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THE GEOLOGY AND PETROLOGY OF THE MOUNT PAINTER COMPLEX

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LOCATION AND DEFINITION OF AREA

The Mount Painter Province is located in the Northern Flinders Ranges, approximately 350 miles north of Adelaide and 60 miles east of Leigh Creek. The area to be described is bounded by longitudes 139°10' - 139°50'E and latitudes 29°45' - 30°27'S.

Because of low rainfall and harsh climate the area is sparsely settled, industry being almost entirely restricted to grazing. Three sheep stations, Moolawatana, Wooltana and Arkarool[illegible] occur in the area. Current mining operations are limited to the extraction of talc at Mount Fitton.

The northern region is served by the "Talc road" which branches off the main north road at Lyndhurst and passes via the Mount Fitton Talc Mine to Moolawatana. The mail road from Copley to Moolawatana via Wooltana provides access to the southern and eastern areas. The central region is served by a branch road to Umberatana. Few tracks exist within the ranges and most are negotiable only with four-wheel-drive vehicles.

PHYSIOGRAPHY

The Mount Painter region forms the rugged, northeastern extremity of the Flinders Ranges which rise abruptly from the Lake Frome plains along their eastern margin but gradually decline towards the north, eventually merging with the plains of the Great Artesian Basin. The present elevated position of the ranges is primarily due to the exhumation and doming of an old peneplain surface (Mid Tertiary?) which reached its culmination at Freeling

Heights (3,120 feet), the highest peak in the area. Although subsequent active dissection has largely destroyed the surface, erosional remnants are preserved on theharder rock types.

The position of the warped peneplain surface may be inferred from the concordance of summit levels such as Mt. Painter (2,850 feet), Mt. Pitt (2,804 feet), and Mt. Babbage (1,210 feet).

More recent uplift of the area is suggested by steep drainage gradients, actively degrading streams, youthful valleys, perched oxbows (up to 100 feet above present base level), valley in valley structure, incised meanders and high level fluviatile deposits. These morphological features are most marked along the eastern flank of the ranges which is defined by a bold scarp and sharp zig-zag lineaments.

The elevated part of the area is composed of ancient metasediments and granites, contrasting with the more subdued relief produced by the less resistant sediments of the Adelaide System. The crystalline core forms, in part, the watershed between the streams flowing eastwards into the Lake Frome depression and those flowing northwards into the Lake Eyre - Lake Gregory and Lake Blanche depression. The principal east-flowing streams are the Arkaroola, Paralana, [redacted] Four Mile, Pepegoona and Parabarana Creeks. The main drainage components flowing to the north are the Tindelpina, MacDonnell, Yerila and Mudnawatana Creeks. The Hamilton Creek, rising in rugged country north of Freeling Heights, initially flows northeastwards but on reaching the plains near Moolawatana is diverted southeasterly into Lake Frome. A number of impermanent water holes, such as Terrapinna occur along the major creeks. The climate of the region is semi-arid with marked diurnal and seasonal temperature variations. Rainfall is deficient and unreliable, averaging less than 10 inches per annum. The general semi-arid climate combined with rapid erosion by flash flooding after infrequent thunderstorms has prevented the development of extensive soil cover within the ranges. As a consequence continuous outcrop of little-weathered bedrock occurs over the major part of the area.

Because of limited rainfall there has been little leaching of the soil profile. As a result rapid regrowth of plants occurs after heavy rains. Vegetation is however, stunted and sparse. Mitchell grass, blue bush and salt bush predominate on the plains while mallees favour the more limy horizons and mulga predominates on arenaceous rock types within the ranges. Spinifex occurs ubiquitously throughout the ranges, while red gums line the major creeks.

PREVIOUS INVESTIGATIONS

The Mount Painter region was initially opened up by pastoralists in 1857. The subsequent discovery of copper, lead, uranium and talc deposits resulted in intensive mining and exploration activity.

Because of its remoteness and inaccessibility only limited geological investigation was carried out prior to 1945. Early workers such as L.K. Ward, R.L. Jack and H.Y.L. Brown were mainly concerned with assessment of the mineral potential. Of note is the pioneering work of Mawson who carried out stratigraphic and petrologic investigations near Mount Painter, Freeling Heights, Yudnamutana, Arkaroola and Wooltana.

In 1945 a geological reconnaissance of the greater part of the Mount Painter Province was carried out by Sprigg, Sullivan, Dickinson, Webb, Wade, Johns, King and Wegener (Dickinson et al 1945, 1954) in order to determine its uranium potential. Subsequent investigations by Ridgway, Broadhurst, Sprigg, Dickinson and Hughes were limited to the reassessment of copper and talc deposits. Brief references to the local geology are included inthese reports.

Systematic mapping of the region was commenced in 1955 by Campana, Coats, Horwitz and Thatcher. Mapping of the crystalline basement was completed by Coats in 1959. Air photos were supplied by the Department of Lands and base maps have been compiled by the Cartographic Section of the Department of Mines. As a result of this work the Umberatana, Paralana, Gardiner, and Moolawatana 1:63,360 sheets were published. Information from unpublished maps compiled by previous workers was incorporated in the published sheets.

Metamorphic and granitic rocks of the Mount Painter region were referred by Mawson (1912) to the Archaeozoic Era. Later Mawson (1923) reassigned the crystalline rocks to the early or Middle Precambrian, recognizing a major unconformity with the overlying "Adelaidean" beds. Mapping by the Geological Survey has largely substantiated Mawson's conclusions.

Sprigg (in Dickinson et al., 1945) and (1953) considered that metasediments of the "central igneous and metamorphic belt" (Mount Painter Complex) were recognizable units of the Torrensian Series which had been intruded and granitised by lower Palaeozoic granites.

Bowes (1952, 1953, 1954, 1956) agreed with Sprigg's concept of the granitisation of the Adelaide System, presenting petrological and chemical data to support the transformation of tillite to migmatitic augen granite in the Mount Fitton area. The terms "Mount Babbage Migmatite Complex" and "Terrapinna Migmatite Complex" were introduced by Bowes to define the granitised terrains.

The crystalline rocks outcropping north of Mount Fitton were defined by Sprigg (in Dickinson et. al 1951), as the Mount Babbage Granite Complex", being separated from the "Terra-pinna Granite Complex" to the south by a narrow corridor of less metamorphosed tillite. Since the complexes include common rock units, the present author favours general usage of the term Mount Painter Complex to embrace all crystalline terrains of the

Mount Painter Province. However, because of its discrete structural position the northern exposure of crystalline basement rocks is termed the Mount Babbage Block and the outcrops south of Terrapinna Waterhole are defined as the Mount Painter Block. (Figure 2).

MOUNT PAINTER COMPLEX

A combination of excellent exposures, structural simplicity and lack of high grade metamorphism of the Mount Painter Complex has enabled the recognition of a stratigraphic succession totalling 25,000 feet in thickness.

This dominantly arenaceous sequence is here named the Radium Creek Metamorphics. The Radium Creek Metamorphics were intruded by two generations of granites, referred to as the "Older" and "Younger Granite Suites" and dated by Compston, (in Compston, Crawford and Bofinger, 1966) at about 1,600 million years (Carpentarian) and 450 million years (Lower Ordovician) respectively. As no absolute or lower age limit can be placed on the metasediments, the sequence is referred to the loose timeterm, Older Precambrian with the suggestion that it may be Lower Proterozoic. The Radium Creek Metamorphics and "Older Granite Suite" together comprise the Mount Painter Complex.

Radium Creek Metamorphics

The metasedimentary sequence is divisible into two lithologically distinct formations. The dominantly arenaceous upper unit, termed the Freeling Heights Quartzite, conformably succeeds a sequence of mica schists and non-clastics referred to as the Brindina Schist. The Freeling Heights Quartzite is subdivided into three members.

Freeling Heights Quartzite

The Freeling Heights Quartzite is the highest formation of the Older Precambrian metasedimentary sequence. The more quartzitic upper and lower members give rise to much of the bold topographic relief extending from near North Well through Mount Pitt, Yudnamutana Hill and Freeling Heights to Moolawatana woolshed. Remnants of the Freeling Heights Quartzite occur in the Mount Babbage Complex. The formation includes a lenticular unit of arenaceous schists (Radium Creek Schist Member) which forms a belt of more subdued relief from Mount Pitt to a point 1-2 miles northwest of Mount Adams. At the latter locality the Radium Creek Schist is underlain by a sequence of argillaceous sandstone and orthoquartzites forming the lowest member (unnamed) of the Freeling Heights Quartzite.

Although the formation has been metamorphosed, sedimentary structures are well preserved in the more quartzitic units. The upper member of the Freeling Heights Quartzite was correlated by Sprigg (1945) with the "Mount Aroona Quartzite" (Copley Quartzite), described earlier by Mawson (1941) from the Copley area. The existance of a major unconformity above the Freeling Heights Quartzite and the recognition of the Copley Quartzite in the overlying Adelaidean sequence, refutes Sprigg's correlation.

Upper Member (Unnamed)

The upper member of the Freeling Heights Quartzite, exposed in the vicinity of Freeling Heights, consists of a well-bedded sequence of medium to fine grained orthoquartzites with minor developments of feldspathic quartzites and argillaceous sar stones. (See Appendix I, P.358/55); A thin lenticular quartz-pebble bed occurs near the base of the unit to the north of Freeling Heights. Occasional "erratic" boulders of quartzite up to 1 foot in length occur at various horizons. The boulders are randomly oriented and generally dispersed through an argillaceo sandstone matrix.

Aqueous cross-bedding with high-angle foreset beds occurs throughout the sequence, the cross-bedding often highlighted by heavy mineral concentrations and grit bands. Ripple marks have been noted in the creek section east of Green Hill copper mine.

The upper member passes gradationally downwards into the Corundum Creek Schist by an increase in argillaceous content. The thickness of the upper member is approximately 13,000 feet.

Middle Member (Corundum Creek Schist)

In contrast to the lofty summits produced by the upper and lower members, the intervening Radium Creek Schist occupies a belt of subdued relief. The unit consists essentially of a succession of interbedded arenaceous schists and quartzites, the schists probably representing metamorphosed argillaceous sandstones. Lesser developments of muscovite-biotite-, and corundum-spinel schists occur (See Appendix 1, P.313/57). Between Mount Pitt and Yudnamutana Gorge the sequence was extensively injected by granites to form migmatitic rocks. The Corundum Creek Schist appears to tongue out to the northeast of Freeling Heights. The thickness of the unit is difficult to determine because of structural complexities but is estimated to be approximately 3,500 feet.

Lower Member (Unnamed)

The lower member of the Freeling Heights Quartzite is exposed in the keel of the Moolawatana Syncline between Mount Adams and Moolawatana woolshed and as ungranitized remnants within the Mount Babbage Block. The unit consists predominantly of well bedded orthoquartzites, lithologically indistinguishable from the upper member. Arenaceous schists appear in the passage zone into the Corundum Creek Schists and thin lenticular quartz-pebble beds occur at and near the base of the unit. Heavy mineral lamination and cross-bedding are not as well developed as in the upper member. The lower member appears to intertongue with the Brindina Schists at the headwaters of Pepegoona Creek, 3½ miles west-south-west of Mount Neill. The estimated thickness of the lower member is 7,000 feet.

Brindina Schist

The Brindina Schist is the lowest formation exposed in sequence, conformably underlying and locally intertonguing with the Freeling Heights Quartzite. The upper member of the Brindina Schist is exposed on the southern limb of the Moolawatana Syncline, a tight synclinal structure extending in a northeasterly direction from the headwaters of Pepegoona Creek to Moolawatana woolshed. Equivalent units on the northern limb of the syncline are granitised where they occur in contact with rapakivi type granite (Terrapinna Granite. The upper sequence is also typically developed 1½ miles south of Twelve Springs (Moolawatana 1:63,360 sheet) where it is separated from the Freeling Heights Quartzite by a tongue of white granite (Wattleowie Granite)

The upper sequence [redacted] of the Brindina Schist consists essentially of metasedimentary amphibolites, muscovite and biotite-schists. Minor developments of chlorite-anthorphyllite-cummingtonite and garnet-sericite-schists, epidotite quartzite, hornfels, and garnet rocks occur. (See Appendix I p. 59/57 (1), (2).

The only exposure of the lower sequence is north of Parabarena Hill (Moolawatana 1:63,360 sheet), where a steeply dipping sequence of arenaceous-muscovite- and biotite-schists with minor quartzite is separated from the upper sequence by tongues of granite porphyry (Mount Neill Porphyry) and the Terrapinna Granite. As the granite rocks were primarily emplaced by doming of the sediments without much stoping it is probable that much of the original succession is preserved. The thickness of the lower sequence is approximately 1,200 feet and the upper succession about 2,000 feet giving a total thickness of 3,200 feet for the formation.

Stratigraphic Position Uncertain

Quartzites and phyllites of uncertain stratigraphic position are exposed south of Mount Adams on a fault block elevated by upthrust movements on the Adams Fault. The metasediments were discordantly intruded by a large body of Mount Neill Porphyry which is nowhere exposed on the western fault block. Although the quartzite beds resemble the lower member of the Freeling Heights Quartzite the underlying monotonous phyllite sequence forms a lithological unit distinct from the Brindina Schist exposed on the western fault block 2 - 3 miles southwest of Mount Neill.

The absence of Mount Neill Porphyry west of the Mount Adams Fault, the distinctive lithology of the phyllites and the relative elevation of the eastern fault block suggest that the metasedimentary units in question represent a succession which underlies the Brindina Schist. As no direct relationship exists between the quartzite-phyllite succession and Brindina Schist the exact stratigraphic position of the former units remains in doubt.

The quartzite and phyllite succession outlines a southwesterly plunging east limb drag fold, a local plunge reversal giving rise to a domal structure in the phyllites. Stratigraphic relationships between the two units, confirmed by cross-bedding facings, show that the quartzites conformably succeed the phyllites.

Quartzites (Unnamed)

The quartzites are generally pale grey or pink in colour and usually well bedded particularly towards their base.

The units are sometimes cross-bedded, this feature occasionally being outlined by heavy minerals and grits. The quartzite is slightly feldspathic, medium grained and often sericitic.

Phyllites (Unnamed)

This unit is a monotonous succession of phyllites underlying the unnamed quartzites with a sharp conformable contact. A thin discontinouous quartzite interbed occurs in the upper part of the sequence. The phyllites are characteristically rhymically laminated (¼"), consisting of silty bands alternating with silky phyllitic bands.

SEDIMENTARY ENVIRONMENT

The presence of steep foreset beds in the Freeling Heights Quartzite is indicative of a high energy medium of transport. Ripple marks, aqueous cross-bedding and heavy mineral concentrations point to near-shore deposition, possibly in a deltaic or shoal-water environment. The essentially homogeneous composition of the sediments points to uniform source and environmental conditions, although slow subsidence of the depositional basin must have occurred to permit the accumulation of such a vast thickness of sediments. The cyclic nature of sedimentation is demonstrated by repetition of three thick units of quartzite in the succession.

INTER-REGIONAL CORRELATIONS

Possible time and rock equivalents of the Radium Creek Metamorphics are exposed in the Olary - Broken Hill Province (Willyama "Series") and the Peake and Denison Ranges (Peake "Series").

Olary - Broken Hill Province

In the Olary region the Willyama "series" and anatectic granites are overlain with local strong unconformity by formations of the Torrensian Burra Group. Maximum datings on granites and davidite show the age of the Willyama "Series" to be greater than 1660 million years.

Campana (in Campana and King 1958) recognized a "Lower", "Middle" and "Upper" group within the metasedimentary sequence. Campana described the "Upper Group" as a thick sequence of generally well bedded arkosic quartzites and arkoses (?), frequently including bedded iron formations. The "Middle Group" is essentially the economically important Ethiudna Calc- Silicate Group, a sequence of mineralized actinolitic dolomites, marbles, tremolite-diopside rocks, garnet rocks, amphibolites and epidote - actinolite quartzites. The "Lower Group" or Weekeroo-Billeroo Schists are described as a sequence of mica schists, parageisses, laminated quartzitic sandstones and silky phyllitic schists. When compared with the less metamorphosed sedimentary sequence of the Mount Painter Complex, the Willyama "Series" shows a more than coincidental lithologic and stratigraphic correspondence. Thus the "Upper Group" is essentially arenaceous which suggests correlation with the Freeling Heights Quartzite, the metamorphic mineral assemblage of the "Middle Group" compares favourably with the Brindina Schist and the "Lower Group" corresponds with the phyllites, the lowest unit exposed in the Mount Painter Province. Although no iron formations have been mapped in the Mount Painter Province, the iron rich composition of the Brindina Schist suggests a basis for correlation of the two units.

Peake and Denison Ranges

A pre-Willouran assemblage of slates, phyllites, sericitic quartzites, mica schists, possible basic volcanic rocks and granite gneiss were termed the Peake "Series" by Reyner (1955). The presence of several thick sericitic quartzites in the sequence suggests affinities with the Freeling Heights Quartzite. Because of the lack of high grade metamorphism Reyner suggested that the age of the Peake Series may be post-Archaean and pre-Adelaide System.

"Older Granite Suite"

The "Older Granite Suite" comprises both massive and foliated granites dated by Compston et al. at approximately 1,600 million years. The occurrence of Boulders referable to the "Older Granite Suite" in the basal conglomerate of the Callanna Beds established the pre-Willouran age of the suite.

The massive types (rapakivi type granite, granite porphyry, medium grained granite, and granodiorite) are structureless or only weakly foliated. Primary directional fabrics (flow banding and lineation of felspar laths) are well developed in the foliated types (quartz-feldspar porphyry, gneissic granite and tabular felspar granite).

Contact relationships with metasediments are generally concordant to low angle discordant; strong discordances of the rapakivi granite and granite porphyry occur locally. Partial cross sectional views of foliated and massive granite bodies, exemplified by the Mount Neill massif, show the domed tops and flat bases of classical laccoliths. Thus, in the Mount Painter Province the granite space problem is resolved by uparching of the strata. The strongly discordant re-entrant of granite porphyry between Yudnamutana Hill and Mount Pitt, is believed to be a feeder for an extensive laccolith which was largely eroded prior to the deposition of the Adelaide System.

The older granites were emplaced at varying stratigraphic levels throughout the sedimentary sequence, the intrusions favouring bedding planes and formation contacts. Granite apophyses are rare and do not penetrate far from the contact, while pegmatites appear to be absent. Stoping by the rapakivi granite has been observed locally. The rapakivi granite and granite porphyry invariably occupy the cores of laccolithic structures and intruded all foliated granites and porphyries. Thus the massive granites represent the youngest phase of the "Older Granite Suite".

Considerable field and petrological evidence has accumulated to demonstrate the magmatitic origin of the older granites, as follows:

1. Strong, local discordant relationships with metasediments, e.g. the Yudnamutana Hill laccolithic feeder.
2. Sharp contacts e.g. with Freeling Heights Quartzite.
3. Doming of roof rocks, implying hydrostatic pressure and therefore a fluid medium e.g. Mount Neill laccolith.
4. Resorption phenomena e.g. Pepegoona Porphyry.
5. Stoping of country rocks.
6. Reaction borders on xenoliths.

The Freeling Heights Quartzite shows little evidence of contact metasomatism or metamorphism. However, granitisation of presumed argillaceous sediments tentatively referred to [redacted] the Brindina Schist, occurred extensively throughout the Mount Babbage Block and to a lesser extent within the Mount Painter Block. The metasomatic processes are considered to be related to the emplacement of a magmatic granite - the rapakivi type granite.

The directional structures of the foliated granites and porphyries, with the exception of schistosity, are interpreted as flow banding. The ratio of height to base of the Mount Neill laccolith is approximately 1:4. The development of regular flow banding, the marked doming of the laccoliths indicated by their height to base ratio and lack of fracturing of the roof rocks are indicative of a passively emplaced viscous magma. Emplacement of the granite bodies of similar composition and texture at varying levels, however, implies local disruption of the roof rocks.

Terrapinna Granite (Rapakivi type granite)

The term rapakivi is derived from the Finnish 'rapautukiv which means disintegrating rock, referring to its ready mode of weathering. The type rapakivi of southwestern Finland was first fully described by Serderholm (1923) in his classical memoir on migmatites and related granites.

The Swedish and Finnish rapakivis are characterised by large ovoid potash feldspars (orthoclase or microcline perthite), bipyramidal phenocrysts of quartz set in a medium to fine grained ground mass of quartz, potash feldspar, plagoiclase and biotite. Some ovoids are surrounded by a shell of small prismatic oligoclas crystals, often referred to as the rapakivi texture. Many petrographers unfortunately adopt the mantling of feldspars as a criterion for rapakivi, although the texture is exceptional in granite massifs. In addition both mantled and unmantled ovoids may occur side by side, making a rock unit distinction impossible.

Granite of the rapakivi type forms the major rock unit of the Mount Babbage Block and the northern areas of the Mount Painter Block. The biotite rapakivi granite of the Mount Painter Province, referred to as the Terrapinna Granite, produces a characteristic dendritic drainage pattern and a moderate to subdued relief. The rock is locally disintegrated by weathering, giving rise to a mantle of coarse gravels, containing quartz, micas and fragmented ovoids. These deposits resemble "moro", the peculiar gravels derived from the rapakivis of Finland described by Eskola (1930).

Contacts with metasediments and other older granites are invariably sharp. In the Mount Painter Block contacts are generally concordant or low angle discordant. More discordant relationships are evident in the Mount Babbage Block. The Terrapinna Granite does not appear to have been emplaced much above the base of the Freeling Heights Quartzite. Locally, apophyses, sills and pods of the granite penetrate the country rocks up to ½ mile from the main contact. Between Parabarana Hill and Moolawatana woolshed cross-sectional views of rapakivi granite bodies show a typical laccolithic profile. Rapakivi type granite, forming the core of the Parabarana Hill laccolith was exposed by differential erosion of a fault block elevated by movements along a north-westerly trending fault. Tabular feldspar granite, occupying the outer shell of the laccolith is considered to be a marginal flow phase of the rapakivi granite. The absence of a flow banded phase in upper contact zones, as for example 3 - 4 miles north of Mount Adams, is possibly due to intrusion of the rapakivi granite above the level of the earlier formed foliated granite.

~~Metasediments show widely divergent metamorphic and metasomatic responses to intrusion by the Terrapinna Granite.~~ There is general agreement among most Fennoscandian geologists that the rapakivis were magmatic. Backlund, (1938) Read (1944) alone favour a metasomatic origin.

The rapakivis are considered to be anomalous because of their apparent inverse crystallization sequence compared with "normal granites". Another unusual feature is the crystallization of two generations of quartz and feldspar. The Mount Painter rapakivi shows a similar crystallization trend. Thus the phenocrysts represent the first generation of potash feldspar and quartz, the later generation forming part of the ground mass. The major part of the biotite appears to have crystallized at a late stage; biotite inclusions in the potash feldspar may represent an earlier generation. A unique and puzzling feature of rapakivi granites is the shape of the feldspar crystals. The reason for the development of an ovoidal form has not been satisfactorily explained, most petrographers favouring a process of resorption. The ovoidal arrangement of the inclusions suggests that the crystals grew as ovoids. The development of feldspar ovoids in metasedimentary wall rocks reported by many authors supports this contention. Since a sphere has the least surface energy of any geometric shape the ovoidal form may be due to the tendency of both the crystal form [redacted] and a spherical shape to develop simultaneously under strong confining pressures which might be expected at a depth of 5 miles. Occasional vague pinacoid faces tend to be developed in feldspar ovoids of the Mount Painter rapakivi granite. Turner and Verhoogen (1960 tentatively accept a crystallization temperature of 700-800°C and a pressure of 5,000 bars for the rapakivis on experimental evidence presented by Yoder, Stewart and Smith. It is probable that the Mount Painter rapakivi granite crystallized under more extreme pressures than those postulated for the type rapakivi of Fennoscandina. This conclusion is suggested by the almost spherical form crystal of quartz [redacted] and the absence of microlitic cavities in the Mount Painter rocks. The only evidence of alteration in the Freeling Heights Quartzite is silicification and sericitisation, the latter metamorphism probably resulting from dislocation movements. Likewise pre-rapakivi granites were inert. By contra the Brindina Schist is extensively metasomatised and metamorphose except where "armouring" by the earlier non-reactive granites occurred.

[redacted]

The Terrapinna Granite is a massive grey rock when fres but acquires a brownish tint on weathering. The rock consists of abundant, randomly-oriented pearl white (pink on weathering) ovoi of potash feldspar (perthitic microcline, orthoclase), rounded or slightly ovoid crystals of pale blue opalescent quartz and aggreg ates of biotite. The ground mass is composed of a coarse mosaic of potash feldspar, quartz, micas and sodic plagioclase. (See

Appendix 1, P452/65). Because of the close packing of the phenocrysts the groundmass forms only about 25% of the rock volume. Accessory minerals recorded from the rapakivi are tourmaline, apatite, zircon, sphene and magnetite.

The size of the feldspar ovoids may vary between 1.3 x 1cm and 5 x 3cm in one outcrop but are more commonly of the order of 2.5 x 2cm. Primary quartz crystals range from 4mm up to 2cm across. Feldspar ovoids are invariably twinned according to the Carlsbad law. No mantled feldspars have been observed. The potash feldspar often contains irregular intergrowths with quartz and inclusions of tourmaline and biotite. The inclusions may have a crude ovoidal arrangement concentric with the margins of the crystal. A cluster of biotite crystals sometimes occurs at the centre of the feldspar ovoid.

Variants of the Terrapinna Granite containing ovoids of plagioclase occur locally (See Appendix 1, P.376/55). Bowes (1953) recorded a "migmatitic augen granite" from the "Terrapinna Migmatite Complex" in which plagioclase (Ab68) is the dominant feldspar.

Shearing of the rapakivi granite resulted in deformation of the ovoids to form augen and a marked development of biotite. Augen gneisses form a major part of the Mount Babbage Block.

Campana (1963) attributed ovoid feldspar development in the rapakivi granite and granite porphyry to metamorphism of an earlier magmatitic granite, the necessary physico-chemical changes being induced by "varying depths of burial, sedimentary loads and erosional unloadings" prior to deposition of the Sturtian Series. Campana's thesis is refuted by the pre-Willouran age of the rapakivi, indeed also the age of the ovoids. The presence of detrital fragments of feldspar ovoids in the basal Willouran conglomerate also denies the younger metamorphic age postulated by Campana. The magmatic origin of the Mount Painter rapakivi is supported by a laccolithic form of the granite bodies, sharp contacts, and the absence of relict sedimentary structures.

<u>Mount Neill Porphyry</u> (Granite Porphyry)

The Mount Neill porphyry outcrops extensively within the Mount Painter Block, forming cores of laccoliths, sills and lenses. The Porphyry occurs at varying stratigraphic levels of the metasedimentary sequence and was presumably emplaced over a vertical interval of at least 25,000 feet. Where the granite porphyry and rapakivi are associated, the porphyry invariably occurs at a higher stratigraphic level.

Contact relationships with metasediments are generally concordant to low angle discordant although local strong discordances are evident between Mount Pitt and Yudnamutana Hill and 1 mile south of Mount Adams. Eruptive breccias (?) occur along the strongly discordant contact with laminated phyllites south of Mount Adams.

The granite porphyry is massive with a fine to medium grained groundmass, is composed of recrystallized quartz, microcline and small amounts of oligoclase (Ab88). Biotite is relatively abundant, tending to aggregate in "clots". Accessory minerals are rutile, ilmenite, tourmaline, euhedral zircon, sphene, apatite and hornblende. (See Appendix I; P125/60, P449/65).

Microcline ovoids are occasionally mantled by clear albite, while some ovoids include concentric shells of biotite, plagioclase and accessories. (See Appendix I, P448/65).

In the hand specimen the granite porphyry [redacted] resembles [redacted] the rapakivi type granite, being referred to in the field as the "little rapakivi". Macroscopic characteristics of the granite porphyry which enable it to be distinguished from the rapakivi are the finer-grained groundmass, and smaller ovoids. Minor differences in chemical composition appear to be a slightly lower silica percentage for the rapakivi and a higher soda-potash ratio for the granite porphyry. (See Appendix II).

The granite porphyry is believed to represent a higher level, slightly chilled phase of the rapakivi granite. Emplacement of the porphyry as laccoliths and laccolithic feeders and its intrusive relationships establish the magmatic origin beyond reasonable doubt. Soda enrichment is possibly indicated by late-stage formation of albite and the higher soda-potash ratio compared with the rapakivi granite.

The large tongue of granite porphyry outcropping between Mount Pitt and Yudnamutana Hill occupies the axial region of a major west plunging anticline and shows a strong local discordance with the Freeling Heights Quartzite in the vicinity of the Camel Pad. This relationship contrasts with the general concordant to slightly discordant contacts to the north-east and south where the granite porphyry overlies the Freeling Heights Quartzite. Clearly the porphyry has broken through the quartzite and been concordantly emplaced at a higher level as a sheet or laccolith. Although subsequently folded, faulted and eroded the essentially concordant mass can be traced southwards and eastwards to the vicinity of Paralana Hot Springs and northwards to Mount Shanahan Uranium Prospect. Unfolding of the mass suggests that the base of the intrusion extended over a distance of at least 35 miles. The structural relationships suggest that the porphyry tongue formed a feeder to the intrusion.

<u>Yerila Granite</u> (Tabular-feldspar Granite)

The Yerila Granite is restricted to the Mount Babbage Block outcropping as an east-west oriented elliptical mass between Mudnawatana Creek and Mount Babbage. The rock is characterized by a striking development of feldspar laths which exhibit a linear parallelism. Biotite schlieren occur towards the margins of the granite and generally have a preferred orientation paralleling the feldspar laths. Fine grained variants lacking in phenocrysts occur as narrow layers within the granite. The bands are parallel to the phenocryst orientation. Occasional ovoid feldspars occur in the granite.

A plot of the linear elements shows that the granite mass has a general synclinal form with a flat easterly plunge. A strong schistosity, trending between east south-east and east, has been imposed on the granite. Shearing produced a marked development of biotite and granulation of the rock fabric. In zones of more intense dislocation, for example near the faulted contact with the tillite, crushing of quartz phenocrysts and complete retrograde metamorphism of feldspars to sericite occurred.

The Yerila Granite was locally intruded by the rapakivi granite, an obvious intrusive contact occurring west of the Mudnawatana Creek. Xenoliths of the tabular feldspar granite were incorporated in the rapakivi granite.

The Yerila Granite is typically a coarse-grained, mottled rock, composed essentially of euhedral twinned tablets of microcline up to 2.5 centimetres in length, irregular crystals of quartz and aggregates of biotite. The ground mass is composed of a fine-grained granular mosaic of quartz, microcline and albite (Ab92). Accessories are monazite, ilmenite, apatite, zircon and tourmaline. (See Appendix I, P[redacted] 368/55).

The Yerila Granite is considered to have crystallized initially under extreme pressure conditions, similar to those postulated for the rapakivi granite. The physical conditions resulted in crystallization of first generation ovoid crystals of potash feldspar and quartz. At this stage, relief of pressure, presumably due to escape of volatiles, resulted in crystallization of second generation euhedral feldspars.

The linear parallelism of the feldspar laths is interpreted as a platy flow structure. The development of regular flow structure suggests that the Yerila Granite was a marginal facies of a viscous magmatic granite. The similarity in norms, calculated from analyses quoted in appendix II, of the Yerila and Terrapinna Granites suggests that they were comagmatic. Intrusion of the Yerila Granite by the massive Terrapinna Granite establishes the relative ages of the two granites. Contacts are markedly discordant west of Mudnawatana Creek and south of Mount Babbage, but essentially concordant to the north of Mudnawatana Creek. All contacts are sharp.

Pepegoona Porphyry (Quartz-feldspar porphyry)

The main body of the Pepegoona Porphyry crops out in the vicinity of Mount Neill. Other isolated outcrops occur 2 miles north-east, 2¼ miles south-east and 3¼ miles southwest of Mount Adams, and from ½ to 2½ miles north-east of Paralana Hot Springs. Most contacts with metasediments are faulted and only at a point 1¾ miles west north-west of Mount Neill is a normal contact preserved. At this locality the porphyry is essentially concordant with the Brindina Schists. A crude parallelism of feldspar laths is evident in the porphyry. Narrow bands of chloritic schists, essentially lacking in phenocryst development are interlayered with the porphyry, paralleling the feldspar lineation. The directional structures are interpreted as flow structures.

Consistently steep north-dipping lineations indicate that the present plan view of the Mount Neill massif approximates closely to a true vertical section. The typical flat base and domed top of a large scale laccolith is admirably displayed, the Pepegoona Porphyry forming the outer shell of the structure. Contact relationships in the Mount Neill and Mount Adams massifs indicate that the Pepegoona Porphyry was intruded by the Mount Neill Porphyry.

The Pepegoona Porphyry is typically dark green when fresh but forms rusty outcrops on weathering. The porphyry contains occasional ovoid, round or subhedral phenocrysts of microcline and oligoclase (Ab88) between ½ inch and 1 inch diameter, abundant subhedral to euhedral laths of microcline and oligoclase up to $\frac{1}{4}$ inch long and round and pale blue to violet quartz. The phenocrysts are set in a fine-grained almost glassy ground mass of anhedral microcline, oligoclase, hornblende and biotite. Accessories are sphene, ilmenite, magnetite, and euhedral zircon and apatite. Fluorite and pyrite occur in trace amounts (See Appendix I; P451/65, P449/59). Phenocrysts of quartz and feldspar are strongly corroded and embayed. Microcline contains inclusions of biotite, hornblende and epidote. Feldspar phenocrysts are rare to absent in marginal facies of the porphyry but become progressively more abundant and closely packed towards the core of the laccolith.

By comparison with the majority of the older granites, the Pepegoona Porphyry is anomalously soda rich, the soda/potash ratios being approximately 4.9:1 and 1.6:1 compared with 0.6:1 for the granite porphyry. (See Appendix II).

The laccolithic form of the Pepegoona Porphyry and the presence of resorption phenomena are strongly suggestive of a magmatic origin. Flow banding indicates a marginal phase of intrusion.

Concordant contacts with metasediments suggest that the Pepegoona Porphyry was emplaced in a flat-lying sequence. This thesis suggests that intrusion of the porphyry occurred under a sedimentary cover of at least 25,000 feet, the total estimated thickness of the metasedimentary sequence. The great depth of emplacement of the porphyry would appear to be inconsistent with its fine-grained almost glassy ground mass unless rapid chilling occurred. Chilling along the margins of the laccolith probably resulted in progressive consolidation from the margin towards the core of the structure. The paucity of feldspar phenocrysts near the roof and their concentration towards the base of the intrusion may be attributable to crystal settling. This process may also explain strong resorption of the phenocrysts in the lower levels.

Intrusion by the Mount Neill Porphyry shows that the Pepegoona Porphyry is relatively older. The high sodium content of the Pepegoona Porphyry may be related to soda metasomatism by the Mount Neill Porphyry, although it would not be anticipated from the mineral assemblage.

Wattleowie Granite (White granite)

The Wattleowie Granite is restricted essentially to the Mount Babbage Block occurring as irregular masses in the rapakivi granite or as 'sandwiches' between the rapakivi and metasediments. A few outcrops also occur in the northern part of the Mount Painter Block to the east and south-east of Mount Fitton. Contacts with metasediments and rapakivi granite are invariably sharp.

The Wattleowie Granite is slightly gneissic, and typically light-coloured and coarse grained. The rock is composed essentially of quartz, microcline, oligoclase (Ab86), biotite and accessories (zircon, sphene, apatite and tourmaline). Subhedral phenocrysts of microcline and subordinate oligoclase occur in a ground mass of microcline and albite (Ab92). Microcline contains inclusions of quartz and plagioclase. Oligoclase phenocrysts show a faint zoning and partial alteration to sericite, penninite, calcite and clay minerals. Clear albite occurs as small crystals in the ground mass and as rims to the oligoclase. Myrmekite is developed where albite is in contact with the potash feldspar. Brown biotite occurs as long flakes, showing partial alteration to chlorite. Irregular quartz crystals are strained (See Appendix 1, P245/65).

The intervention of the Wattleowie Granite between the rapakivi and granitised metasediments is suggestive of a metasomatic origin for the Wattleowie Granite. On the other hand, doming of the metasediments by the granite (2.5 miles northeast of Mt. Babbage) and the sharp contacts point to a magmatic origin if it is assumed that granitization would occur at constant volume. Where bodies of the Wattleowie Granite are isolated by narrow tongues of rapakivi, the margins of the masses may be fitted together with a fair degree of conformity. These relationships suggest that the Wattleowie Granite was intruded, but not metasomatised by the rapakivi. The late stage development of albite suggests that soda enrichment of the white granite magma may have occurred.

"YOUNGER GRANITE SUITE"

The "Younger Granite Suite" includes soda leucogranites, albitites, granodiorites, aplites, sodic and potassic pegmatites. Pegmatitic offshoots from the granodiorites intruded the Callanna Beds, Burra Group and Yudnamutana Sub-Group. Samarskite from a pegmatite intrusive into the Mount Painter Complex was dated at 400 ± 50 million years (Ordovician-Silurian) by Kleeman (1946) using U/Pb ratios. More recent dating (Rb/Sr method) by Compston (in Compston, Crawford and Bofinger, 1966) of a pegmatite emplaced in the Callanna Beds indicates a best age of 460 million years. This figure is concordant with a date of about 430 m.y. quoted by the same authors for the Mudnawatana Granite. The soda leucogranites were unsuitable for dating but are suggested by Compston et. al. to be younger than 700 m.y. Thus age dating suggests that the Younger Granite Suite was emplaced at about 450 m.y. (Lower Ordovician).

Soda Leuco-Granites and Albitites

Soda leuco-granites, albitite and aplites outcrop as small isolated bodies in a belt which extends from Umberatana H.S. to the vicinity of Arkaroola Bore. The individual outcrops were termed "Giant's Head," "Tourmaline Hill," "The Needles," "The Pinnacles" and "Sitting Bull" by Mawson and Dallwitz (1945). Soda granites and pegmatites also occur in a complexly folded outlier of ? Callanna Beds to the west of Mt. Adams. In the southern region the soda granites are almost exclusively located in metamorphosed diapiric sediments referable to the Willouran Callanna Beds and are conspicuously absent from the Mount Painter Complex. The margins of the granite bodies are brecciated and small masses were seen to be enveloped by diapiric breccia. Albitite veins injected brecciated slates of the Sturtian Tapley Hill Formation 3 miles northwest of Yadaninna Outstation.

In decreasing order of abundance the soda leuco-granites are composed of albite (sodaclase), quartz, potash feldspar (orthoclase, microcline and pertnite), accessories (tourmaline, garnet, sphene and apatite) and minor amounts of muscovite. Quartz occurs as euhedral to subhedral hexagonal crystals and as graphic intergrowths with albite. Gaseous and liquid inclusions in the quartz were noted by Mawson and Dallwitz. The textures of the soda granites are characteristically spongy and granular.

Mawson and Dallwitz visualised the soda leuco-granite bodies as high level cupola-like projections from an extensive subsurface igneous mass. According to these authors intrusion of the granites and introduction of large volumes of soda, chlorine and boron into the surrounding sedimentary sequences led to contact metamorphism and metasomatism. These processes resulted in the formation of hornfels and marbles containing various assemblages of quartz, albite, bytownite, microcline, scapolite, biotite, zinnwaldite, phlogopite, tremolite, calcite, vesuvianite, tourmaline and glaucophane.

Mawson and Dallwitz noted a progressive increase of potash with depth, attributing the composition of the leucogranites to soda enrichment in the upper levels. In the present author's opinion brecciation and envelopment of the soda granite bodies by diapiric breccia show conclusively that the granite intrusions were dismembered by diapirism. Their absence from the Mount Painter Complex and the age dating, however, suggests that they intruded the Adelaide System. If it is accepted that the soda leucogranites and Arkaroola pegmatite are of the same age, a post-Lower Ordovician phase of diapirism is indicated.

Mudnawatana Granite (Granodiorite)

The Mudnawatana Granite (Bowes, 1953) crops out as an irregular body between Mt. Babbage and Mudnawatana Creek. Granodiorites of similar composition, texture and grain size form a large oval massif on the Freeling Heights plateau and a narrow elongate body to the north of Paralana Hot Springs. Because of near petrologic identity the rock types forming the three massifs are referred to the Mudnawatana Granite. The Mount Babbage and Freeling Heights massifs are unsheared, although the presence of strained quartz indicates some deformation. The Hot Springs massif outcrops in the core of a tight syncline formed by rocks of the crystalline basement. The granodiorite is schistose, the shear planes trending in a northeasterly direction parallel to the inferred axial plane of the fold.

Pegmatitic offshoots from the Mt. Babbage massif cut across a major plane of decollement which separates the crystalline basement from the "lower tillite" (Yudnamutana Sub-Group) and were also injected along cleavages in the tillite. These relationships point to a post orogenic phase of intrusion. On the other hand the apparent structural repetition of the Freeling Heights and Hot Springs massifs across a major anticlinal axis implies a pre-orogenic phase of intrusion in the southern area. Three possibilities exist which could explain the apparent contradiction.

1. One phase of igneous activity occurred in the region and fold movements were earlier in the Mount Babbage area.
2. Igneous activity post dated one phase of folding in the two areas i.e. the structural repetition is spurious.

3. Folding was synchronous in the two areas and two phases of granite emplacement occurred.

If it is accepted that all younger granites are of the same age as the Arkaroola pegmatite (i.e. Lower Ordovician) the hypothesis of a pre-orogenic granite is supported by disruption of the soda-leucogranites by a diapiric mechanism; diapirism is believed to be initiated by fold movements.

Mount Babbage Massif

The Mudnawatana Granite crops out over an area of 4 square miles, exhibiting strong discordant contacts with schistose rapakivi and tabular feldspar granite of the "Older Granite Suite". The granodiorite is typically medium-grained and massive. A flat jointing is strongly developed and gives rise to bench-like outcrops. The joints are sometimes occupied by pegmatites and aplites and were probably cooling joints.

Contacts on the northern margins of the massif generally dip northwards, with attitudes varying between steep and subhorizontal. Contact relationships suggest that the massif expands in depth. This concept is supported by the widespread distribution of pegmatite swarms and quartz reefs to the north and south. Pegmatite, aplite and granodiorite apophyses were injected along a strong east-west schistosity in the older granites.

Bowes (op. cit.) quoted the following evidence to support a magmatic origin for the Mudnawatana Granite.

1. Discordant contacts
2. Injection of tongues of granodiorite, aplite, pegmatite and quartz along shear planes in the country rocks.
3. Presence of disoriented xenoliths in the granodiorite.
4. Allotriomorphic-hypidiomorphic texture.
5. Zoning of plagioclase, corresponding to Bowen's ideal cooling curve for plagioclase in a melt.

Freeling Heights Massif

The Freeling Heights grandioritic massif crops out over an area of approximately 13 square miles, forming a large oval mass in the north but tonguing out rapidly towards the south. Contacts with the Freeling Heights Quartzite are generally only slightly discordant, although the isolated body between Yudnamutana Creek and the British Empire Copper Mine shows strong discordant relationships.

Large rafts ofthe Freeling Heights Quartzite, preserved within the granodiorite show little sign of contact metamorphism or metasomatism except silicification and incipient biotite development. Pegmatite offshoots are common along the western margin of the massif, but are absent from the eastern contact zone. A potassic hornblende pegmatite intruding Callanna Beds ½ mile south of Green Hill Copper mine is presumed to be an offshoot from a subsurface extension of the Freeling Heights massif. Pegmatite distribution suggests that the western contact forms the roof and the eastern margin the base of the intrusion.

Contact dips are flat in the north-east but steepen to the south and west. Thus the extensive outcrop in the north may be explained by the flat attitude of the mass. It is probable that the Freeling Heights granodiorite forms a tabular body of no great thickness.

The massif is strongly jointed, the major joint directions being approximately east-west and slightly west of north. The north-south joints are more persistent and appear to be relatively younger than the closely spaced east-west system. A northeast-southwest set is weakly developed.

Paralana Springs Massif

This body outcrops over an area of approximately 3 square miles forming an elongate northeasterly trending massif to the north and north-east of Paralana Hot Springs. Lit par lit tongues of granodiorite were injected along planes of schistosity in a gneissic granite of the "Older Granite Suite". Local discordant contacts with the country rocks leave no doubt of the intrusive nature of the granodiorite. Occasional potassic pegmatites are associated with the massif. Numerous steeply-dipping sedimentary bands included within the massif are separated by lit-par-lit tongues of granodiorite. The massif is sheared and jointed in a northeast-southwest direction, the structures paralleling the inferred axial plane in the gneissic granite. The schistosity is interpreted as a cleavage and suggests that the granodiorite body was folded. Dislocation by Tertiary-Recent (?) faulting cannot entirely be discounted as movements along the marginal fault immediately to the east may have resulted in shearing of the massif.

On the western margin of the massif contact dips are of the order of 60 degrees to the east, approximating to the attitude of the underlying gneissic granite and metasediments.

The structural detail suggests that the Paralana Springs granodioritic massif has a synform structure and further suggests that the body was folded.

AMPHIBOLITES

Amphibolites of basic composition extensively intruded the Mount Painter Complex and locally the Willouran Paralana Quartzite and Marinoan Wilpena Group as sills and dykes. The sills were subsequently folded and invaded by pegmatitic offshoots from the Mudnawatana Granite. The apparent absence of folding in the dykes is possibly explained by their steep dip. The concordant relationship of sills with Older Precambrian metasediments implies that these bodies were emplaced as flat lying sheets which supports the earlier conclusion that the Mount Painter Complex was little folded prior to deposition of the Adelaide System.

Near the southern edge of the Mount Babbage Block a strongly discordant amphibolitic dyke is exposed over a distance of about 12 miles. Bowes (1952) considered the amphibolite to be transformed tillite, attributing the basic composition of the rock to introduction of Fe, Mg, Ca, Ti, Mn and Cr and expulsion of K, Na and Si. The present author suggests that the strongly discordant relationships and chilled margins of the body leave no doubt concerning its intrusive igneous origin. Coarsely crystalline carbonate bodies are locally associated with the dyke. The basic character of the Mount Babbage amphibolite is demonstrated by analyses of the "basified tillite" quoted by Bowes (op. cit) in which the silica percentage of four specimens varied between 52% and 49%.

The texture of the amphibolites varies from glassy to gabbroid, this variation often occurring within one body. The presence of vesicles, often filled with quartz, indicates a near-surface emplacement. The coarse gabbroic types are usually mottled and have a relictophitic texture. The fine-grained amphibolites are dark green in colour and often occur as chilled margins to the gabbroic types (See Appendix I p. 374/55).

The amphibolites are essentially composed of hornblende and andesine-labradorite. Although no relict pyroxene has been recognized the amphibolites are thought to be altered dolerites. Bowes (1953) described a uralitised dyke from Hamilton Creek, ½ mile south of Terrapinna Waterhole which consisted of saussuritized basic plagioclase (Ab48) and prismatic crystals of uralitic hornblende.

If only one age of basic igneous intrusion is accepted, this phase clearly occurred in the late Marinean to early Ordovician interval. Alternatively an early Willouran phase would be inferred from the close proximity of the basic Wooltana Volcanics. Thus it is possible that two periods of basic igneous intrusion are represented in the Mount Painter Province.

STRUCTURE

Mobility of the crystalline basement is indicated by structural relationships of the Mount Babbage Block with the Sturtian glacial sequence (Yudnamutana Sub-Group). Between Terrapinna W.H. and Mount Babbage trig station the entire northern limb of a major syncline, involving approximately 10,000 feet of the Bolla Bollanna Formation, was eliminated (Figure 2). Three miles west of Mount Babbage remnants of the northern limb are represented by a about 500 feet of the Fitton Formation. Normal stratigraphic and structural relationships are apparently preserved 12 miles west of Mount Babbage. A sheared contact dipping southerly at 50-80 degrees intervenes between the Bolla Bollanna Formation and the Fitton Formation in the central region. The structural break occurs between the Mount Painter Complex and Bolla Bollanna Formation in the eastern section. The shear zone is characterized by a notable development of chiastolite schist and was locally intruded by quartz veins. Pegmatite offshoots from the Mudnawatana Granite cut through the shear. Other structures developed in the tillite 'corridor' north of Terrapinna W.H. were the slight overturning of the sequence to the north, the thinning of the Bolla Bollanna Formation towards the east, and a strong cleavage trending east-northeast and inclined steeply to the south.

The structural features are suggestive of underthrust movement of the Mount Babbage Block and compression of the Bolla Bollanna Formation between the Mount Babbage and Mount Painter Blocks, the maximum differential movement occurring at the eastern extremity of the tillite corridor. Actual dislocation occurred between units of the Yudnamutana Sub-Group; the Fitton Formation reacted in conformity with the crystalline basement. Evidence of considerable displacement in the east and zero displacement in the west implies a clockwise rotation of the Mount Babbage Block. The last major movement of the block clearly predated intrusion of the Mudnawatana Granite (Lower Ordovician). Minor offsetting of the pegmatites by the east-northeast cleavage may indicate subsequent limited movement of the Mount Babbage Block.

Contrasting responses to deformative stress are evident within the Mount Painter Complex. Thus, between Greenhill Hut and Yudnamutana Mines, fold structures developed in the Adelaide System were faithfully reproduced in the dominantly arenaceous sequence of the crystalline basement. Faulting was subordinate to folding. It is clear that even thick arenaceous sequences were semi-plastic during folding. In the dominantly massive granite terrains of the Mount Babbage Block and the northern part of the Mount Painter Block, faulting was more strongly developed. The unequal behaviour of the structural units was clearly related to competency and the volume of rock involved. Foliated granites and thin massive granite bodies also appear to have behaved semi-plastically. Thus fold stresses were accommodated in foliated granites mainly by ship along primary foliation planes, resulting in the development of augen and flaser gneisses. Folding of small bodies of massive granite was accomplished by fracture cleavage. The lack of directional fabrics in large bodies of massive granite porphyry and rapakivi granite show that large granite massifs behaved rigidly during folding.

Plasticity of all rocks was probably increased by deep burial beneath a thick sedimentary mantle of Adelaide System and Cambrian rocks. The crystalline basement was subsequently exposed as anticlinal axial culminations by folding. Structural relationships of the Mount Painter Complex with the Callanna Beds and Burra Group are essentially concordant; relationships between the Yudnamutana Sub-group and crystalline basement are misleading because of the highly transgressive character of the glacial unit.

An exception to the concordant relationship is the violent unconformable contact of the Callanna Beds and Freeling Heights Quartzite between Yudnamutana Hill and Yudnamutana mines.

Structural detail suggests upturning of the northern limb but not of the southern limb of the anticline. Analogous structures have been mapped on the flanks of diapiric domes, for example the Witchelina Diapir (Coats 1964). An exposed cross sectional view of this structure shows a marked upturning of the intruded sequence on the western limb only. The asymmetric development of the structure is attributed to greater differential vertical movement of plastic Willouran core material along the western margin of the structure. Clearly at this stage of development erosion of the diapiric dome, followed by sedimentation, would result in a strong unconformity on the western limb and a low angle unconformity on the eastern limb.

Likewise it is postulated that upturning of the Freeling Heights Quartzite was produced by an intrusive body, in this case a large pipe of granite porphyry. The porphyry pipe is considered as a feeder to an extensive laccolith which was largely eroded prior to deposition of the Callanna Beds. Clearly, upturning cannot be related to doming by the laccolith itself as uplift was restricted to the top of the intruded mass. Inter-tonguing of the porphyry with metasediments northeast of Corundum Mine suggests that the greater volume of magma was introduced along the northern contact. The remarkable straightness of the unconformity is suggestive of either a pediplained surface or a fault line. Erosion or faulting truncated the Upturned Freeling Heights Quartzite prior to deposition of the basal Callanna Beds.

Thus it is believed that only mild folding of the Mount Painter Complex occurred before deposition of the Adelaide System. The continuation of crystalline basement fold structures into sediments of the Adelaide System without significant variation in plunge shows that the two rock units were folded together.

A major structural feature of the Mount Painter Province is the Paralana Fault, a compound system of steep west-dipping upthrust faults. The Paralana Fault System (Crawford, 1963) exten[ds] in a general north-south direction from beyond the southern limit of the map area to East Painter Creek where it is apparently hing[ed]

South of Boulder Bore the Fault System consists of two parallel strike faults with a cumulative throw of between 22,500 feet and 25,000 feet (Crawford, 1963). The western member having the greatest displacement, throws lower Burra Group against middle Umberatana Group units. The eastern member faults the latter units against formations of the lower Wilpena and Upper Umberatana Groups.

North of Boulder Bore several northeasterly trending splinter faults branch off the Paralana Fault. One of these structures, the Lady Buxton Fault, develops northeastwards into a major structure. At Yudnamutana Creek a right angle deflection in trend of the Lady Buxton Fault line occurs locally, the change in strike coinciding with a marked topographic re-entrant in the ranges. At present the physiographic feature is thought to be related to a flattening of the westerly inclined fault plane, but insufficient structural information is available to be certain.

The radioactive Paralana Hot Springs are located on the Lady Buxton Fault one mile north of Yudnamutana Creek. The northeasterly trend is resumed north of Paralana Hot Springs, and persists to a point 2½ miles north-northeast of Mount Adams. Here the Lady Buxton Fault was apparently truncated by an easterly dipping upthrust fault (Mount Adams Fault). Opposing reverse movements on the two structures, involving over-riding of Willouran Callanna Beds by crystalline basement, resulted in the preservation of a strongly folded outlier of the Callanna beds. The dip of the Lady Buxton Fault is subvertical west of Mount Adams but apparently flattens appreciably towards the north. Thus at the northern limit of the Willouran outlier the topographic expression of the faulted contact suggests that the Lady Buxton Fault has a flat northerly attitude.

One and a quarter miles southwest of Mount Adams, the Mount Adams Fault is marked by a zone of granite breccia dipping at 50-60 degrees to the east. The Mount Adams Fault strikes northeasterly to a point three miles northeast of Mount Adams where it appears to die out. West of Pepegoona Creek it is a compound structure. East of this locality the fault line has a marked sinuous trend, suggesting a flattening of the fault plane.

A sub-parallel en-echelon fault is developed 1¼ miles north of Mount Neill and extends eastwards to Parabarana Hill. The trace of the fault line indicates a steeply inclined structure

Maximum displacement of the Mount Adams Fault occurred west of Mount Adams where ? Callanna Beds were faulted against the lowest exposed metasedimentary units of the Mount Painter Complex. If the sediments of the Adelaidean outlier are referred to the Callanna Beds, the throw on the fault is estimated to be of the order of 25,000 - 30,000 feet.

GRANITISATION

Bowes (1952) discussed mineralogical and chemical changes involved in transformation of quartzite to "migmatitic augen granite" (sheared rapakivi granite). The present author suggests that the migmatitic augen granite was not the end product of granitisation but was in fact an igneous rock responsible for the transformation processes. According to Bowes (op. cit.) granitisation of quartzite involved a decrease in the amount of silica and an increase in K, Al, Na, Ti, Fe Mg, Ca and H.

The rock unit most susceptible to transformation was the Brindina Schist, originally a succession of sandy shales, shales and Mg-Fe-Ca rich non-clastics. By comparison the Freeling Heights Quartzite shows little change. The unequal response to granitisation is well illustrated in the northern part of the Mount Painter Block. Here both units are in contact with the rapakivi granite and the Freeling Heights Quartzite is not granitised whereas the Brindina Schist is homogenized to a medium-grained white rock of granitic composition. Where the Brindina Schist is separated from the rapakivi granite by the earlier granite porphyry, as for example three miles southwest of Moolawatana Homestead, the sediments are not granitised. By contrast stratigraphically equivalent beds on the northern limb of the Moolawatana Syncline were transformed. The granite porphyry is little altered and presumably formed an impermeable medium between the Brindina Schist and rapakivi granite.

Granitization of inferred Brindina Schist was widespread in the Mount Painter Complex of the Mount Babbage Block where isolated sedimentary remnants were engulfed by rapakivi granite. The preservation of ungranitized Brindina Schist three miles northeast of Mount Babbage is attributed to "armouring", in this case by the white granite. Southwest of Union Trig cross bedded argillaceous quartzites of unknown stratigraphic position were transformed to a 'pied de poule' granite, an unusual rock characterized by decussate aggregates of biotite (see Appendix 1, P59/57,(3)). The sedimentary parentage of the pied de poule rock is established by the preservation of cross bedding.

Contacts between granitized rocks and rapakivi granite are sharp and there is little evidence of the intervening migmatite stage of granitization except in the area to the east and south of Mount Painter. Here the Corundum Creek Schist and gneissic granite were injected by lit-par-lit tongues of a white granite. At the moment it is not clear whether migmatization of these rocks is related to the "Younger" or "Older Granite Suites".

Ovoid feldspar development in wall rocks reported by many authors from rapakivi granite massifs has not been observed in metasediments of the Mount Painter Complex. Granitic rock types occurring as lenticular concordant bodies in contact zones show no compositional and textural differences from the rapakivi granite massif except a slight decrease in grain size of the former rocks. The lenticular bodies are assumed to be offshoots from the massif and unrelated to granitisation.

Studies in the Mount Painter Province emphasize the compatibility of granitization and magmatitic processes, a concept which is often overlooked by ardent transformationists and magmatists. Among the older granites the process of granitization was uniquely related to the rapakivi granite. Argillaceous sequences were more susceptible to granitization than arenaceous units.

METAMORPHISM

Although only small bodies of the "Younger Granite Suite" are exposed in the Mount Painter Province the broad metamorphic aureole developed in rocks of the Adelaide System suggests that the Palaeozoic granites had a profound metamorphic influence on the Mount Painter Complex. The widespread distribution of pegmatite and tourmaline-bearing quartz reefs throughout lower Adelaide System and crystalline basement terrains is indicative of a shallow granite massif of batholithic proportions, the exposed masses representing cupola summits of the body. Thus it is likely that metamorphic changes induced in sediments of the Mount Painter Complex by the "Older Granite Suite" were masked by the subsequent Palaeozoic igneous activity.

The extensive metamorphic halo may also be attributable to a considerable overburden thickness of Adelaide System and Cambrian sediments which formed an insulating blanket and permitted uniform [redacted] heating of the lower sequences by isolated igneous centres. Maximum overburden thickness in the Mount Painter Province was of the order of 100,000 feet. This thesis implies that the younger granites were subsequently elevated from a considerable depth to a near-surface position, presumably by folding.

In common with the granitisation process metamorphic responses were controlled by the original composition of the sediments. The only change in arenaceous rock types of the Freeling Heights Quartzite was the introduction of silica, whereas argillaceous and non-clastic members of the Brindina Schist were converted to cordierite-mica schists, skarns, and amphibolites. Metamorphic minerals recorded from metasedimentary formations of the Mount Painter Complex are as follows:

ROCK UNIT	ROCK TYPE	METAMORPHIC MINERAL	ESSENTIAL COMPOSITION
		Cummingtonite	(Mg, Fe)
		Anthophyllite	(Mg, Fe)
		Actinolite	(Mg, Fe)
		Hornblende	Ca, (Mg, Fe)
		Almandine	Fe, Al
	Calc-silicate Rocks	Andradite	Ca, Fe
		Labradorite	Ca, Na
		Microcline	K
		Chlorite	(Mg, Fe)
		Epidote, clinozoisite	Ca, (Al, Fe)
		Magnetite	Fe
BRINDINA SCHIST		Sphene	Ca, Ti
		Apatite	Ca, P, (F, Cl)
		Muscovite	K
	Arenaceous Schists	Biotite	Mg, Fe
		Cordierite	Mg
		Sillimanite	Al
		Garnet	var. unknown
		Corundum (inc. sapphire)	Al
		Garnet	var. unknown
Corundum Creek Schist	Arenaceous Schists	Spinel	var. unknown
		Muscovite	K
		Sillimanite	Al
		Biotite	Mg, Fe
		Andalusite (?)	Al

Although the amphibolitic members of the Brindina Schist may be formed by migration and concentration of mafic constituents during granitization it is more likely that the metamorphic assemblage reflects the Mg - Fe rich composition of the original sediments. The metamorphic assemblage is similar to that reported by Ayres (1966) from a sedimentary iron formationoccuring in Section 72, Hundred of Minbring, Eyre Peninsula and to a lesser extent with the Ethiudna Calc-Silicate Group (Campana in Campana and King, 1958) of the Olary Province. The presence of abundant disseminated octahedral crystals of magnetite in amphibolitic members of the Brindina Schist emphasizes further the iron rich character of the sediments. The magnetite may represent excess iron after requirements for the amphiboles were satisfied.

The metamorphic assemblages represented in the Mount Painter Complex are referable to the cordierite-anthophyllite and sillimanite-almandine subfacies fo the amphibolite facies (Turner and Verhoogen 1960). According to Turner and Verhoogen (op. cit. the facies correspond to medium and high grades of regional metamorphism and medium grades of contact metamorphism.

Metamorphism produced by shearing of the Mount Painter Complex was most extensively developed in the Mount Babbage Block Intense shearing of metasediments and older granites along east-west trending zones and faults produced granulation of rock fabri and a marked development of biotite. The Terrapinna Granite was locally converted to an augen gneiss. Shearing of the Freeling Heights Quartzite resulted in conversion of the clay and feldspar fractions to sericite and muscovite.

Structural relationships in the Mount Babbage Block sho that the major dislocation metamorphism occurred before emplacement of the Mudnawatana Granite and amphibolites.

CONCLUSIONS

Delineation of the major rock units in the Mount Painte Province provides a basis for systematic petrology. It is hoped that presentation of this report will stimulate further geological and petrographic investigations in this classical area.

Specification of the type sections of metasedimentary units is deferred until mapping is completed.

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R. P. Coats

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REGIONAL MAPPING SECTION

RPC:DLH
30/6/1966.

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APPENDIX I

EXTRACTS FROM PETROLOGICAL REPORTS
(Australian Mineral Development Laboratories)

RADIUM CREEK SEQUENCE

Classification: Quartzite (P358/55)

Rock Unit: Freeling Heights Quartzite (Upper member).

Location: 0.3 miles SW Freeling Heights

PETROGRAPHY:

A slightly impure quartzite, fine to medium grained and pale grey in colour. It consists mainly of quartz grains of varying sizes, sutured together. Other minerals present are sericite, magnetite and zircon. The sericite occurs as small flakes which have a slight tendency for orientation. Magnetite occurs as subhedral crystals, which are concentrated along planes of original structures in the rock. Zircon occurs as a minor accessory. The quartz is cloudy due to minute opaque inclusions.

Investigated by: A.J. Marlow.

Classification: Corundum schist (P313/57)

Rock Unit: Corundum Creek Schist

Location: Corundum Mine

Petrography:

The sample is composed of feldspar, crowded with minute crystals of rutile, coarse flakes of biotite and muscovite, hydromica, corundum, dark blue sapphire and quartz.

Investigated by: N. Chebotarev.

Classification: Plagioclase amphibolite

Rock Unit: Brindina Schist (P59/57, 1.)

Location: 1.5 miles SSE Twelve Springs

Petrography:

This is a grey, fine grained plagioclase amphibolite, composed of actinolite, labradorite, sphene, clinozoisite and minor amounts of zircon and black opaque material. Actinolite and labradorite are the main constituents.

Actinolite is pale green and occurs as subhedral and prismatic crystals. Actinolite has a poikilitic texture towards labradorite.

Labradorite (Ab 36) occurs as small subhedral crystals.

Sphene is the most noteable feature of the rock. Euhedral brown sphene ranges in size up to over 2.5 inches long. Small euhedral crystals and aggregates occur throughout the rock.

Euhedral crystals of clinozoisite are relatively common. Traces of black opaque minerals and euhedral crystals of zircon are present.

Investigated by: A.J. Marlow.

Classification: Amphibolite (P59/57,(2))

Rock Unit: Brindina Schist

Location: 1.5 miles SSE Twelve Springs.

Petrography:

This is a grey, fine to medium grained amphibolite composed of cummingtonite, labradorite, almandine, apatite and an opaque iron mineral.

The cummingtonite is almost colourless in thin section. It occurs as small well developed euhedral and prismatic crystals.

Twinned labradorite is common as small interlocking, subhedral to anhedral crystals.

Dark red almandine is also abundant, occurring as well developed dodecahedral, cubic and octahedral crystals.

Black, opaque material is abundant, occurring through the rock as subhedral and euhedral crystals, giving it a spotted appearance. Small euhedral crystals of apatite are present.

Investigated by: A.J. Marlow.

Classification: "Pied de poulo" Rock (P59/57,(3))

Rock Unit: Brindina Schist (?)

Location: 1 mile SW Union Trig

Petrography:

This is a light coloured medium grained rock, with a dark "pied de poule" structure. Main constituents of the rock are quartz, microcline, biotite, altered plagioclase and muscovite.

Quartz occurs as relatively coarse, irregular, interlocking crystals. The quartz has an undulatory extinction and some crystals are shattered. Quartz is the most abundant mineral and some has crystallized after the feldspars, as crystals of microcline are enclosed by large crystals of quartz. Quartz has also intruded some feldspars along the twin planes.

Both types of feldspar are altered - microcline to kaolin and plagioclase to sericite. Microcline occurs as irregular somewhat corroded crystals. Inclusions of corroded and altered plagioclase and quartz are found in the microcline. The plagioclase (oligoclase) is subordinate to microcline. Myrmekite has developed where the oligoclase is in contact with microcline.

Biotite forms in aggregate giving the rock the "pied de poule" structure. These aggregates are composed of short brown flakes having no predominant orientation. Flakes of muscovite and small crystals of magnetite occur in small amounts with the biotite.

Minor amount of euhedral zircon and apatite are present.

<u>Investigated by:</u> A.J. Marlow.

OLDER GRANITE SUITE

<u>Classification:</u> Biotite rapakivi granite (P452/65)

<u>Rock Unit:</u> Terrapinna Granite.

<u>Location:</u> Hamilton Creek, 1½ miles S.S.W. of Terrapinna W.H.

<u>Petrography:</u>

Large subrounded, perthitic microcline phenocrysts are set in a coarse grained ground mass of potash feldspar, quartz, mica and sodic plagioclase. Minor amounts of blue tourmaline, opaques, apatite and zircon are also present.

The microcline phenocrysts contain irregular intergrowth of quartz as well as inclusions of tourmaline, biotite, muscovite and sericite. The edges are granulated because of the deformation the rock has undergone. Approximate modal proportions are:

	%
Quartz	25
potash feldspar	55
plagioclase	6
muscovite and sericite	7
biotite	4
accessories	3

__Investigated by:__ I.F. Scott

__Classification:__ Variant of biotite rapakivi granite (P376/55).

__Rock Unit:__ Terrapinna Granite.

__Location:__ 1·7 miles S Union Trig

__Petrography:__

A light coloured, medium to coarse grained adamellite, composed of oligoclase, quartz, microcline and biotite. Other minerals present are muscovite, zircon, apatite and magnetite. Quartz, calcite and chlorite are secondary minerals. Oligoclase (Ab_{84}) is in the form of large irregular crystals. Exsolved microcline or antiperthite is noted in the oligoclase. The latter mineral is highly altered with consequent development of small flakes of sericite and muscovite. Small anhedredral grains of quartz are enclosed in the oligoclase. Microcline occurs in large irregular crystals, which contain inclusions of quartz. Quartz is noted as large irregular crystals with an undulatory extinction. Brown biotite is abundant, occurring as small flakes in large clots, which give the rock a spotted appearance. Muscovite occurs as short flakes usually associated with the biotite clots or as an alteration product of oligoclase. Apatite and magnetite are also associated with the biotite clots - apatite as euhedral crystals and magnetite as anhedral masses. Small, euhedral zircons are scattered throughout the rock. Calcite and chlorite have developed by alteration of oligoclase. Secondary quartz has formed due to recrystallization of primary quartz.

Investigated by: A.J. Marlow

Classification: Granite porphyry (P449/65)

Rock Unit: Mount Neill Porphyry

Location: 1 mile SE of Mount Neill

Petrography:

This rock is a coarse grained granite containing small ovoid perthitic microcline crystals. Plagioclase feldspar grains are present only as remnants, almost completely replaced by microcline or as highly sericitised intergrowths with quartz. Micrographic quartz - potash feldspar intergrowths are not infrequent. The quartz grains are finely granulated along their grain boundaries and exhibit strain extinction.

Biotite is present in significant amounts and sometimes show a very definite preferred orientation. Opaques, zircon, fluorite and epidote are present as accessory minerals.

Approximate modal percentages are:

	%
quartz	32
microcline (perthitic)	37
plagioclase (sodic)	10
muscovite and sericite	4
biotite	14
accessories	3

Investigated by: I.P. Scott

Classification: Alkali granite porphyry (P125/60)

Rock Unit: Mount Neill Porphyry

Location: 2 miles NW of Mount Painter

Petrography:

This is an albitised alkali granite porphyry. The bulk of the rock is a coarse and partly recrystallized mass composed of feldspar crystals interlocked with quartz and secondary albite. The albite forms clear rims round the crystals which are free from alteration; it also replaces some altered feldspar. The original feldspars are thickly clouded with clayey and sericitic materials. The porphyroblasts are microperthitic of poikilitic texture. The rock includes segregations of sphene and secondary calcite. Iron minerals, apatite and zircon are quite abundant accessories. Hornblende, epidote, chlorite and other accessories occur occasionally.

Approximate modal percentages are:-

	%
Quartz	17
potash feldspar and sericite	33
albite and plagioclase	47
opaques	1
epidote	1

Investigated by:

Classification: Feldspar ovoid (P448/65).

Rock Unit: Mount Neill Porphyry

Location: 2½ miles E.S.E. of North Well

Petrography:

The large feldspar ovoid consists of more than one orientation of perthitic microcline and these contain inclusions of zircon, opaques, biotite and plagioclase.

In the hand specimen these inclusions are seen to occur in roughly circular patterns parallel to the ovoid shape of the host. This suggests that the actual microcline phenocryst has grown in a concretionary manner under confining pressures.

Investigated by: I.F. Scott

Classification: Tabular feldspar granite (P368/55)

Rock Unit: Yerila Granite

Location: *Mudnawatana Creek, 3.3 miles SE Union Trig.*

Petrography:

The texture of this rock is unusual, with long tabular felspars, ranging in size up to 25mm in length and aligned in a roughly parallel manner. The grain size is variable. Large phenocrysts of microcline, coarse mosaics of quartz and clots of biotite are surrounded by a finer grained groundmass of quartz, albite and microcline.

The large crystals of microcline - orthoclase are highly altered and traversed by cracks infilled with oligoclase, quartz, biotite and muscovite. Small strings of exsolved plagioclase are present in the microcline. The large mosaics of interlocking quartz crystals may have been phenocrysts which have been crushed. The quartz grains have an undulatory extinction and are slightly recrystallized on the margins. Greenish brown biotite occurs in large clots. Some of these enclose small crystals of monazite and ilmenite. The granular ground mass is fine grained and composed of interlocking crystals of quartz, microcline and albite (Ab_{92}).

Biotite is abundant in the form of short flakes, some of which are oriented in a roughly parallel direction.

Associated with biotite are granular crystals of an altered epidote mineral. Muscovite is present as irregular flakes scattered sparsely throughout the ground mass. Apatite and euhedral zircon occur as numerous small sporadically distributed crystals. A trace of tourmaline is present.

Investigated by: A.J. Marlow

Classification: Quartz-feldspar porphyry (P451/65)

Rock Unit: Pepegoona Porphyry

Location: Pepegoona Ck., 2¼ miles N of Pepegoona Well.

Petrography:

This rock is a quartz-feldspar porphyry which has undergone severe alteration. Green biotite, muscovite and sericite have developed to a considerable extent.

Large round corroded (resorbed) plagioclase phenocrysts (up to 1.5cm diameter) contain subradial quartz inclusions and mica minerals randomly distributed. Blue tourmaline and opaques are also present as inclusions. Corroded quartz phenocrysts with shadowy extinction also occur in this rock. The feldspar and quartz phenocrysts are set in a very fine grained quartz-feldspar-mica ground mass which exhibits a relict flow texture. It is possible that the texture is a result of cataclastic deformation. Micrographic quartz-feldspar intergrowths were observed.

Approximate model proportions are:-

	%
Quartz	30
Plagioclase	37
Muscovite and sericite	14
Biotite	17
Accessories	2

Investigated by: I.F. Scott.

Classification: Porphyritic rhyolite (P449/59)

Rock Unit: Pepegoona Porphyry

Location: Pepegoona Creek, ½ mile N Pepegoona Well.

Petrography:

The rocks is a stressed and somewhat brecciated porphyritic rhyolite, with embayed, corroded phenocrysts of quartz, anorthoclase, albite and chequer albite in a fine grained holocrystalline ground mass of quartz, albite and potassic feldspar. Green biotite is abundant, and late-stage muscovite replaces other minerals. Accessories are abundant and consist of disseminated sphene, shapeless apatite, euhedral zircon, xenotime (?) and traces of fluorite.

Investigated by: H.W. Fander.

Classification: White Granite (P245/65)

Rock Unit: Wattleowie Granite

Location: 1 mile S. of Wattleowie Well.

Petrography:

This rock is a very coarse grained granite consisting mainly of microcline phenocrysts, a few plagioclase phenocrysts, quartz and biotite. Dynamic metamorphism has been the prime cause of any mineral changes in the rock. These changes take the form of recrystallisation of biotite, and possibly of feldspar and quartz to give myrmkite in the more intensely affected area. Nearly all quartz grains present exhibit shadowy extinction because of the absorbed stresses. The occasional curvature of plagioclase twins has a similar origin. The phenocrysts of perthitic microcline and smaller sodic plagioclase have remained intact.

Plagioclase phenocrysts are oligoclase with thin albite rims. However these zones are very weakly developed, sometimes exhibiting only one or two degrees difference in the extinction angle. Some degree of preferred orientation of the biotite flakes is seen in the hand specimen. In thin section this feature is parallel to the shear directions in the sample and suggests some recrystallization. The biotite flakes, although mostly recrystallised, are sometimes present as remnants in feldspar phenocrysts.

Accessory amounts of zircon, apatite and opaques occur in association with the biotite flakes, the zircon being responsible for occasional pleochroic.

It is considered that thermal metamorphism has had little or no effect on this rock. The sample has undergone some degree of deformation but this apparently has not altered the original mineralogy to any extent.

The approximate mineral proportions are:-

	%
Potash feldspar, myremkite, microperthite	50
Quartz	30
Plagioclase, myremkite	15
Biotite	5

Investigated by: I.P. Scott

YOUNGER GRANITE SUITE

Classification: Granodiorite (P359/55)

Rock Unit: Mudnawatana Granite

Location: 1.8 miles S.E. Freeling Heights

Petrography:

A grey coloured medium grained granodiorite. The main constituents are plagioclase,quartz, biotite and muscovite. Some microcline is present. Accessory minerals include ilmenite, zircon, rutile and epidote.

The plagioclase is oligoclase (Ab_{82}). It occurs as large irregular crystals, some of which contain inclusions of microcline. Quartz is in the form of large irregular crystals with an undulatory extinction. A small amount of microcline is present as irregular crystals. Oligoclase, quartz and microcline have a slightly cloudy appearance due to minute, opaque inclusions

Biotite occurs as greenish-brown flakes, some of which contain small radioactive zircons. Biotite is altering to a pale green chlorite. Muscovite is in the form of broad irregular flakes.

The rock has a medium grained, xenomorphic, granular texture.

Investigated by: A.J. Harlow

AMPHIBOLITES

Classification: Amphibolite (P352/55)

Rock Unit: Amphibolite

Location: Yudnamutana Ck., 1 mile S. Mount Macdonnell.

Petrography:

A grey, fine grained metamorphic rock consisting essentially of actinolite, quartz, scapolite and magnetite. Sphene and biotite are relatively abundant. Minor amounts of apatite, zircon and tourmaline are present. A small amount of secondary calcite si also noted.

Green actinolite is very abundant and occurs as prismatic crystals and as aggregates. Quartz is seen as small interlocking crystals of scapolite. Magnetite occurs as subhedral and euhedral crystals of varying size.

Sphene is present as subhedral and euhedral crystals scattered through the rock. Brown biotite occurs as small flakes usually associated with actinolite. Subhedral and euhedral crystals of apatite, zircon and tourmaline are present as accessory minerals.

Investigated by: A.J. Marlow

Classification: Diorite (P374/55)

Rock Unit: Amphibolite

Location: 1.5 miles SSE Union Trig.

Petrography:

A dark grey, fine grained diorite composed of hornblende, andesine and subsidiary biotite. Apatite and an opaque mineral occurs as accessories. Green hornblende is abundant and occurs as anhedral crystals which are slightly altered. Andesine, (Ab_{64}) is present as subhedral crystals. Brown biotite occurs as small anhedral flakes usually associated with the opaque mineral.

Accessory apatite occurs as euhedral and subhedral crystals. Ilmenite is an abundant accessory as anhedral and subhedral crystals.

The texture of the rock is hypidiomorphic.

Investigated by: A.J. Marlow

APPENDIX II

ROCK ANALYSES

(Australian Mineral Development Laboratories)

OLDER GRANITE SUITE

	A3827/62	A666/65	A665/65	A668/65	A663/65
SiO_2	73.8	75.6	72.1	72.5	74.3
Al_2O_3	13.3	12.0	13.0	13.5	12.6
Fe_2O_3	0.79	0.18	1.90	1.25	0.61
FeO	1.44	1.98	2.45	2.10	1.97
MgO	0.39	0.28	0.33	2.10	0.25
CaO	0.95	0.95	1.18	0.21	1.06
Na_2O	2.50	2.65	2.85	4.25	2.50
K_2O	5.55	4.70	5.40	2.70	5.55
H_2O+	0.08	0.17	0.09	0.22	0.07
H_2O-	0.76	0.54	0.41	1.08	0.41
CO_2	0.14	0.24	0.19	0.03	0.04
TiO_2	0.21	0.23	0.20	0.38	0.33
P_2O_5	0.09	0.04	0.03	0.05	0.07
MnO	0.03	0.04	0.03	0.02	0.05
	99.7	99.6	100.2	100.4	99.8

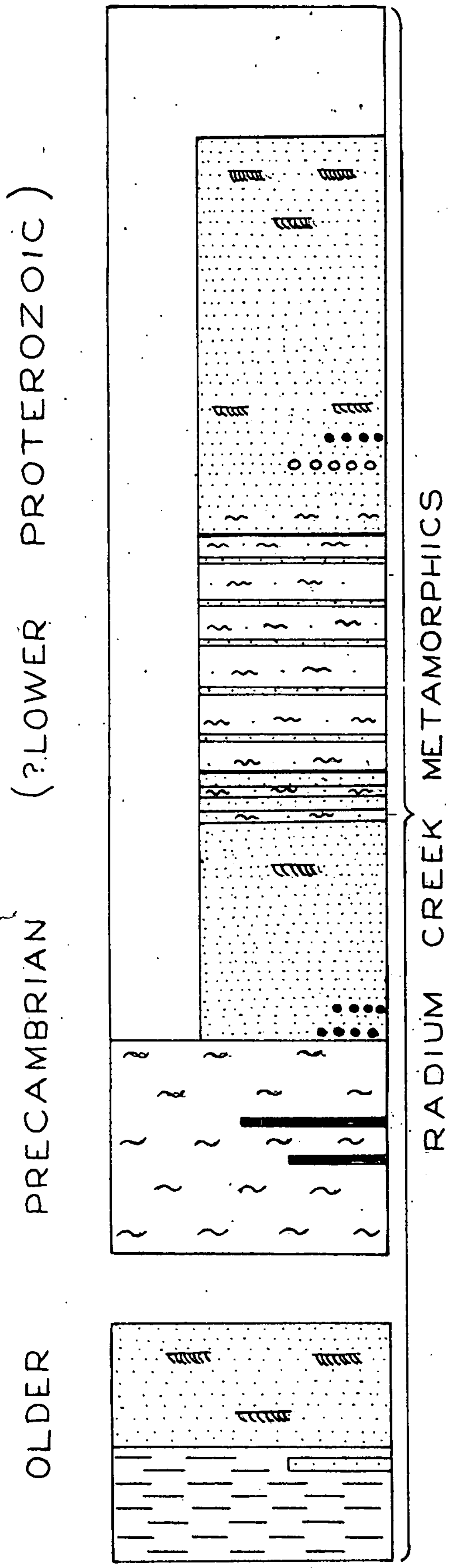
A 3827/62 Terrapinna Granite, ¼ mile S Terrapinna W.H.

A 666/65 Mount Neill Porphyry, ¾ mile W Mount Neill

A 665/65 Yerila Granite, 3 miles SSW Wattleowie Well

A 668/65 Pepegoona Porphyry, Pepegoona Creek, 2½ miles WSW Mount Neill.

A 663/65 Wattleowie Granite, 1 mile S Wattleowie Well



FREELING HEIGHTS QUARTZITE

UPPER QUARTZITE MEMBER (U.N.):
Fine-medium grained, heavy mineral laminated, cross-bedded quartzites; argillaceous sandstones, arenaceous schists, grits.

Quartz pebble bed
Quartzite pebble bed

CORUNDUM CREEK SCHIST:
Arenaceous schists, quartzites; muscovite-, biotite-, corundum-schists.

LOWER QUARTZITE MEMBER (U.N.):
Fine-medium grained quartzites; sandstones, arenaceous-schists.

Quartz pebble beds

BRINDINA SCHIST:
Muscovite-, biotite schists, arenaceous schists; garnet-sericite-schists, epidote quartzite, hornfels, garnet rocks.
Amphibolites

(Base not exposed)

(Top not exposed)

QUARTZITE (U.N.):
Medium grained heavy mineral laminated quartzites, grits.

PHYLLITE (U.N.):
Laminated phyllites; lenticular quartzite.

(Base not exposed)

STRATIGRAPHIC TABLE **FIG. 1**

RADIUM CREEK METAMORPHICS

S 5233
Cd.