1 ARUNTA INLIER SYNTHESIS

Compiled by Anthony Budd

1.1 Executive Summary - Geology

The Arunta Inlier has a very limited history of mining and exploration, and although several mines have been operated, total production is low. The deposits mined include gold, copper, lead and zinc, tin-tungsten-tantalum, fluorite and mica. Exploration has been limited, partly due to poor outcrop, isolation, and a perception that the Inlier is too highly metamorphosed to host significant deposits.

The regional geology of the Arunta Inlier was reviewed in terms of its tectonic setting in two papers: Stewart, Shaw and Black (1984); and Shaw, Stewart and Black (1984). In these works, the Arunta Block was seen to be made up of a partly fault bounded Central Tectonic Province of high-grade metamorphic rocks and a few granites, flanked by the Northern and Southern provinces, which contain low to high-grade metamorphic rocks and numerous granite intrusions. The stratigraphy thought to comprise three major divisions. Division 1 was inferred to be the oldest, and was made up of mafic and felsic granulites that in part represented a bimodal metavolcanic assemblage interlayered with minor metasediments. This was most common in the central province, but also occurred in the northern province. Division 2 rocks, mainly immature metasediments of turbiditic origin, covered extensive areas of the northern province. Division 3 rocks were platform-style sediments comprising quartzite-shale-carbonate successions that locally unconformably overlay the two other divisions. Later work by Collins and Shaw (1995) suggested that no major structural discontinuity exists between the northern and central tectonic provinces, but that the Redbank Thrust Zone is, at least in part, a province boundary. Also, these authors state that rocks originally assigned to divisions are better grouped into a larger number of lithological assemblages until better stratigraphic and isotopic correlations can be made. These authors proposed a tectonic history nomenclature consisting of several chronologically constrained tectonic events, orogenies and uplift phases.

Granites were intruded mostly syntectonically during the history of the Arunta Inlier. The earliest known granites are dated at ~1880 Ma, and the youngest at ~1140 Ma. The largest granite intrusive event is dated at about 1770 Ma. The two most mineralised granite events are dated at 1713 Ma and 1570 Ma. Generally, the granites in the Arunta Inlier were emplaced at deep crustal levels, and show little sign of extensive alteration. Most are Sr-depleted, Y-undepleted, indicating a plagioclase-residual source, and an ensialic rifting environment during emplacement. Most are I-type, with few S-types.

1.2 Executive Summary - Metallogenic Potential

This compilation has assessed the potential of each granite suite based on the criteria set out in the Project Proposal. Suites which have been identified as having high potential for granite-related mineralisation are as follows:

The Atnarpa Suite at 1880 Ma has unknown potential, due to the difficulty in determining the extent of fractionation in this suite. It shares some similarities with Phanerozoic magma systems associated with porphyry-style deposits, although it is more felsic. There are numerous Au occurrences nearby and within this suite, and although some of these deposits have been related to the Palaeozoic Alice Springs Orogeny (Warren et al. 1974), some of the gold may be sourced from this suite. On this basis, the suite may have a high potential for further gold occurrences.

The Napperby Suite at 1770 Ma is one of the most extensive suites in the Inlier. It shows fractionation and evidence of the activity of a fluid phase, however, it crystallised over a very narrow silica range, and there are very few known mineral occurrences near this suite. This suite therefore has only moderate potential for copper, gold and tungsten-molybdenum.
The Jinka Suite at 1713 Ma is felsic, fractionated, enriched in heat-producing elements, shows evidence of a fluid phase, is an I-type, and is associated with known mineralisation. It is also a high-fluorine suite, associated with known fluorite and scheelite deposits, and has high potential for further tungsten, tantalum and molybdenum deposits.

The Alarinjela Suite, thought to be intruded at 1713 Ma, is fractionated, red to pink, oxidised, shows evidence of a fluid phase, intrudes suitable host rocks, and is possibly associated with mineralisation. It is assigned high potential for copper, lead and zinc, and moderate potential for gold.

The Barrow Creek Suite at 1713 Ma, is one of only a few S-type granites in the Inlier. It is fractionated, has abundant pegmatite, is host to many small occurrences of tin-tantalum-tungsten and molybdenum, and its oxidation state increases with fractionation. It is considered to have a high potential for further similar mineralisation.

The Ali Curung Suite at 1713 Ma is metaluminous, oxidised, fractionated, has a mapped contact aureole, and is near several known mineral deposits. However, it is volumetrically small, has a short fractionation range, and is not strongly fractionated or enriched in heat-producing elements. It is considered to have moderate potential for copper, gold, lead and zinc mineralisation.

The Mount Webb Suite at 1615 Ma shows evidence of fractionation, brecciation, late-stage fluids and hydrothermal alteration. It has probably been emplaced at shallow levels and thus epithermal or vein style mineralisation are possibilities. It has high potential for copper and gold mineralisation. Little exploration has been conducted in the area, therefore this suite may be considered as having ‘greenfields’ potential.

The Ennugan Mountains Suite at 1600 Ma is enriched, abundant in fluorine, and has several tin, tantalum and uranium occurrences associated with it. It has moderate potential for further similar mineralisation.

The Southwark Suite at 1570 Ma is fractionated, has a broad compositional range, has pegmatite, aplite, microgranite and greisen phases, and is associated with copper, molybdenum and silver deposits. It is similar to the Cullen Batholith in the Pine Creek Inlier, and is considered to have moderate to high potential for mineralisation of many types.

The Teapot Suite at 1140 Ma is the youngest Proterozoic granite in the Arunta Inlier. It is fractionated, enriched, oxidised, and ranges from tonalite to granite in composition. It has no known mineralisation nearby, but is considered to have moderate potential for copper and gold.

### 1.3 Methods

**Information Sources:** 1:250 000 maps and notes, 1:100 000 maps and commentaries where available, published ages, AGSO OZCHEM database supplemented with data from NTGS and University of Adelaide, AGSO Minloc database, AGSO magnetics and gravity.

**Classification of Granites:** In this report the granites have been divided into suites based on the age, geographic location, and geochemistry of each pluton. Using this method, approximately 30 suites are recognised (Table 1.1).

**Host Rocks:** The country rocks which are thought to be intruded by each suite have been summarised, and classified according to mineralogical characteristics thought to be important in determining the metallogenic potential of a granite intrusive event. This has been a little difficult in the Arunta, due to limited outcrop, and the fact that division of units was based on tectonostratigraphic packages, rather than lithologies.

**Relating Mineralisation:** One of the greatest problems in this compilation has been attempting to relate known mineralisation with a source, be it granite or otherwise. Very little direct dating of mineralisation is available in the Arunta Inlier. Further, only brief descriptions are available for most deposits. Therefore, the method used has been to exclude all deposits more than 5 km from a known outcropping granite, then for those remaining, to make an assessment of the likelihood that they may be derived from granite intrusive activity (based on deposit style). The
existence of known mineralisation thought to be associated with a granite has been a factor in categorising the metallogenic potential of that granite, however, it is only one criterion of several.

1.4 References & Bibliography


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2 ATNARPA SUITE

2.1 Timing 1880 Ma

2.2 Individual Ages Primary Ages:
1. Atnarpa gabbro, diorite, tonalite, trondhjemite ‘suite’ 1873 ± 11 Ma, U-Pb
2. Atnarpa low-Al tonalite, trondhjemite, granodiorite ‘suite’ 1879 ± 11 Ma, U-Pb
3. [Atnarpa younger tonalite ‘suite’ 1751 ± 12 Ma, U-Pb - remelted]
Source: Zhao and Cooper (1995).

2.3 Regional Setting The Atnarpa Igneous Complex occurs in the Alice Springs 1:250 000 map sheet area. Zhao and Cooper (1995) suggested that this southeastern margin of the Arunta Inlier represents a convergent continental margin active during the Early to Middle Proterozoic which has undergone at least two episodes of subduction-related magmatism (1860-1880 Ma and 1730-1770 Ma). This differs from the crustal underplating model of Wyborn et al. (1992).
These are amongst the oldest granites dated in the Arunta Inlier. The so-called ‘Atnarpa younger tonalite suite’ (above) dated at 1751 Ma is thought to have formed by reworking of the older granites at the same time as the intrusion of the Alice Springs Granite, and other granites along the southern margin of the Arunta Inlier.
The Atnarpa Igneous Complex intrudes the Tommys Gap metamorphics, the Cavenagh metamorphics, the Hillsoak Bore metamorphics, and the unnamed units pC and pCf.

2.4 Summary Zhao and Cooper (1995) and Zhao and McCulloch (1995) subdivided the Atnarpa Igneous Complex into three suites (see ages above). This is not followed here, due to a lack of descriptive data, and the complex is regarded as one suite.
The suite can be classed as an oxidised metaluminous granite. It covers a broad SiO\textsubscript{2} range, from tonalite to aplite, and is fractionated, although samples are not available of the most fractionated rocks. These characteristics mean that the Complex has good potential for generating a fluid phase. Also, there reportedly are suitable host rocks within 5 km of the granite. However, the lack of available descriptive and geochemical data make it difficult to make further conclusions about the metallogenic potential of this intrusive event.
The suite is Sr-undepleted, Y-depleted, indicative of a garnet-residual source.

2.5 Potential The relationship between the abundant although small gold deposits of the Arltunga and White Range goldfields and the Atnarpa Igneous Complex is not determined. There is a strong spatial correlation, but it has been shown that the present deposits were formed during the Palaeozoic Alice Springs Orogeny. However, the Atnarpa Igneous Complex has geochemical characteristics (such as wide crystallisation range, fractionated, and alkaline nature) that make it a possible source for gold, and may have formed earlier deposits which have since been remobilised.
Cu: uncertain - could be high
Au: uncertain - could be high
Pb/Zn: very low
Sn: none

© Geoscience Australia 2001 Arunta Inlier 2.1
2.6 Descriptive Data

**Location:** Southeastern margin of Arunta Inlier, 80 km east of Alice Springs, on Alice Springs 1:250 000 sheet.

**Dimensions and area:** 40 x 25 km, about 1000 km².

2.7 Intrusives

**Component plutons:** The granites of the Atnarpa Igneous Complex have not been mapped out into plutons (on the Alice Springs 1:250 000 Sheet). Shaw *et al.* (1979) report that the Atnarpa Igneous Complex is the group of plutonic igneous rocks comprising (in order of decreasing abundance) tonalite, diorite, granite, granodiorite, hypabyssal haplogranite, and other dyke rocks. Studies by Zhao and Cooper (1992) break the Atnarpa Igneous Complex into three suites (see Ages above).

**Form:** Several large round plutons, fault bounded in places.

**Metamorphism and Deformation:** All the igneous rocks of the Atnarpa Igneous Complex exhibit a schistosity imparted by the preferred dimensional orientation of the dark minerals, and numerous secondary minerals are present. The assemblages indicate that all the rocks in the Complex have undergone retrogressive metamorphism to greenschist facies.

**Dominant intrusive rock types:** Tonalite, diorite, granite, granodiorite, trondhjemite, gabbro.

**Colour:** The typical diorite is a black and white speckled rock, the tonalite is speckled in black and tints of cream, pink, or very pale greenish-yellow. The granite is leucocratic, and speckled red and black.

**Veins, Pegmatites, Aplites, Greisens:** Minor microdiorite, microtonalite, micromonzogranite, microgranite, haplogranite, aplite, pegmatite, and calcite+quartz dykes are present.

**Distinctive mineralogical characteristics:** The Atnarpa Igneous Complex is a group of intermediate to felsic igneous plutonic and hypabyssal rocks of which hornblende-bearing diorite and tonalite make up about 90%. The other 10% consists of leucocratic granitic rocks which lack hornblende, and contain very little biotite.

The diorite is a heterogeneous body, composed of meladiorite, tonalite, monzogranite and granite. The typical diorite is a medium or coarse-grained black and white speckled rock with a preferred dimensional orientation of the dark minerals. It is not layered. Melanocratic diorite contains about 25% hornblende, very calcic andesine, little quartz, with biotite and microcline absent. This rock also contains some tremolite and epidote. A thin section of less mafic diorite consisted of 58% andesine extensively altered to sericite and hornblende, 15% hornblende pleochroic from blue-green to yellow-green to yellow, 15% biotite much altered to chlorite, 7% quartz, 5% epidote and accessory titanite, allanite, and ‘opaque material’. The blue-green hornblende may be indicative of metasomatism by an Fe-rich fluid.

Leucocratic variants of the diorite include (1) tonalitic types in which the plagioclase is commonly oligoclase, hornblende has decreased in abundance to about 5%, quartz has increased to about 30%, and a small amount of microcline appears, and (2) granitic and adamellite types in which hornblende is absent and the microcline content has increased still further.

The tonalite is also heterogeneous, including diorite, trondhjemite, granodiorite and monzogranite, and is medium-grained, speckled in black and tints of cream, pink, or very pale greenish-yellow. The typical tonalite consists of subhedral andesine (55 to 70%) which is largely converted to sericite and epidote, quartz (15 to 25%) recrystallised to lobate aggregates, bent and broken microcline (5%), chloritised or bleached biotite (10%) with abundant granules of titanite, common hornblende (0 to 12%) partly altered to biotite or epidote, and discrete epidote grains (3 to 8%). Allanite, titanite, and primary muscovite are abundant accessories.

The melanocratic varieties include: diorite consisting of sericitised calcic andesine (68%), hornblende (30%), epidote (2%) and accessory titanite, hematite, and ilmenite largely converted to leucoxene; trondhjemite consisting of sodic andesine (60%), recrystallised quartz (18%), biotite (15%), epidote (5%), hornblende (2%), and accessory allanite, apatite, titanite, and opaque grains; and granodiorite consisting of andesine (50%), microcline (20%), quartz (15%) and biotite (15%). Granodiorite is also a leucocratic variant, composed of oligoclase (55%), microcline (20%), recrystallised quartz (15%), chlorite (7%) and epidote (3%).
Granite consists of aggregates of many small and a few large grains of partly sericitised albite (about 35%), coarse recrystallised quartz (about 35%) in aggregates of lobate grains, large grains of microcline (about 25%) containing numerous small blebs of albite, aggregates of chlorite + titanite + magnetite after biotite (4%), and muscovite (1%) associated with the altered biotite and enclosed in the albite.

Monzogranite consists of approximately 25% strained or recrystallised quartz, sericitised plagioclase (35%), microcline (35%), biotite, muscovite and epidote (together about 10%), and accessory ilmenite, titanite, and calcite.

Granodiorite is medium-grained, schistose and consists essentially of quartz which is everywhere strained and partly recrystallised to aggregates of small polygonal grains, andesine which is slightly to copiously sericitised, strained and fractured microcline grains, biotite which is commonly kinked, chlorite and epidote. Hornblende is present in small amounts, and accessory minerals include allanite, apatite, and titanite.

Breccias: Palaeozoic faulting has caused some localised brecciation of the diorite. No other brecciation is noted in the literature.

Alteration in the granite: None recorded.

2.8 Extrusives Parts of the unnamed and undivided map unit $pC_x$ may be a volcanic equivalent to the Atnarpa Igneous Complex. Only one geochemical sample is available, and it is indistinguishable from the Atnarpa Igneous Complex.

2.9 Country Rock Contact metamorphism: None noted.

Reaction with country rock: None noted.

Units the granite intrudes: The Atnarpa Igneous Complex intrudes the Tommys Gap metamorphics, Cavenagh metamorphics, Hillsoak Bore metamorphics, various rocks of the unnamed and undivided complex $pE_x$, and the unnamed unit $pEf$.

Dominant rock types: Tommys Gap metamorphics - hornblende gneiss, amphibolite, feldspar-quartz metasediment, basic metavolcanics, marble, quartzite calc-silicate rock, chlorite schist. Cavenagh metamorphics - well-layered and massive quartzofeldspathic gneiss, para-amphibolite, amphibolite; rare calc-silicate rock, hematite quartzite. Hillsoak Bore metamorphics - biotite and garnet-biotite gneiss, sillimanite gneiss; amphibolite, biotite-muscovite schist, calc-silicate rock, marble, quartzite, andalusite schist, granitic gneiss, rare garnet-cordierite-anthophyllite rock. Unnamed unit $pE_x$ - garnetiferous biotite-rich gneiss; some quartzofeldspathic gneiss, amphibolite, sillimanite gneiss; rare amphibolite. Unnamed unit $pE_xi$ - homogenous quartzofeldspathic and biotite gneiss of granitic appearance, muscovite-biotite quartzofeldspathic gneiss; some amphibolite, mafic granulite, hornblende gneiss. Unnamed unit $pE_xv$ - layered quartzofeldspathic gneiss; some amphibolite, biotite gneiss, calcareous gneiss, marble. Unnamed unit $pEf$ - quartzofeldspathic gneiss, biotite gneiss, amphibolite, hornblende gneiss; all commonly metamorphically retrogressed to greenschist facies.

Potential hosts: Components of all of the intruded rocks are potential hosts, particularly mafic or calcareous facies.

2.10 Mineralisation Gold: Crushings at the Arltunga Battery up to 1913 produced 360 kg of gold from 6800 tonnes of ore. The many small gold lodes near Arltunga lie in or close to zones of severe deformation activated during the Alice Springs Orogeny. The gold lodes consist of quartz and gold-bearing pyrite, with minor chalcopyrite in places, small quantities of calcite, and rarely siderite. Most of the lodes mined were made economic by secondary enrichment. Auriferous quartz reefs are transgressive, tend to be relatively small and regular in size and shape, and are clearly associated with late-stage faulting that postdated the main deformation. The country rocks include Heavitree Quartzite, the Cadney and Cavenagh metamorphics, the unnamed unit $pE_x$, and the Atnarpa Igneous Complex. Most deposits are close to or within the Atnarpa Igneous Complex.

The origin of the lodes is not clear. Warren et al. (1974) suggested that the lodes of the White Range field hosted in the metamorphosed Heavitree Quartzite are of Devonian to Carboniferous age, but those lying beyond the zone of intense deformation are not necessarily contemporaneous with them. Two episodes of gold mineralisation may have occurred, the first
being associated with the formation of the Arunta basement, the second being a Devonian to Carboniferous remobilisation of the first. Evidence of this was that the lodes are hypogene, with assemblages stable over a wide temperature range, and that the assemblages were auriferous pyrite-quartz. If the lodes were to have originated from mobilisation of alluvial gold from the basal part of the Heavitree Quartzite, the assemblages should be gold-quartz.

Stewart and Warren (1977) however, noted that basement rocks of the Arunta Block north of White Range are retrogressively metamorphosed. They argue that the abundance of carbonates in the auriferous lodes in the Arunta basement rocks north of White Range indicate that these lodes are hydrothermal concentrations, in fissures, of silica and carbonate that were mobilised during the retrogressive metamorphism, and hence are also of Devonian to Carboniferous age.

Perhaps the most likely genesis of the gold within and around the Atnarpa Igneous Complex is for the gold to have been sourced from the Complex, and remobilised during retrogressive metamorphism associated with the Alice Springs Orogeny. It is unlikely that significant deposits were formed during the Proterozoic, and most of the present deposits are made economic by secondary enrichment.

Other: There are also Pb and Cu occurrences spatially associated with the Atnarpa Igneous complex, hosted within the Hillsoak Bore Metamorphics.

2.11 Geochemical Data

Data source: Samples were collected during regional mapping conducted by BMR/AGSO during the early 1970s, and also for MSc and PhD studies by J.-X. Zhao.

Data quality: Good; most samples were analysed at BMR/AGSO.

Are the data representative? Possibly not. Although all major mapped rock types have been sampled, the samples come only from the southern part of the Complex. The northern part of the complex is mapped as being retrogressively metamorphosed. Also, the emphasis of Zhao’s work was tectonic history and identity of the source regions of the Arunta Inlier, rather than of the fractionation history of the Atnarpa Igneous Complex.

Are the data adequate? No. Given the Au association of this suite, the data are inadequate. Further sampling and geological mapping are definitely warranted, and possibly further investigation into the source of the gold of the White Range and Arltunga fields.

\[ SiO_2 \text{ range (Fig. 2.1): } SiO_2 \text{ ranges from 53.4 wt.\% to 76.04 wt.\%, with a peak at around 65 wt.\%.} \]

Alteration (Fig. 2.2): Samples from this part of the Complex are essentially unaltered, with the exception of sample 71911830 (potassic altered) and 71911883 (U-depleted, weathered/oxidised).

- **SiO\text{2}:** No silicification is evident.
• **K2O/Na2O**: One sample shows addition of K2O, with depletion of Na2O and CaO; otherwise, the samples show no alteration.

• **Th/U**: The Th/U ratio shows some scatter, with most samples in the normal range, some samples above or below this range, and one sample (7191883) being anomalous.

• **Fe2O3/(FeO+Fe2O3)**: The trend is mostly flat, with an apparent kick at higher SiO2 - this however is due to some alteration of two samples.

**Fractionation Plots (Fig. 2.3)**: The Atnarpa Igneous Complex covers a wide range of rocktypes, and shows moderate fractionation. The literature states that aplites do occur, but no samples of these more fractionated rocks exist.

• **Rb**: Values are low, with a slight increase at higher SiO2.

• **U**: Values are low, with a slight increase at higher SiO2.

• **Y**: Values are low, with a slight increase at higher SiO2.

• **P2O5**: Decreases with increasing SiO2.

• **Th**: Values are low, but increase with increasing SiO2. One sample has anomalously high Th, which may be due to alteration (the same sample is K-altered).

• **K/Rb**: This ratio shows moderate to high values, and a very slight increase with increasing SiO2.

• **Rb-Ba-Sr**: The majority of samples plot in the monzogranite field, with others in the granite fields, and one in the tonalite field. Sample 88091 shows Ba depletion.

• **Sr**: Values range from high to low, with a decreasing trend with increasing SiO2. The most felsic samples may show Sr depletion.

• **Rb/Sr**: Values for this ratio are extremely low, but increase in the more felsic samples.

• **Ba**: Values are mostly moderate, and show scatter. There is possibly a decrease at higher SiO2, but this may be due to alteration.

• **F**: F has moderate values (up to 760 ppm), and decreases with increasing SiO2.

**Metals (Fig. 2.4)**: The base metals show an apparent trend with fractionation, with Cu and Zn decreasing, and Pb increasing.

• **Cu**: Values are mostly low, and show a slight decrease with increasing SiO2.

• **Pb**: Shows moderate values, possibly with an increasing trend.

• **Zn**: Values are moderate, and show a clearly decreasing trend.

• **Sn**: All values are low.

**High field strength elements (Fig. 2.5)**: All values are low.

• **Zr**: Values are moderate to low, and decrease noticeably with increasing SiO2.

• **Nb**: All values are low.

• **Ce**: All values are low.

**Classification (Fig. 2.6)**: The Atnarpa Igneous Complex is a complex of intermediate to felsic I-type granites. It shows fractionation, but geochemical samples are not available for the higher degrees of fractionation. It is Sr-undepleted, Y-depleted, indicative of a garnet-residual source. This has been used as evidence for subduction processes operating in the Arunta Block during the Proterozoic.

• **The CaO/Na2O/K2O plot of White, quoted in Sheraton and Simons (1992)**: The majority of samples are tonalite or granodiorite, with some granite and lesser trondhjemite.

• **Zr/Y vs Sr/Sr***: The samples plot above and below the line, showing an increase in the Sr ratio with increasing Zr/Y. It is a little unusual for Proterozoic granites to plot as far from the Sr/Sr* axis as these samples do.

• **Spidergram**: The selected samples are Sr-undepleted, Y-depleted.

• **Oxidation plot of Champion and Heinemann (1994)**: All samples are oxidised, with one sample being altered and strongly oxidised.

• **ASI**: The samples show an increasing trend, with ASI values all below 1.1 up to 72 wt.% SiO2, at which point some samples are >1.1.

• **A-type plot of Eby (1990)**: Most samples plot in the OGT field (I-, S- and M-type), with a few in the fractionated granite field.
Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-(tonalitic) and I-(granodioritic).

**Australian Proterozoic granite type**: Sally Downs.

### 2.12 Geophysics

**Radiometrics (Fig. 2.7)**: The median value of K\textsubscript{2}O is slightly below the Proterozoic median, and the medians for U and Th are well below. This gives a predicted RGB colour of very dark red.

**Gravity**: The majority of the Atnarpa Igneous Complex has a moderate gravity signature. The northern margin is partly within a significant gravity high lineament, which is probably the eastward extension of the Redbank Thrust Zone of Collins and Shaw (1995).

**Magnetics**: The magnetic signature of the Atnarpa complex is fairly homogeneous, being little different from the regional background. This may imply that the Atnarpa Suite does extend beneath cover to the north, along with other units in the area.

### 2.13 References


2.2A: Na2O vs K2O

2.2B: Th/U vs SiO2

2.2C: Fe2O3/(FeO+Fe2O3)

Legend

+ Atnarpa Suite
× pCx
2.3A: Rb vs SiO$_2$

2.3B: U vs SiO$_2$

2.3C: Y vs SiO$_2$

Legend

+ Atnarpa Suite
× pCx
2.3G: Rb-Ba-Sr

Legend

+ Atnarpa Suite
× pCx

2.3H: Sr vs SiO$_2$

2.3I: Rb/Sr vs SiO$_2$
2.5A: Zr vs SiO$_2$

Legend

+ Atnarpa Suite
× pCx
2.6A: CaO-Na₂O-K₂O

Legend

+ Atnarpa Suite
× pCx

2.6B: Zr/Y vs Sr/Sr*

2.6C: Spidergram
SiO₂ range: 67-74.9%
ATNARPA SUITE

2.6D: Redox plot

Strongly oxidised
Oxidised
Reduced
Strongly Reduced

2.6E: ASI vs SiO_2

ASI

55 60 65 70 75
SiO_2

2.6F: Ga/Al vs HFSE
(Eby 1990)

10000Ga/Al

Zr+Nb+Ce+Y

Legend

+ Atnarpa Suite
× pCx
### Atnarpa GDTTG Suite

#### MEANS AND STANDARD DEVIATIONS

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3 NARWIE TOOMA FELDSPATHIC ROCKS

3.1 Timing

1880 Ma & 1770 Ma.

3.2 Individual Ages

Primary Ages:

1. Bunghara Metamorphics 1880 ± 5 Ma, Sm-Nd

Source: Sun et al. (1995).

3.3 Regional Setting

The Narwietooma Feldspathic Rocks includes the Illyabba Metamorphics, Bunghara Metamorphics, Mount Hay Granulite, Mount Chapple Metamorphics, and the unnamed unit Pnx which forms scattered outcrops in the northeast (no geochemical analyses are available for unit Pnx, so it is not considered further). These four units appear to be closely related to the Sliding Rock and Randall Peak metamorphics in the Alice Springs 1:250 000 Sheet area, as they all contain rocks of very similar mafic, intermediate, and felsic igneous compositions. The Narwietooma Feldspathic Rocks are characterised by a continuum from mafic through intermediate to felsic compositions, in contrast to other igneous units within the Arunta Block, which are distinctly bimodal. They are not considered to be a suite (according to strict definition) because of the likelihood that the metamorphic units include rocks other than granites.

The Narwietooma Feldspathic Rocks were deformed and metamorphosed to high grade during the Strangways Orogeny (1760-1750 Ma), and intruded by syntectonic granite at the same time (the Forty-Five Augen Gneiss and Mt Zeil Granite; Black and Shaw 1992). The ages of their protoliths are unknown. By correlation with the Randall Peak metamorphics, felsic-intermediate gneisses within the Rocks are about 1770 Ma old (Zhao 1992). Also, geophysical data imply that high-grade gneisses of the Rocks extend northwest to underlie the Lander Rock beds, which older than 1880 Ma (Young et al. 1992). Further, the Rocks include mafic rocks with two very different geochemical signatures, and the Sm-Nd age of 2237 Ma (Sun et al. 1995) requires an input from older crustal material. Therefore, the Narwietooma Feldspathic Rocks may contain two major components of differing age, one formed at about 1770 Ma and the other at or older than 1880 Ma. Alternatively, the younger age may represent reworking of the older material.

3.4 Summary

This unit is metaluminous, mostly unfractonated/restite-dominated, and ranges from mafic to felsic. It is probable that all or parts of it were emplaced at ~1880 Ma, and were reworked and/or added to at about 1770 Ma. It has been strongly affected by later deformation, particularly during movement on the Redbank Thrust Zone.

3.5 Potential

This unit is considered to have no significant mineralisation potential. It does not have the geochemical or textural and mineralogical indicators of extensive fractionation, and has no association with known mineralisation.

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3.6 Descriptive Data

Location: Central southern margin of the Burt Plain, north of the Redbank Thrust Zone; part of the Central Province. The unit lies mostly on the Hermannsburg 1:250 000 Sheet area, but extends east and west onto the Alice Springs and Mount Liebig Sheet areas.
Dimensions and area: All units of this unit are elongated west-northwest. Bunghara Metamorphics: 100 km x 10 km; 1000 km². Illyabba Metamorphics: 50 km x 5 km; 250 km². Mt Chapple Metamorphics: 90 km x 15 km; 1350 km². Mt Hay Granulite: 35 km x 10 km; 350 km².

The total area (excluding unit Pnx) is about 3000 km².

3.7 Intrusives

Component plutons: Bunghara Metamorphics, Illyabba Metamorphics, Mt Hay Granulite, Mt Chapple Metamorphics, unnamed unit Pnx.

Form: Elongated west-northwest.

Metamorphism and Deformation: All units have been strongly deformed in the Strangways Orogeny and metamorphosed, probably subsequently, to granulite facies. This makes recognition of individual rocks within the units difficult, hence the units are not subdivided.

Dominant intrusive rock types: The Bunghara Metamorphics consist of meta-igneous rocks and very minor metasediments. Mafic to intermediate granulites predominate, and the more felsic units are migmatitic. Metamorphic facies range from granulite to upper amphibolite.

The Illyabba Metamorphics are compositionally layered, migmatitically differentiated gneisses, ranging from biotite-rich to felsic (includes metagranite), amphibolite, and metasediments. They are strongly deformed and metamorphosed at or close to granulite facies, resulting in the formation of very extensive migmatites, then thoroughly deformed (mylonitised) under amphibolite facies conditions.

The Mt Chapple Metamorphics consist of mafic to intermediate granulite, gneissic granite, quartzofeldspathic gneiss, and metasediments.

The Mt Hay Granulite consists of fine to very fine-grained mafic granulite and minor interlayered metamorphosed leucogabbro-anorthosite, felsic granulite and gneiss, quartzose metasediments and calc-silicate rocks. Felsic granulite, mainly tonalitic to granodioritic, may form up to 10% of the unit. Quartzofeldspathic gneiss, some with garnet, is generally granitic in composition.

Colour: Not reported in literature.

Veins, Pegmatites, Aplites, Greisens: None reported.

Distinctive mineralogical characteristics: Not reported in literature.

Breccias: None reported.

Alteration in the granite: None reported - would probably have been overprinted by metamorphism if it did exist.

3.8 Extrusives

None recognised.

3.9 Country Rock

Contact metamorphism: None recorded.

Reaction with country rock: None recorded.

Units the granite intrudes: Both the Mount Chapple Metamorphics and Mount Hay Granulite occur as isolated massifs surrounded by Cainozoic cover. The Illyabba and Bunghara Metamorphics are bounded to the south by the Redbank Thrust Zone, and are similarly covered on all other sides. Therefore, the intrusive relationships of the Narwietooma Feldspathic Rocks cannot be determined. They are the oldest known rocks in the area.

Dominant rock types: Unknown.

Potential hosts: Unknown.

3.10 Mineralisation

None known.

3.11 Geochemical Data

Data source: All samples were collected by AGSO workers during reconnaissance field mapping during the 1970s and 1980s.

Data quality: Most samples were analysed at AGSO, and so the data are considered to be excellent. However, some samples were analysed for a restricted range of elements.
Are the data representative? The samples appear to be well distributed over most of the units, so the sampling is probably representative.

Are the data adequate? The data available are adequate to conclude that this unit has no significant mineral potential. However, more data would be needed for the Bunghara and Illyabba Metamorphics for a more detailed description of the unit.

$SiO_2$ range (Fig. 3.1): This unit covers a wide $SiO_2$ range, from less than 50 wt.% to 75 wt.%. There are too few samples available to make any conclusions about the distribution.

Alteration (Fig. 3.2): The effects of alteration in this unit are subtle and varied. Considering the amount of deformation of these rocks, alteration signatures may be confused or hidden by metamorphic overprinting.

- $SiO_2$: No alteration is obvious.
- $K_2O/Na_2O$: Some samples of the Mt Hay Granulite show K-loss, others are mafic so have low K anyway. The other units show no obvious alteration.
- $Th/U$: This plot shows that alteration has taken place in most samples, with samples being either above or below the normal range of granites.
- $Fe_2O_3/(FeO+Fe_2O_3)$: All samples are reduced, again showing the effects of alteration/weathering.

Fractionation Plots (Fig. 3.3): The effects of fractionation are obscured by mobilisation of many of these trace elements during alteration/metamorphism. However, it is likely that no fractionation took place until the highest $SiO_2$ levels were reached, at which point fractionation just started to occur.

- $Rb$: Increases substantially from low values at low $SiO_2$, to moderate values at ~75 wt.% $SiO_2$.
- $U$: Values are all low.
- $Y$: A great deal of scatter is shown on this plot, probably indicating alteration/metamorphism.
- $P_2O_5$: A weak decreasing trend is observed, but also with substantial scatter.
- $Th$: Most values are low, with a slight increase at higher $SiO_2$.
- $K/Rb$: Shows a flat trend, indicating little fractionation in this unit.
- $Rb$-$Ba$-$Sr$: Most samples plot in the granite to monzogranite fields. One sample of each of the Illyabba and Mt Chapple Metamorphics plot in the strongly differentiated field, possibly indicating fractionation at more evolved levels.
- $Sr$: Values are low to moderate, with too much scatter to indicate a trend.
- $Rb/Sr$: Most values are extremely low, with only a slight increase in the highest $SiO_2$ samples.
- $Ba$: This plot shows a lot of scatter, again indicating alteration/metamorphism. Values are low to moderate.
- $F$: No data available.
Metals (Fig. 3.4): Copper, lead and zinc show stronger trends than most of the other trace elements. Cu and Zn decrease strongly with increasing SiO$_2$, Pb increases, and Sn shows no change.

- **Cu**: There is a strong decreasing trend from moderate values to almost zero at higher SiO$_2$.
- **Pb**: Increases with increasing SiO$_2$, up to moderate values (~50 ppm).
- **Zn**: Decreases strongly with increasing SiO$_2$.
- **Sn**: All values are low.

High field strength elements (Fig. 3.5): Most values are low to moderate, which is normal for granites of the Proterozoic in Australia. However, the observable scatter probably indicates the effects of metamorphism and/or alteration.

- **Zr**: Values are low to moderate, with the scatter possibly being caused by alteration/metamorphism.
- **Nb**: All values are low.
- **Ce**: Most values are low, with some scatter.

Classification (Fig. 3.6):

- The CaO/Na$_2$O/K$_2$O plot of White, quoted in Sheraton and Simons (1992): The unit forms a series from tonalite through to granite.
- **Zr/Y vs Sr/Sr**: All values are low, typical of Proterozoic granites.
- **Spidergram**: The suite is Sr-depleted, Y-undepleted, although Y is obviously effected by alteration/metamorphism. There is also some scatter in Ba, Th, U, La and Ce.
- **Oxidation plot of Champion and Heinemann (1994)**: Many samples cannot be plotted on this graph because they are too rich in iron, but those that do plot are oxidised.
- **ASI**: The suite is dominantly metaluminous, showing a trend from strongly metaluminous to peraluminous with increasing SiO$_2$. This is typical of some I-type granite suites.
- **A-type plot of Eby (1990)**: Most samples plot in the fractionated granite field - this is probably due to alteration or metamorphism, as the unit is only slightly fractionated in its most felsic phases. Some samples plot in the A-type field, these are probably the fractionated samples. Other samples plot in the ordinary granites field.


Australian Proterozoic granite type: Unclassified.

3.12 Geophysics

Radiometrics (Fig. 3.7): The Bunghara Metamorphics have higher K and lower U and Th than the Proterozoic median, and are predicted to have been red. The Illyabba Metamorphics have considerably higher K, lower U, and Th equal to the Proterozoic median, and are predicted to have been strongly red with a slight blue tinge. The Mount Chapple Metamorphics have a spread of K values, with a median a little below the Proterozoic median. U and Th are well below. The predicted colour range for this unit is deep red to red. The Mount Hay Granulite has a wide range of K values, but with the median well below the Proterozoic median. U and Th are also very low, so its predicted RGB colour is red-black.

Gravity: A large gravity-low lineament defining the Redbank Thrust Zone obscures the gravity effects of this suite.

Magnetics: The magnetic signature of this suite is partially obscured by the large regional magnetic low of the Redbank Thrust Zone, and elsewhere is not significantly different from background.

3.13 References


NARWIETOOMA FELDSPATHIC ROCKS

Legend

* Bunghara Mmics
☐ Illyabba Mmics
◊ Mt Chapple Mmics
○ Mt Hay Granulite

3.2A: Na₂O vs K₂O

3.2B: Th/U vs SiO₂

3.2C: Fe₂O₃/(FeO+Fe₂O₃)
NARWIETOOMA FELDSPATHIC ROCKS

3.3A: Rb vs SiO₂

3.3B: U vs SiO₂

3.3C: Y vs SiO₂

Legend

* Bunghara Mmics
□ Illyabba Mmics
◊ Mt Chapple Mmics
○ Mt Hay Granulite
NARWIETOOMA FELDSPATHIC ROCKS

Legend

* Bunghara Mmics
□ Illyabba Mmics
◊ Mt Chapple Mmics
○ Mt Hay Granulite
NARWIETOOMA FELDSPATHIC ROCKS

3.3G: Rb-Ba-Sr

Legend

- * Bunghara Mmics
- □ Illyabba Mmics
- ◇ Mt Chapple Mmics
- ○ Mt Hay Granulite

Granite

Strongly differentiated granite

Anomalous granite

Monzogranite

Tonalite

3.3H: Sr vs SiO$_2$

3.3I: Rb/Sr vs SiO$_2$
NO FLUORINE DATA AVAILABLE
NARWIETOOMA FELDSPATHIC ROCKS

Legend

- * Bunghara Mmics
- □ Illyabba Mmics
- ◇ Mt Chapple Mmics
- ○ Mt Hay Granulite

3.4B: Pb vs SiO₂

3.4C: Zn vs SiO₂

3.4D: Sn vs SiO₂
NARWIETOOMA FELDSPATHIC ROCKS

3.5A: Zr vs SiO$_2$

3.5B: Nb vs SiO$_2$

3.5C: Ce vs SiO$_2$

Legend
- * Bunghara Mmics
- □ Illyabba Mmics
- ♦ Mt Chapple Mmics
- ○ Mt Hay Granulite

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Arunta Inlier 3.12
NARWIETOOMA FELDSPATHIC ROCKS

Legend

* Bunghara Mmics
☐ Illyabba Mmics
◊ Mt Chapple Mmics
○ Mt Hay Granulite

3.6A: CaO-Na₂O-K₂O

3.6B: Zr/Y vs Sr/Sr*

3.6C: Spidergram
SiO₂ range: 65.5-66.5%
### Bunghara Metamorphics

**MEANS AND STANDARD DEVIATIONS**

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## Illyabba Metamorphics

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Mt Chapple Metamorphics

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4 HARVERSON SUITE

4.1 Timing
1820 Ma

4.2 Individual Ages

Primary Ages:

1. Harverson Granite\(^1\) 1820 ± 7 Ma, Sm-Nd
2. Harverson Granite\(^2\) 1818 ± 8 Ma, SHRIMP
3. Mt Stafford/Anmatjira Orthogneiss\(^2\) 1818 ± 15 Ma, SHRIMP


4.3 Regional Setting

The Harverson Suite is mapped in the Anmatjira and Reynolds Ranges, and in the valley in between. It is one of the oldest suites in the Arunta Inlier, and one of the most extensive. Units of the suite had previously been thought to be some of the youngest granites in the area. In particular, Rb-Sr dating of the Harverson Granite and the Anmatjira Orthogneiss gave very imprecise ages (900 ± 200 Ma and 1600 ± 100 Ma, respectively). Also, it was noted that metamorphosed amphibolite dykes which cut the Mount Airy Orthogneiss do not intrude the Harverson Granite; this was taken as further evidence of a young age of the Harverson Granite. However, later mapping showed that a poorly exposed shear zones truncates the dykes against the Harverson Granite.

4.4 Summary

This suite is fractionated, but covers only a very narrow crystallisation interval, and is felsic with the composition of a minimum melt. It is remarkably homogeneous over an extensive area. Evidence of relict cordierite indicates that it is a S-type suite.

4.5 Potential

The Harverson Suite is an S-type suite with a very narrow composition range. Although it shows some evidence of deuteric alteration and pegmatites, its mineralisation potential is considered to be low, as there are few mineral occurrences nearby.

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4.6 Descriptive Data

Location: Northern Arunta Inlier, making up the Reynolds and Anmatjira Ranges. About 200 km northwest of Alice Springs.

Dimensions and area: Anmatjira Orthogneiss: 80 x 10 km, 800 km\(^2\). Harverson Granite: 8 x 8 km, 64 km\(^2\). Yaningidjara and Mount Airy Orthogneisses: 35 x 11 km, 385 km\(^2\). The total area is 1250 km\(^2\).

4.7 Intrusives

Component plutons: Harverson Granite, Anmatjira Orthogneiss, Yaningidjara Orthogneiss, Mount Airy Orthogneiss.

Form: The Anmatjira Orthogneiss is very elongate in a northwest direction. The Mount Airy Orthogneiss and the Yaningidjara Orthogneiss also lie in the same orientation, but are less elongate. The Harverson Granite is equant, and crops out in the valley between the Anmatjira and Reynolds Ranges.

Metamorphism and Deformation: The Harverson Granite is slightly deformed and markedly deutericly altered. The Anmatjira Orthogneiss is everywhere foliated and usually also
lineated. The Mount Airy Orthogneiss is metamorphosed to low-amphibolite facies, and is weakly foliated in its eastern and northern parts. The Yaningidjara Orthogneiss is strongly foliated but generally not layered, and is metamorphosed to a higher grade than the Mount Airy Orthogneiss, with (metamorphic) garnet being present.

**Dominant intrusive rock types:** Coarse-grained megacrystic granite, variably foliated. Augen and rapakivi textures are present in all the granites.

**Colour:** Grey.

**Veins, Pegmatites, Aplites, Greisens:** The Harverson Granite is intruded by many quartz veins, and by a few dykes of aplite and tourmaline-bearing pegmatite. The Anmatjira Orthogneiss is intruded by vein quartz and by dykes of pegmatite, aplite, microgranite and amphibolite. The Mount Airy Orthogneiss is also intruded by dykes of amphibolitised basic rock, microgranite, aplite and quartz veins. The Yaningidjara Orthogneiss is cut in places by dykes of foliated microgranite up to 3 m wide, and also by aplite and pegmatite.

**Distinctive mineralogical characteristics:** The Harverson Granite is a very coarse-grained megacrystic leucocratic porphyritic grey granite. It contains white to pale grey phenocrysts of microcline perthite up to 7 cm long, some are ovoid, some euhedral. The granite also contains yellowish-green plagioclase, grey translucent quartz, and small fine-grained aggregates of biotite, muscovite, and biotite and muscovite together. In places biotite occurs with muscovite as small square aggregates, which are probably pseudomorphs after cordierite (Collins and Williams 1995). Rapakivi-textured feldspar is present in places. Biotite may in part pseudomorph garnet. Biotite occurs as foxy-red flakes (Collins and Williams 1995).

The Anmatjira Orthogneiss (Mount Stafford Granite of Collins and Williams 1995) is a coarse-grained grey granitic augen gneiss. It consists essentially of microcline, plagioclase, quartz, biotite and muscovite. Some biotite is foxy-red, and rare euhedral cordierite grains are found, most of which are now recrystallised aggregates of muscovite and greenish biotite (Collins and Williams 1995). Zircon, tourmaline, apatite, ilmenite, andalusite and fluorspar are accessory, with sericite, clinozoisite, epidote, chlorite and titanite being secondary. Microcline is mantled by sericitised plagioclase, and occurs as large round ovoids up to 10 cm across, and as subhedra up to 2.5 cm long.

The Mount Airy Orthogneiss is a coarse-grained granitic augen gneiss. Biotite is characteristic, forming fine-grained ovoid to lenticular clots up to 1 cm long. Garnet is absent.

The Yaningidjara Orthogneiss is a coarse-grained garnetiferous granitic augen gneiss. It consists of large microcline augen which weather white, orange-weathering plagioclase, quartz, biotite as thin films curved around the augen, abundant garnet, sillimanite, and opaque grains. The garnet and sillimanite have grown at the expense of biotite and feldspar. Garnet is partly replaced by chlorite and/or sericite, and iron oxide.

**Breccias:** None noted in literature.

**Alteration in the granite:** The Harverson Granite is extensively deuterically altered.

4.8 **Extrusives**

None recognised.

4.9 **Country Rock**

**Contact metamorphism:** Stewart et al. (1980) noted that the Harverson Granite metamorphoses the Lander Rock Beds. Other than this, there is no mention of the granites metamorphosing the units they intrude.

**Reaction with country rock:** None.

**Units the granite intrudes:** All the granite units intrude the Lander Rock beds. The Anmatjira Orthogneiss also intrudes the Mount Stafford beds, the Weldon metamorphics, and the Tyson Creek granulite.

**Dominant rock types:** The Lander Rock beds are a highly folded sequence of pelitic and impure psammitic metasediments. The most abundant rock types are impure quartz sandstone containing detrital muscovite and biotite, siltstone (in places carbonateous), shale, and sericite slate. Other rocks include phyllite, quartzite and chert, andalusite-biotite slate, mica schist, sillimanite-biotite-muscovite schist, various biotite gneisses, and cordierite-quartz and cordierite-orthoclase granofels which contain sillimanite, garnet and biotite. The sediments appear to have originated from a largely granitic terrain. The Mount Stafford beds are a
distinctly layered assemblage of various types of metapelitic cordierite hornfelses. The Mount Stafford beds are regarded as a markedly pelitic facies variant of the Lander Rock beds. The Tyson Creek granulite comprises interlayered mafic granulite and subordinate felsic granulite. Layers range from a few centimetres to a few metres thick. The mafic granulite possibly represents volcanic flows or sills, while the felsic granulite masses may have formed by metamorphic segregation or partial melting. The metapelitic Weldon metamorphics probably represent interbedded shale, shaly sandstone and greywacke, and small amounts of mafic igneous rock. It consists of coarse-grained migmatitic gneiss, granofels, felsic granulite, and quartzose granulite.

**Potential hosts:** The more mafic components of the Tyson Creek granulite and the Weldon metamorphics are the only potential hosts; the other units are largely unreactive. The mafic units may provide a redox contrast, given their iron-rich composition.

### 4.10 Mineralisation

Several deposits occur close to granites of the Harverson Suite. However, being a S-type, it is most unlikely that the granites of this suite are genetically related to the mineralisation. For completeness, the deposits are described below anyway.

The Reward Copper Mine is situated north of the Lander River and about 6 km east of Lander Bore. Mining produced about 8 t copper from secondary ore between 1953-1957. Mineralisation was hosted in quartz veining in a shear zone, in andalusite-mica schist and quartz-mica schist. Primary mineralisation consisted of chalcopyrite, pyrite and galena. The Pine Hill gold-copper prospect occurs in a quartz reef 3 km east-southeast of Lander Bore. Wolframite has been reported at several localities near Ingellina Gap, about 6 km north of the Reward Mine. The Lander Copper Prospects consist of four small secondary copper concentrations northeast of Lander Bore. The ore is in lodes composed of quartz, malachite, cuprite, and iron oxides. The country rocks consist of psammitic schist of the Lander Rock beds, intruded by hornblende diorite and, about 1 km to the east, by granite (Anmatjira Orthogneiss). Farther south, secondary copper mineralisation in a shear zone 7 km west of White Hill Yard contains 5% copper.

### 4.11 Geochemical Data

**Data source:** All samples were collected by BMR/AGSO workers during regional mapping in the 1970s and specific granite sampling surveys in the early-mid 1980s.

**Data quality:** The samples collected during the early 1970s was analysed by AMDEL, but have subsequently been re-analysed at AGSO, so are good.

![Histogram of SiO2 values](image)

**Figure 4.1:** Histogram of SiO2 values.

**Are the data representative?** There are only two samples available for the Mount Airy Orthogneiss, and three for the Harverson Granite. More samples would be more representative for these two granites. The data for the Anmatjira Orthogneiss and the Yaningidjara Orthogneiss are probably representative.

**Are the data adequate?** The granites are seemingly quite homogeneous, and only felsic units are present, so the data are mostly adequate, even with the few samples of the two granites noted above.

**SiO2 range (Fig. 4.1):** The granites are all felsic, ranging from 70.6 wt.% SiO2 to 77.85 wt.% SiO2.
Alteration (Fig. 4.2): The granites have been partly deformed and metamorphosed, and the Harverson Granite shows deuteric alteration. On the whole, the samples available show little of this alteration.

- **SiO$_2$**: None of the samples show obvious silicic alteration, although the literature does record outcrops of silicic alteration.
- **K$_2$O/Na$_2$O**: Two samples of the Anmatjira Orthogneiss have been K-depleted, Na-enriched (sodic alteration). All other samples appear to be normal.
- **Th/U**: About half of the samples show a slightly elevated Th/U ratio, whereas the others are in the normal range.
- **Fe$_2$O$_3$/FeO**: Most of the samples show a trend to increasing oxidation with increasing SiO$_2$; however, one sample of the Anmatjira Orthogneiss shows the effects of weathering (more reduced).

Fractionation Plots (Fig. 4.3): Although this suite is represented by only a narrow range of crystallisation, it is evident that it is strongly fractionated. In particular, Rb is very high, and nearly all samples plot in the strongly differentiated field on the Rb-Ba-Sr plot. This suite has a near minimum-melt composition.

- **Rb**: Shows scatter, with values ranging from ~190 ppm to 650 ppm. There may be a slight increasing trend with increasing SiO$_2$ in the Anmatjira Orthogneiss.
- **U**: Again there may be a slightly increasing trend with increasing SiO$_2$ in the Anmatjira Orthogneiss, the Harverson Granite, and the Yaningidjara Orthogneiss. However, U values are relatively low throughout.
- **Y**: Y values are moderate, and show a probable increase with increasing SiO$_2$.
- **P$_2$O$_5$**: Shows low values throughout, with a slightly decreasing trend with increasing SiO$_2$.
- **Th**: Shows a decrease with increasing SiO$_2$, with moderate values. One sample is anomalously elevated.
- **K/Rb**: Values are low, with a flat trend.
- **Rb-Ba-Sr**: Most samples plot in the strongly differentiated granite field.
- **Sr**: All values for Sr are very low, with a very slightly decreasing trend with increasing SiO$_2$.
- **Rb/Sr**: Values are moderate to high, with a strongly increasing trend with increasing SiO$_2$.
- **Ba**: Values are low, and decrease with increasing SiO$_2$.
- **F**: Few analyses are available, but these show a strongly decreasing trend.

Metals (Fig. 4.4): Most metal values are low to moderate. Sn, however, shows some higher values, which may be significant.

- **Cu**: Values are low, and decrease slightly with increasing SiO$_2$.
- **Pb**: Values are moderate, and show a decrease with increasing SiO$_2$.
- **Zn**: Values are low to moderate, and show a slight decrease.
- **Sn**: Values are scattered, and range from low to high. No trends are evident for each granite. The scatter and high values of some samples may be due to enrichment by fractionation.

High field strength elements (Fig. 4.5): This group of elements show the effects of some fractionation, with Zr decreasing, and Y increasing, with increasing SiO$_2$. Their abundances are all low–moderate.

- **Zr**: Values are low and decrease with increasing SiO$_2$.
- **Nb**: Values are low and decrease slightly with increasing SiO$_2$.
- **Ce**: Values are low and decrease markedly with increasing SiO$_2$.

Classification (Fig. 4.6): This suite is part of the ‘normal’ group of granites of Warren (1989).

- **The CaO/Na$_2$O/K$_2$O plot of White, quoted in Sheraton and Simons (1992)**: All but one of the samples plot in the granite or (upper) monzogranite fields, reflecting their felsic compositions.
- **Zr/Y vs Sr/Sr**: All values are low, typical of most Australian Proterozoic granites.
- **Spidergram**: The suite is Sr-depleted, Y-undepleted as is typical of the majority of Australian Proterozoic granites. The effects of some fractionation are evident.
Oxidation plot of Champion and Heinemann (1994): Generally, the more iron-rich samples plot in the reduced field, while the less iron-rich samples plot in the oxidised field. This trend from reduced to oxidised with fractionation is unusual in S-type granites.

ASI: Most samples are peraluminous.

A-type plot of Eby (1990): All samples but one fall within the fractionated and ordinary granite fields, with a fairly even distribution between these two fields.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): The presence of cordierite (or its pseudomorphs) indicates the suite is a S-type.

Australian Proterozoic granite type: Allia.

4.12 Geophysical Signature

Radiometrics (Fig. 4.7): In general, the four units of this suite have very similar K, U and Th contents. U and Th in the Anmatjira Orthogneiss show more spread to higher values than in the other units. Generally, K is significantly higher than the Proterozoic median, U is very close to the median, and Th is a little higher. The predicted RGB colour for most of the suite is therefore red-yellow.

Gravity: The gravity image shows that granites of this suite have a moderate gravity signature, indicating that they are not particularly thick.

Magnetism: The suite mostly occupies linear lows between the highs of northwest-trending metasedimentary units.

4.13 References


**Legend**

- △ Mt Airy Orthogneiss
- ▽ Anmatjira Orthogneis
- × Harverston Granite
- + Yaningidjara Orthogn

**4.2A: Na₂O vs K₂O**

**4.2B: Th/U vs SiO₂**

**4.2C: Fe₂O₃/(FeO+Fe₂O₃)**
HARVERSON SUITE

Legend

- △ Mt Airy Orthogneiss
- ▼ Anmatjira Orthogneis
- × Harverson Granite
- + Yaningidjara Orthogn

4.3A: Rb vs SiO₂

4.3B: U vs SiO₂

4.3C: Y vs SiO₂
HARVERSON SUITE

Legend

- ▲ Mt Airy Orthogneiss
- ▼ Anmatjira Orthogneiss
- × Harverson Granite
- + Yaningidjara Orthogn

4.3G: Rb-Ba-Sr

Strongly differentiated granite

Granite

Anomalous granite

Monzogranite Tonalite

4.3H: Sr vs SiO₂

4.3I: Rb/Sr vs SiO₂
HARVERSON SUITE

Legend

△ Mt Airy Orthogneiss
▼ Anmatjira Orthogneiss
× Harverson Granite
+ Yaningidjara Orthogn
4.4B: Pb vs SiO$_2$

4.4C: Zn vs SiO$_2$

4.4D: Sn vs SiO$_2$

Legend

- △ Mt Airy Orthogneiss
- ▽ Anmatjira Orthogneiss
- × Harverson Granite
- + Yaningidjara Orthogneiss
HARVERSON SUITE

Legend

- ▲ Mt Airy Orthogneiss
- ▽ Anmatjira Orthogneiss
- × Harverson Granite
- + Yaningidjara Orthogn

4.6A: CaO-Na₂O-K₂O

4.6B: Zr/Y vs Sr/Sr*

4.6C: Spidergram

SiO₂ range: 73.3-73.5%
4.6D: Redox plot

Legend

△ Mt Airy Orthogneiss
▼ Anmatjira Orthogneiss
× Harverson Granite
+ Yaningidjara Orthogn

4.6E: ASI vs SiO₂

4.6F: Ga/Al vs HFSE (Eby 1990)
Harverson Granite

MEANS AND STANDARD DEVIATIONS

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Anmatjira Orthogneiss

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Yanidingjara Orthogneiss

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5 WARIMBI SUITE

5.1 Timing
1785 Ma

5.2 Individual Ages
Primary Ages:
1. Warimbi granite 1785 ± 22 Ma, SHRIMP

Inheritance:
1868 ± 12 Ma, SHRIMP

5.3 Regional Setting
The Warimbi granite intrudes all three units of the Reynolds Range Group. Where least deformed, the rock is an even-grained microgranite, with a distinct contact aureole defined by andalusite and cordierite porphyroblasts. The andalusite porphyroblasts contain aligned quartz inclusion trails that are interpreted to be the early stage of regional subvertical foliation. The granite is macroscopically folded, and the deformation is correlated with late upright folds in the Anmatjira Range. The folds formed at peak metamorphic conditions in the Reynolds Range, and represent the culmination of the D₂ tectonic cycle in the area. Therefore, the Warimbi granite intruded relatively early in the D₂ tectonic cycle.

Collins and Williams (1995) suggest that a cluster of zircon ages at 1868±12 Ma represents inheritance; three Archaean ages were also determined.

5.4 Summary
The Warimbi granite is a porphyritic micromonzogranite intruded as a lopolith, and has since been metamorphosed and strongly deformed. It has been rotated to the subvertical, so now outcrops in cross section. Only four geochemical analyses are available, and according to descriptions in the literature, these are probably representative of the granite. These samples are felsic, and represent too narrow a SiO₂ range to give any information on fractionation in this granite, or about the granite type.

5.5 Potential
It is not possible to determine the granite type, or the fractionation history of this granite. However, there is no textural or geochemical evidence for the presence of a fluid phase, and this, combined with the relatively small size of the granite, indicate that the mineralisation potential of this granite is very limited.

Cu: Low
Au: Low
Pb/Zn: Low
Sn: Low
Mo/W: Low
Confidence level: 320

5.6 Descriptive Data
Location: The Warimbi granite outcrops in the central part of the Reynolds Range, about 180 km north-west of Alice Springs, on the Napperby 1:250 000 sheet area.

Dimensions and area: The thickness of the lopolith varies up to 1000 m. Outcrop occurs over about 190 x 20 km, with an area of about 1800 km².

5.7 Intrusives
Component plutons: Warimbi granite. This unit has previously been identified as the Warimbi Schist, or Orthoschist.

Form: The main intrusion is a thick lopolith emplaced into the Mount Thomas Quartzite, and there are two thinner sills at higher levels in the Quartzite. Folding of the Reynolds Range

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Group into an isoclinal syncline has tilted the porphyry body so that its present outcrop amounts to a cross-sectional view.

**Metamorphism and Deformation:** The Warimbi granite is metamorphosed and strongly deformed.

**Dominant intrusive rock types:** Porphyritic micromonzogranite.

**Colour:** Speckled grey to grey-green.

**Veins, Pegmatites, Aplites, Greisens:** None noted in literature.

**Distinctive mineralogical characteristics:** In hand-specimen the rock is phyllonitic, and consists of blue-grey or brown augen of quartz in a fine-grained grey to grey-green schistose feldspathic groundmass streaked with dark elongate smears of biotite. Where undeformed, the rock consists of pinkish-brown quartz phenocrysts and clots of fine-grained biotite in a grey-green hornblende-groundmass. The quartz augen are single crystals with deep narrow corrosion embayments; many of the crystals are round, broken, and fragmented, but a few are euhedral bipyramids. Biotite forms oriented elongate clots or aggregates of many small flakes which are generally themselves randomly oriented inside each clot; hematite and zircon are common accessories in the biotite aggregates. The groundmass of the rock consists of fine-grained recrystallised quartz, forming lenticles of different grain size or a polygonal mosaic, muscovite in small oriented flakes, and a minor amount of biotite. The overall modal composition of the rock is quartz (57%), muscovite (30%), biotite (13%). Feldspar is generally absent and presumably underwent metamorphism to quartz and muscovite; phenocrysts of partly weathered feldspar were observed at a few localities.

**Breccias:** None mentioned.

**Alteration in the granite:** None mentioned.

### 5.8 Extrusives
None recognised.

### 5.9 Country Rock

**Contact metamorphism:** Where least deformed, the rock has a distinct contact aureole defined by andalusite and cordierite porphyroblasts.

**Reaction with country rock:** Not reported.

**Units the granite intrudes:** The Warimbi granite intrudes units of the Reynolds Range Group: the Mount Thomas Quartzite, the Algamba Dolomite Member, and the Pine Hill Formation. It also intrudes the Lander Rock beds.

**Dominant rock types:** The Mount Thomas Quartzite, where intruded by the Warimbi granite, consists of pinkish-brown micaceous sandstone as well as orthoquartzite, and also coarser grained, recrystallised quartzite. The Pine Hill Formation in the northern part consists of shale, and subordinate slate, siltstone, and fine-grained sandstone. In the southern part, it consists of coarse-grained muscovite schist with interbeds of metasandstone and coarse metaquartzite. The Algamba Dolomite Member is composed of fine to coarse-grained, recrystallised dolomite and subordinate limestone. Where intruded by the Warimbi granite, the Lander Rock beds consist of mica schist and andalusite-biotite slate.

**Potential hosts:** Only the Algamba Dolomite Member provides a potentially reactive host lithology.

### 5.10 Mineralisation
None.

### 5.11 Geochemical Data

**Data source:** All four of the geochemical samples come from field mapping carried out by BMR workers in 1972.

**Data quality:** The analyses were all carried out at the BMR, and are considered to be excellent.

**Are the data representative?** The samples available all show extensive sodium and calcium loss, resulting from metamorphism and deformation of the rocks. The literature however reports that relatively undeformed rocks are present; therefore, the data may not be totally representative.
Are the data adequate? The data is considered to be adequate for the purposes of this project.

*SiO<sub>2</sub> range (Fig. 5.1):* The Warimbi granite covers an extremely narrow SiO<sub>2</sub> range.

*Alteration (Fig. 5.2):* All of the available samples show sodium and calcium loss, probably due to metamorphism and deformation. One sample is more oxidised than the others, and is probably altered.

- **SiO<sub>2</sub>:** The granite does not appear to be silicified.
- **K<sub>2</sub>O/Na<sub>2</sub>O:** One sample has lost all its sodium and does not plot, two other samples have lost most of their sodium, and one other appears normal. The potassium contents appear normal.
- **Th/U:** All samples appear normal.
- **Fe<sub>2</sub>O<sub>3</sub>/(FeO+Fe<sub>2</sub>O<sub>3</sub>):** Three samples are reduced, while the other is oxidised, and probably altered.

*Fractionation Plots (Fig. 5.3):* There is an insufficient spread of analyses to determine whether or not this granite is fractionated.

- **Rb:** Values are moderate, and possibly show a decrease with increasing SiO<sub>2</sub>, although this is difficult to tell with so few samples.
- **U:** Values are low, and again possibly show a decrease with increasing SiO<sub>2</sub>.
- **Y:** Values are moderate, and again possibly show a decrease with increasing SiO<sub>2</sub>.
- **P<sub>2</sub>O<sub>5</sub>:** Values are moderate, with no trend discernible.
- **Th:** Values are low, with no trend.
- **K/Rb:** Values are moderate, with no trend.
- **Rb-Ba-Sr:** Three samples plot in the granite field, with one sample plotting in the differentiated field. This may reflect loss of Ba rather than fractionation.
- **Sr:** All values are extremely low.
- **Rb/Sr:** A lot of scatter is evident in this plot, reflecting loss of Sr.
- **Ba:** Values range from moderate to low, probably reflecting loss of Ba in some samples.
- **F:** Only one sample is available, and it has a moderate-low value.

*Metals (Fig. 5.4):* Some moderate to high values of Zn and Cu are present. There is insufficient spread in the samples to show any trends with SiO<sub>2</sub>.

- **Cu:** Values show some spread, with moderate and low values.
- **Pb:** Values are low.
- **Zn:** Shows a lot of spread, from moderate to high values.
- **Sn:** Shows low-moderate values.

*High field strength elements (Fig. 5.5):* Again, there is insufficient spread in the samples to show any trends.
- Zr: Values are moderate.
- Nb: Values are low.
- Ce: Values are low.

Classification (Fig. 5.6): There is insufficient data to classify this granite.

- The CaO/Na₂O/K₂O plot of White, quoted in Sheraton and Simons (1992): This plot shows the loss of sodium and calcium in these samples.
- Zr/Y vs Sr/Sr*: All values are very low.
- Spidergram: The granite is Sr-depleted, Y-undepleted, but shows loss of sodium and probable loss of Sr.
- Oxidation plot of Champion and Heinemann (1994): Three samples plot near the reduced-oxidised boundary, and one other is anomalously strongly oxidised. All samples have surprisingly high iron contents.
- ASI: Due to the loss of sodium and calcium, the samples have unrealistically high ASI values, as is shown by the scale of the plot.
- A-type plot of Eby (1990): The samples plot on the boundary between fractionated granites and Palaeozoic A-type granites.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): There are insufficient data to classify this granite.

Australian Proterozoic granite type: There are insufficient data to categorise this granite.

5.12 Geophysical Signature

Radiometrics (Fig. 5.7): The median for all three elements is slightly above the Proterozoic median, so the granite is predicted to have a white RGB colour.

Gravity: The southern part of the Warimbi granite sits on a shallow gravity low, while the rest of the granite has ‘background’ values. The gravity low is possibly a regional feature, as the granite outcrops in cross section, so it is known that it is not very thick; however, the depth extent of the granite is not known.

Magnetics: This unit sits on a magnetic high, which is elongate north-west along a trend with other metasedimentary units.

5.13 References


5.2A: Na₂O vs K₂O

5.2B: Th/U vs SiO₂

5.2C: Fe₂O₃/(FeO+Fe₂O₃)
WARIMBI SUITE

Legend

△ Warimbi granite

5.3D: $P_2O_5$ vs $SiO_2$

5.3E: $Th$ vs $SiO_2$

5.3F: $K/Rb$ vs $SiO_2$
5.3G: Rb-Ba-Sr

Strongly differentiated granite

Granite

Anomalous granite

Monzogranite

Tonalite

Legend

▼ Warimbi granite

5.3H: Sr vs SiO$_2$

5.3I: Rb/Sr vs SiO$_2$
5.4B: Pb vs SiO₂

5.4C: Zn vs SiO₂

5.4D: Sn vs SiO₂
5.5A: Zr vs SiO₂

5.5B: Nb vs SiO₂

5.5C: Ce vs SiO₂

Legend

▲ Warimbi granite
5.6A: CaO-Na₂O-K₂O

Legend

△ Warimbi granite

5.6B: Zr/Y vs Sr/Sr*

5.6C: Spidergram
SiO₂ range: 69-71%
5.6D: Redox plot

Legend

▶ Warimbi granite

5.6E: ASI vs SiO₂

NOTE: This plot is not on normal scale.

5.6F: Ga/Al vs HFSE (Eby 1990)
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6 CARRINGTON SUITE

6.1 Timing

1780 Ma

6.2 Individual Ages

Primary Ages:

1. Carrington Granitic Suite 1779 ± 6 Ma, SHRIMP


6.3 Regional Setting

The Carrington suite occurs widely in the Mount Doreen area, where it intrudes the Lander Rock beds, and postdates the Yuendumu Tectonic Event. Plutons from the suite are commonly strongly foliated, and in many places contain flattened mafic to intermediate enclaves. The foliations are thought to have been formed during the Hardy Tectonic Phase, because they postdate the Yuendumu Tectonic Event and are different in style and orientation from the lower-grade cleavages characteristic of the Wabudali Tectonic Phase.

Zircons in a sample of the Carrington Granitic Suite show inheritance of up to 2570 Ma. Other age results are ~1800 and ~1885 Ma.

6.4 Summary

This suite is composed mostly of felsic granites that show little fractionation. The granites are generally small bodies, and are variably deformed. The available samples are mostly peraluminous, however, it cannot be confidently said whether this is an I-type or an S-type suite.

6.5 Potential

The mineralisation potential of this suite is small, because the granite is not significantly fractionated; other factors include the lack of evidence for a fluid phase, and the absence of known mineralisation associated with this suite.

Cu: Low
Au: Low
Pb/Zn: Low
Sn: Low
Mo/W: Low
Confidence level: 210

6.6 Descriptive Data

Location: The Carrington suite occurs in an arc across the northern part of the Mount Doreen 1:250 000 Sheet area, and extends onto the Napperby Shee areaat. It also occurs on the southern part of the Mount Doreen Sheet area, south of the Ngalia Basin.

Dimensions and area: The suite outcrops over an area of approximately 620 km².

6.7 Intrusives

Component plutons: The suite is made up of the Carrington Granitic Suite, and the Yulyupunyu Granitic Gneiss.

Form: On the map, the suite appears to be fairly well exposed, occurring as moderately-sized, equant outcrops.

Metamorphism and Deformation: Rocks of the Carrington Granitic Suite are weakly to strongly foliated; the Yulyupunyu Granitic Gneiss is strongly foliated to mylonitic. Deformation is thought to have occurred during the Hardy Tectonic Phase. No metamorphism of the granites is noted.

Dominant intrusive rock types: The Carrington Granitic Suite ranges from biotite tonalite through to muscovite-biotite granite, with biotite granodiorite predominating. Most of the
rocks are even-grained and medium-grained, but feldspar phenocrysts up to 1 cm are present in places. The Yulyupunyu Granitic Gneiss is coarse-grained and felsic.

**Colour:** Not reported.

**Veins, Pegmatites, Aplites, Greisens:** Minor pegmatite, aplite and microgranite are associated with exposures of the Carrington Granitic Suite near Buger Creek.

**Distinctive mineralogical characteristics:** The dated sample of the Carrington Granitic Suite is a granodiorite from near Mount Hardy. It has a strong foliation defined by biotite and fine-grained secondary muscovite, epidote, chlorite and recrystallised quartz. Plagioclase is preserved as larger equant crystals (up to 5 mm) within the medium-grained groundmass. Some rocks contain subhedral andalusite, and one outcrop contains allanite crystals 1-2 mm across with coronas of epidote.

Granite of the Yulyupunyu Granitic Gneiss is a felsic, biotite-bearing rock with lesser fine muscovite and elongated porphyroblasts of K-feldspar up to 4 cm long within the strong fabric. Granite with a mylonitic fabric commonly contains large rounded K-feldspar megacrysts, with lesser fine muscovite.

**Breccias:** None reported in literature.

**Alteration in the granite:** None reported in literature.

### 6.8 Extrusives

None.

### 6.9 Country Rock

**Contact metamorphism:** Retrograde metamorphism in cordierite-andalusite-K-feldspar high-grade rocks of the Lander Rock beds (unit Plrc) nearby Meercantie Creek was probably caused by the intrusion of rocks of the (possibly water-rich) Carrington Granitic Suite.

**Reaction with country rock:** Retrograde metamorphism of the unit Plrc of the Lander Rock beds (see above) has caused the growth of abundant coarse secondary biotite and muscovite.

**Units the granite intrudes:** The Carrington Granitic Suite intrudes several units of the Lander Rock beds. The intrusive relationships of the Yulyupunyu Granitic Gneiss are not shown on either the Mount Doreen or Napperby map sheets.

**Dominant rock types:** Units of the Lander Rock beds include: Plrg - muscovite-chlorite-quartz schist, quartzite; Plra - biotite-muscovite-andalusite-quartz schist, quartzite; Plrc - cordierite-microcline-andalusite-biotite-muscovite-quartz granofels; and Plrm - gneiss, schist, migmatite.

**Potential hosts:** None of the rocks intruded by this suite are thought to be potential hosts.

### 6.10 Mineralisation

None of the mineral deposits in the Mount Doreen area are thought to be related to this suite.

### 6.11 Geochemical Data

**Data source:** All samples were collected by NTGS workers during mapping in the early 1990s.

**Data quality:** All samples were analysed at AGSO, and are considered to be of excellent quality.

**Are the data representative?** No. The Carrington suite is composed of tonalite through to granite, but no samples of the tonalite are available. Therefore, the data are not wholly representative.

**Are the data adequate?** No. Samples of the mafic end-member of the suite are not available, therefore the data are not adequate to quantify the complete fractionation history of the suite.

**SiO₂ range (Fig. 6.1):** The available samples range from 66 wt.% to 75 wt.% SiO₂.

**Alteration (Fig. 6.2):** One sample shows loss of uranium, probably during deformation - otherwise, the suite is unaltered.

- **SiO₂:** No silicic alteration is described in the literature or is evident in the geochemical data.
- **K₂O/Na₂O:** The samples all appear to be normal.
• **Th/U**: One sample is anomalously high - this can be shown to be due to uranium loss. All other samples are within the normal range for granites.

• **Fe_{2}O_{3}/(FeO+Fe_{2}O_{3})**: No alteration is evident.

**Fractionation Plots (Fig. 6.3):** The Carrington Granitic Suite shows no signs of fractionation, whereas the one sample from the Yulyupunyu Granitic Gneiss is more differentiated.

• **Rb**: All samples have moderate values, and show a slightly increasing trend with increasing SiO_{2}. The Yulyupunyu granite is somewhat higher than the rest of the suite.

• **U**: All values are low.

• **Y**: All values are moderately low, and show a slightly decreasing trend with increasing SiO_{2}. The Yulyupunyu granite is somewhat higher than the rest of the suite.

• **P_{2}O_{5}**: All values are low, and show a slightly decreasing trend with increasing SiO_{2}.

• **Th**: All values are low. The Yulyupunyu granite is somewhat higher than the rest of the suite.

• **K/Rb**: All values are moderately low, with a flat trend.

• **Rb-Ba-Sr**: Most samples plot in the granite or anomalous granite fields, with the Yulyupunyu granite being more differentiated than the rest of the suite.

• **Sr**: All values are low, and show a slightly decreasing trend with increasing SiO_{2}.

• **Rb/Sr**: All values are very low. The Yulyupunyu granite is somewhat higher than the rest of the suite.

• **Ba**: All values are low, and show a decreasing trend with increasing SiO_{2}.

• **F**: No data available.

**Metals (Fig. 6.4):** Most metals have low abundances in this suite.

• **Cu**: All values are low, and decrease slightly with increasing SiO_{2}.

• **Pb**: All values are moderate, with no clear trend.

• **Zn**: This plot shows some scatter, with values from low to moderate.

• **Sn**: Values are moderately low.

**High field strength elements (Fig. 6.5):** The HFSE are low.

• **Zr**: Values are low, and possibly show a slightly decreasing trend with increasing SiO_{2}.

• **Nb**: All values are low.

• **Ce**: Values are low to moderate.

**Classification (Fig. 6.6):** The granite shows little or no fractionation, but unfortunately, insufficient data are available to determine the granite source type.

• **The CaO/Na_{2}O/K_{2}O plot of White, quoted in Sheraton and Simons (1992)**: The samples plot in the range of granodiorite to granite. However, it is stated in the literature that tonalites are a part of this suite.

• **Zr/Y vs Sr/Sr**: All values are low.
• **Spidergram:** All samples are Sr-depleted, Y-undepleted. The Yulyupunyu granite is more differentiated than the rest of the suite. One sample of the Carrington granite appears to be depleted in La, Ce and Nd, possibly lost during metamorphism.

• **Oxidation plot of Champion and Heinemann (1994):** Most samples are slightly oxidised, others are only slightly more reduced. No clear trend of changing redox with increasing SiO\(_2\) is evident.

• **ASI:** The trend on this plot is not clear. The more mafic samples (66-69 wt.% SiO\(_2\)) are peraluminous, which would suggest that the suite is an S-type. However, the most felsic sample has an anomalously high ASI, but this may be due to alteration. Descriptions and geochemical data from the tonalite members of this suite would assist greatly in determining the origin of this suite.

• **A-type plot of Eby (1990):** Most samples plot within the fractionated granite field, on a trend of increasing Ga/Al with increasing Zr+Nb+Ce+Y.

*Granite type (Chappell and White 1974; Chappell and Stephens 1988): Unknown.*

**Australian Proterozoic granite type:** Unknown.

### 6.12 Geophysical Signature

**Radiometrics (Fig. 6.7):** The Carrington granites have moderately high K\(_2\)O in relation to the Proterozoic median, slightly higher Th, and slightly lower U. This would give the suite a predicted RGB colour of darkish yellow. The Yulyupunyu granite has significantly higher K\(_2\)O and Th, and slightly higher U. This would give it a predicted colour of yellow or whitish yellow.

**Gravity:** The granites of this suite to the north of the Ngali Basin show no obvious gravity anomaly. Those on the south side of the Basin, however, show a significant high (part of a regional feature), indicating that the granites are extensive and thick.

**Magnetics:** The Carrington Suite shows small localised highs and is generally a little higher than background.

### 6.13 References


6.3A: Rb vs SiO$_2$

6.3B: U vs SiO$_2$

6.3C: Y vs SiO$_2$

Legend

\[\text{Carrington Granitic}\]
\[\text{Yulyupunyu Granitic}\]
6.3D: $P_2O_5$ vs $SiO_2$

6.3E: Th vs $SiO_2$

6.3F: $K/Rb$ vs $SiO_2$

Legend

- Carrington Granitic
- Yulyupunyu Granitic
6.3G: Rb-Ba-Sr

6.3H: Sr vs SiO₂

6.3I: Rb/Sr vs SiO₂

Legend

▼ Carrington Granitic
✯ Yulyupunya Granitic

Strongly differentiated granite
Granite
Anomalous granite
Monzogranite
Tonalite
NO FLUORINE DATA AVAILABLE
CARRINGTON SUITE

6.4B: Pb vs SiO$_2$

6.4C: Zn vs SiO$_2$

6.4D: Sn vs SiO$_2$

Legend

▼ Carrington Granitic
★ Yulyupunu Granitic
CARRINGTON SUITE

Legend

- Carrington Granitic
- Yulyupunyu Granitic

6.5A: Zr vs SiO₂

6.5B: Nb vs SiO₂

6.5C: Ce vs SiO₂
CARRINGTON SUITE

6.6D: Redox plot

- Strongly oxidised
- Oxidised
- Reduced
- Strongly Reduced

6.6E: ASI vs SiO₂

6.6F: Ga/Al vs HFSE (Eby 1990)

Legend

- Carrington Granitic
- Yulyupunyu Granitic

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Arunta Inlier 6.13
CARRINGTON SUITE

Legend

- Carrington Granitic
- Yulyupunya Granitic

6.7A: K$_2$O% Box-whisker

Proterozoic median

6.7B: Th ppm Box-whisker

Proterozoic median

6.7C: U ppm Box-whisker

Proterozoic median
## Carrington Granitic Suite

### MEANS AND STANDARD DEVIATIONS

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Yulyupunyu Granitic Gneiss

MEANS AND STANDARD DEVIATIONS

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7 NAPPERBY SUITE

7.1 Timing 1780 Ma

7.2 Individual Ages

Primary Ages:
1. Napperby Gneiss 1780 ± 10 Ma, SHRIMP
2. Possum Creek Charnockite 1774 ± 6 Ma, SHRIMP


7.3 Regional Setting

The Napperby suite is a part of the Arunta-wide intrusion of granites at 1780 - 1770 Ma, the most active period of granite emplacement in the Inlier. This period correlates with the Early Strangways orogeny, which is probably a single Arunta-wide event, but may be a series of separate short-lived, smaller-scale events. Locally (in relation to the Napperby suite), the metamorphism and deformation at this time is known as the Weldon tectonic phase.

7.4 Summary

The Napperby suite is an extensive suite of strongly to moderately metamorphosed, fractionated, I-type felsic granites. They are dominantly coarse-grained, in some places megacrystic, and commonly foliated. Little mineralisation is associated with these granites, although they do show similarities to the Cullen-type granites. They show some evidence for the evolution of a fluid phase.

7.5 Potential

Although the granite is extensive and quite fractionated, and shows some signs of the presence of a fluid phase, the crystallisation interval over which the granite fractionated is narrow. Also, there are few known mineral deposits near granites of this suite. These factors indicate that the suite has only moderate mineralisation potential at best.

Cu: Moderate
Au: Moderate
Pb/Zn: Low
Sn: Low
Mo/W: Moderate
Confidence level: 321

7.6 Descriptive Data

Location: The Napperby suite lies some 100 km northwest of Alice Springs. It outcrops mostly to the north of the Ngalia Basin, with only limited outcrop south of the Basin.

Dimensions and area: North of the Ngalila Basin, the granites are elongated west-northwest, approximately 180 km x 30 km (5400 km²). South of the Basin, the granite has limited outcrop and is estimated at 110 km x 25 km (2750 km²), elongated east-west.

7.7 Intrusives

Component plutons: Napperby Gneiss, Boothby Orthogneiss, Possum Creek Charnockite, Ngalurbindi Orthogneiss, Wangala Granite, Uldirra Porphyry, Yakalibadgi Microgranite.

Form: The gravity image shows that the granite to the south of the Ngalila Basin is thick, and thins northward. In general, the granite is massive, and elongated west-northwest. The Possum Creek Charnockite which occurs farther north-east than other granites in the suite, in the Anmatjira Ranges, occurs as thin composite sheets, the combined thickness of which rarely exceeds 300 m.

Metamorphism and Deformation: All units of this suite are variably metamorphosed and deformed.
**Dominant intrusive rock types:** Medium to coarse-grained granite, fine-grained granite, coarse-grained porphyroblastic granitic augen gneiss, porphyritic granite, charnockite, megacrystic orthogneiss, coarse rapakivi granite, microgranite, porphyritic microgranite.

**Colour:** The Napperby Granite is grey; the Possum Creek Charnockite is white to greyish-brown; the Uldirra Porphyry is yellow-brown, grey or white; Yakalibadj Microgranite is dark grey. No colours are noted for other granites of the suite.

**Veins, Pegmatites, Aplites, Greisens:** Dirks and Hand (1991) showed that in the Napperby Gneiss in the Reynolds Range area, migmatisation at granulite facies conditions (700-750°C, 4-4.5 kbar) caused partial melting, resulting in the formation of foliated quartzofeldspathic gneiss, leucocratic gneiss and mobilisate. This veining is clearly metamorphic. Elsewhere, the Napperby Gneiss is intruded by dykes of pegmatite, feldspar porphyry, aplite, microgranite, and vein quartz of uncertain origin.

The Ngalurbindi Orthogneiss is in places intruded by pegmatite dykes up to 3 m thick, feldspar porphyry, and a small number of aplite, quartz-tourmaline and porphyry dykes. Parts of the Wangala Granite are cut by pegmatite dykes and porphyritic aplites. No other veining etc. is noted for other units.

**Distinctive mineralogical characteristics:** The Napperby Gneiss is a medium-grained equigranular grey granitic gneiss which is everywhere strongly foliated. In places, the rock is discontinuously layered. The Gneiss is commonly heterogeneous, and comprises a mixture of medium to coarse-grained granitic gneiss, irregular lenses and swirls of fine-grained granite, and irregular masses of pegmatitic granite. The dominant medium-grained granitic gneiss has an allotriomorphic texture, and consists essentially of strained microcline (50-65%), strained and partly recrystallised quartz (20-30%), sericitised plagioclase (10-15%), and greenish-brown oriented biotite (5%) intergrown with muscovite. Apatite, pink zircon, and ilmenite are accessory, and sericite, epidote, clinozoisite, and titanite are secondary.

The Boothby Orthogneiss is mainly a coarse-grained porphyroblastic granitic augen gneiss (orthogneiss) accompanied by strongly sheared equivalents, and to a lesser extent porphyritic granite with elongate euhedral phenocrysts. Gneissic foliation is well developed, and its intensity is reflected by the degree of flattening of the lenticular feldspar augen. Microcline commonly forms the larger augen whereas plagioclase forms smaller but better crystallised grains. The K-feldspar augen in the orthogneiss are generally microcline, although untwinned orthoclase is also present. Microperthitic textures are present in some grains. The plagioclase is commonly sericised to different degrees, whereas the K-feldspar is relatively unclouded. The Orthogneiss varies from types containing only K-feldspar to types containing equal amounts of K-feldspar and plagioclase. In some samples, plagioclase rims microcline in typical rapakiv fashion. Quartz forms between a quarter and a third of the rock. The most abundant ferromagnesian component is biotite, which normally forms less than 10% of the rock. Chlorite is common, normally as an alteration product of biotite and feldspar. Interleaved chlorite-biotite flakes are common. Epidote, zircon, opaque grains (ilmenite?), and titanite are accessory. Some chlorite-biotite flakes include muscovite flakes which are clearly younger than the biotite and possibly represent deuteric alteration.

The Possum Creek Charnockite is a hypersthene granite. It contains high-temperature feldspar (sanidine), hypersthene, green-brown primary hornblende, and antiperthitic plagioclase. The granite is strongly deformed and exhibits well-developed foliation defined by hypersthene and hornblende±clinopyroxene±dark-brown biotite, indicating that the granite is synmetamorphic, with peak metamorphic conditions persisting during granite intrusion (Collins and Williams 1995).

The Ngalurbindi Orthogneiss consists of K-feldspar megacrysts and augen up to 3.5 cm long in a finer-grained schistose matrix composed of anastomosing films of quartz, feldspar, and biotite. About 8 km northeast of Dingo Dam, the Orthogneiss is strongly deformed and consists of quartz-veined schistose muscovite-biotite granite and biotite-muscovite-quartz-feldspar schist. Near Mica Dam, the Ngalurbindi Orthogneiss is commonly cut by pegmatite dykes, and includes lenticular aggregates of feldspar up to 6 cm long by 1 cm thick, quartz, and biotite. The Orthogneiss is porphyritic in places and locally contains muscovite. Other parts of the Orthogneiss near Mica Dam are migmatic and agmatitic, consisting of banded gneiss, fragments of medium-grained granitic gneiss, and large masses of coarse-grained very micaceous quartzofeldspathic rock. In the vicinity of Ngamadingi Hill, and also about 5 km northeast of Brookes Well, the Ngalurbindi Orthogneiss forms scattered exposures of banded
gneiss composed of quartz-feldspar layers from 5 to 10 mm wide separated by biotite-rich zones.

The Wangala Granite is a composite fault-bounded batholith comprising at least eight different types of granite. The earliest intrusion is a coarse-grained porphyritic granite characterised by euhedral tabular phenocrysts of microcline. The rock is a two-mica granite, and consists of quartz, oligoclase, microcline which contains blebs of sericitised plagioclase rimmed with unaltered more sodic plagioclase, biotite, muscovite, and apatite. The second variant of the Granite is a medium even-grained granite, which crops out in the central part of the batholith. The rock ranges from massive to weakly foliated to strongly foliated, and consists of microcline, sodic andesine, quartz, muscovite in large clear flakes, and biotite. The third variety is a coarse to very coarse-grained rapakivi granite that crops out in the southwestern part of the batholith. The rock ranges from massive, containing nearly circular megacrysts of microcline up to 3 cm across, rare euhedral mantled feldspars 1 cm long, and small euhedral grains of plagioclase 0.3 cm across, to foliated, in which the microcline megacrysts are augen-shaped to lenticular. The rock is adamellite in composition; the plagioclase is oligoclase, and a small amount of muscovite is intergrown with the biotite. The fourth variety is a medium-grained porphyritic granite containing phenocrysts of microcline up to 1.5 cm long, and crops out in the northwestern part of the batholith. The fifth variant of the Wangala Granite is represented by a small exposure of granitic augen gneiss. The rock is coarse-grained, strongly foliated, and the microcline augen are up to 2 cm long. The sixth variety is an even-grained microgranite. It lacks phenocrysts, contains only 15% quartz, and allanite and titanite are abundant. It also contains secondary muscovite, and biotite forms only 5% of the rock. The seventh variety is a coarse even-grained granite with grains generally about 5 mm across or slightly larger, and is weakly to strongly foliated. The eighth variety is a fine- to medium- to coarse-grained leucogranite that contains abundant tourmaline and muscovite, whereas biotite is rare or absent.

The Uldirra Porphyry is made up mostly of porphyritic microgranite, comprising phenocrysts up to 5 mm across in a yellow-brown, grey or white, weakly to moderately foliated fine-grained groundmass. There is considerable variation throughout the Porphyry in the types and proportions of mineral constituents. In general, phenocrysts in the rock are composed of quartz as embayed single crystals or elongated and lenticular glomerophenocrysts, microcline, and plagioclase. The groundmass in all samples is composed largely of quartz and microcline forming a recrystallised polygonal mosaic. Other microphenocrysts occasionally found include dark yellow titanite, muscovite, chlorite after biotite, biotite, allanite, andesine, hematite, epidote and zircon.

The Yakalibadgi Microgranite consists of metamorphosed medium-grained granite, metamorphosed porphyritic microgranite, and biotite orthoschist. The medium-grained granite consists of partially recrystallised microcline, quartz and sericitised plagioclase with clots and stringers of chloritised biotite, muscovite, and opaque grains. The porphyritic microgranite consists of larger grains of ragged quartz and heavily sericitised plagioclase in a fine-grained matrix of quartz-microcline-plagioclase-biotite-muscovite. Retrogressed and sheared parts of this unit crop out as the biotite orthoschist.

Breccias: None noted in literature.

Alteration in the granite: In the Boothby Orthogneiss, muscovite is younger than the biotite; this possibly represents deuteric alteration. Unweathered samples of the Uldirra Porphyry contain sericitised and saussuritised plagioclase.

7.8 Extrusives

None noted in literature.

7.9 Country Rock

Contact metamorphism: Collins and Shaw (1995) noted that metamorphic grade generally decreases away from extensive granite sheets and migmatites into regional low-grade rocks in the Anmatjira and Reynolds Ranges. However, they were not specific as to which granites in particular they were referring to; they may have been referring to the Harverson or Ennugan Mountains suites. Elsewhere, it is noted that between Wickstead Creek and Wallaby Creek, the Napperby Gneiss commonly includes roof pendants of calc-silicate rock of the Wickstead Creek beds. These pendants are abundantly intruded by tourmaline-bearing coarse-grained porphyritic microcline pegmatite emanating from the granite. Other than these observations, metamorphic effects are not mentioned in the literature, suggesting that the granites had little metamorphic effect.
Reaction with country rock: None noted in literature.

Units the granite intrudes: The Possum Creek Charnockite intrudes the Tyson Creek granulite, the Aloolya Gneiss, and the Anmatjira Orthogneiss. The Yakalibadg Microgranite intrudes the Lander Rock beds, and the unnamed unit \( pC \). The Boothby Orthogneiss intrudes the Aileron metamorphics and the Lander Rock beds. The Ngalarbindi Orthogneiss intrudes the Lander Rock beds and the unnamed unit \( pG \). The Napperby Gneiss intrudes the Single Hill Formation, the Mount Dunkin and Mount Freeling schists, the Wickstead Creek beds, and the Aileron metamorphics. The Wangala Granite intrudes the Ngalarbindi Orthgneiss, the Wickstead Creek beds, the quartzofeldspathic gneiss \( pF \), and the unnamed schist \( pC2 \). The Uliddra Porphyry intrudes the unnamed schist \( pC3 \), and the Ngalarbindi Orthogneiss.

Dominant rock types: The Tyson Creek granulite is composed of biotite-hypersthene- clinopyroxene-labradorite mafic granulite, with minor felsic granulite and biotite-garnet- andalusite-orthoclase felsic granulite. The Aloolya Gneiss is a medium-grained even granitic gneiss with tourmaline and garnet. The Anmatjira Orthogneiss is a coarse porphyritic granitic augen gneiss with mantled feldspars, and massive rapakivi granite. The Aileron metamorphics are dominated by felsic granulite, commonly accompanied by mafic granulite; subsidiary rock types are cordierite gneiss, garnet-biotite gneiss, calc-silicate rock and marble, sillimanite gneiss, quartz-rich metasediments and quartzofeldspathic gneiss. The Lander Rock beds are a highly folded sequence of pelitic and psammitic metasediments, and range in metamorphic facies from low greenschist to high amphibolite and low granulite. Units of the Lander Rock beds intruded by the Napperby suite include mica-quartz sandstone, siltstone, shale, slate, schist, phyllite, andalusite hornfels, amphibolite, garnet-cordierite-biotite-quartz granofels and tourmaline metaquartzite. The Mount Freeling schist consists dominantly of muscovite-biotite schist, together with smaller amounts of quartzite, quartz-rich metasediments and sillimanite schist. The Mount Dunkin schist is similar to the Mount Freeling schist but is distinguished by its greater abundance of sillimanite, and by the presence of interlayered biotite schist and some calcareous rocks, including chondrodite-forsterite marble. The Wickstead Creek beds are an assemblage of diverse calc-silicate rocks, marble, gneiss and schist; pelitic schist, gneiss and quartzite; and quartz-rich metasediments and quartzofeldspathic gneiss. The Pine Hill Formation includes shale, slate, siltstone, fine-grained sandstone, coarse-grained muscovite schist with interbeds of metasedimentary and coarse metabasalts, coarse-grained granofels, garnet-biotite gneiss, felsic granulite, and cordierite granulite. The unnamed unit \( pCf \) consists of quartzofeldspathic gneiss, with small amounts of granitic gneiss, porphyroblastic gneiss, biotite gneiss, and sillimanite schist. The unnamed unit \( pC2 \) consists of quartzofeldspathic schist containing dark grey quartz augen up to 1.5 cm long, and smaller augen of creamy microcline, in fine-grained schistose grey or cream groundmass of muscovite, recrystallised quartz, microcline, biotite and opaque grains. The unnamed unit \( pC3 \) consists of muscovite schist and metasiltstone; the schist comprises yellow-brown very fine-grained sericite schist, and mottled pink and cream augen schist, the augen being quartz with hematite? inclusions. The unnamed unit \( pGi \) is a schistose granitic gneiss.

Potential hosts: The mafic Tyson Creek granulite, and the mafic granulite of the Aileron metamorphics, may provide a redox contrast to mineralising fluids. The calc-silicate rock and marble of the Wickstead Creek beds may host skarn-type deposits.

7.10 Mineralisation

Several small W deposits and one Cu occurrence are found in the northern part of the Wangala Granite. Stewart and Warren (1977) classify these as pegmatitic, with tungsten occurring as wolframite in pegmatic segregations or quartz veins in the border zones of granites. They state that at all such occurrences in the northern Arunta Block, the wolframite-bearing granite is surrounded by metapelitic schist and sandstone of Division 2.

7.11 Geochemical Data

Data source: Samples were collected during reconnaissance mapping by BMR fieldworkers during 1972 and 1984-85.

Data quality: Samples were analysed at BMR/AGSO, and are considered to be excellent.

Are the data representative? Yes.

Are the data adequate? Sampling of the numerous cross-cutting pegmatites would assist in determining if these were derived from the granites (and thus give further information about the fractionation of these granites), or are much later intrusives. Otherwise, the data are considered to be adequate.
SiO$_2$ range (Fig. 7.1): 66 wt.% to 76 wt.%, with most samples in the range 71-74 wt.%.

Alteration (Fig. 7.2): The samples appear to have lost some uranium, but are otherwise normal.

- SiO$_2$: All values appear to be normal.
- K$_2$O/Na$_2$O: All values appear to be normal.
- Th/U: Most values are slightly above the normal range.
- Fe$_2$O$_3$/(FeO+Fe$_2$O$_3$): Most samples are reduced. There is a steep trend towards increasing oxidation with increasing SiO$_2$. One sample has a Fe$_2$O$_3$/(Fe$_2$O$_3$+FeO) value of one, which is obviously incorrect.

Fractionation Plots (Fig. 7.3): This suite is probably strongly fractionated (as on the Rb-Sr-Ba ternary plot), but due to the narrow crystallisation interval covered, the trend is not readily seen.

- Rb: There is considerable scatter in this plot, and values are moderately low to moderately high.
- U: Most values are low, but some values are high
- Y: There is some scatter, with mostly moderate values. There is possibly a downward trend, with increasing SiO$_2$.
- P$_2$O$_5$: There is a clear trend towards low values with increasing SiO$_2$. Values are moderate to low.
- Th: Some scatter is evident in this plot, possibly reflecting some alteration. Most values are moderate.
- K/Rb: Most values are moderate, with little scatter. There is insufficient spread of values and too small a SiO$_2$ range to define any trend.
- Rb-Ba-Sr: Most samples plot in the granite and strongly differentiated granite fields, indicating that this suite is strongly fractionated.
- Sr: All values are low, with a flat trend.
- Rb/Sr: Values are low to moderate, with an increasing trend with increasing SiO$_2$.
- Ba: There is some scatter in this plot, but generally it shows a decreasing trend with increasing SiO$_2$. Values are moderate to low.
- F: Values are low to moderate, with possibly a decreasing trend with increasing SiO$_2$.

Metals (Fig. 7.4):

- Cu: The majority of samples have low copper values. The more mafic samples (from the Possum Creek Charnockite) have higher values, and one sample from the Wangala Granite has a moderately high value. This may be significant, considering that a copper deposit occurs in the Wangala Granite.
- Pb: A wide spread of values is seen on this plot, from low to high. The Possum Creek Charnockite shows increasing values with increasing SiO$_2$.
- Zn: A strongly decreasing trend is seen, from moderate values to low.
- Sn: A good deal of scatter is evident in this plot. Generally, values appear to be increasing with increasing SiO$_2$. 

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Arunta Inlier 7.5
High field strength elements (Fig. 7.5): Most samples for these elements are very coherent, and are mostly low.

- **Zr:** A strongly decreasing trend is shown, from moderate values to low values.
- **Nb:** All values are low to moderate, with insufficient spread to define a trend.
- **Ce:** Most values are low, however, some values for the Napperby Gneiss are high, while some for the Wangala Granite are very low.

Classification (Fig. 7.6): This suite consists of fractionated felsic I-type monzogranites and granites.

- **The CaO/Na₂O/K₂O plot of White, quoted in Sheraton and Simons (1992):** Most samples are granite or monzogranite, with only one sample plotting in the granodiorite field. This reflects the fractionated nature of these granites.
- **Zr/Y vs Sr/Sr*: Si/Sr* values are very low, Zr/Y values are low.
- **Spidergram:** All samples are Sr-depleted, Y-undepleted, and show the effects of fractionation.
- **Oxidation plot of Champion and Heinemann (1994):** Most samples are oxidised. The Wangala Granite in particular appears to show a trend from oxidised to reduced.
- **ASI:** The trend is from metaluminous to peraluminous, typical of fractionated I-type granites.
- **A-type plot of Eby (1990):** Most samples plot around the boundary between ‘A-type’ and fractionated or ordinary granite. The Wangala Granite stands out on its own with lower HFSE but higher Ga/Al.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-type.

Australian Proterozoic granite type: Cullen type.

### 7.12 Geophysical Signature

Radiometrics (Fig. 7.7): Most of the units have similar medians for all three elements. That is, K is well above the Proterozoic median, Th is a little above the median, and U is about equal to the median. This would give a predicted RGB colour of yellowish-red. Note that the Napperby Gneiss has a wide spread of values (on a real image it would vary possibly from white through to dark colours), and that the Wangala Granite has significantly higher U than other units, giving it a bluer colour.

Gravity: The northern part of the Napperby suite (north of the Ngalia Basin) has a fairly neutral gravity signature. The southern part of the suite, however, has a low signature, indicating that the granite is thick.

Magnetics: The eastern and southern parts of this suite show complex magnetic patters, while the northwestern parts are less complex. The complexity in the southern and eastern parts may reflect the actual position of the granites beneath cover.

### 7.13 References


NAPPERBY SUITE

7.3G: Rb-Ba-Sr

Strongly differentiated granite

Granite

Anomalous granite

Monzogranite Tonalite

Legend

□ Napperby Orthogneiss
△ Boothby Orthogneiss
○ Ngalurbindi Orthogneiss
△ Possum Creek Charnoc
▼ Wangala Granite
● Ulirro Porphyry
+ Yakalbadgi Microgra

7.3H: Sr vs SiO₂

7.3I: Rb/Sr vs SiO₂
NAPPERBY SUITE

Legend

- Napperby Orthogneiss
- Boothby Orthogneiss
- Ngalurbindi Orthogn
- Possum Creek Charnoc
- Wangala Granite
- Ularro Porphyry
- Yakalbadgi Microgra

7.3J: Ba vs SiO₂

7.3K: F vs SiO₂

7.4A: Cu vs SiO₂
Legend

- □ Napperby Orthogneiss
- ◊ Boothby Orthogneiss
- ○ Ngurlumbid Orthogne
- ▲ Possum Creek Charnoc
- ▼ Wangala Granite
- ☯ Ulirro Porphyry
- + Yakalbadji Microgra
7.5A: Zr vs SiO$_2$

7.5B: Nb vs SiO$_2$

7.5C: Ce vs SiO$_2$

Legend

- □ Napperby Orthogneiss
- ◊ Boothby Orthogneiss
- ○ Ngatrubindi Orthogn
- △ Possum Creek Charnoc
- ▽ Wangala Granite
- ○ Ulirro Porphyry
- ◆ Yakalbadji Microgra
NAPPERBY SUITE

Legend

- Napperby Orthogneiss
- Boothby Orthogneiss
- Ngurlurindi Orthogneiss
- Possum Creek Charnoc
- Wangala Granite
- Ulirro Porphyry
- Yakalbadji Microgra

7.6A: CaO-Na$_2$O-K$_2$O

7.6B: Zr/Y vs Sr/Sr$^*$

7.6C: Spidergram
SiO$_2$ range: 68-73%
NAPPERBY SUITE

Legend

- Napperby Orthogneiss
- Boothby Orthogneiss
- Ngalurbundi Orthogne
- Possum Creek Charnoc
- Wangala Granite
- Uligro Porphyry
- Yakalbadgi Microgra

7.6D: Redox plot

Strongly oxidised
Oxidised
Reduced
Strongly Reduced

7.6E: ASI vs SiO₂

ASI
SiO₂

7.6F: Ga/Al vs HFSE (Eby 1990)

10000×Ga/Al
Zr+Nb+Ce+Y

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# Napperby Gneiss

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Arunta Inlier 7.18
## Boothby Orthogneiss

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Uldirra Porphyry

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8 JENNINGS SUITE

8.1 Timing 1770 Ma

8.2 Individual Ages Primary Ages:

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2. Flint Spring gneiss$^1$ 1771 Ma, U-Pb
3. Georgina Gap granitic gneiss$^1$ 1771 Ma, U-Pb
4. Randall Peak metamorphics$^2$ 1771 ± 9 Ma, SHRIMP
5. Oolbra orthogneiss$^1$ 1770 Ma, U-Pb


8.3 Regional Setting

The regional setting of the rocks of this area is poorly constrained. They are thought by most authors to be part of the Southern Province (e.g., Collins and Shaw 1995). The Redbank Thrust Zone separates the Southern Province from the Central Province. Most rocks of the Southern Province are younger than 1680 Ma, however, this suite is part of the 1780-1750 Ma granites which represent the most active period of granite emplacement in the Arunta Inlier. For most of the suite, no intrusive relationships are seen, so this suite may represent basement.

These granites are grouped on the basis of location, geochemistry and age (where available). Several units which are regarded as Early Proterozoic Division One or Two granites (sensu lato) or felsic or mafic granulites on the Alice Springs 1:250 000 Sheet area have been included in this suite on the basis of geochemical similarity. The Ongeva granulite may be part of the Strangways Metamorphics Complex (and unrelated to the Jennings suite), but has been included here on the basis of its similar geochemistry. The Casey Bore granite has also been included in this suite, even though it lies some 30 km to the east-southeast of the main part of the suite. It is in an outlier of the Arunta Block, and is grouped with the Jennings suite on the basis of lithology and geochemistry.

Other units near the Jennings suite (e.g., unit Px on our granite map) have not been included because they have insufficient samples (or none) to establish their groupings. Even some of the units assigned here to the Jennings suite have been done so on the basis of only a few samples. Also, of the five units that have been dated, literature is only available for one of the units. The combination of few geochemical samples and few good age samples, as well as apparent lack of intrusive relationships, means that the makeup of this suite is somewhat speculative, although the available geochemical samples and field descriptions do provide a good fit.

Twenty of 22 zircons from tonalitic gneiss of the Randall Peak metamorphics have indistinguishable ages of which the most precise $^{207}\text{Pb}^{206}\text{Pb}$ age of 1771±9 Ma is considered to be the best estimate of the magmatic crystallisation age of the tonalitic parent. This tonalitic orthogneiss may be the western extension of the Jennings Granitic Gneiss, because of its similar mineral composition. One zircon grain yielded a $^{207}\text{Pb}^{206}\text{Pb}$ age of 1866±18 Ma, and another has a concordant age of 1684±18 Ma. In a regional context, the older age is within error of the ~1880 Ma age of the Atnarpa Complex, perhaps indicating that rocks of the Jennings suite represent reworking of granites of the Barramundi Igneous Association. The ~1680 Ma age is the same age as the Argilke tectonic event (~1680-1660 Ma), which tectonically affected the Wigley Zone, and is the same age as new growth of zircon in the Napperby Gneiss, indicating elevated geotherms in at least the northern province.
8.4 Summary

This suite is I-type, and is slightly fractionated. It possibly originated synorogenically during the ~1780-1770 Ma Early Strangways orogeny, and has subsequently been further deformed and metamorphosed. Some of the units included in this suite may represent strongly metamorphosed co-volcanic rocks.

8.5 Potential

The lack of any evidence of a fluid phase, and the fact that although the suite covers a wide fractionation range, neither the suite as a whole, nor any single granite is extensively fractionated, mean that this suite has only limited potential for mineralisation. Some minor mineralisation occurs nearby and within the Sliding Rock metamorphics, however it is difficult to establish any genetic relationship. Other gold and base metal mineralisation nearby is almost certainly stratabound volcanogenic and associated with the Strangways Metamorphic Complex, not with this suite, or was hydrothermally emplaced in quartz-pyrite veins during the Alice Springs orogeny.

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<tr>
<td>Pb/Zn</td>
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<tr>
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</tr>
<tr>
<td>Mo/W</td>
<td>None - not highly fractionated</td>
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Confidence level: 321

8.6 Descriptive Data

Location: Northeast of Alice Springs, in the Alice Springs 1:250 000 Sheet area.

Dimensions and area: The Jennings suite covers an area of about 90 km x 30 km, approximately 2700 km².

8.7 Intrusives

Component plutons: Jennings Granitic Gneiss, Charles River gneiss, Flint Spring gneiss, Georgina Gap granitic gneiss, Mulga Creek granite, Ongeva granulite, Oolbra orthogneiss, Randall Peak metamorphics, Sliding Rock metamorphics, Trephina granitic gneiss, Casey Bore granite, and the unnamed unit.

Form: The Jennings suite covers a large area, in an arcuate shape extending approximately from north of Alice Springs, eastward to Mordor Pound, then northwesternwards to the Narbib Ranges. Individual units are generally fault-bounded and not equidimensional.

Metamorphism and Deformation: The Jennings suite was probably synorogenically intruded during the Early Strangways orogeny at ~1780-1770 Ma, and was subsequently affected by the Late Strangways orogeny (~1745-1730 Ma), the Chewings orogeny (~1600 Ma), and the Alice Springs intracratonic orogeny (~400-300 Ma). All units of the Jennings suite have been variably deformed, folded and metamorphosed.

Dominant intrusive rock types: The predominant rock types of the suite are: granitic gneiss, megacrystic granite/granitic gneiss, quartzofelspathic gneiss, biotite gneiss, porphyroblastic gneiss, amphibolite, garnet-biotite gneiss, hornblende gneiss, and hornblende-biotite gneiss. See below for descriptions of each unit.

Colour: Not reported.

Veins, Pegmatites, Aplites, Greisens: Aplites, pegmatites and rare narrow quartz veins occur within the Casey Bore granite. The Jennings Granitic Gneiss contains pegmatite, and also epidote veins thought to have formed during retrogressive metamorphism.

Distinctive mineralogical characteristics: The Jennings Granitic Gneiss is made up of coarse-grained granitic gneiss, fine-grained granitic gneiss, porphyroblastic gneiss, amphibolite and hornblende gneiss. The coarse granitic gneiss consists of quartz (~15%), microcline (~60%), sericitised plagioclase (~16%), chloritised biotite (~5%), hornblende (~5%), garnet (~2%), and accessory titanium, epidote, and allanite. The fine-grained granitic gneiss is leucocratic and composed of xenoblastic quartz (30%), microcline (60%), sericitised oligoclase (5%), and biotite (~5%). The porphyroblastic gneiss is medium-grained and granitic in composition. The amphibolite is fine to medium to coarse-grained, heterogeneous, and ranges in composition from quartz diorite to nearly pure amphibole rock.

The Charles River gneiss consists of garnet-biotite gneiss, biotite gneiss, amphibolite, migmatic, and a small amount of quartzofelspathic gneiss. At the type locality, the garnet-
biotite gneiss is medium-grained and consists of plagioclase, strongly deformed quartz, biotite, garnet, and accessory opaque and epidote grains.

The Flint Spring gneiss consists largely of, and is typified by, porphyroblastic and augen gneiss composed of large augen and ovoids of feldspar up to 10 cm or more long, in a dark fine-grained matrix. The rest of the unit comprises quartzofeldspathic gneiss, banded biotite gneiss containing garnet in a few places, schistose biotite gneiss, and a small number of amphibolite layers and lenses.

The Georgina Gap granitic gneiss has a biotite content of up to 20%, and is coarse-grained for the most part. The gneissic layering is not as markedly developed as that in other granitic gneisses in the area. The granitic gneiss is distinguished by its large K-feldspar megacrysts which are up to 5 cm across.

The Mulga Creek granite contains muscovite (2%), biotite (3%), plagioclase (45%) showing slight alteration to sericite, quartz (30%), and microcline (20%). It is fine-grained, slightly schistose, and distinguished from the Georgina Gap granitic gneiss by its finer grain-size and lack of K-feldspar megacrysts.

The Ongeva granulite is clearly distinguished from the surrounding rock types by its characteristic mafic and felsic interlayering, and lack of calc-silicate rock. In the type area, hornblende-hypersthene-diopside-plagioclase mafic granulite and hornblende-hypersthene-quartz-plagioclase mafic granulite are interlayered with hypersthene-plagioclase-microperthite-quartz felsic granulite and mobilisate-rich biotite-plagioclase-microperthite-quartz quartzofeldspathic gneiss.

In the type area the Oolbra orthogneiss is porphyroblastic and schistose, and consists of large porphyroblasts of orthoclase (50%) in a matrix of quartz (20%), biotite (10%), plagioclase (5%), garnet (5%), orthoclase (5%), hornblende (3%), and opaque minerals (2%). The porphyroblasts are rounded and heavily fractured.

The Randall Peak metamorphics are made up of quartzofeldspathic gneiss (30%), amphibolite (30%), biotite gneiss (30% or more), muscovite-biotite gneiss (5% or less), and hornblende gneiss, sillimanite gneiss and megacrystic feldspar gneiss making up 5% together. The quartzofeldspathic gneiss is adamellite in composition, has well developed gneissic layering, and is fine to medium-grained. Two thin sections show granitic (hypidiomorphic) rather than gneissic textures. Biotite gneiss is typically medium-grained, poorly or very finely foliated, and distinguished by its biotite content, which varies from 10 to 30%. The amphibolite is commonly fine to medium-grained, and shows a wide variety of textures. It typically contains about twice as much hornblende as plagioclase and 5 to 15 percent quartz. The hornblende is commonly a bluish green variety, and in a few places is completely retrogressed to actinolite. The muscovite-bearing biotite gneiss is generally quartz rich and fine to coarse-grained; muscovite is nearly everywhere subordinate and commonly occurs as conspicuous coarse-grained aggregates.

The Sliding Rock metamorphics are a sequence of hornblende-biotite-gneiss, garnet-biotite gneiss, biotite gneiss, quartzofeldspathic gneiss and amphibolite. The hornblende-bearing gneiss contains quartz (30%), poorly twinned plagioclase (20%), biotite (10%), green hornblende (35%) and garnet (1%), in addition to secondary sericite, epidote, and chlorite. Granoblastic texture is characteristic. The garnet-biotite gneiss has garnet that is typically poikiloblastic, seldom exceeds 10% of the rock, and is generally localised in separate quartz-rich layers. Quartz and biotite contents are slightly higher than in the hornblende-biotite gneiss, and reach 50 to 20% respectively. The texture is granoblastic. Accessory minerals include magnetite, zircon and apatite. The biotite gneiss has a very similar felsic content and texture to the above gneisses, but lacks hornblende and garnet. The biotite content varies from 10 to 35 percent. The composition of the gneiss varies in a broad sense from monzogranite to granodiorite. Quartzofeldspathic gneiss is granodioritic in composition, consisting of quartz (40%), plagioclase (33%), microcline (23%), muscovite (3%) and opaque grains (1%). Amphibolite is made up of three varieties: the first has a mineral content transitional between that of hornblende-biotite gneiss and amphibolite, the second is a metagabbro, and the third consists of hornblende, plagioclase and accessories.

The Trephina granitic gneiss is a biotite granitic gneiss, containing K-feldspar megacrysts (2-5%), and up to 60% biotite where schistose.
The Casey Bore granite is a gneissic megacrystic granite, which contains microcline, quartz, altered plagioclase, biotite, epidote, and metamorphic hornblende enclosing titanite euhedra. Accessory minerals include allanite and traces of late hornblende.

The unnamed unit consists of several unassigned gneisses. The dominant rock types are biotite gneiss, banded biotite gneiss, amphibolite, quartzofeldspathic gneiss, and hornblende gneiss. In several of these units, feldspar is porphyroblastic.

Breciases: None reported.

Alteration in the granite: None reported.

8.8 Extrusives

Some of the gneiss not easily recognised as granite may be extensively metamorphosed volcanics, eg the Charles River gneiss, Flint Spring gneiss, Ongeva granulite, Randall Peak metamorphics, Sliding Rock metamorphics, and the unnamed unit.

8.9 Country Rock

Contact metamorphism: Not reported.

Reaction with country rock: Not reported.

Units the granite intrudes: On the whole, this suite represents the oldest rocks in the area, and forms basement to younger rocks — for most of the units, intrusive relationships are not seen. The Ongeva granulite may be intrusive into the unnamed unit, but is also possible that the Ongeva granulite is part of the Strangways Metamorphic Complex. Most of the units of the Jennings suite are faulted against, grade into, or are conformable with other members of the suite. If the Ongeva granulite is part of the Jennings suite, then it has been intruded into the Cadney metamorphics of the Strangways Metamorphic Complex, and into the unnamed, unassigned unit.

Dominant rock types: The Cadney metamorphics are made up of calc-silicate rock, marble, sillimanite and biotite gneiss, minor quartzofeldspathic gneiss, felsic granulite, mafic granulite, garnet-biotite gneiss, quartzite, and amphibolite. The unit is composed mainly of quartzofeldspathic gneiss, migmatisite, and biotite gneiss, with some garnet-biotite gneiss, amphibolite, mafic granulite, felsic granulite, sillimanite gneiss, actinolite-quartz calc-silicate rock, and muscovite-biotite schist.

Potential hosts: This is difficult to determine, due to the apparent lack of intrusive relationships. The more mafic units of the Jennings suite are all potential hosts, assuming that the necessary intrusive relationships exist (e.g., a felsic unit is intruded into a more mafic unit, rather than being co-intrusive). Assuming that the Ongeva granulite can be grouped with the Jennings suite, then calc-silicate rocks of the Cadney metamorphics, and the calc-silicate rock and mafic granulite of the unnamed unit, are potential hosts.

8.10 Mineralisation

There are several small base metal and gold occurrences along the northern edge of the Jennings suite, within the Sliding Rock metamorphics. Also, several other deposits are near the Sliding Rock metamorphics or the unnamed unit, including the Winnecke Goldfields. The occurrences within the Sliding Rock metamorphics may be genetically linked to the granite; however, they are small, and only one appears on our granite map. Those deposits that occur within the Strangways Metamorphic Complex to the north of the Sliding Rock metamorphics are considered by Stewart and Warren (1977) to be stratabound volcanogenic deposits formed during the deposition of the protolith to the Strangways Metamorphic Complex. Gold at Winnecke is hosted in the Heavitree Quartzite, and is considered to have been deposited during the Palaeozoic Alice Springs orogeny. However, the source of the gold is not known; it occurs in quartz-pyrite veins, so is considered not to have formed solely from mobilisation of alluvial deposits.

8.11 Geochemical Data

Data source: Most samples were collected during mapping carried out by BMR workers between 1972 - 1989.

Data quality: Excellent, as most of the samples have been analysed at AGSO. Some analyses are the originals done by AMDEL in the early-mid 1970s, and these do not cover as broad range of elements as analysed at AGSO.
Are the data representative? Probably not. There is apparently a great variation within the units of this suite, and relatively few samples are available for most units. Also, there are other units near the Jennings suite which have no analyses.

Are the data adequate? No. With the apparent variations in the rock types mapped within each unit, there is still considerable uncertainty as to the makeup of this suite, as well as its fractionation history.

$SiO_2$ range (Fig. 8.1): The samples cover a broad $SiO_2$ range, but with few samples at the mafic end. Most values are between 65 - 74 wt.% $SiO_2$.

Alteration (Fig. 8.2): Some alteration is evident in rocks of this suite, most likely due to metamorphism and weathering.

- $SiO_2$: All values are in the normal range (ie no silicification).
- $K_2O/Na_2O$: Several samples from the Sliding Rock metamorphics, Randall Peak metamorphics, Flint Spring gneiss and the Charles River gneiss show potassium loss, with little sodium loss. One sample from the Ongeva granulate shows potassium gain and sodium loss.
- $Th/U$: Most samples plot above the normal range for this ratio, possibly reflecting U loss during regional metamorphism.
- $Fe_2O_3/(FeO+Fe_2O_3)$: This plot shows some spread. In particular, all samples from the Charles River gneiss are more reduced than the rest of the suite; some samples from the Ongeva granulite, the Oolbra orthogneiss and the Sliding Rock metamorphics are also comparatively more reduced; and a sample from the Georgina Gap granitic gneiss is more oxidised.

Fractionation Plots (Fig. 8.3): This suite shows some fractionation, but does not reach a high degree of differentiation.

- $Rb$: Values are low to moderate, and increase with increasing $SiO_2$. Several samples from the Charles River gneiss, the Ongeva granulate, and the Sliding Rock metamorphics at higher $SiO_2$ have lower values than the trend.
- $U$: Values are low, but there is a slightly increasing trend with increasing $SiO_2$.
- $Y$: Values are moderate, and decrease with increasing $SiO_2$.
- $P_2O_5$: Values are moderate, and decrease with increasing $SiO_2$.
- $Th$: Most values are low to moderate, with a slightly increasing trend with increasing $SiO_2$. Some samples from the Jennings Granitic Gneiss, and the Georgina Gap granitic gneiss have anomalously high values.
- $K/Rb$: Values of this ratio are moderate, and increase slightly with increasing $SiO_2$.
- $Rb-Ba-Sr$: All samples plot in the granite and anomalous granite fields.
- $Sr$: Most values are moderate to low, and show a decreasing trend with increasing $SiO_2$. However, the most mafic sample from the Charles River gneiss is anomalously high.
- $Rb/Sr$: All values are low, but possibly show a slight increase with increasing $SiO_2$. 

Figure 8.1: Histogram of $SiO_2$ values.
• **Ba**: Values are moderate, and most values fall on a decreasing trend with increasing SiO$_2$, however, some more mafic samples from the Charles River gneiss and the Randall Peak metamorphics fall below this trend.

• **F**: No data available.

**Metals (Fig. 8.4):** Pb and Zn show strong trends with fractionation, while Cu shows some scatter.

• **Cu**: There appears to be an U-shaped pattern, with high values at low SiO$_2$ decreasing to low values, then increasing to higher values at higher SiO$_2$. This pattern is probably due to alteration.

• **Pb**: Increases with increasing SiO$_2$, from low to moderately high values. Some samples from the Ongeva granulate fall below the trend.

• **Zn**: Shows a strongly decreasing trend from moderately high values at low SiO$_2$ to low values at high SiO$_2$.

• **Sn**: All values are low.

**High field strength elements (Fig. 8.5):** Values are mostly moderate, with no strong trends present.

• **Zr**: Values are moderate, but show some scatter. There is possibly a trend towards decreasing values with increasing SiO$_2$, if it is assumed that the lower- and higher-SiO$_2$ samples don’t fit the trend.

• **Nb**: Values are low, with a flat trend.

• **Ce**: Values are moderate to low, with scatter about a flat trend.

**Classification (Fig. 8.6):** Members of the suite range from tonalite to granite, and are I-type.

• **The CaO/Na$_2$O/K$_2$O plot of White, quoted in Sheraton and Simons (1992):** The majority of samples plot in the monzogranite field, but range from tonalite to granite.

• **Zr/Y vs Sr/Sr*:** All values for Sr/Sr* are low, while values for Zr/Y range from low to moderate.

• **Spidergram:** Most samples are Sr-depleted, Y-undepleted. Those that are not are assumed to have been altered.

• **Oxidation plot of Champion and Heinemann (1994):** Most samples plot in the oxidised field, with no change in redox with changing FeO(total). However, several of the more felsic samples are anomalous, plotting in the reduced or strongly reduced fields. Also, one sample plots in the strongly oxidised field. These samples are probably altered.

• **ASI:** Apart from some obvious alteration, the trend is one from metaluminous to peraluminous, typical of I-type granites.

• **A-type plot of Eby (1990):** The majority of samples plot in the anomalous field, with some samples in the ordinary granite field and some in the fractionated granite field.

**Granite type (Chappell and White 1974; Chappell and Stephens 1988):** I-(granodiorite) type.

**Australian Proterozoic granite type:** The geochemical criteria best fit the Cullen type: metaluminous (moderate-T), fractionated. The Cullen type is also Au-dominant, however, very little mineralisation is thought to be associated with the Jennings suite.

### 8.12 Geophysical Signature

**Radiometrics (Fig. 8.7):** Most of the granites have K higher than the Proterozoic median, most are higher in Th, and all are lower in U. The predicted colour for each unit is:

- **Jennings Granitic Gneiss:** Mid brownish-red
- **Charles River gneiss:** Dark red
- **Flint Spring gneiss:** Brown
- **Georgina Gap granitic gneiss:** Mid brownish-red, similar to Jennings GG
- **Mulga Creek granite:** No Th or U data
- **Ongeva granulate:** Brownish-red, redder than Jennings GG
- **Oolbra orthogneiss:** Brownish-red
- **Randall Peak metamorphics:** Very dark red
- **Sliding Rock metamorphics:** No Th or U data
- **Trephina granitic gneiss:** Brownish-red, similar to Georgina Gap gg
- **Casey Bore granite:** Brownish-red, similar to Georgina Gap gg
**Gravity:** The dominant feature in the area is the gravity low associated with the Redbank Thrust Zone. This feature is strongest to the north of the suite, but also underlies the suite. The Casey Bore granite, well to the southeast of most of the suite, is underlain by a gravity high, consistent with the granite being a small inlier of Arunta rocks.

**Magnetics:** Data are too coarse to draw any conclusion.

### 8.13 References


Legend

+ Jennings Granitic Gneiss
× Charles River Gneiss
△ Flint Spring Gneiss
▼ Georgina Gap granite
● Mulga Creek granite
○ Ongeva granulite
★ Oolbra orthogneiss
△ Randali Peak mmiics
★ Sliding Rock mmiics
▼ Trephina granitic gn
□ Casey Bore granite
8.3G: Rb-Ba-Sr

Legend

- Jennings Granitic Gneiss
- Charles River Gneiss
- Flint Spring Gneiss
- Georgina Gap granite
- Mulga Creek granite
- Ongeva granite
- Oolbra orthogneiss
- Randall Peak mnsics
- Sliding Rock mnsics
- Trephina granitic gneiss
- Casey Bore granite

8.3H: Sr vs SiO₂

8.3I: Rb/Sr vs SiO₂
JENNINGS SUITE

Legend

+ Jennings Granitic Gn
× Charles River Gneiss
△ Flint Spring Gneiss
▼ Georgina Gap granite
● Mulga Creek granite
○ Ongeva granulite
★ Oobra orthogneiss
◇ Randall Peak mnnics
* Sliding Rock mnnics
▼ Trephina granitic gn
□ Casey Bore granite

---

8.6D: Redox plot

Legend

8.6E: ASI vs SiO₂

8.6F: Ga/Al vs HFSE (Eby 1990)
### Jennings Granitic Gneiss

#### MEANS AND STANDARD DEVIATIONS

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### Georgina Gap granitic gneiss

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## Mulga Creek granitic gneiss

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 Randell Peak metamorphics

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### Sliding Rock metamorphics

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# Casey Bore granite

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Arunta Inlier 8.28