COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT No. 87

The Geology of the South-Western Margin of the Amadeus Basin, Central Australia

BY

D. J. FORMAN

Issued under the Authority of the Hon. David Fairbairn
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MINISTER: THE HON. DAVID FAIRBAIRN, D.F.C., M.P.

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SUMMARY

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

The oldest formations in the area, the Mount Harris Basalt and Bloods Range Beds, are a sequence of Precambrian basic and acid volcanics with interbedded sediments. These formations 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 south-west margin of the basin. It is correlated with the Heavitree Quartzite, which occupies a similar stratigraphical and structural position along the northern margin. The Dean Quartzite is succeeded by the Pinyinna Beds, a sequence of carbonate sediments, shale, and siltstone, which is equivalent to the Bitter Springs Limestone within the Amadeus Basin and along its northern margin.

The Inindia Beds and Winnall Beds are composed of siltstone, sandstone, thin limestone, and dolomite, and are correlated with the Areyonga and Pertatataka Formations of the northern Amadeus Basin. In the south, the Inindia Beds and Winnall Beds are separated by an angular unconformity, but this dies out to the north.

During a major orogeny, the Petermann Ranges Orogeny, in late Upper Proterozoic time, the Precambrian sediments on the southern margin of the Basin were folded: the Mount Harris Basalt, Bloods Range Beds, Dean Quartzite, and 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 30 miles across the strike. During the regional overturning, granite, gneiss, and schist were formed from the Bloods Range Beds and Mount Harris Basalt, but the Dean Quartzite formed a metamorphic barrier which largely protected itself and the Pinyinna Beds from conversion to gneiss and granite. Radioactive age determination on two specimens from one of the large granites indicates that the age of folding is 600 to 670 million years.

During the recumbent folding and regional metamorphism, the Pinyinna Beds and Bitter Springs Limestone were overlain by about 10,000 feet of sediment, the Inindia and Winnall Beds. The Inindia and Winnall Beds were squeezed northwards out of the core of the recumbent fold and slid northwards on a décollement surface in the Pinyinna Beds and Bitter Springs Limestone. The tight isoclinal folding of these formations dies out to the north away from the orogenic zone.

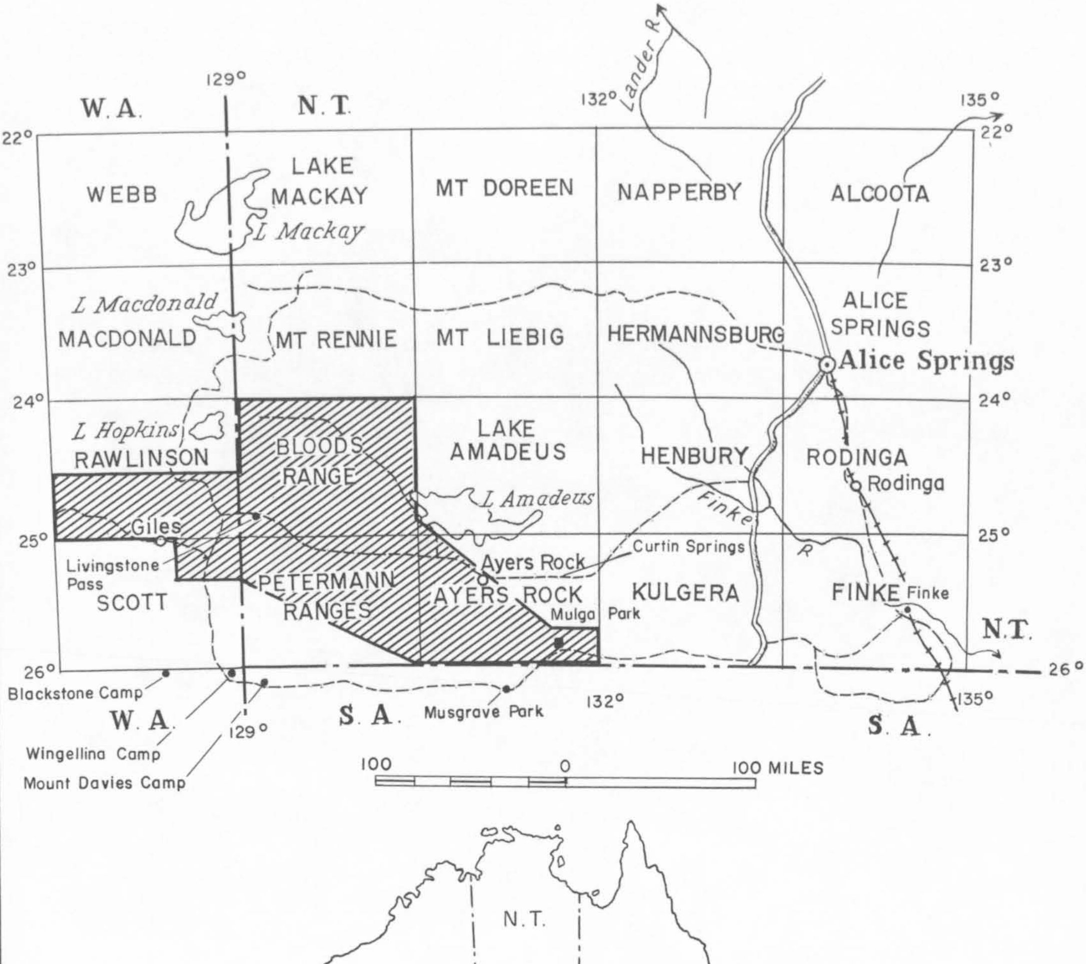
The formation of the regional recumbent fold raised the south-western margin of the Amadeus Basin above sea level, probably as a mountain chain. This elevated area was rapidly eroded, and on the northern flank of the fold, thick wedges of conglomerate and arkose were deposited unconformably on the Upper Proterozoic sediments. The conglomerate (the Mount Currie Conglomerate) and the arkose at Ayers Rock are probably Cambrian in age. Farther north, the post-orogenic Cleland Sandstone was deposited in a deltaic to paralic environment, marginal to the marine Cambrian facies of the Amadeus Basin.

By Ordovician time the mountain chain formed by the Petermann Ranges Orogeny had been eroded, and farther north the Larapinta Group was deposited within the Amadeus Basin in a comparatively stable shelf environment. Marine equivalents of the Larapinta Group were also deposited over parts of the eroded mountain chain in the southern half of the Bloods Range Sheet area and on the north-east quadrant of the Petermann Ranges Sheet area. There has been little tectonic activity along the southern margin of the basin since the Petermann Ranges Orogeny.

Another orogeny, the Alice Springs Orogeny, affected the northern margin of the Amadeus Basin in the Devonian. Like the Petermann Ranges Orogeny, it caused recumbent folding in the Bitter Springs Limestone and older rocks along the margin of the basin, and décollement sliding and folding of the sediments over the Bitter Springs Limestone. Two formations, conformable on the Larapinta Group, reflect this orogeny: the Mereenie Sandstone, which was deposited in the pre-orogenic phase when the sea was driven from the area; and the Pertnjara Formation, which is a thick continental deposit laid down during the orogeny. The Pertnjara Formation was folded together with the older rocks during the Alice Springs Orogeny, but the intensity of the folding decreases to the south.

The youngest rocks in the area include superficial accumulations of Tertiary sandstone and conglomerate, and Quarternary travertine, evaporites, alluvium, and aeolian sand.

The prospects of petroleum accumulation in the Palaeozoic sediments are negligible near the south-west margin of the basin as they are widely exposed and all anticlines are breached to the Upper Proterozoic. The search for oil must be directed at source and reservoir beds in the Upper Proterozoic sediments. The Upper Proterozoic sediments are up to 14,000 feet thick, but much of the area is covered by sand and no closed anticlinal structures or other suitable traps have been mapped on the Bloods Range or Ayers Rock Sheet areas. The petroleum prospects of the area are rated as poor.



Bureau of Mineral Resources, Geology and Geophysics. October, 1964. NT/A 88 LK

Fig.1 LOCALITY MAP and 1:250,000 SHEET INDEX

INTRODUCTION

The area described in this report (Fig. 1) was mapped as part of the regional survey of the Amadeus Basin by the Bureau of Mineral Resources.

Location and Access

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 tracks from Ayers Rock to Giles (Pl.4, fig. 1) and Lake Amadeus are suitable for four-wheel-drive vehicles only.

The Bloods Range and Petermann Ranges Sheet areas and part of the Ayers Rock Sheet area lie within a Northern Territory aboriginal reserve; the Rawlinson and Scott Sheet areas lie within a Western Australian aboriginal reserve, and the road to Giles passes through a South Australian aboriginal reserve. The Giles Meteorological Station is administered and maintained by the Weapons Research Establishment.

Climate

The mean maximum and minimum temperatures and average monthly rainfall for Giles for the period 1957-1962 inclusive are given in Wells, Forman, & Ranford (1965a, Fig. 2). Winter temperatures are pleasant but summer temperatures are uncomfortably high. The area is subject to periodic droughts, and rainfall averages less than 10 inches per annum.

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 and good water was obtained from several bores in the Livingstone Pass area in 1963. The bores near Livingstone Pass were sunk by the Water Resources Board of the Northern Territory Administration with a view to establishing an aboriginal settlement in the area, and at the same time, the Animal Industries Branch of the Northern Territory Administration reported on the grazing prospects of the Petermann Ranges area. There are two good water bores at Ayers Rock, which is well established as a tourist resort. A ranger is permanently employed and good graded roads provide access to and around Mount Olga. Ayers Rock is connected to Curtin Springs station by a first-class graded road, and the station maintains a general store and petrol station for the public. Curtin Springs and Mulga Park stations are connected by a graded road, and the eastern side of the Ayers Rock Sheet area has been developed for grazing.

Other places of interest include the abandoned nickel-prospecting camps at Blackstone and Wingellina in Western Australia and at Mount Davies 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 the aboriginal reserves no watering places (sheds, tanks, catchments, bores, or wells) may be established without the permission of the Aborigines Protection Board, and the aboriginal watering places can only be used in cases of dire necessity.

Survey Method

Mapping was carried out by Land Rover 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 air-photographs at a scale of about 1:46,500 in the Northern Territory, and 1:36,500 in Western Australia. The geology was transferred to transparent controlled slotted templet assemblies which were reduced photographically to a scale of 1:250,000.

Previous Investigations

The south-western margin of the Amadeus Basin was first explored by E. Giles in 1872-1874 and 1876 (Giles, 1889). The first scientific investigations were made by the Central Australian Exploring Expedition in 1889 (Tietkens, 1891), followed by the Horn Scientific Expedition in 1896 (Tate & 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 & George, 1904). During 1902 R.T. Maurice (Murray, 1904) passed through the area and recorded gypsum and dolomitic limestone at Mount Murray. H. Basedow led a prospecting and geological expedition to the area in 1903 and recorded geological observations on 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, which produced a geological sketch map but found no mineralization apart from a trace of gold at Foster Cliff (George,1907). During 1926, H. Basedow and D. Mackay examined the geology of the Bloods Range and Petermann Ranges, and Basedow published a geological report on the Petermann Ranges (Basedow, 1929). This was followed by Mackay's aerial survey of the Petermann Ranges in 1930 (Mackay, 1934).

Lasseter's report of a rich gold reef gave rise to many expeditions in the 1930's, but the reef is now considered to be non-existent. In 1935 the Border Gold Reef Expedition traversed the Olia Chain and the Petermann Ranges into Western Australia in search of the reef. H.A. Ellis was attached as geologist to another party in 1936 (Ellis, 1937). Faith in the existence of Lasseter's Reef was still strong enough 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).

In 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 visited the area during a reconnaissance gravity survey of the Amadeus Basin (Lonsdale & Flavelle, 1963).

The geological mapping of the south-western margin of the Amadeus Basin was carried out by the Bureau of Mineral Resources in the following stages: the Rawlinson and Macdonald Sheet areas were mapped in 1960 (Wells, Forman, & Ranford, 1965a); the Bloods Range Sheet area in 1962 by D.J. Forman and A.J. Stewart (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 in 1963 (Forman & Hancock, 1964).

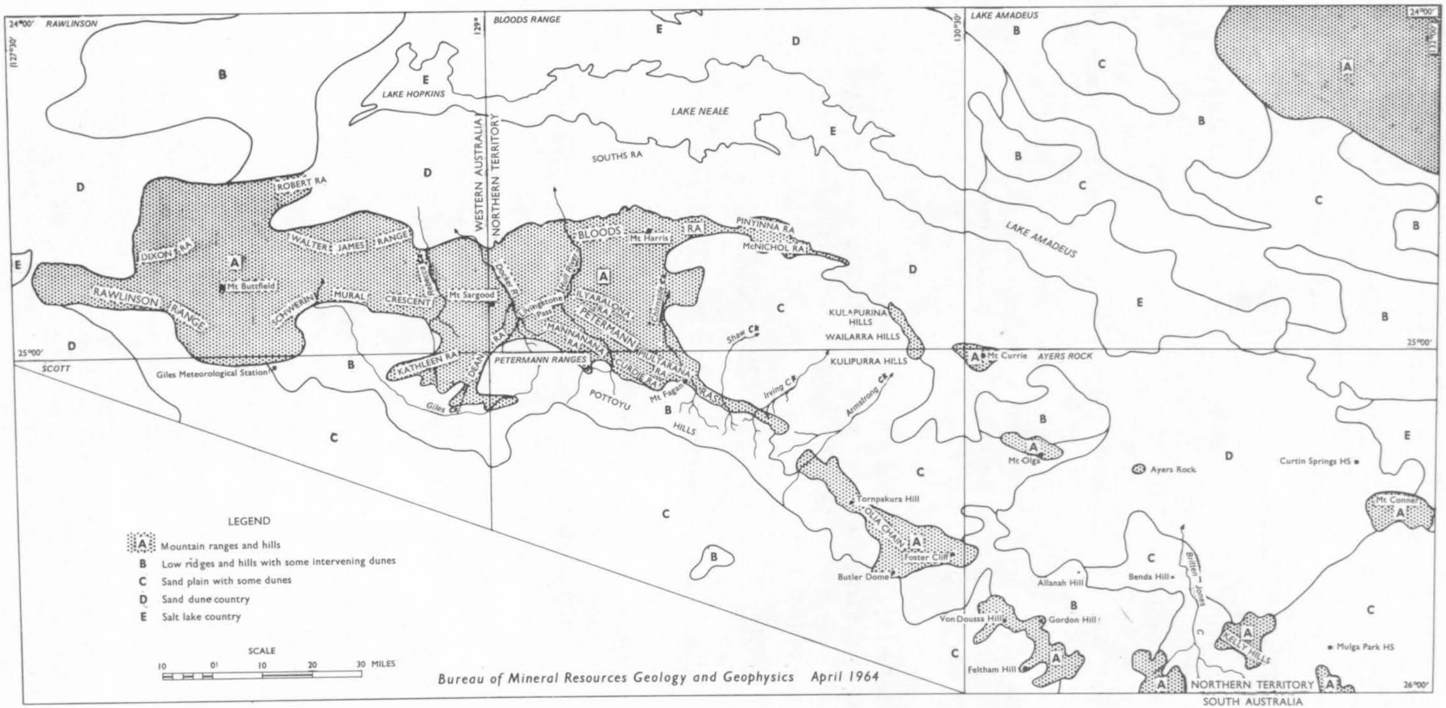


Figure 2 : Physiographic divisions

PHYSIOGRAPHY

The main physiographic divisions along the south-western margin of the Amadeus Basin are as follows (see also Fig. 2): mountain ranges and hills; low ridges and hills with some intervening dunes; sand plain with some dunes; sand dune country; salt lake country.

The mountain ranges and hills are up to 3500 feet above sea level and 1500 feet above the surrounding plain. They form an outstanding feature extending for over 200 miles in an easterly direction from the Rawlinson Range and Schwerin Mural Crescent in Western Australia to the Petermann Ranges (Pl.4, fig. 1) and Olia Chain in the Northern Territory. A parallel chain of ranges and hills farther north 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. The ranges and hills are composed mainly of tough Dean Quartzite. The ranges are long and rugged and generally have steep scarp slopes and moderate dip slopes. The rivers are deeply incised 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 north towards Lakes Hopkins, Neale, and Amadeus.

In the Ayers Rock Sheet area three remarkable inselbergs, Ayers Rock, Mount Olga, and Mount Conner, form conspicuous landmarks to the north of the ranges. The inselbergs, which rise over 1000 feet above the surrounding plain, have been described in detail by Ollier & Tuddenham (1961).

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

Sand plain with some dunes: Sand plain with widely spaced sand dunes and a few low outcrops occurs to the north and south of the 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.

The sand dune country is characterized by closely spaced longitudinal dunes, which are branching and generally trend easterly, and by areas containing a braided network of dunes (Pl. 1, fig. 1). The dunes are composed of unconsolidated sand fixed by spinifex. They range up to 40 feet in height.

Salt lake country: Most of the salt lakes occur in a west-north-west belt to the north of the ranges. They include Lakes Amadeus, Neale (Pl. 1, fig. 2), and Hopkins. The lakes contain numerous islands and are fringed by sand and travertine. They lie about 1500 feet above sea level.

STRATIGRAPHY

Introduction

On the northern margin of the Amadeus Basin the Upper Proterozoic Heavitree Quartzite, which occurs at the base of the sedimentary succession, rests unconformably on the eroded surface of the Arunta Complex of gneiss, granite, and schist, but in the south the junction

TABLE 1 - STRATIGRAPHY OF THE SOUTH-WEST MARGIN, AMADEUS BASIN

AGE	UNIT	MAP SYMBOL	LITHOLOGY	CORRELATION	REMARKS
Quaternary		Qs	Sand		
		Qa	Alluvium		
		Qt	Evaporites		
		Ql	Travertine		
Tertiary?		Tc	Conglomerate		Adjacent to high ranges
		T	Sandstone		
ORDOVICIAN ? CARBONIFEROUS	Pertnjara Formation	Pzp	White siltstone		Very poor outcrop. Only base of unit exposed
	Mereenie Sandstone	Pzm	Brown and white fine-grained sandstone. Large and moderate scale cross bedding		Lithologically similar to Winnall Beds. Conformable on Larapinta Group. Estimated thickness 2000 ft.
ORDOVICIAN	Undifferentiated	O	Sandstone, pipe rock, conglomerate, dolomite, limestone, shale, and siltstone. Some marine fossils	Larapinta Group	Shallow marine sedimentary outliers of Amadeus Basin sediments resting unconformably on gneiss. Some phosphatic sediments
	Larapinta Group	Ol	Sandstone, siltstone, limestone, fine conglomerate, and pipe rock, oolitic hematite, calcareous sandstone, dolomite. Marine fossils		Several thin beds of oolitic hematite. Estimated thickness W.N.W. of Mt. Murray, 1000 ft.
CAMBRIAN	Cleland Sandstone	Єc	Red-brown and brown medium to coarse-grained poorly sorted angular sandstone, conglomeratic sandstone, and conglomerate. Entirely cross-bedded. Some siltstone	Part of Pertaoorrta Formation. Mount Currie Conglomerate. Sir Frederick Conglomerate, Ellis Sandstone, Maurice Formation	Deltaic and paralic sandstone. Uppermost beds may be Ordovician in age. Estimated thickness on eastern side of Sheet area 2000 ft.
	Ayers Rock arkose Mount Currie Conglomerate Dolerite	- Pzc d	Arkose, siltstone Conglomerate, sandstone Dolerite	Pertaoorrta Formation, Sir Frederick Conglomerate, Ellis Sandstone, Maurice Formation	Over 8000 ft. of arkose and conglomerate were deposited as thick wedges in front of the regional recumbent fold. They contain fragments of dolerite
UNCONFORMITY					
PRECAMBRIAN UPPER PROTEROZOIC	Winnall Beds	Ꝑuw	Brown and white, medium and coarse-grained sandstone, pebbly sandstone, conglomerate. Cross-bedded. Poorly exposed siltstone. Some worm trails	Pertatataka Formation, Carnegie Formation	In part similar to Mereenie Sandstone. Crops out as ridges. May be 8000 feet thick
	UNCONFORMITY				
	Inindia Beds	Ꝑun	Red-brown micaceous siltstone with thin interbeds of brecciated chert, sandstone, feldspathic sandstone, arkose, conglomerate, claystone, shale, limestone, and dolomite with some stromatolites	Areyonga Formation, basal Carnegie Formation and Boord Formation	Unconformity exposed at Souths Range. Tightly folded. May be 2000 feet thick
	Bitter Springs Limestone	Ꝑub	Grey, white, pale yellow-brown, pale pink, laminated, partly foetid dolomite and limestone. Three outcrops of gypsum with dolomite	Pinyinna Beds	In northern half of Sheet area. Isoclinally folded. May be 2000 feet thick
	Pinyinna Beds	Ꝑui	Grey, white, pale yellow-brown, pale pink, laminated, partly foetid dolomite limestone with rare stromatolites, and siltstone. Recrystallized in most outcrops to carbonate schist, slate, phyllite, and quartz-sericite schist. Apparently intruded by dolerite on the Petermann Ranges Sheet area	Bitter Springs Limestone	In southern half of Sheet area. Metamorphosed to slightly altered
	Dean Quartzite	Ꝑud	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 1000 to 2000 feet. It has gradational contacts with granite and gneiss and is intruded by granite
REGIONAL UNCONFORMITY WITH BLOODS RANGE BEDS AND MOUNT HARRIS BASALT					
UNDIFFRENTIATED	Unnamed granite	pЄg	Granite, gneiss, schist, amphibolite, quartz-epidote rock, quartzite, porphyroblastic schist		Granite probably formed during folding of Winnall Beds. Gradational into Olia Gneiss
	Pottoyu Granite	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. Gradational into porphyroblastic schist, Bloods Range Beds, and Dean Quartzite
	Porphyroblastic schist	pЄm	Porphyroblastic schist, amphibole schist, quartz-epidote rock, biotite-quartz schist, quartzite,	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		Acid lavas and tuffs in 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. Copper staining	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 and intrusive contact with granite

between the basement and the basal quartzite is not marked by an abrupt unconformity. On the southern margin of the basin, the Dean Quartzite, which is believed to be equivalent to the Heavitree Quartzite, lies with regional unconformity on Precambrian volcanic and sedimentary rocks - 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 overlying Dean Quartzite and Pinyinna Beds were recumbently infolded. The gneiss, granite, schist, and amphibolite, underlying the Dean Quartzite, were formed after the deposition of the Quartzite and the overlying thick succession of Upper Proterozoic sediments. It seems probable that older sediments, gneiss, and granite occur beneath the Mount Harris Basalt, but no such older rocks have been identified in the area. During the regional recumbent folding, the Pinyinna Beds, Dean Quartzite, Bloods Range Beds, and Mount Harris Basalt were overlain by the Upper Proterozoic Inindia Beds and Winnall Beds, which have a total thickness of about 10,000 feet, but they do not appear to be infolded with the underlying strata and their tectonic style of deformation suggests Jura-type folding with a décollement in the incompetent 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 diagramatically in Figure 10. The Mount Currie Conglomerate and the arkose at Ayers Rock are thought to be wedge-like bodies of non-marine sediment deposited in front of the mountain chain formed by recumbent folding. The Cleland Sandstone was deposited farther north in a fluviatile and paralic environment and is succeeded by the Larapinta Group, the Mereenie Sandstone, and the Pertnjara Formation.

The stratigraphy in the southern margin is summarized in Table 1 and Figure 3.

PRECAMBRIAN

Mount Harris Basalt (new name)

The name Mount Harris Basalt is given to the thick sequence of amygdaloidal basalt, green schist, possible tuff and agglomerate, and minor quartzite, which has a gradational contact with granite and is overlain by the Bloods Range Beds. The Mount Harris Basalt is intruded by granite and porphyry, and is associated with brown feldspar porphyry which may be intrusive or extrusive. The beds are extensively fractured, faintly foliated, and contain quartz, quartz-hematite, and calcite veins.

The formation is well exposed near Mount Harris in Bloods Range (Pl.2, fig.1). In the type area between the Ilyaralona Range and Bloods Range, the base of the formation is exposed to the south and east, and the contact with the Bloods Range Beds is exposed north of Ilyaralona Range. The formation has been tentatively identified in the north-east corner of the Scott Sheet area (Fig. 4), and the south-east corner of the Rawlinson Sheet area.

The base of the formation, which crops out in many places as a low ridge, consists of coarse cross-bedded pebbly quartzite; medium laminated, cross-laminated, and moderately sorted quartzite; sericite quartzite; and feldspar-sericite-quartz schist. Ripple marking is present at some localities (Pl.2, fig. 2). The basal beds are gradational into the granite and gneiss below, and are overlain by a sequence of green and green-grey amygdaloidal epidotized basalt with subordinate green chlorite schist, metamorphosed tuff(?), tuffaceous(?) sandstone, and sandstone. In many localities the basalt is brecciated, which suggests the presence of agglomerates, but it is possible that the brecciation is secondary. Considerable areas are poorly exposed, and the overlying scree consists of altered basalt and green chlorite schist, some of which has probably been derived by shearing of the basalt.

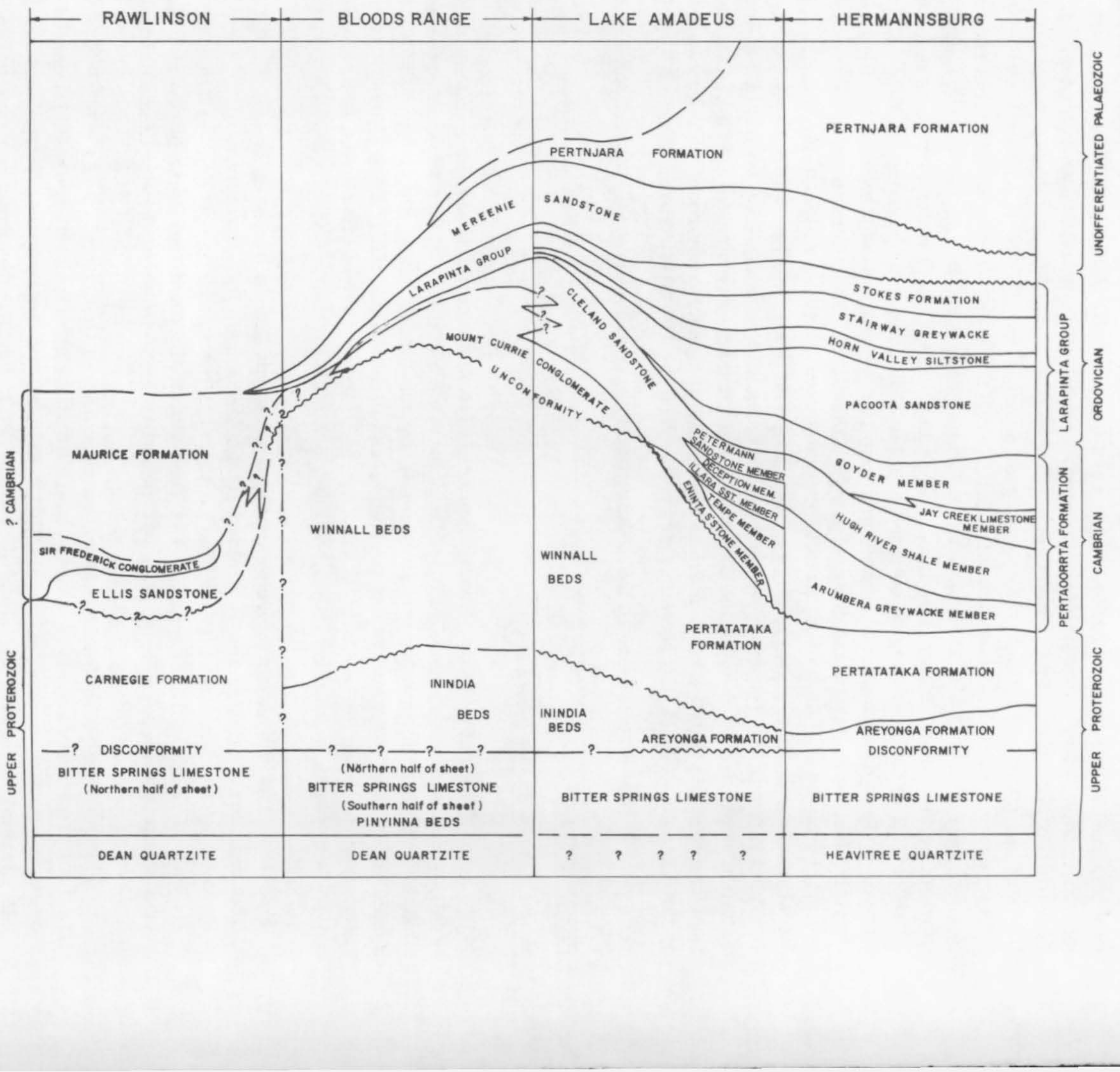


Figure 3 : Tentative correlation of Upper Proterozoic and Palaeozoic rock units

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 the granite the basalt appears to be little altered, but microscopic examination shows that it has been extensively sericitized. To the south, the basalt has been locally altered to chlorite schist and medium and coarse-grained green-grey amphibolite. One of the quartz veins intruding the amphibolite contains secondary lead and copper minerals, galena, and a trace of silver and gold (spec. BR99).

One of the porphyries 8 miles south of Mount Harris is in contact with granite along one margin, and on the other side it is separated from the Mount Harris Basalt by a thin bed of quartzite. In other areas, where porphyry is in direct contact with the basalt, their relationship could not be determined.

Between the Dean Range and the Kathleen Range on the Scott Sheet area 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). The 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 altered basalts and schist are intruded by numerous small veins of quartz and quartz-feldspar pegmatite, some of which contain abundant iron oxide. The sequence includes a boulder bed about 15 feet thick which contains stretched boulders of sericitic quartzite and granite gneiss in a matrix of sericite schist. Malachite occurs in the grey schist about 25 yards north of the boulder bed. A grab sample of the most promising rock assayed 2 percent copper. Traces of copper occur at other localities in the Mount Harris Basalt, but none of the occurrences is considered to be of economic importance.

South of the Kathleen Range (Fig. 4) the Mount Harris Basalt succession of altered basalt and interbedded schists passes up into the Bloods Range Beds, in which there is an increase in the proportion of porphyroblastic schist and quartzite, quartz-sericite schist, and sericite-quartz schist. The contact appears to be gradational and there is no evidence of an unconformity.

The nature of the contact between the Mount Harris Basalt and the granite suggests that the granite was emplaced metasomatically beneath the Mount Harris Basalt, or that the Mount Harris Basalt was deposited over the granite and later deformed with it.

The gradational contact between quartzite and granite is similar in both the Scott and Bloods Range Sheet areas. The schistose coarse-grained gritty cross-bedded sandstone is underlain by a pale green-grey coarse quartz-sericite schist with veinlets and irregular patches of quartz-feldspar pegmatite. Rare feldspars up to 2 inches long appear to have grown in the schist after the schistosity developed. The sericite-feldspar-quartz schist grades 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 could be interpreted as a metamorphosed arkose overlying the granite, or as a zone of feldspathized schist on the margin of the metasomatic granite, or as a zone of sheared granite. If the sericite-feldspar-quartz schist represents a metamorphosed arkose, some granite boulders could be expected to occur near the contact with the granite, but none have been found. Some of the schist may be sheared granite, but in many places there is a gradational contact between the quartzite and schist, which strongly suggests that the schist has been formed by the alteration of pre-existing sediments. In some localities in the Kathleen Range/ Dean Range area the granite is in contact with schist or basalt stratigraphically above the quartzite, and at two localities west of the Dean Range quartzite occurs within the granite.

Probably the strongest evidence for the late emplacement of the granite is that the granite is unsheared within 10 to 20 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 of a late origin of the granite.

At one locality north of the Ilyaralona Range the Bloods Range Beds overlie the Mount Harris Basalt, but 1 mile farther along the strike they rest on granite. This relationship could be explained by an unconformity at the base of the Bloods Range Beds, but it is more likely that the granite is younger than the Mount Harris Basalt and Bloods Range Beds.

The rocks below the Mount Harris Basalt have probably been replaced by granite, but the existence of older rocks is proved by the presence of boulders of granite gneiss in 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 latter may be Middle or Upper Proterozoic.

Bloods Range Beds (new name)

The Bloods Range Beds consist of a sequence of sandstone and quartzite, sericite-feldspar-quartz schist, quartz-sericite schist, sericite-quartz schist, porphyry, slate, and interbedded schistose basic rocks. Some of the schist with a relict fragmental texture and abundant lithic fragments may represent altered tuff and agglomerate, and some of the quartz may have been derived from tuffaceous sandstone. The Bloods Range Beds rest on the Mount Harris Basalt and are overlain with regional unconformity by the Dean Quartzite. Brown feldspar porphyry occurs near many of the outcrops of the Bloods Range Beds, and 4 miles north of the Ilyaralona Range, porphyry occurs in the Bloods Range Beds. Both the porphyry and the basic flows are partly epidotized, and many contain malachite.

The Bloods Range Beds are exposed in the type area between Bloods Range and the Ilyaralona Range on the western side of the Sheet area, where they form low flat-topped ridges. Two miles north of the Ilyaralona Range the Bloods Range Beds rest on Mount Harris Basalt, and 1 mile farther east along the strike they overlie granite. These relationships suggest an angular unconformity at the base of the Beds, but from evidence at other localities it appears that the granite may be intrusive into the Bloods Range Beds. The Mount Harris Basalt and granite are overlain by interlayered pink coarse-grained sericite-feldspar-quartz schist with stretched pebbles of brown feldspar porphyry, vein quartz, quartzite, and schistose pebbly quartzite. The basal beds of sericite-feldspar-quartz schist and schistose quartzite are overlain by green medium-grained epidotized quartz-sericite schist and sericite-quartz schist. Malachite is sparsely distributed in the schist and is also found as rims around hematite in quartz stringers. Some of the schist appears to consist of sheared fragments of basaltic material, and the original rock may have been an agglomerate. The remainder of the schist has the appearance of sheared tuff, tuffaceous sandstone, and impure sandstone. The

GEOLOGY OF THE NORTH-EAST CORNER OF THE SCOTT 1:250.000 SHEET AREA
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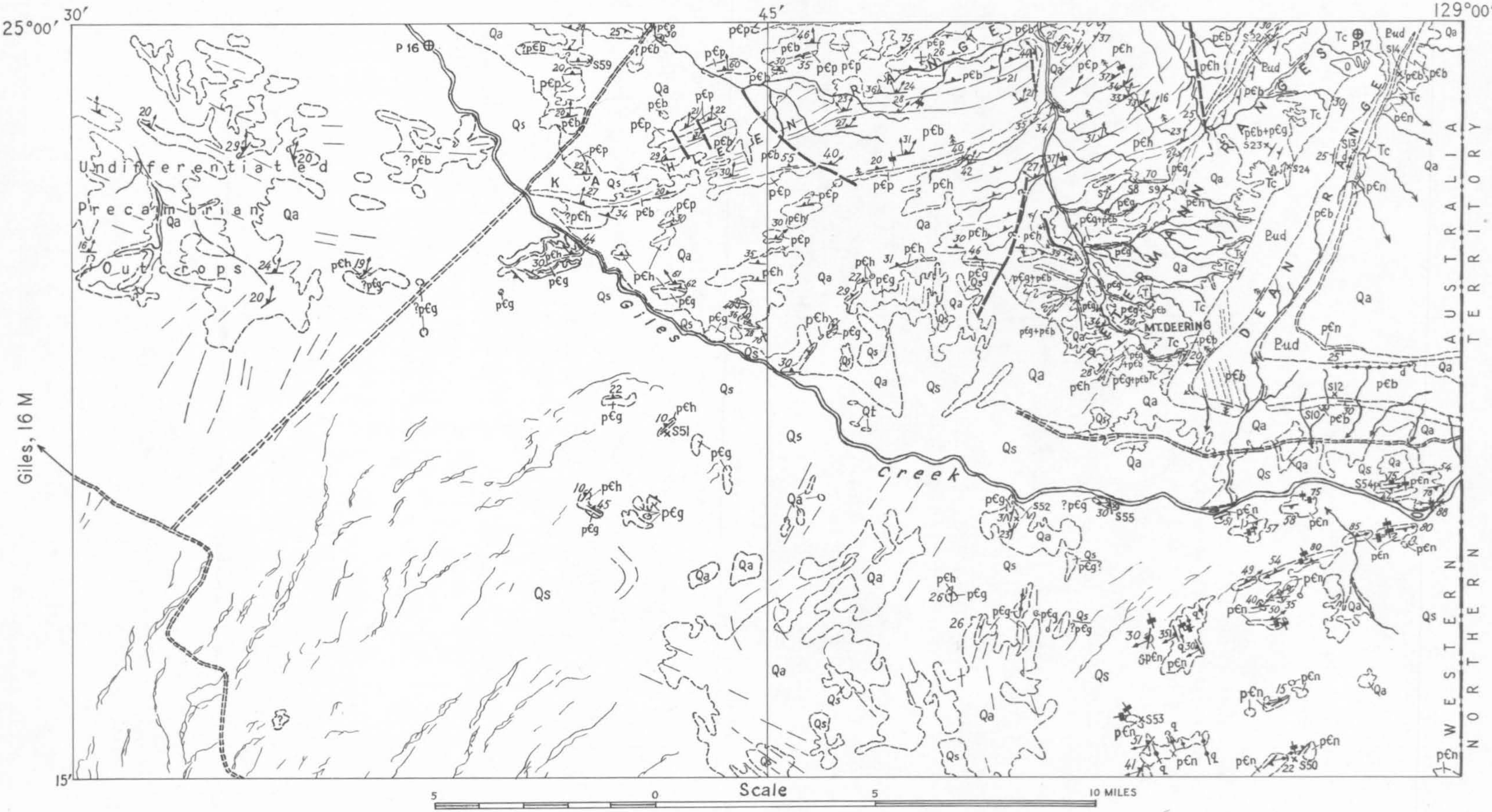
Fig. 4



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

G 52-A6-2 G.M.

section immediately overlying these beds is not exposed, but higher in the sequence the formation consists of sheared acid porphyry, and a metamorphosed sequence of medium to coarse-grained sandstone, tuffaceous sandstone, and tuff with thin flows of amygdaloidal basalt containing a little malachite. The sandstone and tuff are metamorphosed to sericite quartzite and quartz-sericite schist. Farther east there are abundant outcrops of sheared and weathered porphyry and tuff (?).

The rocks south of Bloods Range and west of the Hull River are correlated with the Bloods Range Beds but are less metamorphosed. They include brown and yellow-brown sericitic quartzite; brown slate; brown pebbly slate with volcanic (?) fragments; pink-brown and pale purple-brown medium-grained moderately to poorly sorted laminated and cross-laminated micaceous sandstone; brown feldspar porphyry; epidotized amygdaloidal basalt; purple-brown tuff(?); pink-brown and pale purple-brown medium-grained sericitic tuffaceous(?) sandstone; and agglomerate(?) with fragments averaging about a half to three-quarters of an inch across. The thin beds of white quartz porphyry in the sequence may be either flows or sills.

All thick sequences of basalt have been mapped as Mount Harris Basalt, but it is possible that some of them belong to the Bloods Range Beds.

The Beds also crop out between the Schwerin Mural Crescent and the Dean Range. The porphyroblastic schist south of the Dean and Mannanana Ranges is believed to be derived in part from the Bloods Range Beds, and along the strike the Beds have been altered to gneiss, granite, and amphibolite. The Beds are correlated with the Dixon Range Beds (Wells, Forman, & Ranford, 1965a) in the Rawlinson Sheet area.

The Bloods Range Beds crop out extensively in the area between the Schwerin Mural Crescent and the Dean Range, and in this area they appear to be conformable between the Mount Harris Basalt and the Dean Quartzite. At the base, south of the Kathleen Range, is a northerly-dipping succession of schistose and lineated brown quartz-feldspar porphyry in layers up to 50 feet thick, interbedded with greenish pink chlorite-feldspar-sericite-quartz schist which may be a sheared tuff, a porphyroblastic schist, or an intensely sheared porphyry. The succession includes at least two beds of green epidotized amygdaloidal basalt, brecciated green epidotized amygdaloidal basalt, and green schist. These basal beds are overlain by a considerable thickness of schistose brown and grey quartz-feldspar porphyry, feldspar-sericite-quartz schist, quartz-sericite schist, sericite-quartz schist, and quartzite, which represent altered acid porphyry, tuff, tuffaceous sandstone, and sandstone. Where visible, the original layering is isoclinally folded, and the schistosity is parallel to the axial planes of the folds, and in most places to the bedding. Micaceous malachite occurs in some of the schistose quartzite.

The upper part of the Bloods Range Beds succession is exposed in a broad syncline between the Kathleen Range and the Schwerin Mural Crescent. At least two thick quartz-feldspar porphyries are interbedded with green quartz-epidote rock, a dark grey brecciated rock cemented with epidote, amphibolite, green schist, 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. The Bloods Range Beds below the contact comprise 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, and towards the top of the section, the Bloods Range Beds consist of dark greenish grey slate, 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 in 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 feldspars grades into the schist with large ovoid feldspars, and into the black and dark grey, fine to medium-grained mica schist, and quartz-epidote rock. The pink granite occurs as relatively thin dykes and sills in the ovoid feldspar granite. The pegmatites are coarse-grained and contain pink feldspar crystals up to a foot long. A core of quartz and hematite is common. The zones of granite and porphyroblastic schist are about 100 feet wide and occur parallel to the schistosity and at a slight angle to the regional strike of the bedding. The granite and schist can be traced up to the base of the Dean Quartzite in the ridge 4 miles west of the Dean Range in the Scott Sheet area. The granite and the schist with ovoid feldspar are 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 the schists derived from the Bloods Range Beds are indistinguishable from those 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 porphyroblastic biotite-quartz-feldspar 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 pegmatites. Farther down the section there is a visible gradation from schist to gneiss by progressive feldspathization. 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 the rock grades into porphyroblastic biotite-sericite-quartz-feldspar schistose gneiss, and as schistosity gives way to gneissosity the final product is a porphyroblastic sericite-biotite-quartz-feldspar augen gneiss.

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

Lenses of schist, amphibolite, slate, and quartzite are common in the granite and gneiss, and they are believed to represent remnants of the Bloods Range Beds, the Mount Harris Basalt, or older sediments.

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

Porphyry

Porphyry occurs in the Bloods Range Beds and Mount Harris Basalt. It crops out south of the Kathleen Range, between the Kathleen Range and the Schwerin Mural Crescent, south of Bloods Range, and in the porphyroblastic schist to the south of the Mannanana Range. The porphyries north of the Kathleen Range have been described by Wells, Forman, & Ranford (1965a).

For the purpose of description the porphyries are divided into two 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 with the porphyroblastic schist.

The porphyry west of the Dean Range occurs in bands, from a few feet to several hundred feet thick, towards the top of the Bloods Range Beds. The porphyry is schistose and interbedded with schistose tuff, green schist, amygdaloidal epidotized basalt, sericite schist, sericite-quartz schist, quartz-sericite schist, slate, and occasional quartzite. The porphyries are grey or brown and contain phenocrysts and possible porphyroblasts in a fine-grained matrix. The phenocrysts are of quartz and feldspar. Veins of quartz and pegmatite cut the porphyries. The fact that the porphyries are conformable with the sediments and basalts suggests that they are extrusive, and they probably form part of a suite of volcanic rocks ranging from basic to acid. The vulcanism began with flows of vesicular basalt and associated acid porphyry and tuff. As deposition continued, the acid volcanics became more abundant and towards the top of the Bloods Range Beds the acid porphyries and tuffs predominate.

The phenocrysts in the porphyry consist of subhedral quartz up to 4 mm in diameter, and subhedral to euhedral albite-oligoclase up to 6 mm long. The groundmass is a fine-grained schistose aggregate of quartz, biotite, sericite, iron oxide, and epidote in variable proportions. The quartz phenocrysts show undulose extinction and have irregular margins due to corrosion by the recrystallized groundmass. The feldspar phenocrysts are broken, and extensively altered and rolled. The texture of the rocks is blastoporphyritic.

The porphyry south of Bloods Range forms outcrops up to 6 miles long and 2 miles wide. The porphyries are associated with the Bloods Range Beds and Mount Harris Basalt, and in places they have a schistosity parallel to their margins and to the schistosity in the associated beds. The porphyry contains phenocrysts of pink subhedral albite-oligoclase up to 6 mm long and subhedral quartz up to 3 mm long set in a fine-grained decussate brown matrix of quartz and feldspar with minor iron oxide and chlorite.

Porphyroblastic Schist

The porphyroblastic schist forms 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 proportion of porphyroblastic schist in most of the area mapped as Olia Gneiss. The porphyroblastic schist is associated with amphibole schist, quartz-epidote rock, biotite-quartz schist, quartzite, porphyroblastic gneiss, gneiss, and granite. The schists grade into gneiss and granite, and are also intruded by granite.

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

The feldspar crystals occur in two sizes. The large porphyroblasts are ovoid and up to 2 inches long, but the smaller crystals up to half an inch long probably represent altered phenocrysts in the original porphyry or tuff from which the schist developed. The composition of the porphyroblasts ranges continuously from microperthite to albite. In a few crystals the potash-soda feldspar appears to have been replaced by a soda feldspar showing 'chessboard' twinning, and some of the sodic plagioclase crystals have a core of microperthite. In some crystals a core of microperthite is mantled by a zone of interlocking plagioclase crystals. Some of the large crystals consist of interlocking aggregates of plagioclase or a mixture of plagioclase and microperthite.

It appears that the large quartz and feldspar crystals in the schist were present before the recrystallization of the fine-grained groundmass and the development of the schistosity. The feldspar crystals are extensively sericitized and have ragged, irregular margins where the unaltered groundmass material has grown into them. Some of the crystals are fractured and the fractures contain sericite, biotite, and quartz oriented parallel to the schistosity. The coarse crystals of quartz show undulose extinction, whereas the quartz in the matrix does not. The smaller feldspar crystals in the schist are similar to the phenocrysts in the porphyries of the Bloods Range Beds and Mount Harris Basalt, and the larger ovoid crystals are similar to the porphyroblasts in the porphyroblastic gneiss and the Pottoyu Granite Complex.

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

The porphyroblastic schist grades into porphyroblastic gneiss in which the groundmass is coarser in grain and there is a more pronounced segregation of the mineral components.

Two lineations and two planes of schistosity are present in the schist. The older schistosity, on which the older lineation occurs, is folded, and a second schistosity developed; 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 was recrystallized during the second.

The stratigraphical position of the schist and porphyroblastic schist beneath the Dean Quartzite, and the similarity to the schists and schistose porphyry or tuff in the Bloods Range Beds, suggest 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 Orogeny late in the Upper Proterozoic.

Olia Gneiss (new name)

The name Olia Gneiss is given to the gneiss which crops out between Giles in Western Australia and Mulga Park station in the Northern Territory. The gneiss has intrusive and gradational contacts with granite and grades into the Dean Quartzite, Bloods Range Beds, and probably the Mount Harris Basalt. It crops out extensively south of Giles Creek in the Scott Sheet; in the Pottoyu Hills; in the Olia Chain; in the southern half of the Ayers Rock Sheet area; north of the Petermann Ranges between Shaw and Armstrong Creeks; and 10 miles south of Mount Harris in the Bloods Range Sheet area. Some outcrops of gneiss also occur north of the Ilyaralona and Piultarana Ranges. 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 rich in quartz, with a strong lineation. The gneiss has strong north-south and east-west vertical joints and a weak foliation trending 070°. It contains 40 to 50 percent anhedral quartz oriented parallel to the lineation, subhedral to anhedral microcline, subhedral oligoclase, subparallel streaks of biotite, apatite, and accessory magnetite. To the south, melanocratic biotite amphibolite gneiss up to 100 feet thick is interbanded with the leucocratic gneiss. The mafic gneiss contains 40 to 50 percent of quartz, orthoclase, and oligoclase, and up to 15 percent hornblende and 15 percent biotite. The rock contains abundant apatite.

The gneiss of the Pottoyu Hills and Olia Chain comprises 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 the isoclinal folds, occur on foliation surfaces. In some areas, e.g. south of Tornpakura Hill where there is a strong cross-folding, two foliation planes occur in the gneiss with corresponding lineations. The bands of coarse porphyroblastic and fine-grained gneiss range 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 due to the segregation of the quartzo-feldspathic and micaceous minerals into alternating layers. The micaceous layers are up to a quarter of an inch thick and form augens around the feldspar porphyroblasts in the quartzo-feldspathic layers, which are up to 2 inches thick. Typical specimens of the coarse porphyroblastic gneiss contain 50 to 60 percent of microcline as anhedral twinned grains up to 6 mm long in the matrix, and as porphyroblasts up to 5 mm long; 20 to 30 percent anhedral grains of quartz up to 1.0 mm in diameter, which often show strain effects and an amoeboid texture suggesting shearing and recrystallization; 5 to 20 percent albite-oligoclase as partially sericitized anhedral grains up to 1.5 mm in diameter; 10 to 20 percent biotite as pleochroic greyish yellow to olive-brown sub-parallel elongate streaky patches in the plane of schistosity and along the direction of lineation, with individual flakes up to 2.5 mm. Biotite occurs in bands and as augen around the feldspar porphyroblasts. Epidote forms up to 10 percent of the gneiss. It occurs as discrete rounded grains, up to 0.5 mm in diameter, in association with biotite and garnet. Small flakes of muscovite up to 1.0 mm across also occur in association with biotite. The accessories include minute grains of garnet, crystals of magnetite up to 1.5 mm in diameter, zircon, and apatite. Lobate grains of myrmekite up to 0.5 mm in diameter occur in some specimens. Microcline occurs in the quartzo-feldspathic layers as porphyroblasts, some of which consist of clusters of anhedral grains. The 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.

Bands of foliated fine to medium even-grained leucocratic microcline-albite-quartz gneiss, with a little biotite, garnet, and magnetite, are interbedded with the coarse porphyroblastic augen gneiss.

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 trending north-west, and the lineation is parallel to the fold axes.

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

The fine-grained mafic gneiss is blue-grey to black with ovoid feldspar porphyroblasts up to 1 1/2 inches long and smaller ovoid feldspar porphyroblasts up to half an inch long with their long axes in the plane of the foliation. The fine-grained matrix is composed of feldspar, quartz, biotite, and amphibole. The gneiss has a fine foliation due to the presence of thin alternating bands of quartzo-feldspathic and pelitic minerals. In the hand specimen, the gneiss resembles a sheared porphyry, but it is considered to be a feldspathized porphyroblastic schistose gneiss. The fine-grained leucocratic gneiss consists of quartzo-feldspathic layers, up to a quarter of an inch thick, interbanded with very thin discontinuous biotite-rich bands. The quartzo-feldspathic bands contain quartz and feldspar porphyroblasts up to one quarter of an inch in diameter.

Doleritic dykes, up to 6 feet thick and striking approximately east-west and north-south, cut the gneisses in this area. Occasional lenses of dolerite, which are roughly conformable with the foliation, are also present. They range up to half a mile long and 200 yards wide with east-west dyke off-shoots.

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

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

Nine miles south of Mount Harris, the biotite-quartz-feldspar gneiss is strongly foliated and lineated, medium-grained, pink and greenish grey. The gneissosity dips to the north, and the lineation on the plane of gneissosity is horizontal and parallel to the axial lines of the isoclinal folds in the gneiss. On its southern margin the gneiss abuts against a brown fine-grained schistose rock with phenocrysts or porphyroblasts of quartz and feldspar. Granite occurs to the west-north-west of the gneiss, but the contact is not exposed.

Gneiss crops out 15 miles south of the McNichol Range. It includes strongly foliated grey and pink very coarsely porphyroblastic medium-grained biotite-quartz-feldspar augen gneiss, quartz-biotite-feldspar augen gneiss, and quartz-feldspar augen gneiss. The proportion of porphyroblastic feldspar in the rock is variable, and much of the gneiss is medium-grained and non-porphyroblastic. The gneiss is intruded by thin coarse-grained veins of feldspar-quartz pegmatite.

North of the Ilyaralona and Piultarana Ranges there are a few small outcrops of gneiss. To the north of the Piultarana Range, green schist is interlayered with pink fine and medium-grained quartz-feldspar gneiss, grey augen gneiss, and sericitic quartzite. The gneiss to the north of Ilyaralona Range is a very coarsely porphyroblastic medium-grained pale green-pink quartz-sericite-feldspar gneiss or schist in which the feldspars are oriented in the plane of foliation and show a lineation. Sparse xenolithic fragments of phyllite, vein quartz, and possibly quartzite, occur throughout the rock.

Most of the gneiss is considered to have been formed by metamorphism of sediments underlying the Dean Quartzite during the Petermann Ranges Orogeny. 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 in the Scott and Rawlinson Sheet areas. The quartz-epidote rock with possible relict amygdales, and the pelitic types of gneiss, are considered to be the 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. Most of the gneiss is considered to have been formed by granitization and metamorphism of the Bloods Range Beds and Mount Harris Basalt. However, the gneiss in the northern foothills of the Musgrave Ranges may be an older gneissic basement or a series of metamorphosed sediments which underlie the Mount Harris Basalt.

The gneiss is believed to be of late Upper Proterozoic age. The pegmatite veins which cut the Bloods Range Beds and the Mount Harris Basalt, and their metamorphic equivalents, are considered to have been formed at a late stage during the feldspathization of the sediments and the granitization of the gneiss.

Granite

Granites crop out along a 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 body, known as the Pottoyu Granite Complex, crops out in the Pottoyu Hills. Granite also occurs in the Bloods Range Sheet area between Bloods Range and the Petermann Ranges.

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

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

The granite is a very coarse porphyritic gneissic rock with numerous ovoid phenocrysts of microperthite oriented with their long axes in the plane of gneissosity (Pl. 3, fig. 1). The phenocrysts range from 1 to 2 inches long and some crystals have a rim of anhedral albite-oligoclase. The groundmass is composed of quartz, microcline, albite-oligoclase, and biotite, with accessory iron oxide, muscovite, and zircon. Secondary epidote occurs in veins and in some places replaces the plagioclase.

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 coarse porphyritic biotite granite. The medium-grained granite is massive to weakly foliated. West of Mount Phillips the two types of granite occur together with biotite schist, quartzite, quartz-epidote rock, and possible schistose porphyry. The contact between the granite and the Dean Quartzite is transitional, except in a few places where the granite is clearly intrusive. The main mass of the Pottoyu Granite Complex is composed of the grey coarse-grained porphyritic gneissic rapakivi biotite granite with up to 50 percent 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 oxide-feldspar-quartz pegmatite and quartz.

Two specimens of granite from the Pottoyu Hills were submitted to P.J. Leggo of the Bureau of Mineral Resources for age determination at the Australian National University:

Rb/Sr Age Determinations
(Apparent Ages in Millions of Years)

	1.	2.
Total rock	1190	1150
Biotite	600	570
Microcline	600	-

1. Coarse, porphyritic gneissic granite, 4 miles north-west of Tornpakura Hill (G52/7/1).

2. Leucocratic medium-grained granite, 7 miles south-south-west of Mount McCulloch (G52/7/3).

Other Granites. The granite west of the Dean Range crops out below the Mount Harris Basalt and Dean Quartzite. The granite is coarse-grained, massive to weakly foliated, pink-brown, and poorly-jointed, and in most localities contains abundant large ovoid feldspars up to 2 inches across.

The granite consists of anhedral microperthite up to 4 cm across, anhedral quartz up to 1 cm across, anhedral albite-oligoclase up to 5 mm long, biotite, muscovite, and iron oxides. The ovoid feldspars have a core of microperthite with inclusions of quartz along the cleavage planes, and in some specimens albite appears to have replaced the rims. Some of the microcline in the groundmass has also been 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 on pp.14-15. To the north, the granite is in contact with the Mount Harris Basalt; the nature of the contact has been discussed on pp. 11-12.

The gradational contacts, the folding of the contacts and the relatively slight shearing of the adjacent granite, the presence of xenoliths of what appears to be Mount Harris Basalt in the granite, the presence of pegmatite and quartz veins in the Bloods Range Beds and Mount Harris Basalt, and the local intrusive contact with Dean Quartzite, all support the hypothesis that the granite was emplaced metasomatically at a late stage of the Petermann Ranges Orogeny.

Granite crops out at Butler Dome, south-east of the Pottoyu Hills, over an area of 6 by 4 miles. It is overlain by Dean Quartzite to the east and is in contact with Olia Gneiss to the west. The predominant rock type is a lineated porphyritic coarse-grained gneissic biotite granite. The contact with the augen gneiss of the Olia Gneiss is gradational. The lineation in the granite is due to the preservation of traces of the gneissic structure of the original rocks. The narrow, northerly-trending bands of amphibolite in the granite probably represent amphibolitic layers in the original 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.

A granite 10 miles south of Foster Cliff crops out over an area of 10 by 6 miles. It is a coarsely porphyritic gneissic biotite granite similar to the granite of Butler Dome. The contact with the adjacent gneiss may be gradational or intrusive. Near the granite the Olia Gneiss is coarsely porphyroblastic but farther away it is medium-grained.

In the southern half of the Ayers Rock Sheet area, small bodies of granite, up to 4 square miles in area, crop out. The granite is either a very coarsely porphyritic medium to coarse-grained biotite gneissic granite with gneissic schlieren and basic xenoliths, or a massive coarse even-grained biotite granite. In some areas the foliation in the adjoining gneiss has been partly obliterated by granitization (Pl. 3, fig. 2) and migmatization.

The granite in the Ilyaralona Range/Piultarana Range area is overlain by quartzites belonging to both the Mount Harris Basalt and the Dean Quartzite. It is typically very coarse, porphyritic, and schistose in part. The schistosity is parallel to the schistosity (and bedding) in the Mount Harris Basalt and Dean Quartzite. In a few places, the lineation on the plane of schistosity in the granite and quartzite is gradational over a distance of about 10 feet: from quartzite or sericite-quartz schist to quartz-sericite schist, quartz-feldspar-biotite-sericite schist, quartz-biotite-feldspar gneiss, and finally to granite.

Eight miles south of Mount Harris a medium-grained granite gneiss and coarse-grained biotite granite are in contact with a brown and grey schistose porphyry which is overlain by the Mount Harris Basalt.

Six miles south-west of Mount Harris, a boss of granite, 1 1/2 miles long and half a mile wide, is intrusive into the Mount Harris Basalt. The rock is a medium uneven-grained pink biotite granite composed of microperthite, strained quartz, biotite, plagioclase, and epidote. Biotite and epidote form about 50 percent of the rock. The microperthite and quartz have a micrographic texture, and most of the plagioclase appears to have been formed by replacement of the microperthite. The northern margin of the granite is exposed at locality BR33, where it intrudes dark greenish grey amygdaloidal basalt. The granite adjacent to the basalt is fine-grained and in places porphyritic, but the contact is sharp. The basalt is cut by thin dykes of pink quartz-feldspar porphyry and pink microgranite. The porphyry contains phenocrysts of quartz and microcline showing micrographic intergrowths, iron oxide, and biotite, surrounded by a fine-grained groundmass of quartz and feldspar. The basalt is sericitized adjacent to the granite. Near the southern margin of the granite intrusion the basalt is partly altered to green-grey and green medium and coarse-grained amphibolite. At locality BR99 an east-west quartz vein, several feet thick, contains secondary lead and copper minerals with traces of galena and gold.

Upper Proterozoic

Dean Quartzite (new name)

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

The Dean Quartzite extends for 250 miles in an east-west direction from Mulga Park station in the Northern Territory to the Rawlinson Range in Western Australia. It 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 (Pl. 4, fig. 1), 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 have provided the evidence to show a recumbent fold along the south-west margin of the basin. It is correlated with the Upper Proterozoic Heavitree Quartzite on the northern margin of the Amadeus Basin.

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. In the Schwerin Mural Crescent the schistose Dean Quartzite rests apparently conformably on slate and schist of the Bloods Range Beds, and in the Walter James Range it is apparently conformable with the Dixon Range Beds. In the Dean and Mannanana Ranges (Pl. 4, fig. 2), Mount Sargood, and farther north in Bloods Range, the base of the Dean Quartzite contains local thin beds of conglomerate, conglomeratic sandstone, greywacke, and sandy siltstone. It appears therefore that the Dean Quartzite is conformable or disconformable with the older sediments in the west, but that it may be unconformable in the east. The original relationship of the Dean Quartzite to the older sediments in the Petermann Ranges and Olia Chain, and in the southern half of the Ayers Rock Sheet area, has been masked by the conversion of the older rocks to gneiss and granite into which the Dean Quartzite now grades. In the area between Mulga Park station homestead and Feltham Hill the gneiss underlying the quartzite contains large areas of schist, slate, and amphibolite, which are gradational into the gneiss. It appears probable that the Dean Quartzite was originally underlain by sedimentary or volcanic rocks which were converted to gneiss, schist, and amphibolite during the folding and regional metamorphism of the area.

The Dean Quartzite in the Rawlinson Sheet area has been described by Wells, Forman, & Ranford (1965a). 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 parts of the area where the Dean Quartzite has been deeply infolded it has been metamorphosed 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 ranges 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 ranges from moderate to relatively strong, and schistosity and lineation are well developed. The origin of these structural features is explained on p.37 ff.

In most places the true thickness of the Dean Quartzite cannot be determined because it has been 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 and 1500 feet was estimated in Piultarana Range. The width of outcrop and dip measurements from the air-photographs indicate that the thickness in the Pinyinna Range may be about 2000 feet. The Schwerin Mural Crescent contains recumbently folded Dean Quartzite with an estimated thickness of about 1000 feet.

The Quartzite is overlain directly by 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 sedimentary succession in the Amadeus Basin, on the northern and southern margins respectively.

Pinyinna Beds (new name)

The Pinyinna Beds are defined 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 the 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. The basal siltstone is 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 section is overturned and the beds dip south beneath the Dean Quartzite.

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 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: the Pinyinna Range and Mount Harris adjacent to the most northerly outcrops of the Dean Quartzite, the Dean Range in the Scott Sheet area, the Piultarana Range in the Bloods Range Sheet area, and the Petermann Ranges between Chirnside and Armstrong Creeks in the Petermann Ranges Sheet area. The basal siltstone, immediately overlying the Dean Quartzite, occurs in the cores of many of the isoclinal and recumbent folds.

Near Mount Harris the Pinyinna Beds consist of grey, red, pink, and yellow laminated fine and medium-grained slightly recrystallized limestone and dolomite, interbedded with dark grey laminated micaceous siltstone. The Beds are traversed by veinlets of calcite. The sequence is exposed in the core of a recumbent fold (see Fig. 7), and at the same locality an isoclinal fold with a horizontal axial trace is exposed on a steep hillslope.

In the Piultarana Range the Pinyinna Beds crop out in the core of an isoclinal fold. They overlie the Dean Quartzite and consist of a thin bed of grey and black slate and phyllite, followed by a thick sequence of varicoloured fine to medium-grained foetid dolomite and limestone. The carbonate rocks are sheared, recrystallized, and traversed by carbonate veins. Four miles farther along the strike to the west-north-west the siltstone at the base of the Pinyinna Beds is about 300 feet thick and is metamorphosed to quartz-sericite schist.

The Pinyinna Beds west of the Dean Range are overlain and underlain by schistose and lineated Dean Quartzite. The Beds are grey phyllite and red-brown or pink laminated medium-grained recrystallized lineated dolomite showing small-scale recumbent folds with axes trending 075°. The dolomite is interbedded with yellow-brown sericite schist and contains folded quartz veins.

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 cavities from which hematite cubes or other minerals may have weathered. Intersection of cleavage and bedding was visible in several specimens. The lineation in the dolomite is parallel to the regional lineation. Boulders of dolerite within the area of outcrop of the carbonate suggest that it is intruded by dolerite.

The metamorphosed basal unit of the Pinyinna Beds is poorly exposed in the core of near-recumbent folds in Tornpakura Hill, Stevenson Peak, Butler Dome, and Foster Cliff (Pl.5, fig. 1) of the Olia Chain, and in the Gordon Hill area of the Ayers Rock Sheet. The beds consist of 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 is parallel to the axes 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 in the Rawlinson Sheet area, but the siltstone has been observed north of the Schwerin Mural Crescent (see Fig. 5). Gillespie (1959) reported the occurrence of brown shaly calcareous mudstone and light grey laminated shale about 8 miles south-east of Bungabiddy Rockhole in the Walter James Range.

Bitter Springs Limestone*

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

It crops out on the Bloods Range Sheet area as a thick sequence of crystalline dolomite and limestone with associated gypsum. The dolomite and limestone are in shades of grey and brown, foetid, fine-grained, laminated and thin-bedded, frequently contorted, brecciated, and silicified. The upper and lower contacts are not exposed. The formation is strongly folded, and steep dips and overturning are common. Collenia has been noted at several localities.

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* A report (Ranford, Cook, & Wells, 1965) written concomitantly with this Report adduces reasons for amending the name to 'Bitter Springs Formation', and the unit is likely to be so named in the future.

Gypsum is associated with the dolomite and limestone at the following localities:

(1) At Mount Murray in the Lake Amadeus Sheet area. Highly weathered sheared and laminated gypsum, overlain by isoclinally folded and brecciated dolomite and limestone, crops out in the core of an anticline in Upper Proterozoic and Palaeozoic rocks. The isoclinal folds in the carbonate rocks are much smaller and tighter than the main anticline. The gypsum extends from Mount Murray into the eastern side of the Bloods Range Sheet at about latitude 24° 11'S.

(2) In the north-eastern corner of the Bloods Range Sheet area, where the gypsum is grey, sheared, and contains fragments of dolomite breccia. At locality BR48 a large block of white fine-grained stromatolitic dolomite is surrounded by secondary gypsum in which small patches of the primary grey laminated gypsum can be seen. To the south-east and north-west, the gypsum outcrop abuts against moderately dipping Cleland Sandstone, and the structure suggests that the gypsum is a diapiric intrusion.

(3) At locality BR53, 20 miles west of BR48, there is a similar occurrence. Chaotic blocks of dolomite and limestone form small peaks in an area of secondary gypsum and travertine. The primary grey laminated gypsum is exposed in a few places near the centre of the outcrop of secondary gypsum. No other rocks crop out near the gypsum.

Inindia Beds

The Inindia Beds in the Lake Amadeus Sheet area were named by Ranford, Cook, & Wells (1965). The Beds are described as the sequence of siltstone, sandstone, chert, chert breccia, and thin beds of dolomite, which disconformably overlies the Bitter Springs Limestone, and which is overlain, probably unconformably, by the Winnall Beds. The reference area lies 36 miles south-west of Mount Murray. The beds are named after Inindia Bore in the south-east corner of the Lake Amadeus Sheet area.

In the Bloods Range Sheet area the Inindia Beds are best exposed 4 miles north-east of Mount Unapproachable, where they consist of tightly folded brown and red-brown siltstone, claystone, shale, and thin beds of chert, chert breccia, dolomite, and limestone. The Inindia Beds also crop out in the Lake Neale/Lake Amadeus area, where they are overlain by the Winnall Beds, but the base of the formation was not seen.

The siltstone and shale are poorly exposed. They are brown, laminated, thin-bedded, and cross-laminated. The siltstone, shale, and claystone are partly micaceous, and contain 'biscuits' and veinlets of chert, and beds several feet thick of vuggy chert and chert breccia. The chert has replaced the claystone, shale, and siltstone, which in many places are strongly silicified.

The dolomite and limestone occur in beds up to 50 feet thick. They are pink, grey, and yellow-brown, fine-grained, laminated, and locally foetid, highly brecciated, and contorted. Stromatolites occur in many of the beds.

Two closely spaced beds of fine angular conglomerate are interbedded with the red-brown micaceous siltstone south of Long Range on the eastern edge of the Bloods Range Sheet area.

At Souths Range a sequence of sandstone and siltstone is overlain unconformably by the Winnall Beds. The sandstone is white, medium to coarse-grained, partly conglomeratic; laminated, thin-bedded, cross-laminated, moderately sorted, subrounded, and clean to kaolinitic. The pebbles in the conglomeratic sandstone consist of quartzite, chert, and siltstone. The kaolinitic sandstone contains prominent grains of feldspar and grades into a kaolinitic feldspathic sandstone and arkose. The sequence is probably equivalent to the Inindia Beds.

In the south-east corner of the Bloods Range Sheet area a similar sequence of sandstone and siltstone is overlain unconformably by the Mount Currie Conglomerate. The sandstone is white, fine, medium, and coarse-grained, laminated and thin-bedded, cross-laminated, moderately sorted, moderately rounded, laminated, and in part micaceous. The sequence may be equivalent to the Winnall Beds or the Inindia Beds.

The Inindia Beds have been correlated with the Areyonga Formation by Ranford, Cook, & Wells (1965). The unit also bears some lithological resemblance to the Boord Formation in the Macdonald Sheet area.

Winnall Beds

The Winnall Beds were named by Ranford, Cook, & Wells (1965). The formation consists of siltstone, sandstone, and pebbly sandstone which lie probably unconformably above the Inindia Beds and unconformably below the Pertaoorrta Formation, Cleland Sandstone, and Larapinta Group. The beds are named from Winnall Ridge, a prominent feature in the southern half of the Lake Amadeus Sheet area. Ranford, Cook, & Wells believe that the Winnall Beds interfinger with the Pertatataka Formation.

The Beds crop out in the Ayers Rock, Mount Olga, and Mount Currie areas as long low strike ridges and as small isolated outcrops. The unit appears to be unconformably overlain by the Mount Currie Conglomerate. The thickness of the sequence between Ayers Rock and Mount Currie is estimated from the air-photographs and measured dips to be at least 5000 feet, assuming that there is no repetition by strike faults.

The ridges consist of sandstone with poorly exposed interbeds of siltstone. The gaps between the ridges are covered by alluvium. The sandstone is white 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 exhibits isoclinal folding and a possible faint fracture cleavage.

In the Bloods Range Sheet area, the Winnall Beds crop out as strike ridges at Long Range, Mount Unapproachable, and Souths Range. The sediments in the small structural basins at Mount Cowle and west of the Hull River are tentatively placed in the Winnall Beds. At Long Range and Mount Unapproachable the Winnall Beds overlie the Inindia Beds, but the contact is not exposed. At Souths Range, at least 2000 feet of the Winnall Beds rest uncomformably on probable Inindia Beds. The basal beds are cross-bedded pebble conglomerate and fine pebble conglomerate. Pebbles of black and white laminated chert, kaolinitic feldspathic sandstone (or arkose), coarse quartz sandstone, and silicified white siltstone occur in a medium to coarse-grained moderately sorted, moderately rounded, sandstone matrix. The silicified siltstone fragments are angular. The basal beds are overlain by a clean white medium-grained sandstone which is laminated, extensively cross-laminated on a large, moderate, and small scale, moderately sorted, moderately rounded, and slightly friable to tough. Some of the cross-bed sets are up to 10 feet thick.

Mount Cowle is a basin-shaped structure with an outer ring of clean white medium-grained quartz sandstone which is thinly bedded, well sorted, and well rounded. The centre of the basin is composed of interbedded sandstone and siltstone. The sandstone is grey and white, fine to medium-grained, laminated, cross-laminated, platy, moderately sorted, moderately rounded, silicified and tough. A similar structure occurs in a hill 26 miles west of Mount Cowle. The main mass of the hill is composed of white fine and medium-grained laminated cross-laminated moderately sorted moderately rounded silicified tough sandstone with some ripple marking and mud pellets. It is underlain by pale yellow fine-grained sandstone and grey laminated siltstone. If these two circular outcrops and Souths Range belong to the Winnall Beds the sequence must be very thick, with the greater part of it concealed between Mount Cowle and Souths Range.

Near Lake Neale and Lake Amadeus the formation consists of interbedded red-brown and white sandstones which are medium-grained, moderately sorted, moderately rounded, laminated and thin-bedded, extensively cross-bedded and cross-laminated, friable to tough, partly silicified, partly ferruginous, and partly platy. A few of the sandstone beds are coarse-grained and contain abundant detrital chert. At Mount Unapproachable there are markings on some bedding-planes which may be fossil invertebrate tracks.

The age of the Winnall Beds may be Upper Proterozoic, Cambrian, or both. The lithology and structure suggest a correlation with the Ellis Sandstone in the Macdonald and Rawlinson Sheet area (Wells, Forman, & Ranford 1965a), but it is more probable that the Ellis Sandstone is equivalent to the Mount Currie Conglomerate, and the Winnall Beds are most likely to be partly equivalent to the Carnegie Formation in the Macdonald, Rawlinson, and Mount Rennie Sheet areas (see Fig. 5).

PALAEOZOIC

The Precambrian rocks were folded and metamorphosed during the Petermann Ranges Orogeny. Dolerite was intruded into the Pinyinna Beds and Olia Gneiss shortly after the folding, probably early in the Cambrian. A mountain range was formed by the folding near the present position of the southern margin of the Amadeus Basin and provided a source for the sediments deposited in the basin. Near the mountainous land mass, wedges of arkose and conglomerate were deposited unconformably on the Upper Proterozoic sediments, but farther north the Cleland Sandstone was deposited in a fluviatile and paralic environment. By Ordovician time the mountainous landmass had been eroded, and during a transgression of the sea from the Amadeus Basin, sandstone, limestone, and siltstone were deposited unconformably over the Precambrian rocks and the Larapinta Group was deposited in the Basin. The Mereenie Sandstone and Pertnjara Formation were deposited conformably on the Larapinta Group during parts of the Ordovician, Silurian, Devonian, and possibly Carboniferous.

Dolerite

Sills and dykes of quartz dolerite crop out in the southern part of the Ayers Rock Sheet area and rarely in the Petermann Ranges Sheet area. One uralitized dolerite occurs in the Pinyinna Beds east of Chirnside Creek, but all the other dolerite intrusions occur in coarse porphyroblastic augen gneiss or medium-grained gneiss. The dolerite is typically unaltered and occurs as dykes mostly from 2 to 4 feet, but up to 15 feet, thick. The sills are commonly up to 100 feet thick with occasional considerably thicker laccolithic bodies. The lack of alteration shows that the dykes were injected after the last major orogeny, but the occurrence of laccolithic sills in the gneiss suggests they may have been intruded shortly after the last period of folding while the gneiss was still under stress.

The dolerite contains xenoliths of gneiss and is intruded by thin acid dykes. Although the acid dykes have been traced across the dolerite bodies they have not been proved to intrude the adjacent gneiss and may represent late-stage differentiates of the dolerite. Near the margin of the largest dolerite sills the gneiss is altered to a dark grey porphyroblastic schist remembling a schistose acid porphyry.

In the Kelly Hills 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 clusters of crystals of plagioclase and augite. The matrix consists of euhedral plagioclase laths about 0.5 mm long, iron oxide, and up to 10 percent interstitial micropegmatitic intergrowths of quartz and potash feldspar.

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 Orogeny, which took place late in the Upper Proterozoic.

Mount Currie Conglomerate (new name)

Mount Currie Conglomerate is the name used for a sequence of pebble, cobble, and boulder conglomerate resting unconformably on Upper Proterozoic sediments at Mount Currie. The top of the formation is eroded. Outcrops of the conglomerate occur between Pinyinna Range in the Bloods Range Sheet area and Mount Olga in the Ayers Rock Sheet area. W. Oldershaw (BMR, pers. comm.) has described a sample of the Mount Currie Conglomerate from Mount Olga. 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 not known, but the sequence dips south at a moderate angle for 10 to 16 miles; a possible explanation for this unusual structure is provided in one of the cross-sections on the Ayers Rock Sheet which shows 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.

The actual contact between the Mount Currie Conglomerate and the older rocks is not exposed in the Ayers Rock Sheet area, but they are assumed to be unconformable because there is an angular discordance between the trends of the Conglomerate and the underlying

Winnall Beds; fragments in the conglomerate have been derived from the underlying formations; and there is a visible unconformity at Pinyinna Range in 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 in 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 the Ayers Rock Sheet area. At specimen locality AR100 the basal boulder bed is succeeded by a white and pale purple-brown medium-grained quartz sandstone which consists of thin and medium beds and cross-laminae. Angular to rounded pebbles of chert and silicified sandstone are unevenly distributed amongst the poorly sorted subrounded and subangular sand grains. The beds overlying the quartz sandstone are concealed, but about half a mile farther south there is an outcrop of pebble, cobble, and boulder conglomerate with a matrix and thin interbeds and lenses of epidotized arkose similar to that described by Oldershaw. The phenoclasts are brown weathered amygdaloidal basalt with amygdales of chert rimmed by epidote, brown porphyritic dolerite, banded porphyritic basalt (from the Mount Harris Basalt and dolerite dykes), pink-brown medium and coarse-grained epidotized biotite granite, pink 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, grey quartz sandstone, and rare vein quartz. The pebbles, cobbles, and boulders are well rounded and ellipsoidal, and up to about 14 inches in length. They are set in a medium-grained matrix of quartz, feldspar, and epidote.

Higher in the section towards Mount Olga, the conglomerate contains numerous phenoclasts of fine-grained acid and basic igneous rocks, granite, and gneiss, in an 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 stratigraphical control is poor it seems probable that most of the phenoclasts at the base of the Mount Currie Conglomerate consist of sandstone, with fine-grained acid and basic igneous rocks in the centre, and granite and gneiss towards the top of the formation. The rounded inselbergs, such as Mount Currie and Mount Olga, are found 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. It probably rests unconformably on the Bitter Springs Limestone and Winnall Beds, and was deposited after these sediments were folded, but probably before the folding of the Cleland Sandstone and Larapinta Group. The thin conglomerate at the base of the Cleland Sandstone may be the equivalent of the Mount Currie Conglomerate in the Amadeus Basin.

The thin interbeds and matrix of epidotized arkose in the conglomerate suggest that the arkose with possible epidotized laminae at Ayers Rock may be a lithological variant of the Mount Currie Conglomerate.

The Arkose at Ayers Rock

An estimated 8000 feet of steeply dipping arkose crops out at Ayers Rock, but neither the base nor the top of the unit is exposed. In another outcrop of arkose about 2 1/2 miles south-west of Ayers Rock, the beds have the same attitude and south-west facing as the arkose at Ayers Rock and probably represent part of the same formation. 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 of their stratigraphical 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 formations in the Amadeus Basin and the best correlation seems to be with the Mount Currie Conglomerate, which has an arkosic matrix.

The arkose at Ayers Rock is pale grey, dark grey, pink-grey, or green-grey. It is coarse-grained with some medium-grained laminae, and is almost continuously cross-laminated on a small scale. The 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 in the arkose are between a half and 1 inch long and this arkose may be termed pebbly.

The outcrop 2 1/2 miles to the south-east of Ayers Rock consists of 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 parts of the Maurice Formation (Wells, Forman, & Ranford, 1965a) in the Wallace Hills in the Rawlinson Sheet area.

The Ayers Rock arkose is probably a wedge of sediment deposited adjacent to the tectonically active area to the south. The Mount Currie Conglomerate is a similar wedge, and both units may have been deposited at the same time. Hence the Ayers Rock arkose is tentatively placed in the Cambrian as a lithological variant of the Mount Currie Conglomerate.

Cleland Sandstone

The Cleland Sandstone was named by Wells, Forman, & Ranford (1965b). It consists of a sequence of fine to coarse-grained and locally pebbly ferruginous partly feldspathic and partly micaceous sandstone which lies conformably beneath the Goyder Formation and Pacoota Sandstone in the Mount Liebig Sheet area.

In the northern half of the Bloods Range Sheet area the formation crops out as low hills and ridges. It rests unconformably on the Winnall Beds and is conformably overlain by the Larapinta Group. It crops out as far west as longitude $120^{\circ}25'$ E. In the east, the formation is probably about 2000 feet thick, but it wedges out to the west.

The sandstone is red-brown, yellow-brown, chocolate, medium-grained, poorly sorted, subangular, ferruginous, micaceous, and pebbly. It is almost entirely cross-bedded, and contains slump structures and ripple marks. At some localities the Cleland Sandstone contains conglomerate, the best exposures of which occur north of the western end of Lake Neale. They consist of pebble, cobble, and boulder conglomerate with ellipsoidal fragments of rounded sericitic quartzite, vein quartz, quartzite, chert, and white fine-grained quartz sandstone. The matrix is white poorly sorted angular coarse to very coarse feldspathic sandstone. The phenoclasts have probably been derived from the Dean Quartzite, Inindia Beds, and Winnall Beds. In the east, the top of the Cleland Sandstone is thin-bedded and cross-bedded and contains poorly exposed interbeds of highly micaceous brown and white laminated and cross-laminated siltstone.

The base of the overlying Larapinta Group may be of Lower Ordovician age and the top of the Cleland Sandstone is probably the same age. Wells, Forman, & Ranford (1965b) consider that the basal part of the Cleland Sandstone in the Mount Liebig Sheet area may be equivalent to the Arumbera Greywacke Member of Upper Proterozoic or Lower Cambrian age. However, in the Hermannsburg Sheet area the Arumbera Greywacke Member rests conformably on the Pertatataka Formation (Fig. 3). In the Bloods Range Sheet area the Cleland Sandstone rests unconformably on the Winnall Beds and it is unlikely that any of it was laid down during the Upper Proterozoic. The Cleland Sandstone is considered therefore to be Cambrian and possibly partly Lower Ordovician.

Larapinta Group

The Larapinta Group as defined by Prichard & Quinlan (1962) includes the Pacoota Sandstone, Horn Valley Siltstone, Stairway Greywacke, and Stokes Formation. The Group rests conformably on the Pertaoorrta Group and is separated from the overlying Mereenie Sandstone by a regional unconformity in the Hermannsburg Sheet area. Wells et al. (1965b) revised the name Stairway Greywacke to Stairway Sandstone, and Ranford, Cook, & Wells (1965) revised the name Pertaoorrta Group to Pertaoorrta Formation.

With the exception of the Pacoota Sandstone the subdivisions of the Larapinta Group are nowhere clearly recognizable over the Bloods Range Sheet area. The Larapinta Group is apparently conformable with the overlying Mereenie Sandstone and the underlying Cleland Sandstone.

The group is very poorly exposed as low hills and strike ridges in the northern half of the Bloods Range Sheet area. The thickest exposed section occurs 12 miles west-north-west of Mount Murray. The greatest thickness, estimated from some dip measurements and the air-photographs, is about 1000 feet. The Pacoota Sandstone at the base of the section forms a prominent low ridge containing 60 to 70 feet of clean white medium to coarse-grained 'pipe rock' and sandstone, which are moderately sorted and rounded, thin and medium-bedded, friable, slightly porous, and blocky. The 'pipe rock' contains abundant poorly preserved worm tubes. The section includes some thin interbeds of apparently bimodal medium and coarse-grained white sandstone with thin bedding and well-rounded grains. The Pacoota Sandstone contains very poorly preserved traces of shelly fossils, and at some places there is a very fine conglomerate at the base.

The sediments immediately overlying the Pacoota Sandstone are poorly exposed mottled yellow-brown, pink, and white fine-grained laminated micaceous sandstone, silty sandstone, and siltstone, with thin interbeds of fine-grained sandstone and medium-grained oolitic hematite. Beds of oolitic hematite up to 4 feet thick occur in the Lake Amadeus Sheet area about 4 miles south of Nonane Rockhole, but in the Bloods Range Sheet area most of the oolitic iron ore beds are less than 3 inches thick, and are correlated with the Horn Valley Siltstone. They are overlain by a bed of clean white medium to coarse-grained fossiliferous quartz sandstone, with thin bedding and moderate sorting and rounding. The sediments overlying this sandstone are either poorly exposed or concealed throughout the area. They include pale green, pink, and white fossiliferous interbedded siltstone and fine-grained sandstone. Joyce Gilbert-Tomlinson (BMR, pers. comm.) recognized Middle Ordovician fossils from locality BR12 in this interval. The unit, which is several hundred feet thick, is tentatively correlated with the Stairway Sandstone.

The poorly exposed white laminated siltstone with salt pseudomorphs which overlies the sandstone and siltstone at BR12 may be equivalent to the Stokes Formation.

In the north-western part of the Bloods Range Sheet area the Pacoota Sandstone is overlain by beds containing oolitic hematite. The beds above are concealed except for small outcrops of pale yellow-brown coarse-grained laminated and thinly bedded cross-laminated moderately sorted subrounded calcareous sandstone; and pink and yellow-brown fine-grained laminated limestone or dolomite.

At locality BR22 the Larapinta Group overlies a thin sequence of Cleland Sandstone, and 16 miles farther west a ferruginous sandstone, probably at the base of the Larapinta Group, rests unconformably on steeply dipping Bitter Springs Limestone.

The fossils in the Larapinta Group indicate that they are Ordovician.

Other Ordovician

Fossiliferous marine conglomerate, sandstone, pebbly sandstone, crystalline dolomite and limestone, shale, and siltstone are exposed in the southern half of the Bloods Range Sheet area. The sediments are flat-lying or gently folded and rest unconformably on the metamorphosed and intensely folded Precambrian rocks. Similar sediments occur on the Rawlinson and Petermann Ranges Sheet areas.

The sediments are best exposed on the southern side of the McNichol Range, where they rest unconformably on steeply dipping Dean Quartzite. They comprise coarse brown angular unsorted conglomerate, overlain by interbedded poorly-sorted angular conglomerate and pale pink-brown medium-grained bimodal sandstone containing poorly sorted angular grains. These beds are overlain by 'pipe rock' which is succeeded by poorly exposed pink medium-grained laminated sandstone. The sandstone is moderately sorted, moderately rounded, with a finely pitted weathered surface. The sequence of conglomerate and sandstone dips to the south at a low angle off the range. About 4 miles farther south, a series of interbedded fossiliferous limestone, dolomite, sandstone, shale, and siltstone, about 50 feet thick, crops out. It overlies the Olia Gneiss unconformably. The section, beginning with the youngest rocks, is as follows:

5. Pale blue-grey crystalline limestone - fine-grained, laminated, platy, interbedded with poorly exposed shale and siltstone

4. White sandstone - medium and coarse-grained, thin-bedded, blocky, slightly friable, moderately sorted, moderately rounded, clean, partly calcareous, with some unsorted angular grains

3. Brown micaceous shale with abundant salt pseudomorphs (up to half an inch in size), and thin interbeds of sandstone

2. Red to red-brown fossiliferous crystalline dolomite

1. Pale brown fossiliferous sandstone - medium-grained, bedded, well-sorted, well rounded, clean and friable, with two thin beds of red silty fossiliferous phosphatic limestone (BR75).

Although fragmentary molluscs and trilobites from specimen locality BR75 were not generically identifiable, they indicate an Ordovician age (Joyce Gilbert-Tomlinson, BMR, pers. comm.).

Ordovician sediments crop out in the north-eastern corner of the Petermann Ranges Sheet area. At specimen locality PR25, 43 feet of flat-lying Ordovician sandstone rests unconformably on porphyroblastic fine to medium-grained quartz-biotite-feldspar schist which is intruded by quartz-feldspar veins. At the base is a thin bed of poorly sorted pebbly sandstone. This is succeeded by silicified yellow-brown sandstone and gritty sandstone, which contains both a medium-grained weathered and well-rounded fraction and a coarse-grained poorly sorted and angular fraction. The sandstone is thin and medium-bedded and contains poorly exposed interbeds of 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 occur close to many of the ranges. They rest on metamorphic rocks and are overlain by conglomerate of probable Tertiary age. The presence of silicified wood and casts of vascular plants a few feet above poorly preserved Scolithus tubes, in a similar formation to the north of the Petermann Ranges, shows that some of the beds are younger than Ordovician.

Mereenie Sandstone

The Mereenie Sandstone was named by Madigan (1932). Prichard & Quinlan (1962) define it as a quartz sandstone formation which is separated from the underlying Larapinta Group and overlying Pertnjara Formation by regional unconformities.

In the Bloods Range Sheet area the Mereenie Sandstone apparently rests conformably on the Larapinta Group. At one locality it is overlain by white siltstone which has been mapped as Pertnjara Formation. Elsewhere the sediments overlying the Mereenie Sandstone are concealed by Quaternary sand.

In the northern half of the Bloods Range Sheet area the Mereenie Sandstone forms low hills and ridges. It extends westward into the Rawlinson Sheet area and crops out extensively in the Mount Rennie, Mount Liebig, and Lake Amadeus Sheet areas.

The Mereenie Sandstone is similar to the fine-grained sandstone in the Winnall Beds. It is a fine-grained white or pale brown clean and friable quartz sandstone which is thinly bedded and laminated, moderately sorted, and moderately rounded. Ripple marks and current striations occur on some bedding-planes. The cross-bed foresets are up to 6 feet thick and both low and high angles of repose are visible.

The thickness of the Mereenie Sandstone, calculated from some dips and the width of outcrop on the air-photographs, is estimated to be about 2000 feet.

No diagnostic fossils have been found in the Mereenie Sandstone. It rests conformably on the Larapinta Group of Ordovician age, and this basal part is probably Ordovician. Ranford et al. (1965) have reported a Cruziana from the Mereenie Sandstone in the Lake Amadeus Sheet area which indicates an Ordovician age for the basal part of the formation. As the overlying Pertnjara Formation contains Middle or Upper Devonian fossils (Joyce Gilbert-Tomlinson, BMR, pers. comm., and E.A. Hodgson, 1964) the top of the Mereenie Sandstone is probably Lower or Middle Devonian in age.

Pertnjara Formation

Prichard & Quinlan (1962) defined the Pertnjara Formation as 'the sequence of sandstone, quartz greywacke and conglomerate that overlies the Mereenie Sandstone with a regional unconformity .... Its upper limit is not known'.

Wells et al. (1965b, p.60) have described the Pertnjara Formation in a syncline on the northern margin of the Amadeus Basin (Mount Rennie and Mount Liebig Sheet areas), with conglomerate and sandstone to the north of the synclinal axis and sandstone and siltstone to the south. The distribution of sediments shows that the detritus was derived from the north, and it is possible that the syncline represents the keel of the downwarped area in which the Pertnjara was deposited. If this hypothesis is correct, the Pertnjara should thin and become finer-grained to the south. In the Bloods Range Sheet area, the only outcrop of probable Pertnjara Formation is a white siltstone directly overlying the Mereenie Sandstone, but there is room for a considerable additional thickness of sediment over the Mereenie Sandstone in the sharp, narrow, sand-covered syncline south-west of Mount Murray in the Lake Amadeus Sheet area.

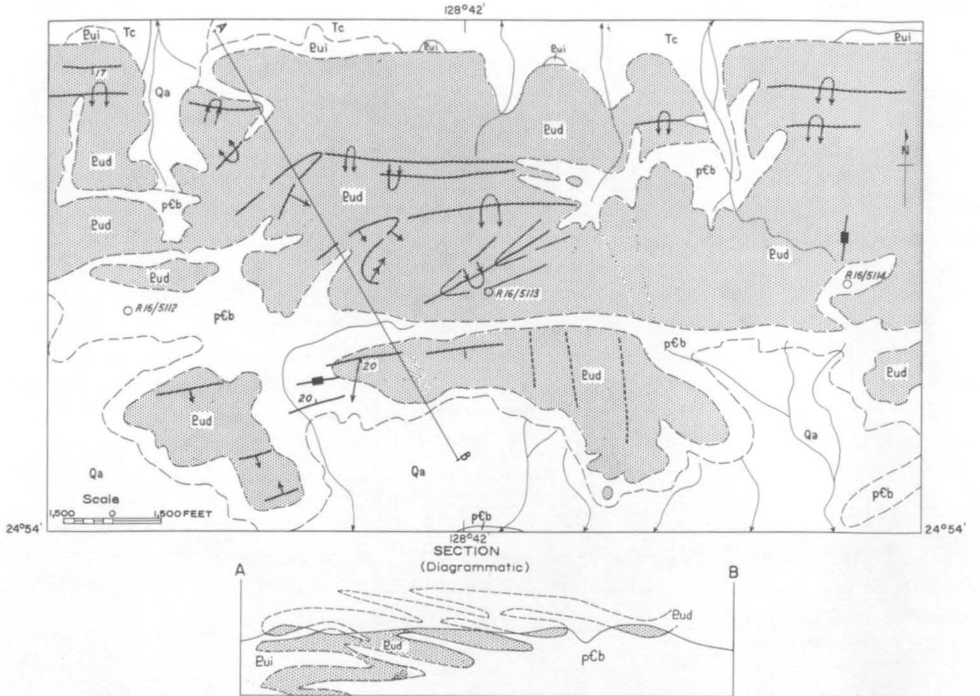
The recent find by R.M. Hopkins of Magellan Petroleum Co. of a placoderm fish plate from the lowest siltstone unit on the northern flank of the Mereenie Anticline indicates a late Middle or Upper Devonian age for the formation (Joyce Gilbert-Tomlinson, BMR, pers. Comm.). A sample of siltstone collected from the Mereenie waterbore No. 2 contained Middle or Upper Devonian plant spores (E.A. Hodgson, 1964).

TERTIARY(?)

Sandstone. Subhorizontal coarse-grained sandstone, about 20 feet thick, crops out at locality PR 78 near the Shaw River to the north of the Petermann Ranges. The sandstone has a grey-brown colour and is indistinctly bedded. It consists of uneven-grained coarse angular fragments of quartz, up to half an inch long, in a fine-grained siliceous matrix. In places the surface zone of the sandstone has been silicified and breaks with a conchoidal fracture, but elsewhere the sandstone is friable. Casts of vascular plants and some silicified wood with vascular bundles were found in the sandstone. Traces of vertical worm tubes occur in a bed just below the horizon containing the fossil wood. The vascular plants indicate a late Palaeozoic to Recent age.

Flat-lying beds of sandstone occur beneath the Tertiary conglomerate near the Dean Range, Foster Cliff, and Gordon Hill. The beds near Foster Cliff contain indeterminate organic markings resembling worm burrows. The conglomerate was deposited on the scoured surface of the sandstone without angular discordance. Similar beds of sandstone occur in the Bloods Range and Rawlinson Sheet areas; some of these beds contain abundant 'pipe rock' and for this reason may be of Ordovician age.

Conglomerate. Lithified piedmont deposits crop out on the flanks of the ranges. They dip outwards beneath the Quaternary sand and alluvium at angles up to 15^{o}. At Foster Cliff, Gordon Hill, and the Petermann Ranges they rest conformably or disconformably on sandstone, and in many places are partly covered by Recent scree. Many small creeks dissect the deposits.



Bureau of Mineral Resources, Geology and Geophysics. October, 1964 NT/A/70

Fig. 5 RECUMBENT FOLDING-SCHWERIN MURAL CRESCENT

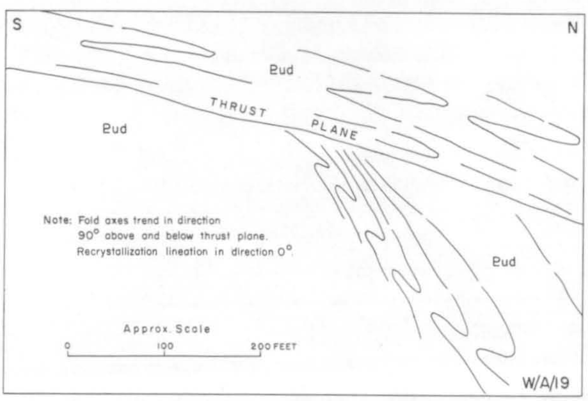


Fig. 6 DEAN QUARTZITE
Sketch of structure exposed in cliff face 2 miles west of Dean Range, W. A.

The phenoclasts are angular to subrounded and poorly sorted, with the largest boulders nearest the hills. The phenoclasts have been derived from the adjacent hills and consist mainly of quartzite with subordinate sericite schist and vein quartz. They range from less than an inch to 2 feet in diameter. Similar conglomerates have been recorded on the northern side of the Amadeus Basin (Prichard & Quinlan, 1962), but they are unlithified.

The conglomerates in the Hermannsburg Sheet area 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

The greater part of the area is covered by superficial aeolian sand, alluvium, travertine, and evaporites, which are assumed to be Quaternary.

Travertine and evaporites form a thin grey to white crust on the dry floor of the lakes. The water-soluble components in a sample of the crust are as follows:

	Cl	SO_4	Ca	Mg	Na	K	NO_3
Percent	12.3	10.8	0.58	0.32	12.8	0.1	Nil

Analyst: S. Baker, BMR.

The material underlying the crust is a red-brown sandy gypsiferous silt. In places near the lake shore, sand has been blown over the evaporite crust. Travertine and some gypsum occur as a fringe around the lake and on the islands inside it (Pl. 1, Fig. 2). The islands are surrounded by steep sides from which travertine and gypsum have crumbled on to the evaporite crust. The islands are capped by yellow-brown crystalline limestone and travertine, which overlies a light grey gypsiferous silt. The limestone and gypsiferous silt probably formed continuous beds which have since been eroded, and the lake bed is probably composed of the gypsiferous silt, wind-blown sand, and weathered limestone.

Sand dunes overlie the travertine on the islands and on the margins of the lake. A large part of the area is covered by orange-brown aeolian sand and sand dunes. The sand is unconsolidated, but is fixed by a cover of light vegetation. The dunes rarely extend more than 10 miles and range up to 60 feet high, with an average of 20 to 30 feet. Branching and braided tops are common.

Alluvium has been deposited in the beds and flood plains of the Docker and Hull Rivers, and Chirnside, Shaw, Irving, Armstrong, and Britten Jones Creeks. Alluvium also occurs on the flanks of the ranges and hills where local runoff has distributed pebbly sand around the Tertiary conglomerates. An extensive alluvial plain occurs along the northern flank of the Musgrave Ranges at Mulga Park.

STRUCTURE

There are two main periods of folding of the Precambrian and Palaeozoic rocks adjacent to the south-west margin of the Amadeus Basin. The first is represented by the isoclinal and recumbent folding and metamorphism of the Mount Harris Basalt, Bloods Range Beds, Dean Quartzite, and Pinyinna Beds, and by the tight folding of the Winnall and Inindia Beds; and the second by the broad, rarely tight, folding of the Cleland Sandstone, Larapinta Group, Mereenie Sandstone, and Pertnjara Formation.

The first period of folding occurred along the south-west Amadeus Basin and is here named the Petermann Ranges Orogeny. The second period of folding, called the Alice Springs Orogeny, was initiated in the north, but is widespread throughout the Amadeus Basin.

Petermann Ranges Orogeny

During the Petermann Ranges Orogeny, rocks along the south-west margin of the Amadeus Basin were folded and metamorphosed. The structures developed are similar to those described by many workers in the Scottish Highlands. Rocks which were originally at no greater depth than about 14,000 feet have been metamorphosed and in places converted to gneiss and granite. The regional metamorphism and granitization of the rocks indicate that they have been buried to a much greater depth, probably by overfolding, and the distribution and structure of the Dean Quartzite can only be explained satisfactorily by regional recumbent folding. The recumbent folding occurred in the rocks below the Bitter Springs Limestone and Pinyinna Beds and was not carried higher in the sequence because of the plasticity of these formations and the relatively competent nature of the Inindia Beds and Winnall Beds. The Inindia Beds and Winnall Beds slid northwards on a décollement surface in the Bitter Springs Limestone and Pinyinna Beds and their folding is of the Jura type.

Style of Deformation

The style of deformation is illustrated in Figures 5 to 8 and Plates 5 to 8. They show the small-scale isoclinal and recumbent folding of the Dean Quartzite in the Schwerin Mural Crescent, to the west of the Dean Range, Bloods Range, in the Petermann Ranges, Rawlinson Range, Olia Chain, and in the southern half of the Ayers Rock Sheet area. Plate 5, Plate 6, figure 1, and Plate 7, figure 1 illustrate that the schistosity is parallel to the axial plane of the folds, and that the lineation is parallel to the axial line of the folds. Figures 5 and 6 show that in some areas a lineation occurs at right angles to the predominant fold direction. The folds trend east-west and the lineation is northerly. The northerly lineation is predominant in this area, and at other localities it is parallel to the axial lines of folds (Pl. 5; Pl. 6, fig. 1).

It appears therefore that there are two directions of recumbent and isoclinal folding, one approximately east-west (F^1), parallel to the main trend of the ranges, and the other at right angles (F^2). Figure 9 shows the regional trend and distribution of the folds. The F^1 folds are known from the Schwerin Mural Crescent, the range of Dean Quartzite 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 the 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 series of folds (F^3), which is apparently later than F^1 or F^2, occurs throughout the region. 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 the ranges. The folds are typically tight, with overturned axes dipping south at moderate to steep angles. The folding has produced a schistosity parallel to the axial planes and a lineation parallel to the b-axes of the folds. Schistosity and lineation associated with F^2 are refolded by F^3 (Pl.9, fig. 1). F^3 folds also occur in the Kathleen Range area in Western Australia and in the southern half of the Ayers Rock Sheet area.

Figure 10 is a block diagram showing F^1, F^2, and F^3 folds in 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 granitic bodies.

Metamorphism in the Recumbent Fold

Figure 10 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 in the upper normal limb of the recumbent fold, where the depth of burial and degree of deformation were at a minimum. As the sediments are traced around the nose of the recumbent fold into the inverted middle limb, the degree of metamorphism increased and the volcanic and clastic sediments have been converted to schist and amphibolite. Continuing along the inverted middle limb, towards the recumbent syclinal 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 the 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 foliation is parallel to the schistosity. It has been noted in the Petermann Ranges, Dean Range, and Butler Dome in particular, that the foliation in the coarsely porphyroblastic augen gneiss is parallel to the axes of the F^2 folds and the schistosity in the Dean Quartzite. The strong lineation L^2 in the plane of foliation is parallel to the plunge and trend of the F^2 folds in the adjacent Dean Quartzite, and to the lineation L^2 on the bedding planes (S^o) in the Dean Quartzite (Pl.5, fig. 2, Pl.6, Fig. 1). F^1 and S^1 have not been proved in these structures, but it is highly probable 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 and 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 Mannanana and Curdie 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 the S^1 and S^2 schistosity and the 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 foliation is the same as S^1 and S^2 and in the schist. The foliation in the gneiss has also been refolded by F^3, and the S^3 schistosity in the gneiss can be seen in Plate 9, figure 1. In the Pottoyu Granite Complex the gneiss grades into granite. The S^3 schistosity and L^2 lineation in the gneiss are folded by F^3. As the gneiss grades into the granite the folding becomes tighter, with S^2 parallel to S^3. In some outcrops L^2 is still visible although L^3 is predominant. In the final stage of the conversion of gneiss to granite, the S^2 schistosity or foliation and F^3 folds are no longer recognizable. The S^3 schistosity and L^3 lineation may be weakly preserved or absent in the granite. In the rapakivi granite the growth of abundant egg-sized ovoid feldspars has largely destroyed the original foliation (S^2), but the original L^2 lineation is still prominantly visible in many outcrops. In the majority of outcrops S^2 and L^2 have been obliterated and only S^3 and L^3 are visible.

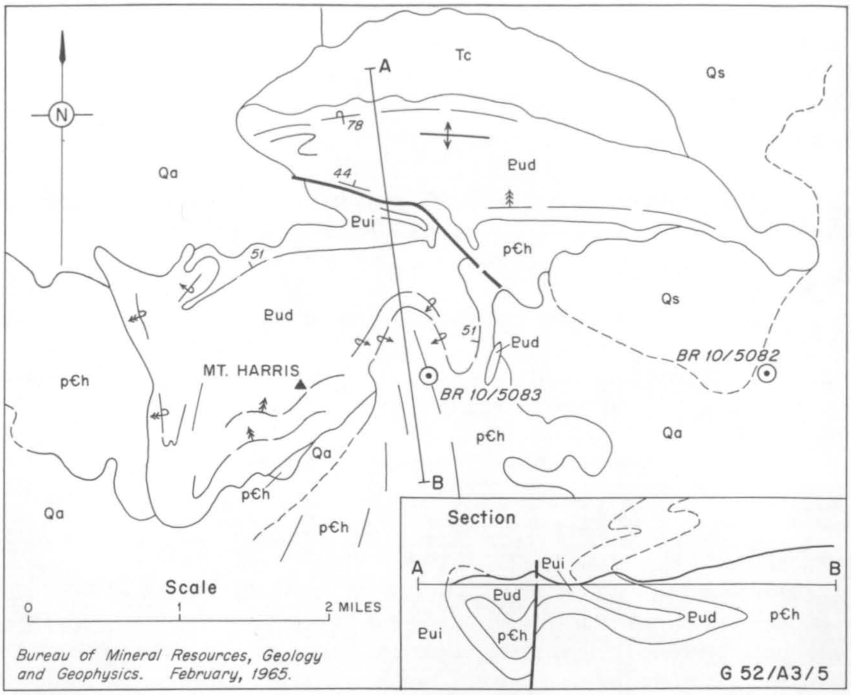


Fig. 7 Recumbent fold, Mount Harris.

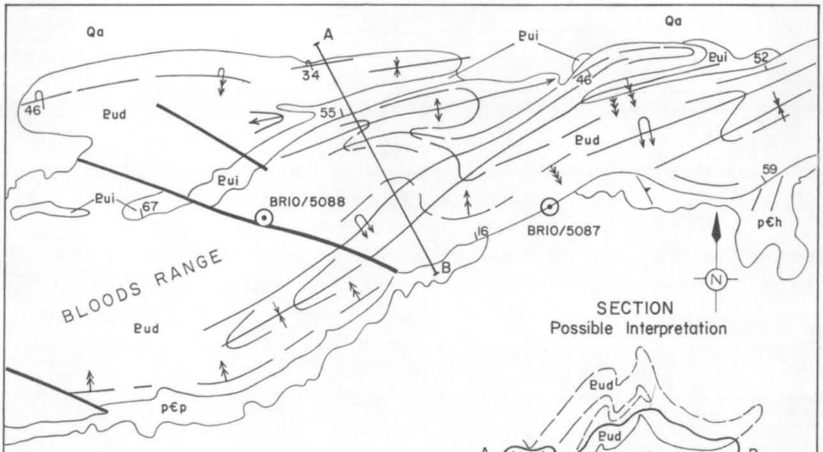


Fig. 8. Recumbent fold — Bloods Range

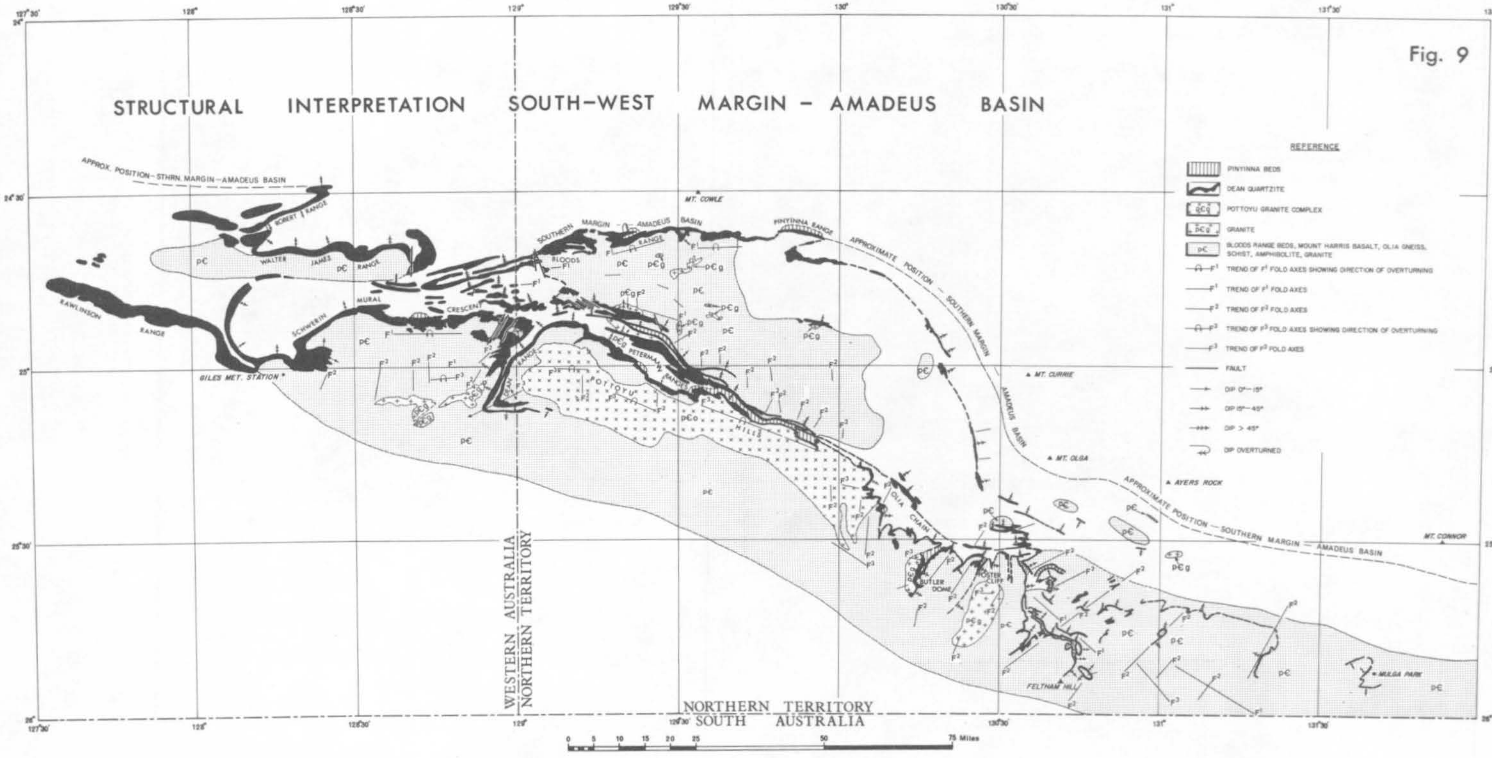
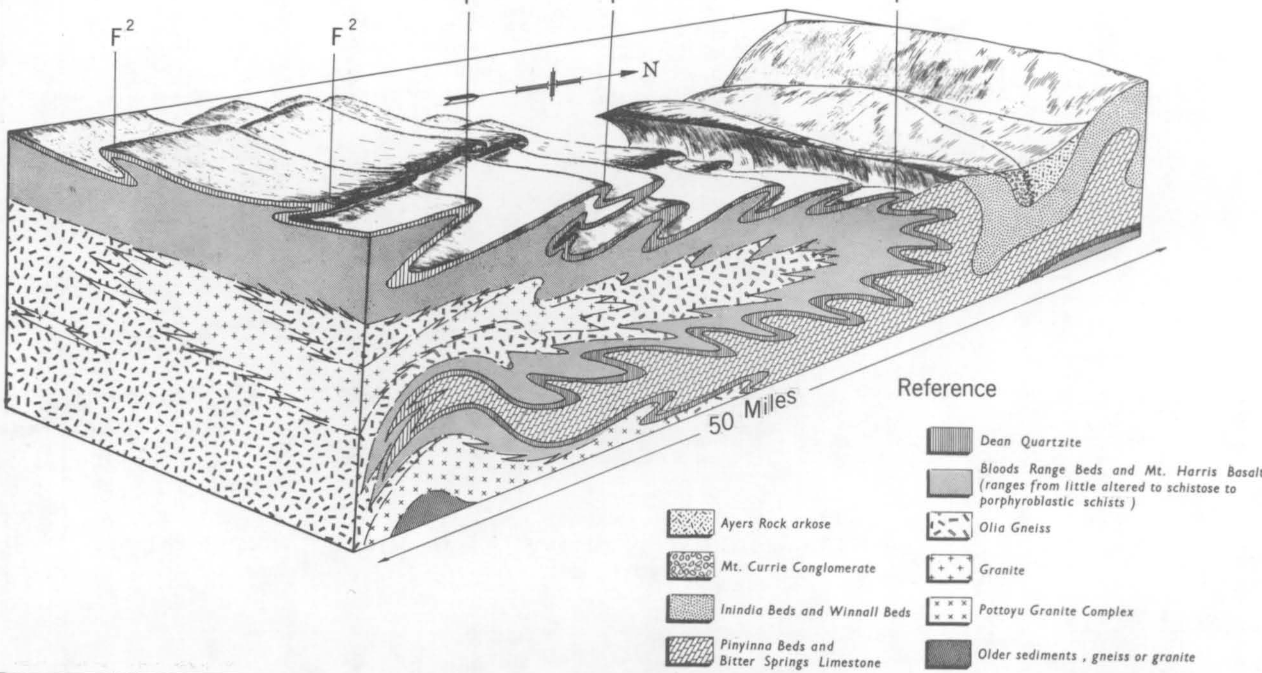


Figure 9 : Structural interpretation of the south-west margin of the Amadeus Basin

Fig 10

RELATIONSHIP OF METAMORPHISM AND MINOR STRUCTURES TO REGIONAL STRUCTURE

SOUTH-WEST MARGIN, AMADEUS BASIN



The preservation of S^2 schistosity or foliation and L^2 lineation in the granite and gradual transition from dominant S^2 and L^2 to dominant S^3 and L^3 are strong evidence that the granite in the Pottoyu Granite Complex was formed by metasomatic replacement. The same sort of structural gradation can be seen in the transitional zone from gneiss to granite west of Butler Dome. It is therefore concluded that much of the granite was formed at a late stage during the F^3 folding. In places the granite has been partly mobilized with sharp intrusive contacts against gneiss and schist.

Lineation is of various types. The most readily recognizable lineation is intersection of bedding and schistosity in the Dean Quartzite. In most outcrops, however, the bedding and schistosity are parallel and the lineation is due to the alignment and streaking of quartz and muscovite down the bedding plane or to the presence of microfolds and undulations on the bedding plane. Plate 6, figure 1 shows quartz rods parallel to the lineation in quartz-sericite schist. In a few places it was found that the direction of elongation of pebbles was parallel to the lineation of the minerals.

The lineation is not always parallel or at right angles to the direction of the 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° 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 are clear and as described here.

Lineation in the gneiss is shown by the crude banding, streaking, and the orientation of the minerals on the plane of foliation. In some of the amphibolite bands in the gneiss, the amphibole is oriented with its long axis parallel to the lineation. In several localities the lineation is parallel to the minor folds in the gneiss (as in Pl. 9, fig. 2). At other localities, particularly in the coarsely porphyroblastic augen gneiss, it is possible that the earlier foliation or schistosity has been folded parallel to the later foliation and that the lineation represents the trace of the earlier foliation or schistosity on the plane of the later foliation. 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 L^1 lineation in the fine to medium-grained gneiss is folded about the F^2 fold axes, whereas the coarse porphyroblastic gneiss contains only the L^2 lineation. It appears therefore that the coarse porphyroblastic gneiss has developed during the F^2 folding, whereas the fine to medium-grained gneiss developed during F^1 folding.

Downward-facing Structures

A number of 'anticlinal' structures have been mapped in which the core contains the youngest rock and the envelope the oldest rock. These are called antiformal synclines and are known at Foster Cliff (Pl. 8) and Butler Dome on the Petermann Ranges Sheet area, and at Ilyaralona Range on the Bloods Range Sheet area. Between Bloods Range and the

Petermann Ranges the eastern ends of four hills near the western side of Bloods Range Sheet area were mapped as easterly plunging antiformal synclines. Many other folds in the area are isoclinal antiforms or synforms.

A number of reclined F^2 folds occur in overturned strata along the northern front of the Petermann Ranges between Chirnside Creek and Shaw Creek. The strata are overturned because the Pinyinna Beds dip north below the Dean Quartzite which in turn dips north beneath the Olia Gneiss.

Conclusions

1. A uniform structural style and sequence of events persists between Giles in Western Australia and Mulga Park station 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 regional metamorphism of the Dean 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 buried under a cover of about 12,000 feet of sediment, but the regional metamorphism of the quartzite was probably due to infolding to a much greater depth.

5. The distribution and structure of the Dean Quartzite indicates the presence of a major recumbent fold over 200 miles long and 30 miles or more wide. If the infold was a vertical or steeply inclined structure its core would lie beneath the Bloods Range and would not appear in the Petermann Ranges and Dean Range.

Folding of the Inindia Beds and Winnall Beds

The Bitter Springs Limestone and equivalent Pinyinna Beds are incompetent members of the sequence and there is a disharmonic relationship between the structures in the rocks above and below them.

In the northern part of the Bloods Range Sheet area near Lake Neale and Lake Amadeus, the Petermann Ranges Orogeny gave rise to tight folds in the Winnall Beds and Inindia Beds. These formations are overlain unconformably by the Cleland Sandstone. The same unconformity is present farther north-east in the Gardiner Range in the Mount Liebig Sheet area, but is not evident in the Hermannsburg Sheet area. Another unconformity occurs beneath the Winnall Beds at Souths Range and also in the Lake Amadeus Sheet area (Ranford et al. 1965). This suggests that the Petermann Ranges Orogeny is reflected by at least two unconformities in the sedimentary succession. The unconformity beneath the Winnall Beds is more marked than farther north, which suggests that the folding was initiated in the south and subsequently extended northwards, and ended with the strong folding in the Lake Neale/Lake Amadeus area.

The Winnall Beds crop out at Mount Unapproachable and the Inindia Beds farther north. The Inindia Beds are tightly folded into a series of anticlines and synclines with flat plunges. The younger Winnall Beds are preserved as canoe-shaped outcrops in tight synclines with flat culmination and depressions of the axis. At Long Range both limbs of one of these synclines dip steeply and the northern limb is overturned. In the Souths Range/Mount Cowle area the same type of structure is preserved on a much larger scale, and plunge reversals of the axis are indicated by the basin-shaped structures of Mount Cowle and its twin, west of the Hull River.

In many places the Petermann Ranges Orogeny has produced numerous joints, but no major faults have been found in either the Winnall Beds or Inindia Beds.

The Winnall Beds and Inindia Beds were probably squeezea out of the recumbent fold with the plastic Pinyinna Beds and it appears that they have slid northwards on a décollement surface in the Bitter Springs Limestone. This relationship is shown diagrammatically in Figure 10, which also shows the wedges of conglomerate and arkose which were deposited in front of the recumbent fold.

Alice Springs Orogeny

The Alice Springs Orogeny succeeded the Petermann Ranges Orogeny after a period of stability. It occurred in the Devonian, and caused recumbent folding in the Bitter Springs Limestone and older rocks along the northern margin of the basin, and décollement sliding and folding of the sediments over the Bitter Springs Limestone. The orogeny accompanied and followed the deposition of the Pertnjara Formation.

In the Bloods Range Sheet area, the Alice Springs Orogeny has caused the development of broad anticlines and synclines with gentle plunge reversals in the sediments overlying the Bitter Springs Limestone. A tight syncline with an overturned northern limb south of Mount Murray is also included in the Alice Springs Orogeny. The tightness of this syncline is probably related to the presence at depth of incompetent gypsum, which is exposed in the adjacent anticline to the north. All anticlines in the Bloods Range Sheet area are breached to Upper Proterozoic sediments which are poorly exposed.

The presence of the gypsum in structures produced during the Alice Springs Orogeny suggests that an incompetent gypsiferous sequence at depth may have caused décollement and diapiric tectonics. The interpreted fault structure 8 miles west of Mount Murray may have been formed in this way.

A décollement is postulated in the Bitter Springs Limestone and Pinyinna Beds during the Petermann Ranges Orogeny to explain the different structures developed in the overlying Winnall Beds and Inindia Beds, and the underlying Dean Quartzite and older rocks. Décollement tectonics are also believed to be responsible for the folds developed within the Amadeus Basin during the Alice Springs Orogeny. The presence of a décollement in the Bitter Springs Limestone and equivalent Pinyinna Beds is indicated by the structure of the units above and below the Bitter Springs Limestone. The relationships are not obvious in the Bloods Range Sheet area, but the evidence for a décollement in the Bitter Springs Limestone in the Amadeus Basin is outlined below:

(1) In all outcrops in the Bloods Range Sheet area the Bitter Springs Limestone is highly contorted, isoclinal folding is common, and gypsum is interbedded at Mount Murray. Near the north-eastern corner of the Bloods Range Sheet area the gypsum intrudes the Cleland Sandstone and gypsum occurs farther west near the core of a possible strike-faulted anticline. Gypsum also crops out in the cores of anticlines in the adjacent Mount Rennie and Lake Amadeus Sheet areas.

(2) Prichard & Quinlan (1962, pp. 31-32) suggested that in the Hermannsburg Sheet area 'compressional stresses were transmitted mainly through the basement Arunta Complex. Dragfolding, close jointing, and occasional recrystallization along the Heavitree Range indicate that the Heavitree Quartzite was also subjected to stress .... Stresses were not transmitted through the thick incompetent Bitter Springs Limestone, but were dissipated by folding within the formation ...... the Bitter Springs Limestone has absorbed the stresses and insulated the overlying sequence from their effects.'

(3) Wells et al. (1965b) state that, in the Mount Liebig and Mount Rennie Sheet areas: 'The folds in evidence at the surface do not seem to be strongly reflected in the basement structure shown by regional gravity. It is probable that the Bitter Springs Limestone has behaved as an incompetent member of the sequence, and has been squeezed from the broad synclinal troughs into the sharp anticlinal crests. Hence the sediments overlying the Bitter Springs Limestone have folded independently of the basement rocks and the Heavitree Quartzite. This structure suggests a décollement within the Bitter Springs Limestone. The best explanation for the number, regularity, and length of the folds in the Amadeus Basin is that the sediments have slid over the incompetent Bitter Springs Limestone following the application of a horizontally directed stress.'

(4) Ranford et al. (1965) suggest that 'Gypsum and possibly other evaporites may be present in the cores of many of the anticlines [in the Lake Amadeus Sheet area], as a result of décollement folding.'

The evidence for a décollement style of folding over the lubricant formation is as follows:

(1) The Heavitree Quartzite is not exposed in the core of any of the anticlines mapped in the Amadeus Basin, and the oldest beds exposed are the Bitter Springs Limestone.

(2) The aeromagnetic profiles across the Amadeus Basin show depth to basement greater than 10,000 feet (Goodeve, 1961) even across areas where the Bitter Springs Limestone crops out at the surface.

(3) The geometry of the Amadeus Basin folds is similar to the geometry of Jura-type folds.

The evidence that stresses transmitted through the basement have been dissipated in the Bitter Springs Limestone is:

(1) The recumbent fold in the Mount Harris Basalt, Bloods Range Beds, Dean Quartzite, and Pinyinna Beds (equivalent of the Bitter Springs Limestone) is not likely to have developed fully until the Winnall Beds were deposited for the following reasons: where the contact between Bitter Springs Limestone and Inindia Beds is exposed it appears to be conformable (Ranford et al. 1965); the Winnall Beds overlie Inindia Beds probably unconformably, but the first known major unconformity in the sedimentary sequence above the Dean Quartzite is at the base of the Cleland Sandstone. This unconformity is accompanied by conglomerate in which fragments of metamorphosed Dean Quartzite are common, and farther south the Mount Currie Conglomerate, with phenoclasts derived from the recumbent fold, sits unconformably on the Winnall Beds. Therefore, the recumbent folding appears to have taken place in the Dean Quartzite, Pinyinna Beds, and Bitter Springs Limestone, but not in the sediments overlying the Bitter Springs Limestone.

(2) See the quotation from Prichard & Quinlan (1962) on p. 46.

It is concluded that there is a décollement in the Bitter Springs Limestone, and that the folding above and below the lubricant formation has different styles even though the folding occurred during one orogeny.

GEOLOGICAL HISTORY

The Mount Harris Basalt and Bloods Range Beds are predominantly of volcanic origin. They were probably deposited unconformably on a basement complex of gneiss, granite, schist, and quartzite. The Bloods Range Beds were uplifted and eroded before deposition of about 4000 feet of the Upper Proterozoic Dean Quartzite, Pinyinna Beds, and Bitter Springs Limestone in a relatively stable, epicontinental, shallow marine environment. A period of instability followed, accompanied by a change from carbonate to clastic sedimentation, as evidenced by the Inindia Beds (about 2000 feet) and an increase in instability as evidenced by the Winnall Beds (about 8000 feet). Part of the Winnall succession may have been deposited in a non-marine environment.

The Petermann Ranges Orogeny followed late in the Upper Proterozoic and was accompanied by metamorphism of the Mount Harris Basalt, Bloods Range Beds, Dean Quartzite, and Pinyinna Beds, and the 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, but the overlying Inindia Beds and Winnall Beds slid northwards on a décollement surface. Dolerite was intruded. The folding was accompanied by uplift and the formation of a mountain range along the southern margin of the basin. Thick wedges of Mount Currie Conglomerate and Ayers Rock arkose were deposited against the northern front of the recumbent fold mountain, probably early in the Cambrian. During the Cambrian, the mountain range and adjacent land masses were eroded, and the post-orogenic Cleland Sandstone was deposited farther north in a deltaic and paralic environment.

A period of tectonic stability followed, during which the Ordovician Larapinta Group was deposited in a shallow marine environment. During a marine transgression in the south a thin veneer of sediment was deposited over parts of the eroded and peneplaned mountain range. At this time the ancient Petermann Ranges and Bloods Range were probably islands or peninsulas.

The deposition of the Mereenie Sandstone probably extended from the Ordovician to early Devonian. During the pre-orogenic phase of the Alice Springs Orogeny the sea retreated and sandstone was formed by reworking of sediment by wind and shallow water, predominantly non-marine. The Pertnjara Formation was deposited as a thick clastic wedge adjacent to the northern margin of the basin, where the Alice Springs Orogeny was initiated. In the Bloods Range Sheet area the Pertnjara Formation is relatively thin and fine-grained. The Alice Springs Orogeny extended southwards thoughout the basin as dĕcollement folding, and the Pertnjara Formation was deformed by it. Some of the fault and fold structures were accentuated by diapiric intrusion and pinching and swelling of incompetent beds at depth.

Deposition of sediments and deformation associated with the Alice Springs Orogeny ceased in the Devonian or early Carboniferous. On the south-western margin of the basin a long period of weathering and erosion followed. Conglomerate and sandstone were deposited near the ranges during a pluvial period in the Tertiary. At the same time the watertable may have risen above the low-lying areas now occupied by Lakes Hopkins, Neale, and Amadeus, and limestone and gypsiferous silt were deposited in them. A period of aridity followed in the Quaternary, during which the watertable dropped and the sand dunes were formed.

The present-day climate may be less arid.

ECONOMIC GEOLOGY

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

Copper. Malachite occurs in Mount Harris Basalt and Bloods Range Beds at a number of localities in the southern part of the Bloods Range Sheet area and near Kathleen Range in the Scott Sheet area. The malachite is found in sericite schist, sericitic quartzite, and epidotized amygdaloidal basalt. In some deposits the malachite is micaceous and is oriented parallel to the metamorphic sericite, but in other deposits it is secondary.

Lead, Silver, and Gold. Secondary lead and copper minerals, galena, silver, and gold have been found in a small quartz vein intruding the Mount Harris Basalt in the Bloods Range Sheet area at locality BR34.

Phosphate. Two beds of red sandy phosphatic limestone less than an inch thick occur at locality BR75 on the Bloods Range Sheet area. A sample of the phosphate was found to contain 10 to 20 percent P_2O_5.

Underground Water. Supplies of underground water are obtained from boreholes at Giles, Livingstone Pass, Ayers Rock, and Mulga Park station, but two bores drilled at Mount Olga were unsuccessful. Bore data for the Livingstone Pass area are summarized in Table 2. Wells et al. (1956a) give bore data for the Giles area and Wells, Stewart & Skwarko (1966) 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 Station.

(1) Giles. Water is obtained from bores along the creek which flows from near Giles through the Pass of the Abencerrages. The water is probably obtained from alluvium overlying schist and gneiss.

(2) Livingstone Pass. The catchment area is in Learmonth Park and the Dean Range/Schwerin Mural Crescent area to the west. One bore was sited in Livingstone Pass to test the subsurface movement from the Learmonth Park catchment area. Several other bores were drilled to the west of Livingstone Pass to test the underground

movement from the Dean Range/Schwerin Mural Crescent catchment area: one of the bores gave a good supply of potable water. The remainder of the bores were sited farther north across the Docker River to test the water beneath the northern gap in the Petermann Ranges, but the water was mostly salty.

All the water is derived from unconsolidated sediments overlying the Dean Quartzite, Pinyinna Beds, or Precambrian metamorphics. The results of the drilling programme carried out by the Water Resources Branch of the Northern Territory Administration in 1963 are tabulated in Table 2 (Youles, 1964):

Table 2. Bore Data, Livingstone Pass Area

Bore No.	Depth (feet)	Total Dissolved solids (ppm)	Yield (gph)	Drawdown (feet)	Remarks
G52/3-1	208	525	1200	4.85	
G52/3-2	130	3860	1400	12.1	
G52/3-3	130	5160	Not tested		
G52/3-4	130	1528	600	14	
G52/3-5	205	546	Not tested		100 feet N.E. of bore 3-10
G52/3-6	117	2832	1000	18.15	
G52/3-7	115	1167	Not tested		
G52/3-8	105	-	Not tested		100 feet S. of bore 3-1
G52/3-9	105	-	Not tested		100 feet N. of bore 3-1
G52/3-10	120	318	1750	22.5	Probable production bore

(3) Ayers Rock. Good water has been obtained from the alluvials near Ayers Rock. Seven bores have been sunk to depths of between 50 and 400 feet through clay, sand, silt, and travertine. The 400-foot bore probably penetrated bedrock, but was unsuccessful. Only two of the bores yielded water in excess of 600 gallons per hour.

(4) Mulga Park Station. No satisfactory records are available of the bores at Mulga Park station. All the bores began in alluvium and many were continued down to bedrock, but it is not known 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 the subsurface basement contours.

Petroleum Prospects. The structure and metamorphism of the rocks along the southern margin of the Amadeus Basin are unfavourable for the preservation of oil, but accumulations of oil could occur in the Basin to the north.

Economic basement in the Amadeus Basin may be extended below the known Cambrian succession to the base of the Heavitree Quartzite or Dean Quartzite. The reason for this is twofold:

(1) Organic life in the Upper Proterozoic seas is proved by the presence of stromatolites of algal origin in the Bitter Springs Limestone and Inindia Beds;

(2) oil or gas which accumulated in Cambrian or Ordovician sediments could have migrated into favourable structures in the older rocks. Assuming thicknesses

of 2000 feet for the Dean Quartzite, 2000 feet for the Pinyinna Beds and Bitter Springs Limestone, 2000 feet for the Inindia Beds, and 8000 feet for the Winnall Beds, and assuming the folding to have occurred over a dêcollement, depth to economic basement may be as much as 14,000 feet.

The Pertnjara Formation, the Mereenie Sandstone, and the Cleland Sandstone are not potential source rocks. The marine sediments of the Larapinta Group could be considered as source rocks, but the prospects of petroleum accumulation in this Group in the Bloods Range Sheet area are negligible, as it is widely exposed and all anticlines are breached to the Upper Proterozoic. The search for oil must be directed at source and reservoir beds in the Upper Proterozoic succession. The Pinyinna Beds, Bitter Springs Limestone, and Inindia Beds may contain source rocks, and suitable sandstone reservoir units and fracture porosity reservoirs may also be present.

No closed anticlinal structure or other suitable traps for oil have been mapped, but suitable structures may be present under the cover of sand. The petroleum prospects of the area are rated as poor.

GEOPHYSICAL DATA

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

In 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 across the Amadeus Basin, the smooth magnetic profile indicates that any fluctuation in magnetic intensity of the basement rocks is obscured by over 10,000 feet of sediments. The smooth profile changes to one of moderate magnetic variation over the Bloods Range Sheet area, starting at a point several miles north-east of the Pinyinna and McNichol Ranges. From this point to Giles, the magnetic basement is interpreted at depth of 0 to 2000 feet and corresponds with the 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 at shallow depth. This result agrees with the extensive outcrops of quartzite, granite, and gneiss from Mount Davies to within 10 miles of Ayers Rock, and suggests that the arkose at Ayers Rock may contain bodies of different magnetic intensity.

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

On the southern margin of the Amadeus Basin the nature of the magnetic basement is known from outcrop geology, but it cannot be assumed to be the same farther north. On the southern margin of the basin the Bloods Range Beds have been metamorphosed and partially granitized, but they may be unaltered if they occur beneath the Dean Quartzite or Heavitree Quartzite in the centre of the basin. In this case, the magnetic basement could be several thousands of feet below the base of the Dean Quartzite where the Bloods Range Beds may be in contact with the Mount Harris Basalt or older igneous and metamorphic rocks. Owing to the regional unconformity below the Dean Quartzite and the difference in intensity of metamorphism of the underlying sediments it is impossible to be certain of the position of the magnetic basement in the deeper parts of the basin. However, it is unlikely that magnetic basement lies above the Dean Quartzite or Heavitree Quartzite.

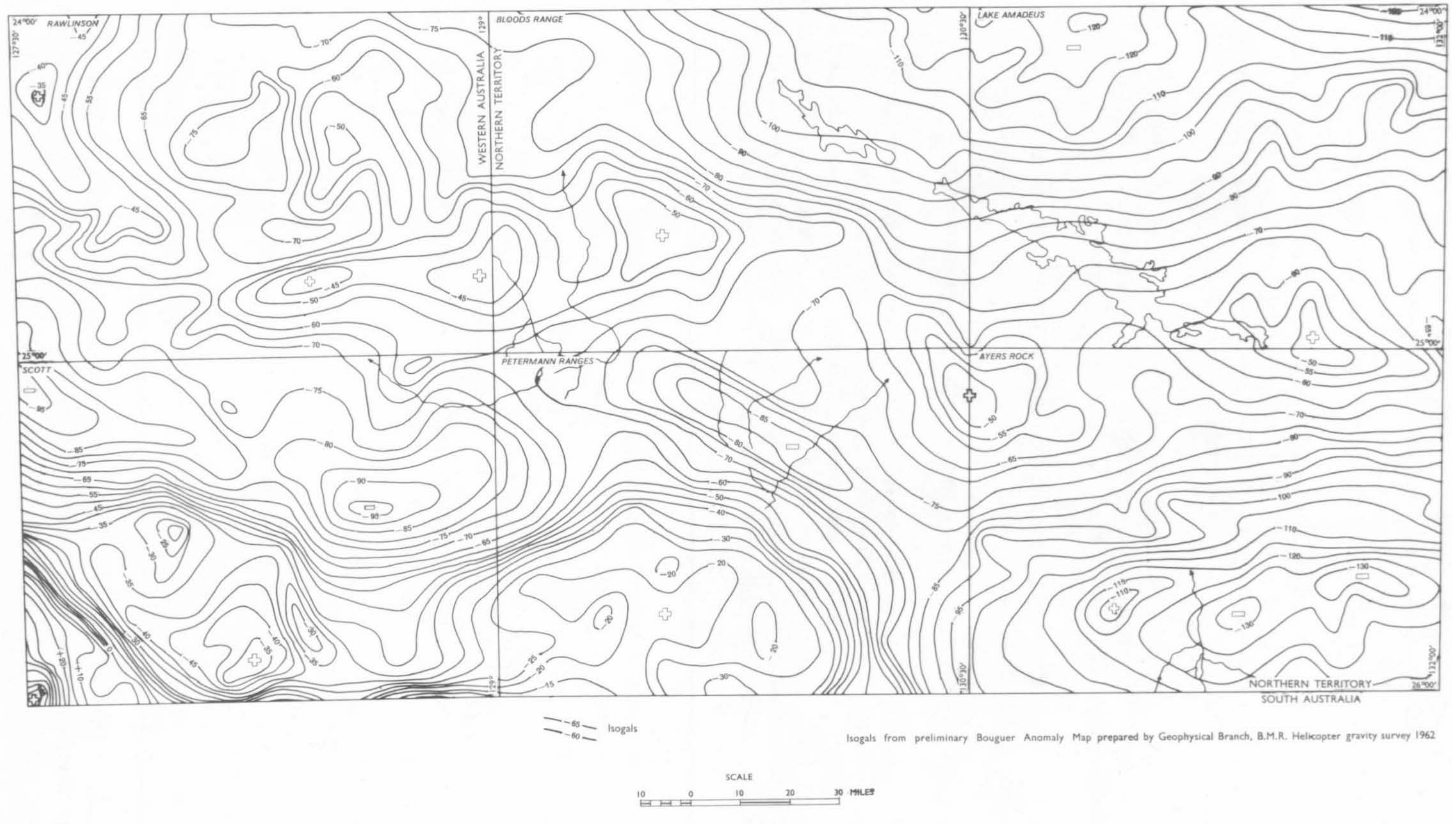


Figure 11 : Bouguer anomalies

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 of the Bureau of Mineral Resources made a regional gravity reconnaissance as part of a larger programme in the Amadeus and Canning Basins (Lonsdale & Flavelle, 1963). Figure 11 shows the preliminary Bouguer anomaly map of the area. The most notable features of this map are:

(1) a gravity minimum which extends from the Kelly Hills in the Ayers Rock Sheet area through the northern half of the Petermann Ranges Sheet area to the Scott Sheet area 20 to 30 miles south of Giles:

(2) a gravity ridge extending along the Bloods Range and the northern part of the Ayers Rock Sheet area; and

(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 great 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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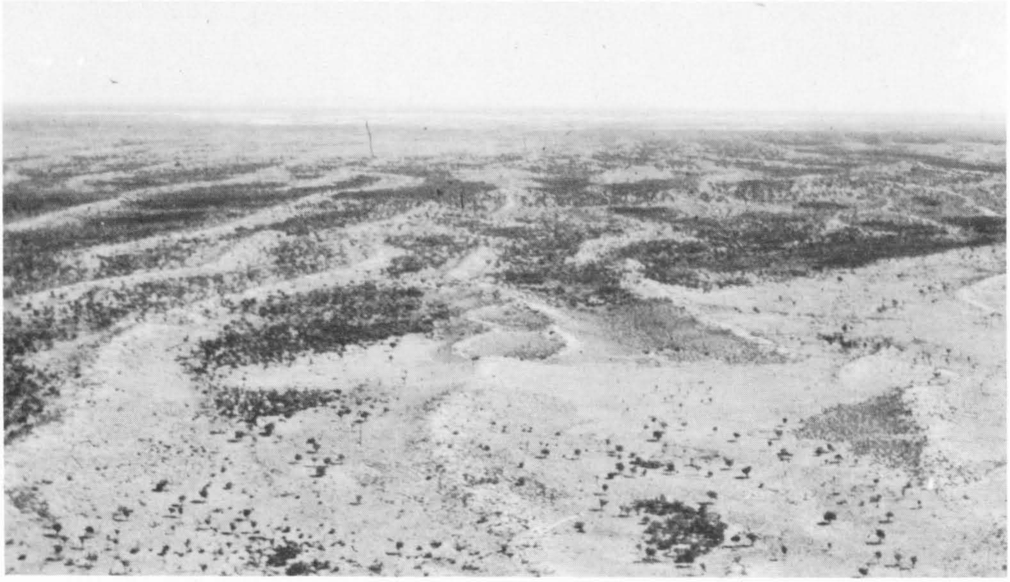


fig. 1 : Sand dunes, looking south-west over Lake Neale towards Bloods Range

fig. 2 : Lake Neale, showing salt lake with islands of travertine

Plate 2

fig. 1 : Mount Harris Basalt near Mount Harris

fig. 2 : Oscillation ripple marks in the basal quartzite of the Mount Harris Basalt

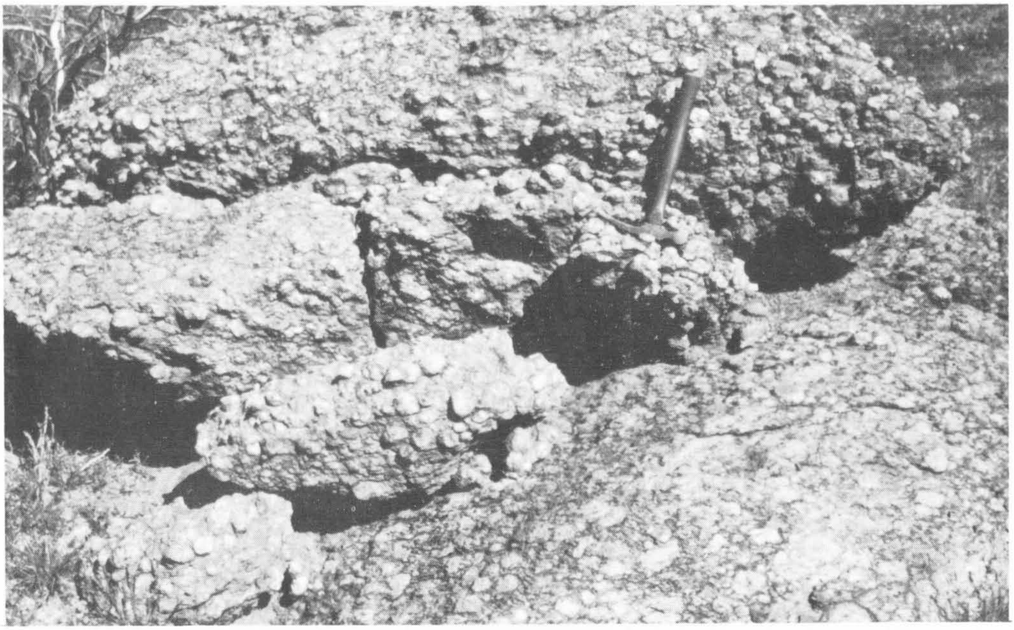


fig. 1 : Coarsely porphyritic gneissic biotite granite, from the Pottoyu Granite Complex, Pottoyu Hills

fig. 2 : Porphyroblastic augen gneiss, 10 miles north of Feltham Hill in the Ayers Rock Sheet area

Plate 4

fig. 1 : Dean Quartzite in the Dean and Mannanana Ranges

fig. 2 : Contact between the Dean Quartzite and schist in the Mannanana Range, a quarter of a mile east of Livingstone Pass

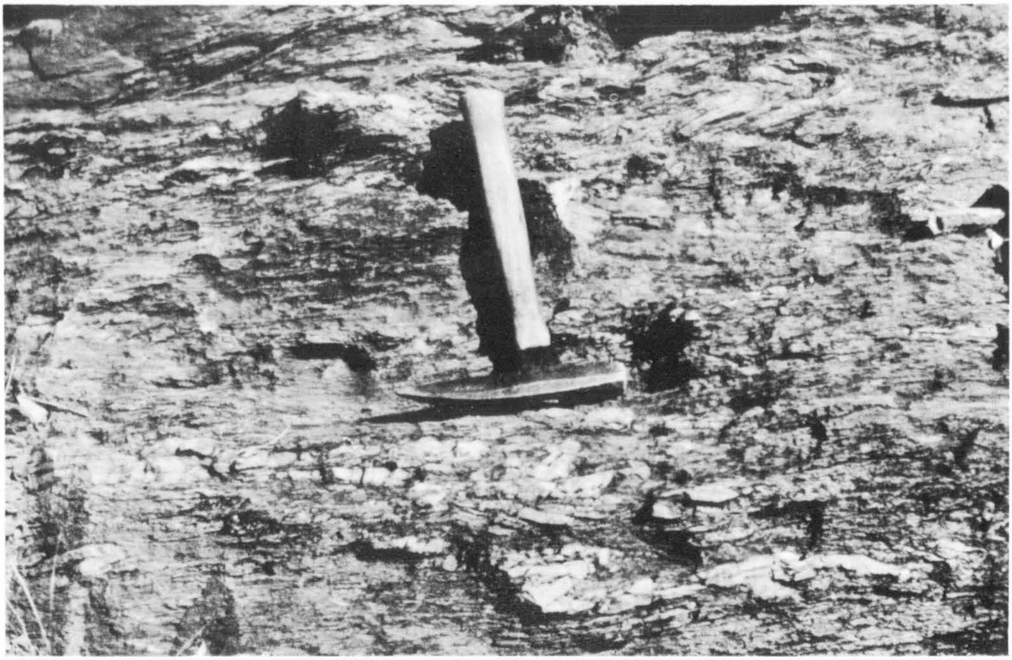


fig. 1 : Recumbent folding in the basal unit of the Pinyinna Beds, Foster Cliff

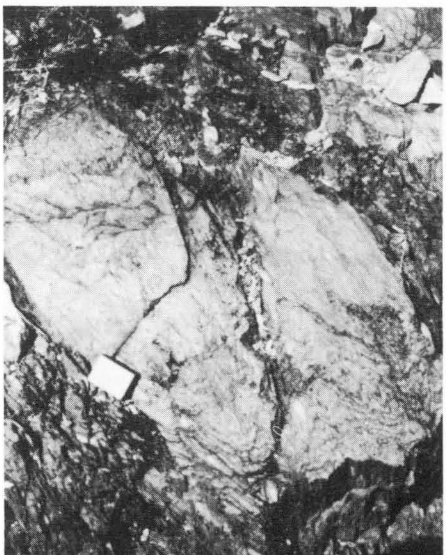


fig. 2 : F^2 folding in the Dean Quartzite, 3 miles north of Mount Phillips, Petermann Ranges

Plate 6

fig. 1 : Vertical schistosity and lineation in the Dean Quartzite, 3 miles north of Mount Phillips

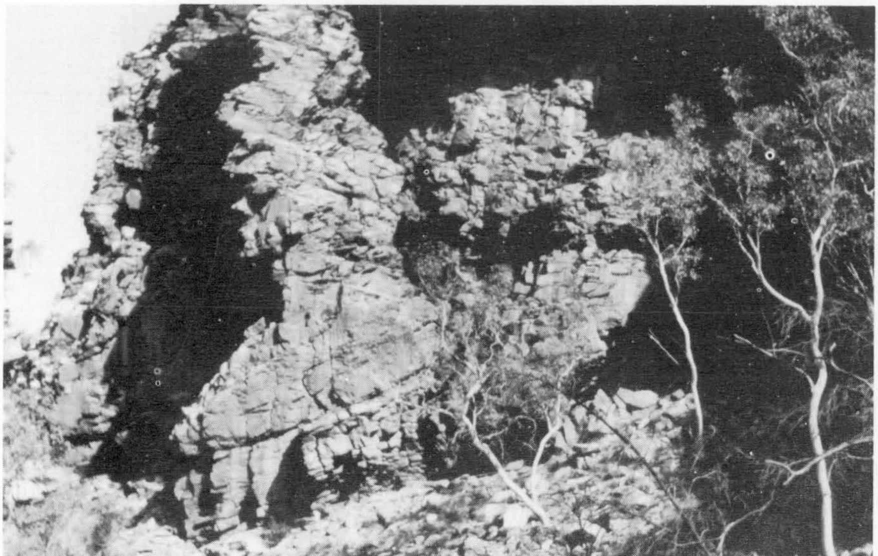


fig. 2 : Recumbent folding in the Dean Quartzite at Glen Cumming, near Mount Russel in the Rawlinson Range, Western Australia

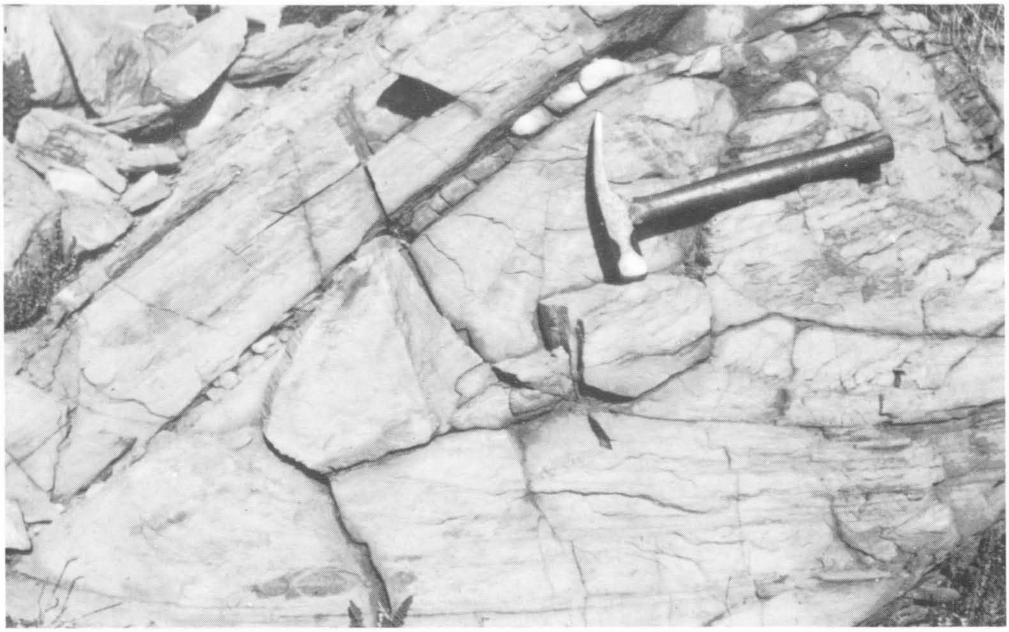
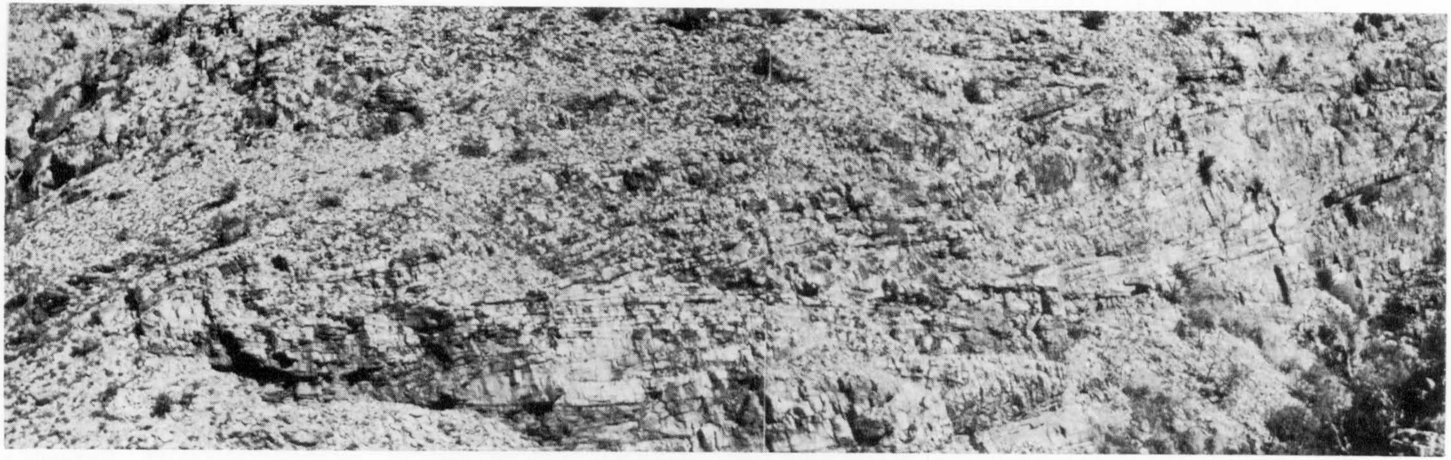


fig. 1 : Isoclinal folding and middle limb shear in the Dean Quartzite, 3 miles west-south-west of Foster Cliff, Northern Territory

fig. 2 : Isoclinally folded Dean Quartzite and porphyroblastic augen gneiss at Butler Dome, Northern Territory



Recumbent fold in the Dean Quartzite and Pinyinna
Beds at Foster Cliff, Northern Territory

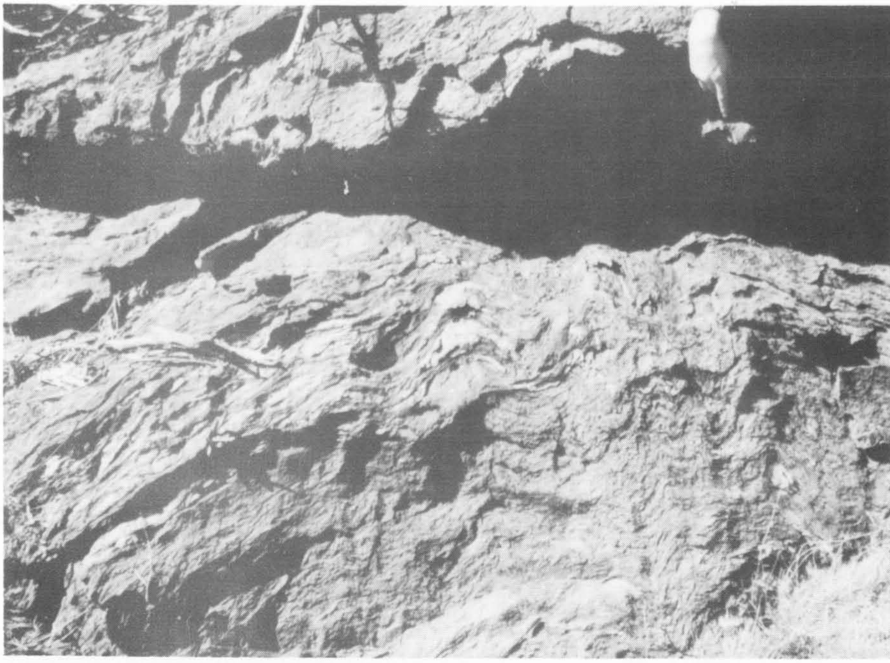


fig. 1 : Olia Gneiss, 2 miles south of Giles Creek

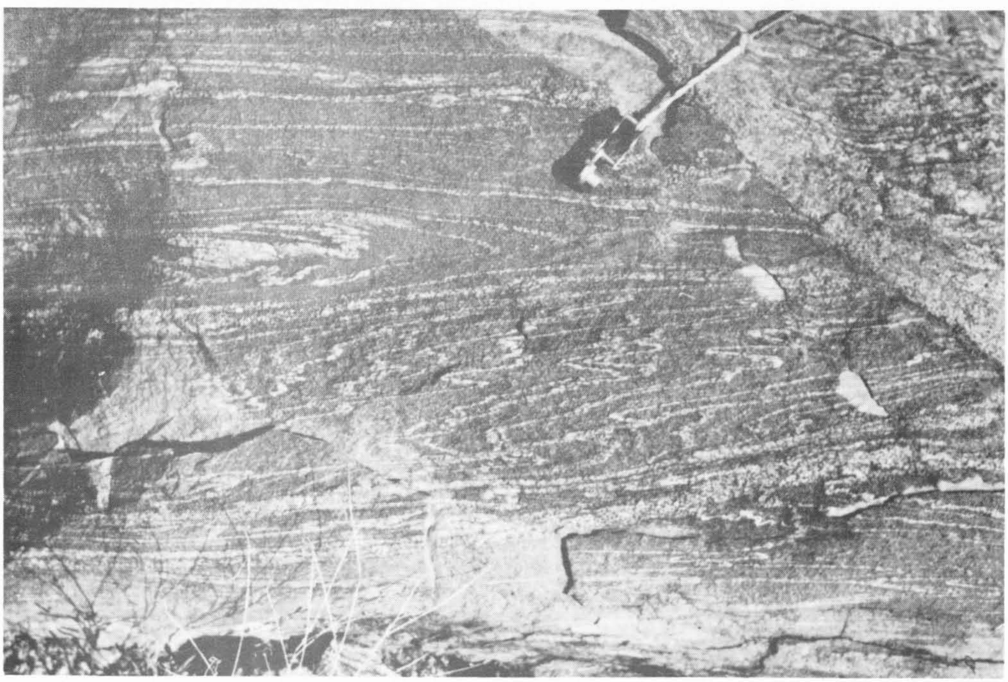


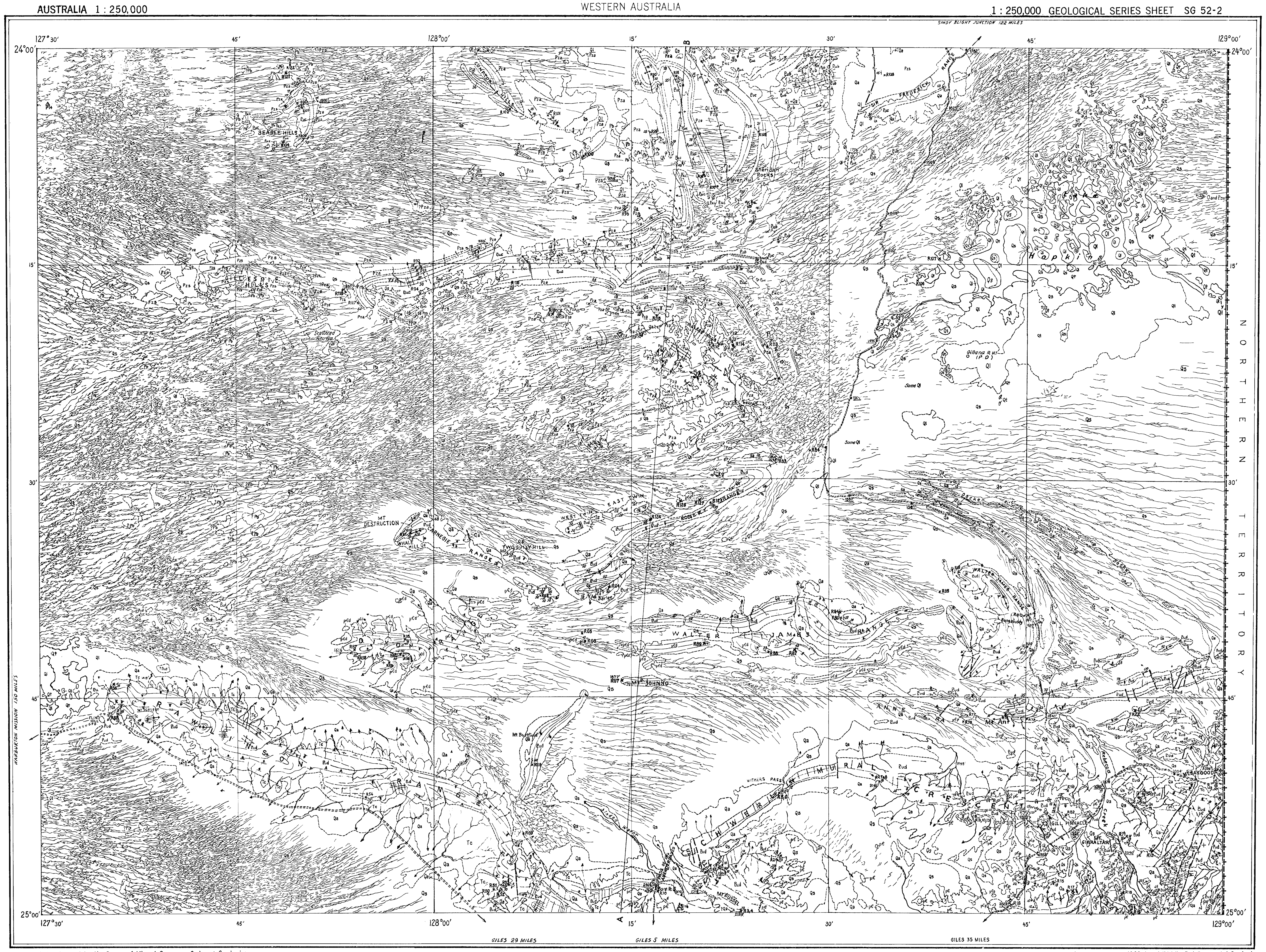
fig. 2 : Folded gneiss south of Giles Creek in the Petermann Ranges Sheet area

AUSTRALIA 1 : 250,000

RAWLINSON

WESTERN AUSTRALIA

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



Reference

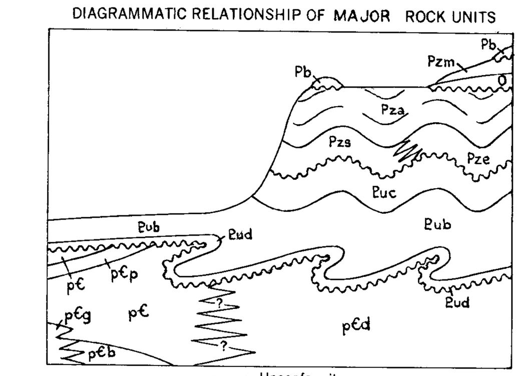
CAINOZOIC	QUATERNARY		Qs	Sand
			Qa	Alluvium
			Qt	Evaporites
			Ql	Travertine
	? TERTIARY		Tc	Conglomerate, sandstone
PALAEOZOIC	PERMIAN	Buck Formation	Pb	Coarse sandstone, siltstone, conglomerate with tillitic texture
	ORDOVICIAN – DEVONIAN	Mereenie Sandstone	Pzm	Fine, white cross bedded quartz sandstone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

- 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° (Air-photo interpretation)
- Dip > 45° (Air-photo interpretation)
- Trend of bedding (Air-photo interpretation)
- Joint pattern (Air-photo interpretation)
- 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
- O 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 (Datum mean sea level. Port Augusta)
- P.D. Position doubtful

DIAGRAMMATIC RELATIONSHIP OF MAJOR ROCK UNITS



Unconformity

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 Australian Air Force; complete vertical coverage at 1:40,000 scale. Transverse Mercator Projection.

INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

URAL SF 51-12	WILSON SF 52-9	WEBB SF 52-10	LAKE MACKAY SF 52-11	MOUNT DOREEN SF 52-12
MORRIS SF 51-16	RYAN SF 52-13	MACDONALD SF 52-14	MOUNT RENNIE SF 52-15	MOUNT LIEBIG SF 52-16
WARRI SG 51-4	COBB SG 52-1	RAWLINSON SG 52-2	BLOODS RANGE SG 52-3	LAKE AMADEUS SG 52-4
BROWNE SG 51-8	BENTLEY SG 52-5	SCOTT SG 52-6	PETERMANN RANGES SG 52-7	AYERS ROCK SG 52-8
YOWALGA SG 51-12	TALBOT SG 52-9	COOPER SG 52-10	MANN SG 52-11	WOODROFFE SG 52-12

ANNUAL CHANGE 1'E

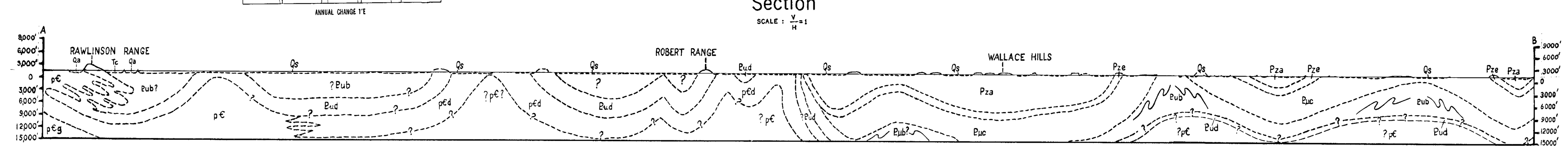
Scale 1 : 250,000

5 0 5 10 15 Miles

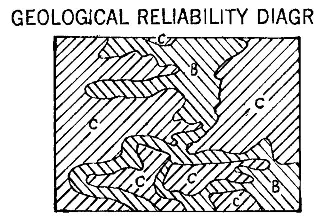
5 0 5 10 15 20 25 Kilometres

Section

SCALE : V/H = 1



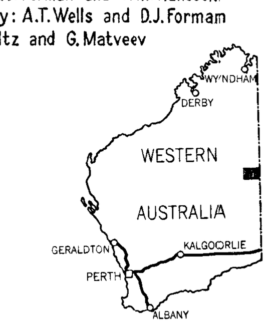
GEOLOGICAL RELIABILITY DIAGRAM



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



RAWLINSON

SHEET SG52-2

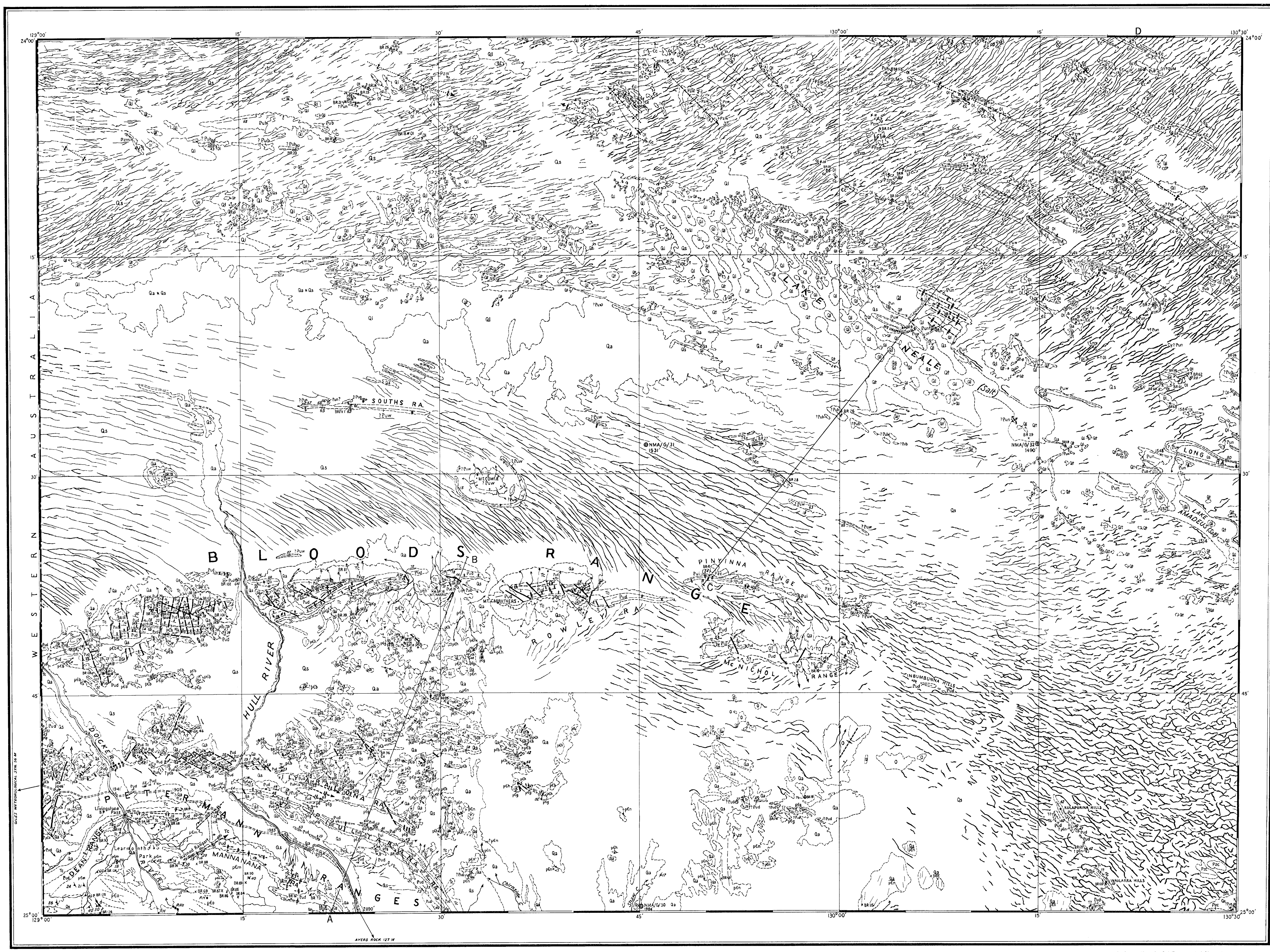
AUSTRALIA 1:250,000

BLOODS RANGE

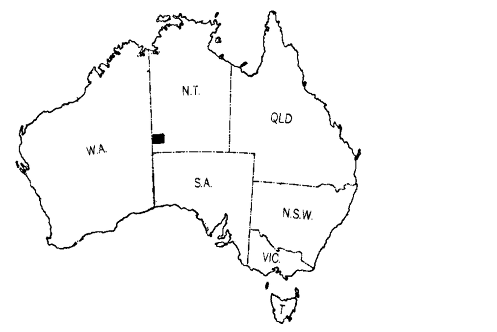
NORTHERN TERRITORY

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

PLATE 11



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.



INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

WILSON SF 52-9	WEBB SF 52-10	LAKE MACKAY SF 52-11	MT. DOREEN SF 52-12	NAPPERBY SF 53-9
RYAN SF 52-13	MACDONALD SF 52-14	MT. RENNIE SF 52-15	MT. LIEBIG 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

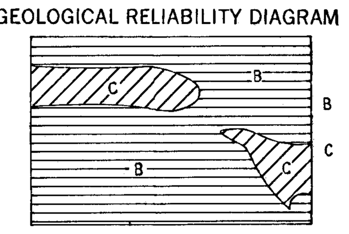
ANNUAL CHANGE 1′E

Scale 1 : 250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

GEOLOGICAL RELIABILITY DIAGRAM

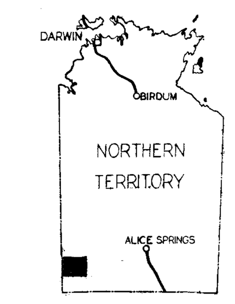


B Reconnaissance-traverses and air-photo interpretation

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

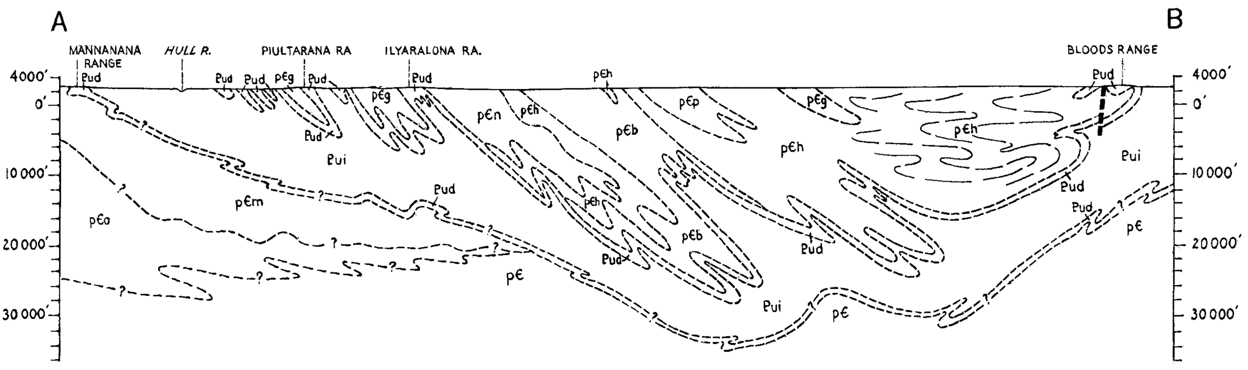
Revised, 1963, by: D.J. Forman

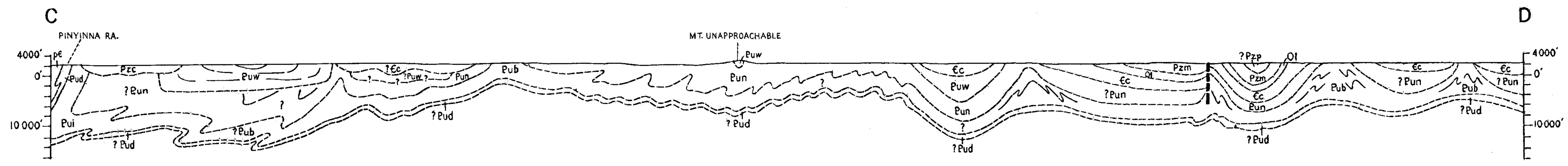


Sections

Scale: V/H = 1

Cainozoic sediments omitted from section





Reference

CAINOZOIC	QUATERNARY		Qs	*Aeolian Sand*
			Qa	*Alluvium*
			Qt	*Evaporites*
			Ql	*Travertine*
	TERTIARY ?		Tc	*Conglomerate*
			T	*Sandstone*
PALAEOZOIC	CARBONIFEROUS–DEVONIAN	Pertnjara Formation	Pzp	*Siltstone*
	DEVONIAN–ORDOVICIAN	Mereenie Sandstone	Pzm	*Brown and white sandstone. Large scale cross bedding*
	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*
		Mt. Currie Conglomerate	Pzc	*Conglomerate*
PRECAMBRIAN	UPPER PROTEROZOIC	Winnall Beds	Puw	*Brown and white sandstone, pebbly sandstone, siltstone*
		Inindia Beds	Pun	*Red siltstone, dolomite, claystone, shale, chert, chert breccia, dolomite and limestone. Stromatolites.*
		Bitter Springs Limestone	Pub	*Crystalline dolomite, limestone, gypsum. Algal stromatolites*
		Pinyinna Beds	Pui	*Dolomite, limestone and siltstone. Stromatolites*
		Dean Quartzite	Pud	*Quartzite and conglomeratic quartzite, sandstone*
	UNDIFFERENTIATED	Pottoyu Granite Complex	p€o	*Very coarse porphyritic granite, fine and medium-grained granite, gneiss, amphibolite, quartz-epidote rock, shist, porphyroblastic schist and quartzite*
			p€g	*Coarse porphyritic granite and medium-grained granite*
		Olia Gneiss	p€n	*Fine to medium-grained gneiss, schistose gneiss, porphyroblastic gneiss, granite, schist and quartzite*
		Undifferentiated	p€	*Granite, schist, gneiss*
			p€m	*Porphyroblastic schists, quartz-feldspar porphyry*
			p€p	*Quartz feldspar porphyry*
		Bloods Range Beds	p€b	*Sandstone siltstone, shale, arkose, tuff, agglomerate, basalt, acid porphyry and metamorphosed equivalents*
		Mount Harris Basalt	p€h	*Epidotized amygdaloidal basalt, tuff, agglomerate, quartzite*

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

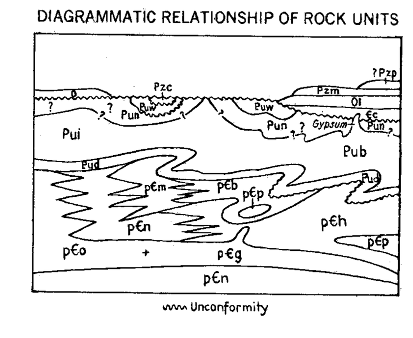
Strike and dip of strata
Vertical strata
Overturned strata
Dip <15°, *Dip 15°–45°*, *Dip >45°*, *Trend lines*, *Joint pattern* — *air-photo interpretation*
Strike and dip of bedding and plunge of lineation
Strike and dip of foliation
Strike and dip of foliation and plunge of lineation
Vertical joint

Macrofossil locality
×BR 84 *Text reference to specimen locality*
Dyke or vein: q – quartz
Minor mineral occurrence
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.*

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



BLOODS RANGE

SHEET SG 52-3

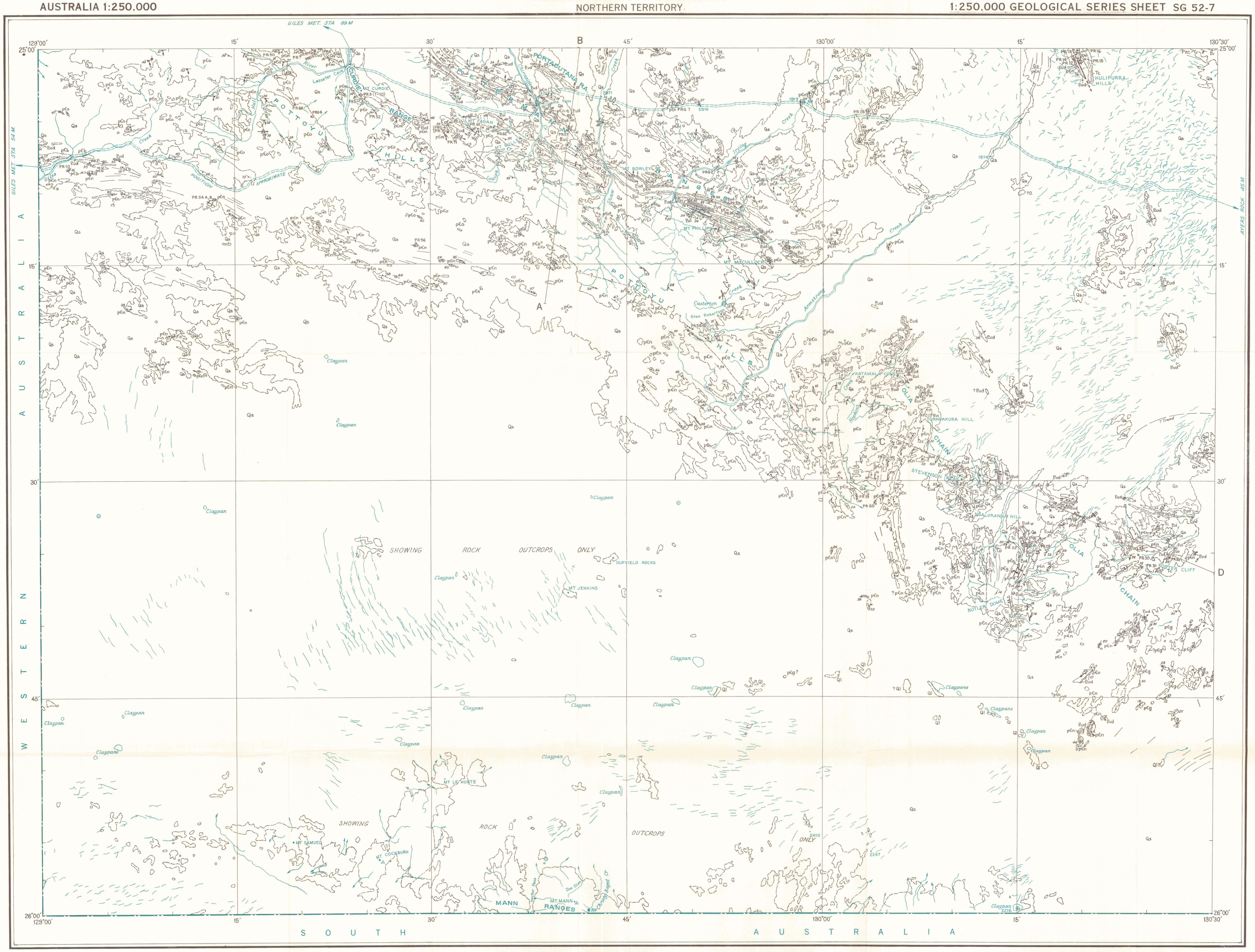
PETERMANN RANGES

NORTHERN TERRITORY

AUSTRALIA 1:250,000

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

PLATE 12.



Reference

CAINOZOIC	QUATERNARY		Qs	Sand
			Qa	Alluvium
			Ql	Travertine
	? TERTIARY		Tc	Conglomerate
			T	Sandstone
PALAEOZOIC	ORDOVICIAN		O	White Sandstone
	CAMBRIAN	Mount Currie Conglomerate	Pzc	Conglomerate
PRECAMBRIAN	UPPER PROTEROZOIC	Inindia Beds	Ꞓun	Sandstone, siltstone
		Pinyinna Beds	Ꞓui	Slate, dolomite schist, schist
		Dean Quartzite	Ꞓud	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

Strike and dip of strata

Vertical strata

Horizontal strata

Overturned strata

Dip < 15° } *air-photo interpretation*

Dip 15° — 45°

Trend lines

Joint pattern

Vertical foliation

Strike and dip of foliation, with lineation

Strike and dip of bedding, with lineation

Direction and plunge of lineation

Vertical joint

Macrofossil locality

x 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

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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
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

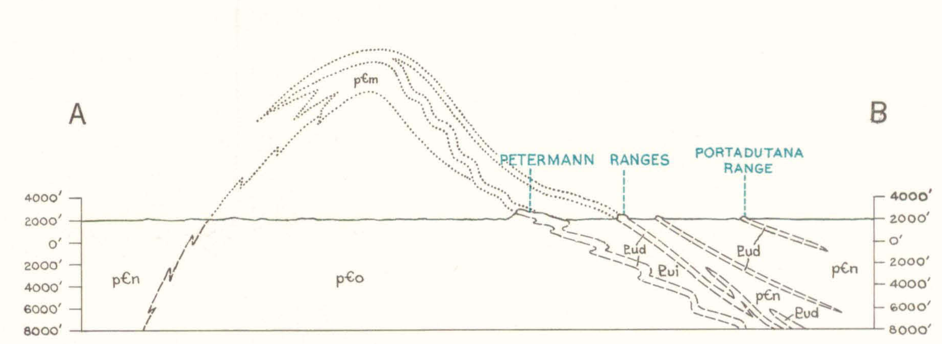
5 0 5 10 15 20 25 KILOMETRES

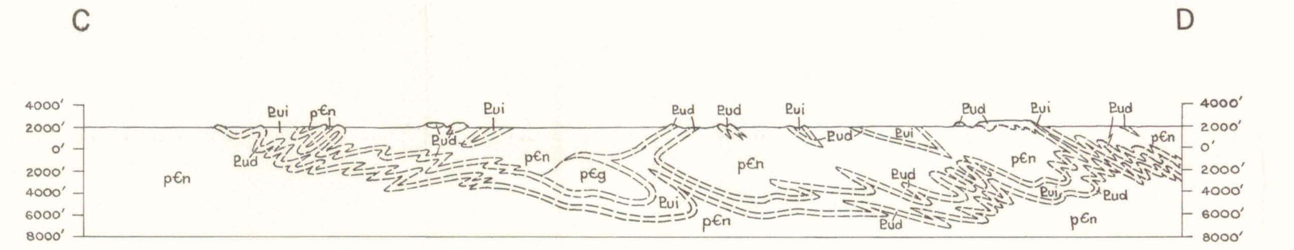
Sections

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

Folding schematic

(Cainozoic units omitted from sections)



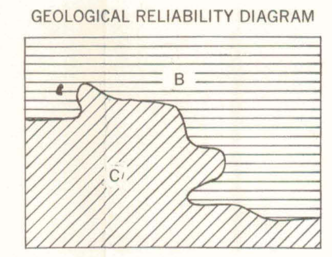


Geology, 1963, by: D.J.Forman, P.M.Hancock.
1962, by: D.J.Forman, A.J.Stewart.

Compiled, 1964, by: D.J.Forman.

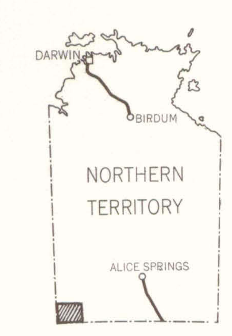
Drawn by: F.J.Roberts.

GEOLOGICAL RELIABILITY DIAGRAM

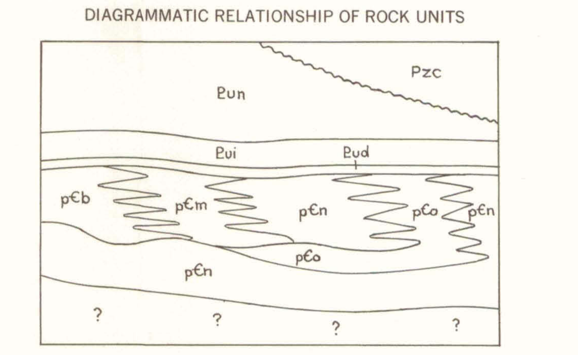


B *Reconnaissance — numerous traverses and air-photo interpretation*

C *Air-photo interpretation*



DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Unconformity

PETERMANN RANGES

SHEET SG 52-7

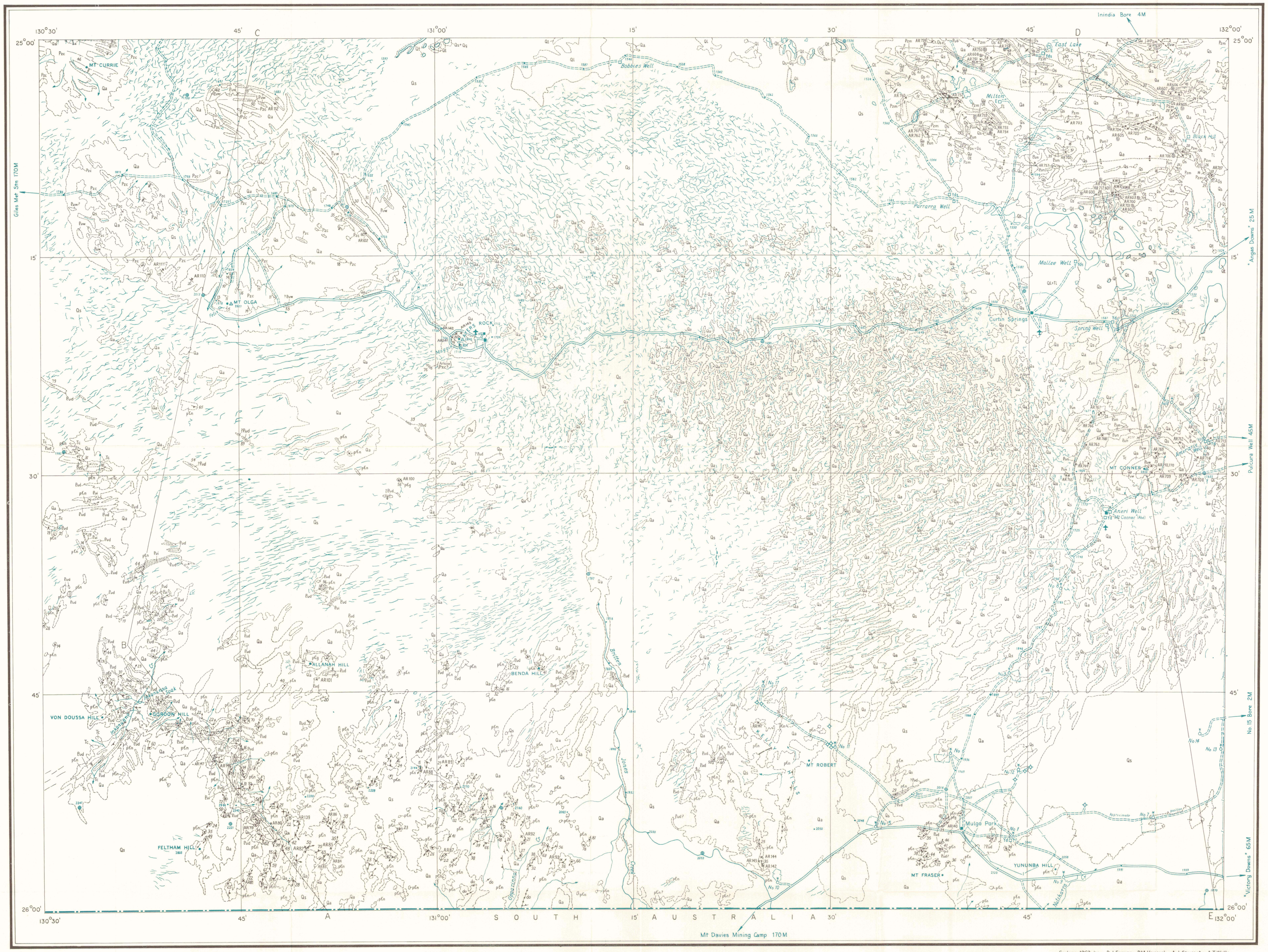
AUSTRALIA 1:250,000

AYERS ROCK

NORTHERN TERRITORY

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

PLATE 13



Reference

CAINOZOIC	QUATERNARY		Qa	Alluvium
			Qs	Sand
			Qt	Evaporites
			Ql	Travertine
			Qg	Gypsum
	TERTIARY		Tc	Conglomerate
			Tl	Limestone
PALAEOZOIC	ORDOVICIAN-DEVONIAN	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	Pebble conglomerate
		Mount Currie Conglomerate	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, quartz-sericite schist, amphibole schist
		Dean Quartzite	Pud	Schistose quartzite
	UNDIFFERENTIATED	Olia Gneiss	pЄn	Gneiss with schist, porphyroblastic schist, amphibolite migmatite and granite
			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° } air-photo interpretation
- Trend lines }
- Joint pattern }
- 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
- ×AR705 Specimen locality
- KW-8 Measured section
- Dyke: do - dolerite

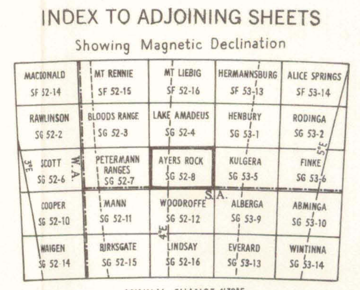
- Bore
- Abandoned bore
- Well
- T Tank
- E Earth tank
- Windpump
- Spring
- RH Rockhole
- Sand dunes
- Salt lake
- Road
- Vehicle track
- State boundary
- Fence
- "Mt.Conner" Homestead
- Landing ground
- Yd Yard
- Astronomical station
- Trigonometrical station
- 1725 Height in feet, instrument levelled } datum: mean sea level
- 1725 Height in feet, barometric } Port Augusta

Compiled and published 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

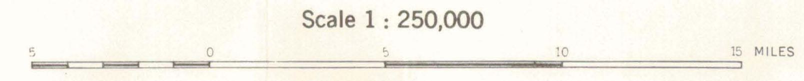
Geology, 1963, by : D.J.Forman, P.M.Hancock, A.J.Stewart, A.T.Wells
Compilation by : D.J.Forman, A.T.Wells, A.S.Mikolajczak
Drawn, 1964, by : A.S.Mikolajczak

INDEX TO ADJOINING SHEETS

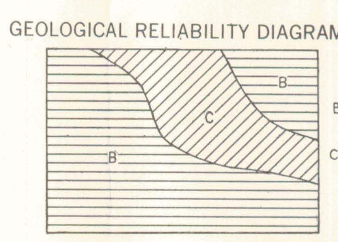
Showing Magnetic Declination



Scale 1 : 250,000

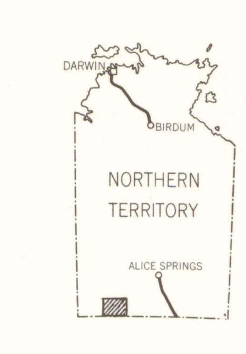


GEOLOGICAL RELIABILITY DIAGRAM



B Reconnaissance, traverses and air-photo interpretation

C Air-photo interpretation only

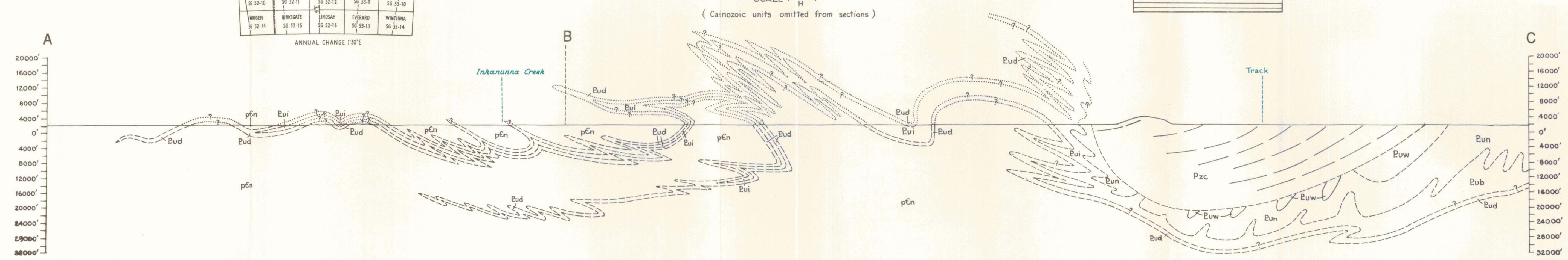


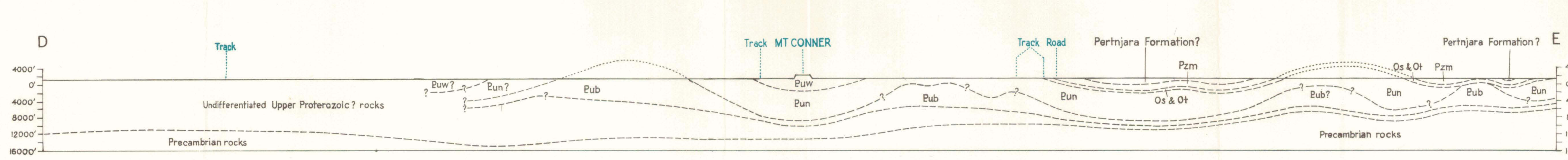
Sections

Folding schematic

SCALE : V/H = 1

(Cainozoic units omitted from sections)

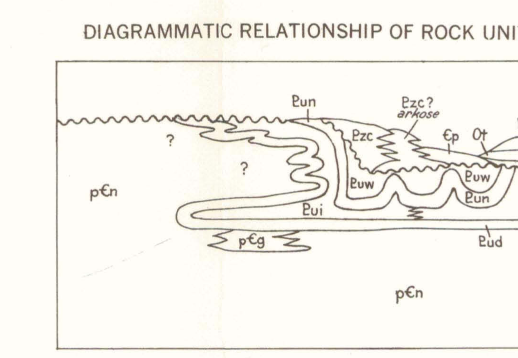




AYERS ROCK

SHEET SG 52-8

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Unconformity

DATE DUE

[illegible]			
~~6.2.93~~			
~~20.2.97~~			
~~5.1.00~~			