstone, chert, sandstone, pebbly siltstone, thin beds of dolomite
		Bitter Springs Limestone	Pub	Dark grey dolomite
		Pinyinna Beds	Pui	Grey phyllite and quartz-sericite schist
		Dean Quartzite	Pud	Schistose quartzite
	UNDIFFERENTIATED		pЄn	Gneiss with schist and amphibolite
			pЄg	Granite

- Geological boundary
- Anticline, showing plunge
- Syncline, showing plunge
- Overturned anticline
- 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
- Horizontal strata
- Overturned strata
- Dip < 15°
- Dip 15°–45°
- Dip > 45°
- Trend lines
- Joint pattern
- (air-photo interpretation)
- Strike and dip of foliation
- Strike and dip of foliation, unmeasured
- Vertical foliation
- Horizontal foliation
- Strike and dip of bedding with trend of lineation
- Strike and dip of foliation with trend of lineation
- Trend of lineation
- Macrofossil locality
- Specimen locality
- Measured section
- Dyke: do - dolerite
- Bore
- Abandoned bore
- Well
- Tank
- Earth tank
- Windpump
- Spring
- Rockhole
- Sand dunes
- Road
- Vehicle track
- State boundary
- Fence
- Homestead
- Landing ground
- Yard
- Astronomical station
- Trigonometrical station
- Height in feet, instrument levelled — datum: mean sea level
- Height in feet, barometric — Port Augusta

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Base map compiled by the Division of National Mapping, Department of National Development. Aerial photography by the Royal Australian Air Force; complete vertical coverage at 1:46,500 scale.
Transverse Mercator Projection

Geology, 1963, by: D.J. Forman, P.M. Hancock, A.J. Stewart, A.T. Wells
Compilation by: D.J. Forman, A.T. Wells, A.S. Mikolajczak
Drawn, 1964, by: A.S. Mikolajczak

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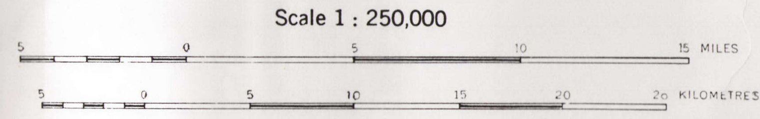
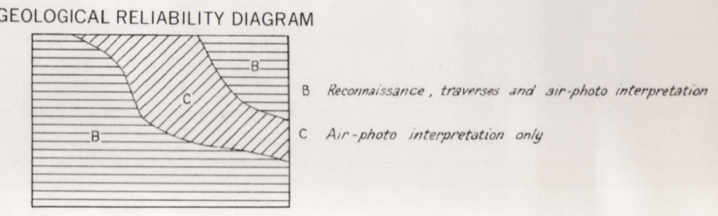
MACDONALD SF 52-14	MT RENNIE SF 52-15	MT LIEBIG SF 52-16	HERMANNSBURG SF 53-13	ALICE SPRINGS SF 53-14
RAWLINSON SG 52-2	BLOODS RANGE SG 52-3	LAKE AMADEUS SG 52-4	HENBURY SG 53-1	RODINGA SG 53-2
SCOTT SG 52-6	PETERMANN RANGES SG 52-7	AYERS ROCK SG 52-8	KULGERA SG 53-5	FINKE SG 53-6
COOPER SG 52-10	MANN SG 52-11	WOODROFFE SG 52-12	ALBERGA SG 53-9	ABMINGA SG 53-10
WAIGEN SG 52-14	BIRKSGATE SG 52-15	LINDSAY SG 52-16	EVERARD SG 53-13	WINTINNA SG 53-14

ANNUAL CHANGE 1'30"E

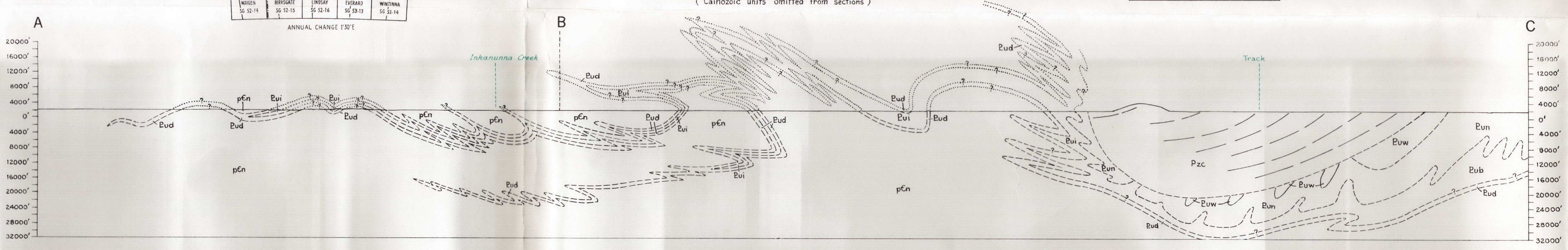
Scale 1 : 250,000

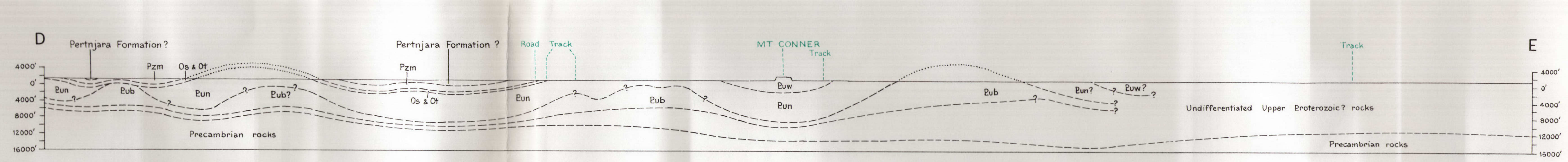


GEOLOGICAL RELIABILITY DIAGRAM



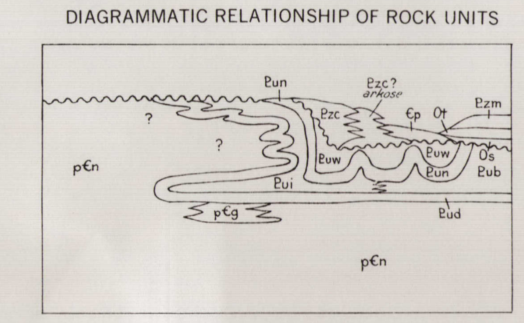
Sections
Folding schematic
SCALE : $\frac{V}{H} = 1$
(Cainozoic units omitted from sections)





AYERS ROCK
SHEET SG 52-8

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



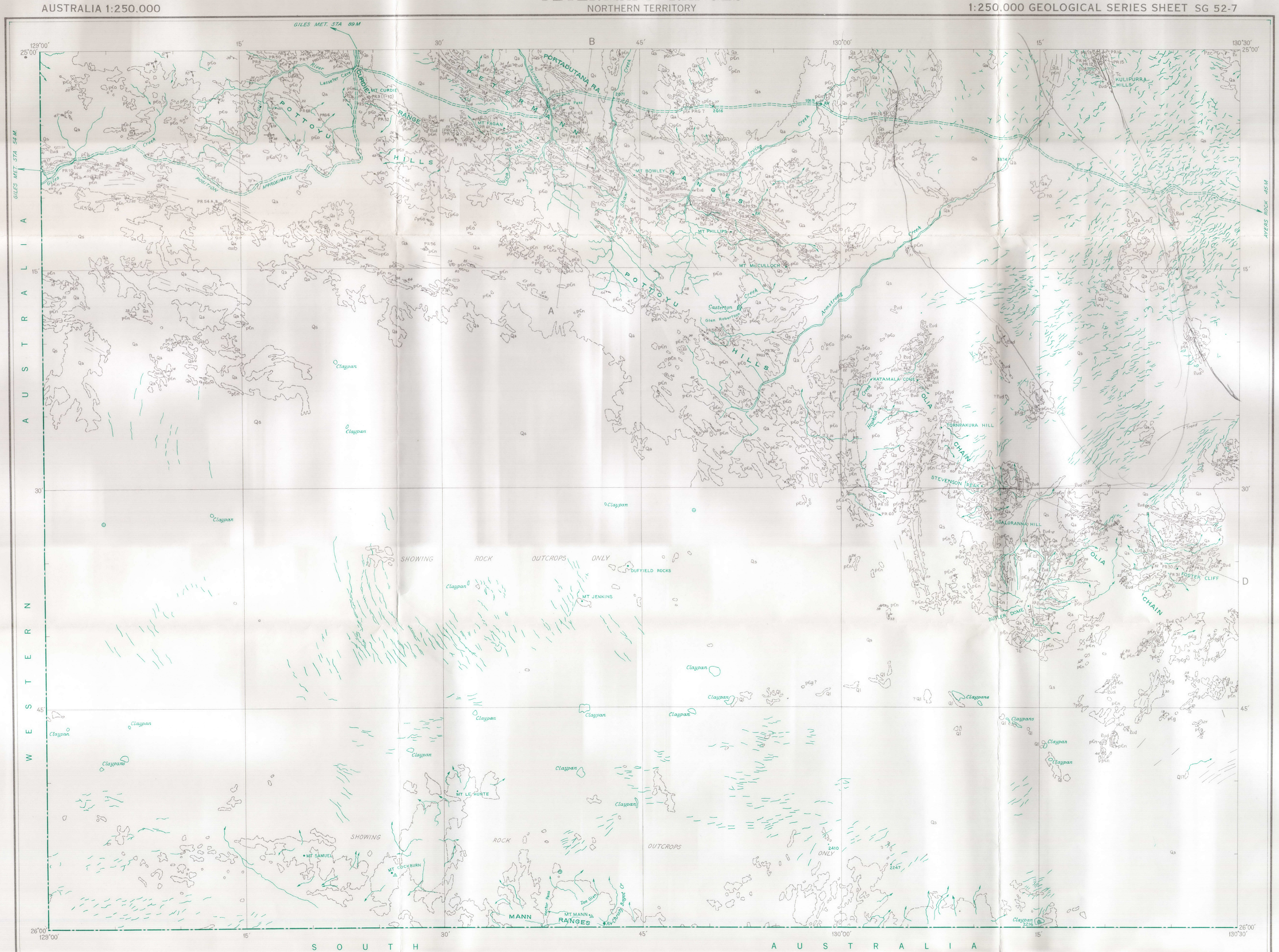
Unconformity

AUSTRALIA 1:250,000

PETERMANN RANGES

NORTHERN TERRITORY

1:250,000 GEOLOGICAL SERIES SHEET SG 52-7



PRELIMINARY EDITION, 1964

SUBJECT TO AMENDMENT

Reference

CAINOZOIC	QUATERNARY		Qs	Sand
			Qa	Alluvium
			Ql	Travertine
	? TERTIARY		Tc	Conglomerate
			T	Sandstone
PALAEOZOIC	ORDOVICIAN		O	White Sandstone
	UNDIFFERENTIATED	Mount Currie Conglomerate	Pzc	Conglomerate
PRECAMBRIAN	UPPER PROTEROZOIC		Ꝑu	Sandstone, siltstone
		Pinyinna Beds	Ꝑui	Slate, dolomite schist, schist
		Dean Quartzite	Ꝑud	Quartzite
	UNDIFFERENTIATED		p€g	Granite
		Pottoyu Granite Complex	p€o	Granite, gneiss, amphibolite, schist
		Olia Gneiss	p€n	Gneiss, porphyroblastic gneiss
			p€m	Porphyroblastic schist, schistose porphyry
		Bloods Range Beds	p€b	Schist, quartzite

- Geological boundary
- Anticline, showing plunge
- Syncline, showing plunge
- Overturned anticline
- Overturned syncline
- 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

- 40 Strike and dip of strata
- Vertical strata
- Horizontal strata
- 70 Overturned strata
- Dip < 15° (air-photo interpretation)
- Dip 15° — 45° (air-photo interpretation)
- Trend lines (air-photo interpretation)
- Joint pattern (air-photo interpretation)
- Vertical foliation (air-photo interpretation)
- 50 Strike and dip of foliation, with lineation
- 31 Strike and dip of bedding, with lineation
- 26 Direction and plunge of lineation
- Vertical joint
- Macrofossil locality
- × PRG 3 Text reference to specimen locality
- Dyke or vein, q - quartz
- RH Rockhole
- Sand dunes
- Scarp
- Vehicle track
- State boundary
- Astronomical station
- Trigonometrical station
- •2247 Height in feet, barometric; datum: mean sea level

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Topographic base compiled by the Division of National Mapping, Department of National Development. Aerial photography by the Royal Australian Air Force; complete vertical coverage at 1:46,500 scale. Transverse Mercator Projection.

INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

RYAN SF 52-13	MACDONALD SF 52-14	MT RENNIE SF 52-15	MT LEIBIG SF 52-16	HERMANNSBURG SF 53-13
COBB SG 52-1	RAWLINSON SG 52-2	BLOODS RANGE SG 52-3	LAKE AMADEUS SG 52-4	HENBURY SG 53-1
BENTLEY SG 52-5	SCOTT SG 52-6	PETERMANN RANGES SG 52-7	AYERS ROCK SG 52-8	KULGERA SG 53-5
TALBOT SG 52-9	COOPER SG 52-10	MANN SG 52-11	WOODROFFE SG 52-12	ALBERGA SG 53-9
LENNIS SG 52-13	WAIGEN SG 52-14	BIRKSGATE SG 52-15	LINDSAY SG 52-16	EVERARD SG 53-13

ANNUAL CHANGE 1′E

Scale 1:250,000

5 0 5 10 15 MILES

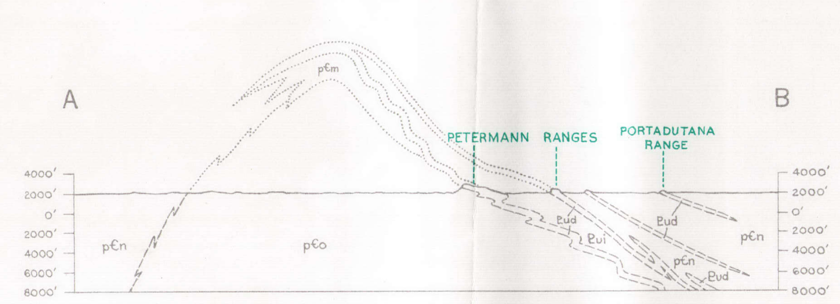
5 0 5 10 15 20 25 KILOMETRES

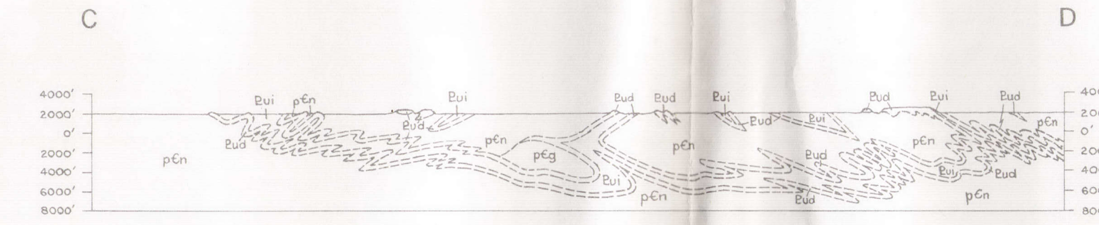
Sections

Scale $\frac{V}{H} = 1$

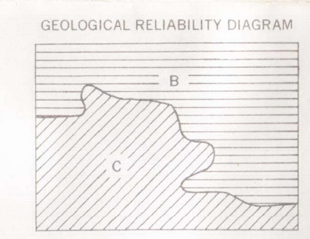
Folding schematic

(Cainozoic units omitted from sections)





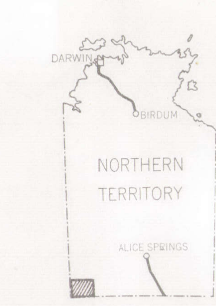
GEOLOGICAL RELIABILITY DIAGRAM



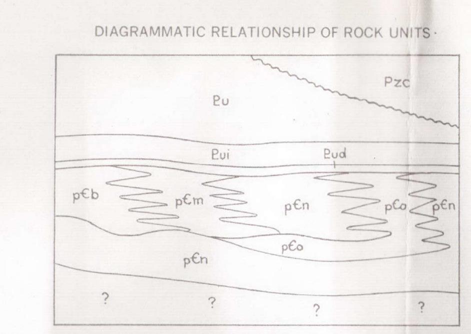
B Reconnaissance — numerous traverses and air-photo interpretation

C Air-photo interpretation

Geology, 1963, by: D.J.Forman, P.M.Hancock.
1962, by: D.J.Forman, A.J.Stewart.
Compiled, 1964, by: D.J.Forman.
Drawn by: F.J.Roberts.



DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Unconformity

PETERMANN RANGES

SHEET SG 52-7

AUSTRALIA 1:250,000

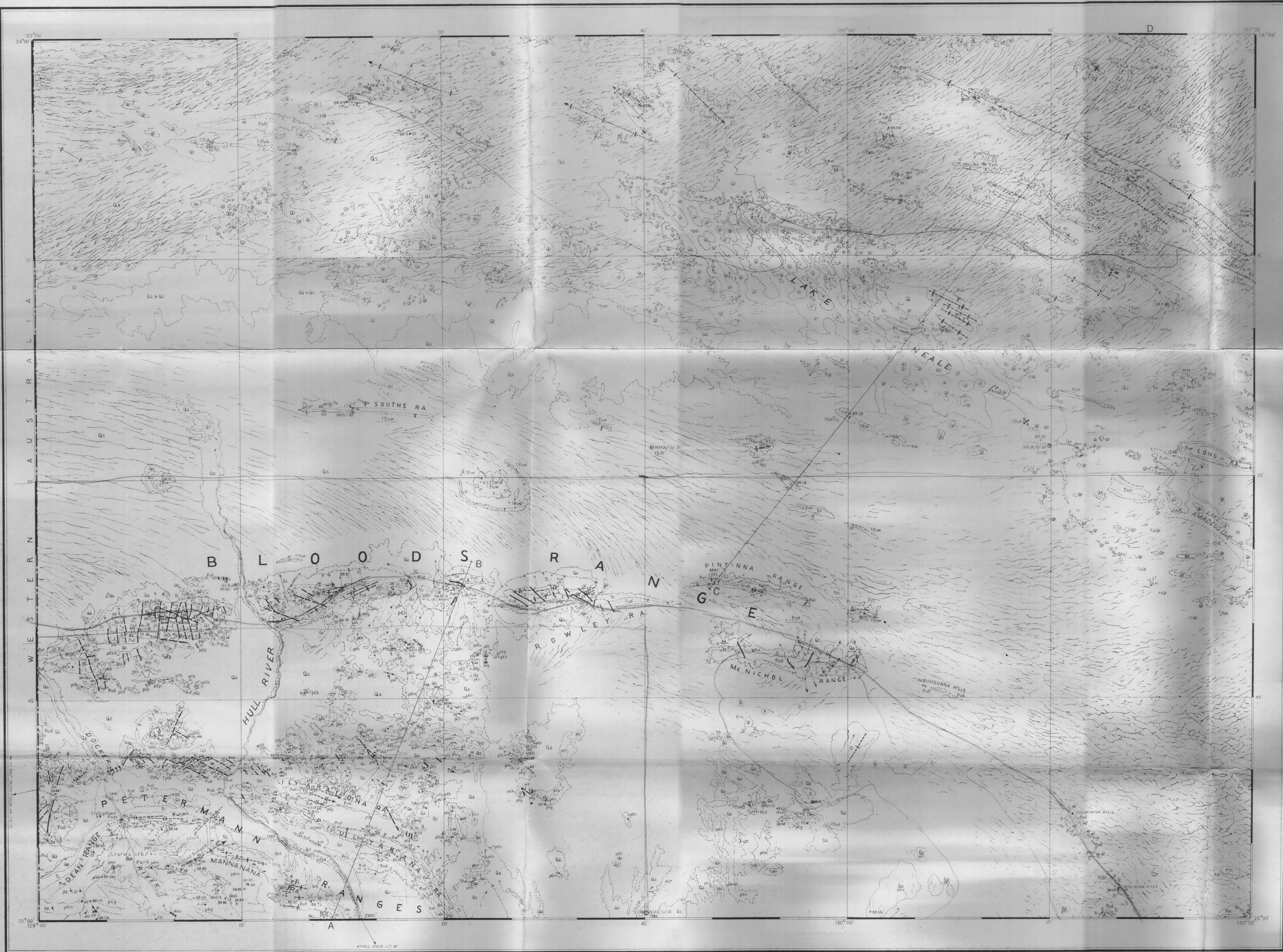
BLOODS RANGE

NORTHERN TERRITORY

1:250,000 GEOLOGICAL SERIES SHEET SG 52-3

PRELIMINARY EDITION, 1963

SUBJECT TO AMENDMENT



Reference

CAINOZOIC	QUATERNARY		Qs	Sand
			Qa	Alluvium
			Qt	Evaporites
			Ql	Travertine
	TERTIARY ?		Tc	Conglomerate
PALAEOZOIC	UNDIFFERENTIATED	Pertnjara Formation	Pzp	Siltstone
		Mereenie Sandstone	Pzm	Brown and white sandstone. Large scale cross bedding
		Mt. Currie Conglomerate	Pzc	Conglomerate
	ORDOVICIAN	Undifferentiated	O	White sandstone, pipe rock, conglomerate dolomite and siltstone, some marine fossils
		Larapinta Group	Ol	Sandstone, siltstone, rare limestone. Marine fossils
	CAMBRIAN	Cleland Sandstone	€c	Crossbedded sandstone and pebbly sandstone, siltstone
PRECAMBRIAN	UPPER PROTEROZOIC	Winnall Beds	Puw	Brown and white sandstone, pebbly sandstone, siltstone
		Undifferentiated	Pu	Sandstone and siltstone
		Inindia Beds	Pun	Red siltstone, dolomite, chert. Algal stromatolites, gypsum
		Bitter Springs Limestone	Pub	Crystalline dolomite. Algal stromatolites
		Pinyinna Beds	Pui	Dolomite and siltstone. Algal stromatolites
		Dean Quartzite	Pud	Quartzite and conglomeratic quartzite, sandstone
	UNDIFFERENTIATED	Undifferentiated	p€p	Quartz feldspar porphyry
			p€	Granite, schist, gneiss
			p€g	Coarse porphyritic granite
			p€n	Gneiss
			p€m	Porphyroblastic schists, quartz-feldspar porphyry
		Bloods Range Beds	p€b	Sandstone, arkose, tuff, agglomerate, basalt and acid porphyry
		Mount Harris Basalt	p€h	Epidotized amygdaloidal basalt

Geological boundary

Syncline, showing plunge

Syncline, overturned

Anticline, showing plunge

Anticline, overturned, showing plunge of axis

Fault

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

Strike and dip of strata

Vertical strata

Overturned strata

Dip < 15°

Dip 15° - 45°

Dip > 45° } air-photo interpretation

Trend lines

Joint pattern

Strike and dip of bedding and plunge of lineation

Strike and dip of foliation

Strike and dip of foliation and plunge of lineation

Vertical joint

Macrofossil locality

×BR 84 Text reference to specimen locality

Dyke or vein: q - quartz

Minor mineral occurrance

Pb Lead

Cu Copper

Ph Phosphate rock

•RH Rockhole

Sand dunes

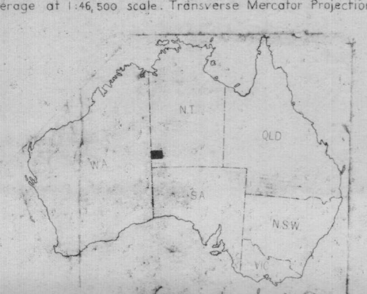
•B Water bore

Vehicle track

⊕NMA/G/30 Astronomical station

·1514' Height in feet, instrument levelled; datum: mean sea level, Port Augusta, S.A.

Compiled and published by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Topographic base compiled by the Division of National Mapping, Department of National Development. Aerial photography by Adastra Airways Pty. Ltd., 1957; complete vertical coverage at 1:46,500 scale. Transverse Mercator Projection.



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COBB SG 52-1	RAWLINSON SG 52-2	BLOODS RANGE SG 52-3	LAKE AMADEUS SG 52-4	HENBURY SG 53-1
BENTLEY SG 52-5	SCOTT SG 52-6	PETERMANN RANGES SG 52-7	AYERS ROCK SG 52-8	KULGERA SG 53-5
TALBOT SG 52-9	COOPER SG 52-10	MANN SG 52-11	WOODROFFE SG 52-12	ALBERGA SG 53-9

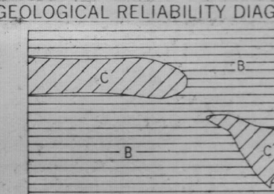
ANNUAL CHANGE 1'E

Scale 1 : 250,000

MILES 5 0 5 10 15

KILOMETRES 5 0 5 10 15 20 25

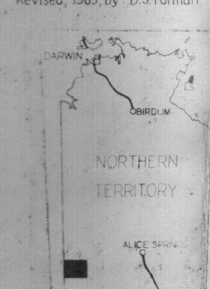
GEOLOGICAL RELIABILITY DIAGRAM



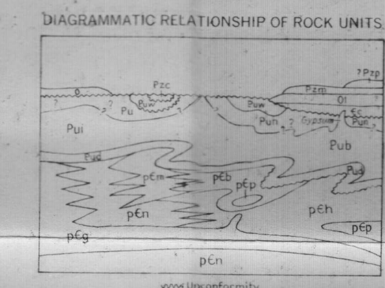
B Reconnaissance-traverses and air-photo interpretation

C Air-photo interpretation

Geology, 1962, by: D.J. Forman, A.J. Stewart
Compiled, 1962, by: D.J. Forman, A.J. Stewart
Drawn by: E.H.J. Feeken
Revised, 1963, by D.J. Forman

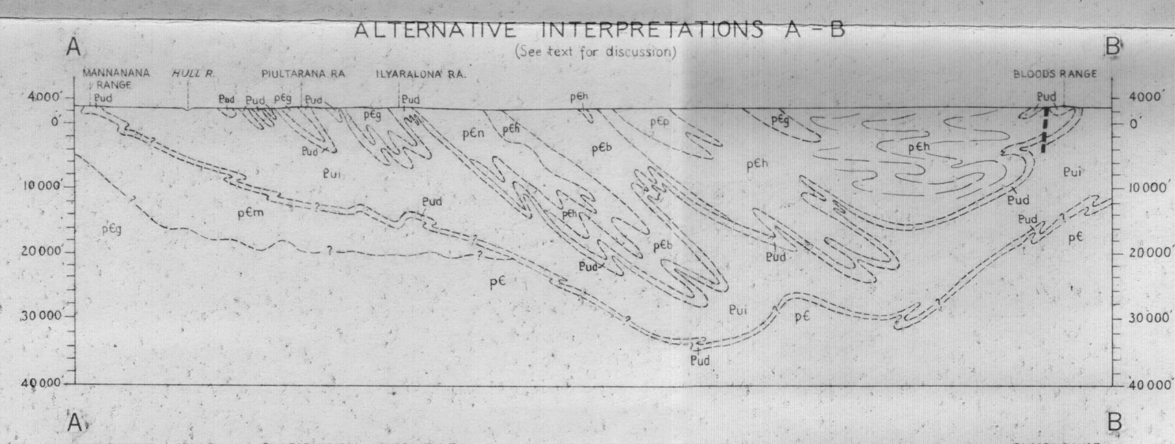


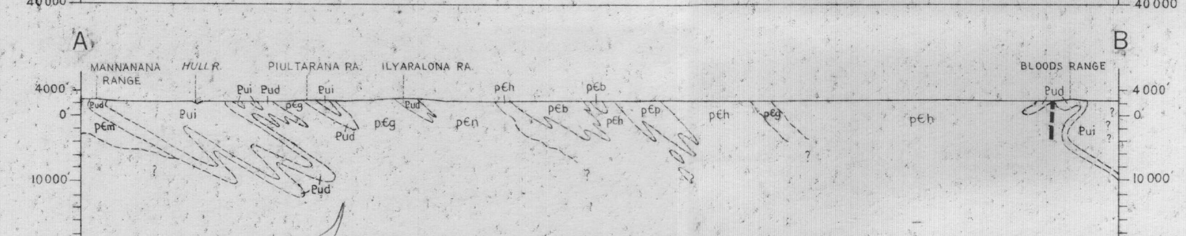
DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



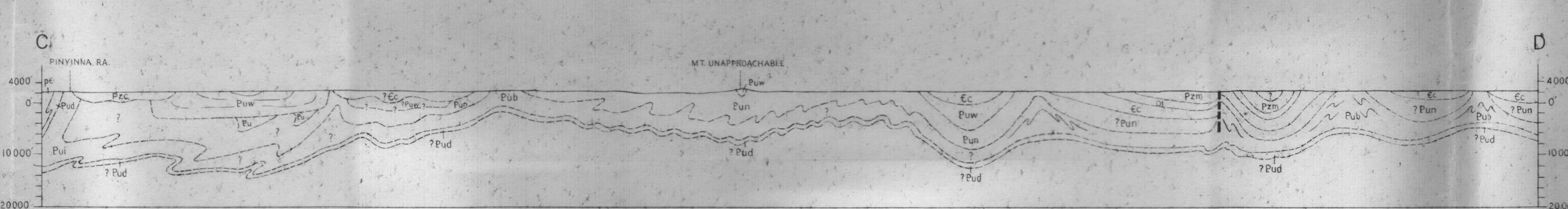
ALTERNATIVE INTERPRETATIONS A - B

(See text for discussion)





Sections



BLOODS RANGE

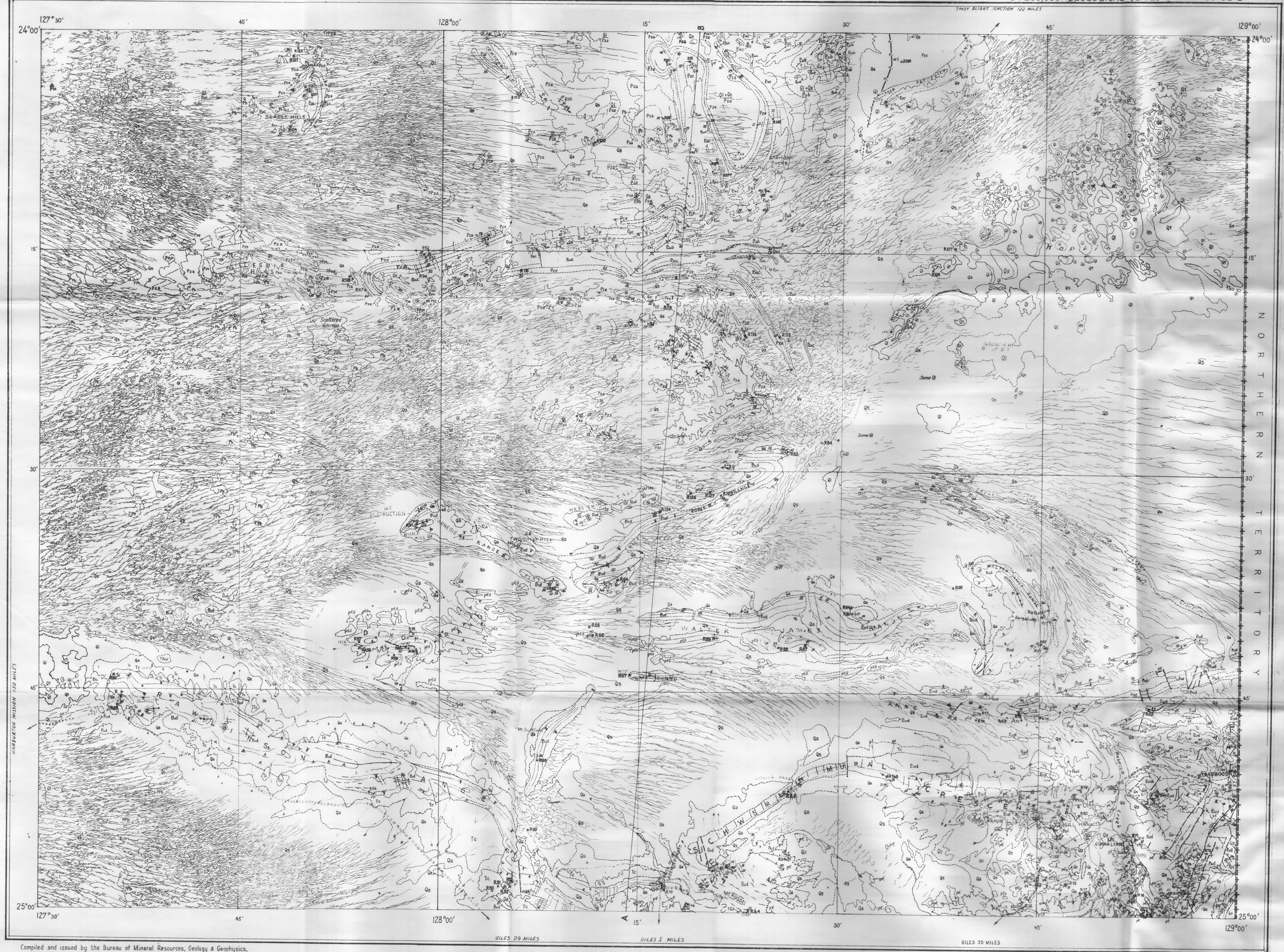
SHEET SG 52-3

AUSTRALIA 1 : 250,000

RAWLINSON

WESTERN AUSTRALIA

1 : 250,000 GEOLOGICAL SERIES SHEET SG 52-2



Reference

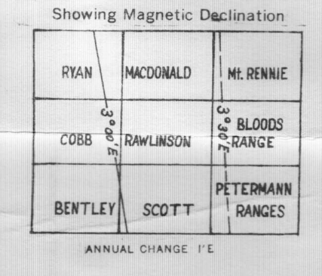
CAINOZOIC	QUATERNARY		Qs	*Sand*
			Qa	*Alluvium*
			Qt	*Evaporites*
			Ql	*Travertine*
	? TERTIARY		Tc	*Conglomerate*
PALAEOZOIC	PERMIAN	Buck Formation	Pb	*Coarse sandstone, conglomerate with tillitic texture and siltstone, erratics*
	UNDIFFERENTIATED	Mereenie Sandstone	Pzm	*Fine, cross bedded quartz sandstone*
	ORDOVICIAN		O	*Mottled pink and white limestone, sandstone with "pipe rock"*
	Unconformity ?			
UPPER PROTEROZOIC -PALAEOZOIC		Maurice Formation	Pza	*Quartz sandstone, quartz greywacke and micaceous siltstone and sandstone*
		Sir Frederick Conglomerate	Pzs	*Boulder pebble and cobble conglomerate. Lenses of sandstone*
		Ellis Sandstone	Pze	*Quartz sandstone, some interbedded calcareous sandstone, pebbly sandstone, siltstone*
PRECAMBRIAN	UPPER PROTEROZOIC	Carnegie Formation	Puc	*Quartz greywacke, sandstone, siltstone and shale*
		Bitter Springs Limestone	Pub	*Dolomite, limestone, calcilutite and siltstone. Stromatolites*
		Dean Quartzite	Pud	*Quartzite, sericitic quartzite, sandstone, sericitic-quartz schist, schistose sericitic quartzite and some conglomerate*
	Unconformity ?			
	UNDIFFERENTIATED	Dixon Range Beds	p€d	*Quartz sandstone, siltstone, fine conglomerate, shale, arkose, arkosic sandstone, some quartz-mica schist and greywacke*
			p€	*Quartzite, quartz sandstone, quartz-sericite schist, quartz-feldspar-sericite schist, slate, chlorite schist, phyllite and sheared basalt*
			p€g	*Granite (section only)*
			p€p	*Quartz-feldspar porphyry*

Geological boundary
Syncline, showing plunge
Anticline, showing plunge
Overturned anticline
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
48 *Strike and dip of strata*
Prevailing dip
Vertical strata
Horizontal strata
Dip < 15° } *Air-photo interpretation*
Dip 15°-45°
Dip > 45°
Trend of bedding
Joint pattern
80 *Strike and dip of joints*
Vertical joints
60 *Strike and dip of foliation*
Vertical foliation
50 *Plunge of lineation*
Measured section
Macrofossil locality
× R21 *Text reference to specimen locality*
B *Bore with windpump*
R.H. *Rock hole*
Sand dune
Road
Track
Trigonometrical station
·1710 *Height in feet, instrument levelled* } *Datum mean sea level. Port Augusta*
·1624 *Height in feet, barometric*
P.D. *Position doubtful*

Compiled and issued by the Bureau of Mineral Resources, Geology & Geophysics, Department of National Development. Topographic base compiled from controlled air-photo mosaics supplied by the Western Australian Department of Lands and Surveys. Aerial photography by the Royal Air Force; complete vertical coverage at 1:40,000 scale. Transverse Mercator Projection.

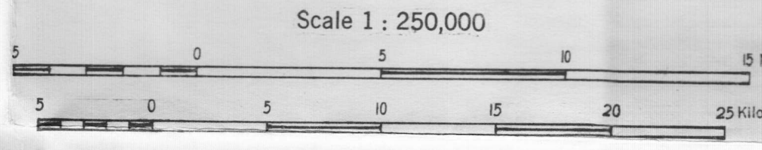
INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

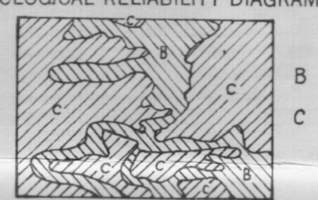


ANNUAL CHANGE 1'E

Scale 1 : 250,000



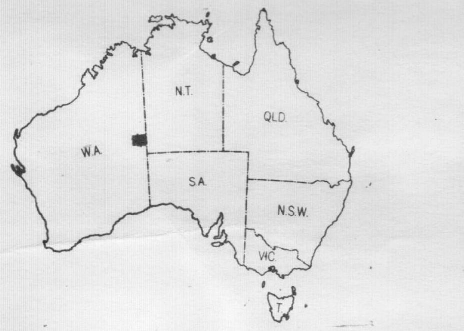
GEOLOGICAL RELIABILITY DIAGRAM



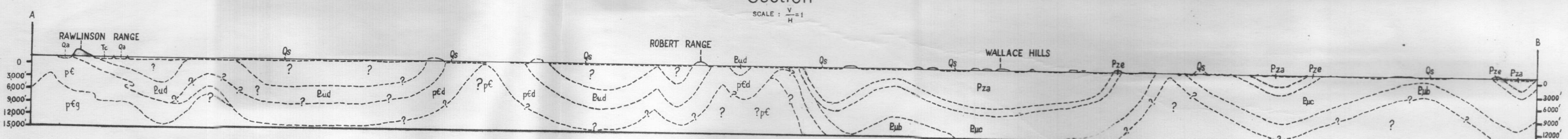
B Reconnaissance: traverses and air-photo interpretation

C Sketchy: air-photo interpretation

Geology and compilation 1962 by: A.T. Wells, D.J. Forman, L.C. Ranford
Geology 1963 by: D.J. Forman and P.M. Hancock
Recompiled 1964 by: A.T. Wells and D.J. Forman
Drawn by: H.F. Boltz and G. Matveev



Section



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SHEET SG52-2