SUPPLEMENTARY DATA

Neoproterozoic reworking of the Palaeoproterozoic Capricorn Orogen of Western Australia and implications for the amalgamation of Rodinia

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S1. Sample Description & Summary

S1.1 Narryer Terrane

Three samples were taken from the Narryer Terrane of the Yilgarn Craton. Granitic gneiss (SO2_7a) consisted largely of quartz, feldspar, biotite and muscovite. Quartz and feldspar domains define a gneissosity, and the rarer biotite and muscovite is roughly aligned parallel to this fabric. A sample of a lens of pelitic schist (SO2_8) that outcrops within granitic gneiss of the Narryer Terrane contains one foliation that consists of biotite and minor feldspar and quartz. Biotite wraps around pseudomorphed porphyroblasts interpreted to be andalusite (Fig. 2a). Andalusite is replaced by very fine-grained mats of sericite and quartz (Fig. 2a). If the andalusite crystallised in the amphibolite facies, then the biotite foliation may have formed in either the amphibolite or greenschist facies (i.e. on the prograde or retrograde path) given that the andalusite porphyroblasts are relatively undeformed but are wrapped by the biotite foliation. The randomly oriented sericite may have crystallised during a greenschist facies retrograde metamorphic event after deformation had ceased. Sample SO2_2a is from an even-grained undeformed biotite granite that intrudes surrounding Archaean granitic gneiss and comprises mainly quartz, feldspar, muscovite, and biotite.

Foliations in samples SO2_7a and SO2_8 are thought to have formed during an Archaean deformation and high-grade metamorphic event (Occhipinti & Sheppard 2001) based on regional structural and metamorphic correlations, and the presence of unfoliated c. 2600 Ga granite sheets and plutons that cut these fabrics in the region. However, the retrograde, unfoliated sericite present in sample SO2_8 could have formed at any time after this Archaean deformation and metamorphism event.

S1.2 Errabiddy Shear Zone

The granitic gneiss sample SAO_02/10 from the Warrigal Gneiss consists of feldspar and quartz, with subordinate biotite, garnet, epidote, and sericite. The rock contains a gneissocity largely defined by alternating bands of randomly orientated biotite and recrystallised relict quartz ribbons. The foliation in the Warrigal Gneiss formed during the c. 2000–1950 Ma Glenburgh Orogeny, based mainly on regional structural and geochronological correlations (Occhipinti & Reddy 2004, Occhipinti *et al.* 2004) . However, the presence of randomly orientated biotite clusters suggests that the biotite may have crystallised or recrystallised after the foliation-forming event.

Metasedimentary rocks analysed as part of this study included diatexite melt from migmatised pelite samples 142905 and 142910, and psammite (168944), and all form part of the Camel Hills Metamorphics. The diatexite melt (142905 and 142910) consists of quartz, plagioclase, k-feldspar, biotite, muscovite, sericite, sillimanite, garnet, and chlorite. A weak gneissocity in sample 142905 is defined by the alignment of biotite and the presence of flattened garnet. In sample 142910 the same generation but more pervasive foliation is largely defined by the alignment of sillimanite (pseudomorphed by randomly oriented sericite) and biotite (Fig. 2b). The presence of the prograde assemblage biotite, K-feldspar, plagioclase, sillimanite, garnet and quartz in samples 142905 and 142910 is indicative of upper amphibolite to granulite facies metamorphism concomitant with the main Glenburgh Orogeny foliation forming event (Occhipinti & Reddy 2004, Occhipinti *et al.* 2004) . Conversly, the mats of unfoliated sericite and muscovite are interpreted to have formed during a retrograde greenschist facies metamorphic event related to the Capricorn Orogeny. The psammite (168944; Fig. 2c) contains a gneissocity mainly comprising quartz, plagioclase, biotite, muscovite, with minor myrmekite, and epidote. This gneissocity developed in the amphibolite facies, based on regional correlations with nearby pelitic assemblages (Occhipinti & Reddy 2004, Occhipinti *et al.* 2004) . The gneissocity is largely inferred from the modal variations of biotite and muscovite throughout bands in the rock. Muscovite locally replaces, and pseudomorphs biotite.

Samples 142911 and 168946, which are granites of the 1960–1945 Ma Bertibubba Supersuite (Occhipinti et al., 2004), consist of feldspar, quartz, biotite, muscovite, sericite with minor epidote. The foliation in these rocks is defined by roughly aligned biotite, and its metamorphic grade is difficult to ascertain given the granitic assemblage. The granites were intruded into the Errabiddy Shear Zone during the Glenburgh Orogeny, and their foliation could have formed at this time or during the later Capricorn Orogeny (Occhipinti & Reddy 2004, Occhipinti *et al.* 2004). Randomly oriented greenschist facies minerals, including sericite or muscovite and epidote locally replace plagioclase feldspar. Muscovite is interpreted to have crystallised during a retrograde metamorphic event that post-dates rock deformation.

Two samples of granite (142900 and SO2_14) and one of pegmatite (SAO_01_67), which have previously been correlated with part of the Moorarie Supersuite [Sheppard et al., 2003; Occhipinti and Reddy, 2004] were analysed from the Errabiddy Shear Zone. Sample 142900 is an unfoliated granite containing variable amounts of feldspar, quartz, biotite, muscovite, sericite, chlorite, and minor garnet and epidote (Fig. 2d). Whereas most of the minerals that comprise the granite appear to be of primary igneous composition, sericite partially replaces feldspar and biotite, and chlorite replaces garnet and biotite. A sample from the Erong Granite (SO2_14) contains an unfoliated mineral assemblage of plagioclase, quartz, K-feldspar, with minor biotite, muscovite, and epidote. Rare aggregates of fine-grained garnet were observed in hand specimen but were not present in the thin-section. Sample SAO_01_67 was taken from an unfoliated muscovite pegmatite and cuts all structural fabrics present in the pelites of the Camel Hills Metamorphics, in the area of sample 142910. The pegmatite is quartz rich (> 60% quartz) and consists of quartz, feldspar and muscovite, with the muscovite forming distinctive books.

The sandy matrix of metasedimentary schist of the Coor-de-Wandy Formation from poorly sorted, metamorphosed conglomeratic sandstone (SAO1_08) was sampled. The matrix contained an undifferentiated foliation that comprises aligned muscovite and may have formed in the greenschist facies, though quantitative pressure and temperature conditions could not be derived from the mineral assemblage.

S1.3 Gascoyne Complex

Samples 142926, 142932, and 142933 from the 2000 – 1970 Ma Dalgaringa Supersuite were analysed using the ^{40}Ar/^{39}Ar method. Sample 142926 consists of a fine- to medium-grained, foliated biotite tonalite, which was metamorphosed at medium grade during the Glenburgh Orogeny (Occhipinti & Sheppard 2001) . The foliation is defined by the rough alignment of biotite. Samples 142926 and 142932 largely comprise variable amounts of feldspar (locally sericitised), quartz, biotite, and minor epidote, and sericite (Fig. 2e). Sample 142932 also contains some muscovite. The foliation in sample 142932 is largely defined by aligned biotite, which forms discontinuous clumps throughout the rock [Occhipinti et al., 2004]. This foliation is interpreted to have formed in the epidote-amphibolite zone (transitional between the amphibolite and greenschist facies) because of the presence of oligoclase–andesine, epidote and biotite in apparent equilibrium (Occhipinti *et al.* 2004) . Subordinate muscovite and sericite are also locally aligned in the foliation. Sample 142933 is a metadiorite, which has been metamorphosed in the granulite facies. This sample consists of plagioclase, clinopyroxene, biotite, and orthopyroxene. Larger biotite grains are randomly oriented throughout the rock; however, smaller biotite is aligned in a weak foliation not defined by any other minerals contained within the rock.

Granite from the Moorarie Supersuite (Sheppard *et al.* 2003) (sample 142924) of the Gascoyne Complex contains muscovite and biotite, which are randomly oriented throughout the rock, and fine-grained sericite that locally replaces feldspar. This granite appeared massive and undeformed in handspecimen; however, in thin-section it contains elongate quartz domains that represent a foliation.

Two samples from low-grade metaconglomerate of the Mount James Formation (SO2_16A and 16C) were taken. Analyses of the conglomerate show the presence of deformed quartz clasts in a matrix of metasandstone consisting of quartz, sericite, and muscovite. Sericite or fine-grained muscovite is aligned parallel to a fabric that is approximately parallel to bedding. These grains are crenulated and a crenulation cleavage is well developed in some parts of the rock. Coarser grained muscovite is not aligned in any fabric, but appears to be deformed and so may be detrital.

Sample CV_065 was taken from metasedimentary rocks of the Morrissey Metamorphics and is a quartz, biotite, muscovite, and feldspar schist. Quartz is strongly recrystallised to strain free polygonal grains, and the pervasive foliation is defined by aligned biotite grains, and locally muscovite that is both locally aligned in, and pre-dates the foliation.

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Supplementary Table 1: Sample Summary

Area	**Sample # Unit Name & Location ([1]AMG) Zone 50**	**Field notes Locality information**	*Petrographic summary*	**Interpreted U-Pb SHRIMP age on zircon or bracketed age**
Narryer Terrane (Yilgarn Craton)	S02_02a ?Archaean Granite (513940E 7149900N)	Granite dyke intruding surrounding granitic gneiss and quartz mylonite. Granite contains xenoliths of surrounding gneiss, is less deformed than gneiss but contains a weak foliation along its' margins, which trends parallel to the foliation in the surrounding gneiss.	Unfoliated quartz, feldspar, muscovite, and biotite granite. Contains abundant accessory zircon	*unknown*
	SO2_7a Narryer gneiss (494780E 7169128N)	Granitic gneiss containing muscovite and biotite.	Granitic gneiss containing a gneissocity defined mostly by quartz, biotite, and muscovite. Contains quartz, feldspar, muscovite, biotite with accessory epidote and zircon. Quartz displays undulose extinction, minor sub-grain development and is also brittley fractured.	*unknown*
	SO2_8 Narryer gneiss (489082E 7171896N)	Lens of biotite schist in among weathered granitic gneiss.	Well-foliated, with the foliation defined by phlogopite (biotite), and feldspar, including K-feldspar, and quartz. Foliation wraps around porphyroblasts of possible sillimanite or andalusite that have been pervasively pseudomorphed by randomly oriented sericite and quartz.	*unknown*
Errabiddy Shear Zone	142900 Moorarie Supersuite (529856E 7197186N)	Small plug of unfoliated muscovite-biotite granite associated with larger mass of foliated two-mica coarse granite and pegmatite. Intruded late during the Capricorn Orogeny.	Microcline (25%), albite-oligoclase (25%), quartz (35%), biotite (5%), muscovite (5%), & garnet (1–3%), sericite & chlorite. Sericite partially replaces feldspar and biotite, & chlorite partially or completely replaces garnet & biotite. Muscovite & biotite range in grain size from 30–300µm.	1802±9Ma
	142905 *Camel Hills Metamorphics —Migmatitic pelitic gneiss* *(547712E 7210422N)*	A weak gneissocity that is folded about upright, tight-isoclinal folds and retrogressed in the greenschist facies during this folding event. Folds developed during the Capricorn Orogeny.	Quartz, plagioclase, k-feldspar, biotite, muscovite, sericite, sillimanite, garnet, & chlorite. Garnet flattened in the foliation. Accessory minerals — zircon & apatite. Plagioclase — andesine–oligoclase, locally replaced by sericite. K-feldspar grains pseudomorphed by sericite. Sericite forms mats over sillimanite. Garnet is variably replaced by chlorite & sericite. Biotite between 50–600µm long, commonly 200–300µm long. Larger biotite grains contain abundant inclusions of opaques & zircon, and smaller grains (50–100µm) are either inclusion free, or contain fewer inclusions relative to the larger grains. Biotite is often partially replaced by muscovite &/or sericite, and muscovite grains are of a similar size variation to biotite.	migmatite c. 1950 (see text); sedimentary protolith <2052±7 Ma
	142907 Biotite monzogranite	Dyke that intrudes mesocratic porphyritic granite and mesocratic granitic gneiss. Deformed by narrow greenschist facies ENE-trending shears.	Feldspar, quartz, biotite, epidote, & muscovite. Feldspar (50%) consists of even amounts of plagioclase and k-feldspar. Biotite replaced locally by muscovite. Epidote & sericite replace feldspar.	2608±3Ma

[1] AMG refers to Map Grid of Australia, Aus Geod 84.

	dyke (504168E 7181130N)		Biotite is up to 260µm long but mostly grains are between 50–100µm long. Only 25% grains between 200–260µm long. Foliation is defined by aligned clusters of biotite; whereas fine-grained muscovite/sericite is not aligned in the foliation. Some biotites are oriented perpendicular to the foliation and may have crystallised post-foliation formation.	
	142910 Camel Hills Metamorphics (477900E 7184200N)	Migmatitic pelitic gneiss. Age of partial melting interpreted from 2 youngest zircons in sample. Intruded by sample 142909 at 1970 ± 15 Ma (Nelson, 1999).	As for 142905 (above), except this sample is foliated. One well-developed foliation is present and is defined by domains of biotite aggregates , with minor muscovite, and mainly ex-sillimanite (now mats of sericite) and separate domains of quartz and plagioclase.	*migmatite c.* 1950 (see text); *sedimentary protolith* <2025±8 Ma
	SAO_02/10 Warrigal Gneiss (470815E 7178831N)	Granitic gneiss consisting of quartz, feldspar (k-feldspar), biotite, garnet, muscovite, sericite, ?epidote, apatite, and zircon. Layers consisting mostly of biotite aggregates define a foliation in the gneiss.	Feldspar (45%), quartz (45%), biotite (5%), garnet (<1%), epidote, sericite Accessories: zircon, opaques Biotite is up to 300 µm long, but commonly between 50–100µm long. Larger grains often contain inclusions of zircon or opaques. Feldspar is deformed, but not recrystallised and is locally replaced by sericite and epidote. Quartz is recrystallised, but may have formed ribbons throughout the gneiss. Garnet is cracked (pulled apart). Within and around the cracks biotite, quartz, and minor epidote have crystallised. Foliation is defined by the alignment of biotite clusters and relic quartz ribbons.	*This locality not dated; however, elsewhere in the ESZ precursor granite to granitic gneiss dated by SHRIMP at 2700–2600 Ma*
	SAO1_08	Low-grade metasedimentary rock of the Coor-de-wandy Formation.	Quartz (50%), white mica (?45%) and accessory zircon, tourmaline, apatite, magnetite and ilmanite. Muscovite and quartz define an undifferentiated foliation.	
	SO2_14 Erong Granite (465738E 7174602N)	Medium-grained, even-textured to coarse-grained event-textured biotite–muscovite–garnet granodiorite, which intrudes Peter Calcsilicate of the Camel Hills Metamorphics	Plagioclase, quartz, k-feldspar (collectively >93%) with minor biotite, muscovite, and epidote (~5%)	*Not dated by SHRIMP; <c. 2000Ma*
	SAO-01/67 Coarse-grained pegmatite (477962E 7184265)	Coarse-grained unfoliated muscovite pegmatite dyke. The pegmatite cuts main foliation in migmatised pelite, trending NNE.	Quartz, feldspar, muscovite. Accessories: zircon Quartz rich granite. Minor replacement of feldspar by sericite. Muscovite consists of books up to 3mm long.	*unknown*
	168944 Camel Hills Metamorphics (449690E 7171338N)	Medium-grade (amphibolite facies) psammite Age of protolith sedimentary rock and possible youngest protolith age (c. 1985)	Quartz (50%), plagioclase (andesine; 20%), biotite (15-20%), muscovite (10%), minor myrmekite & epidote. Accessory phases — zircon & ?apatite. In places a possible weak foliation defined by biotite but the rock mostly looks recrystallised and unfoliated. Fine-grained muscovite and biotite intergrown in clumps throughout the rock. Muscovite pseudomorphs biotite. Sericite partly replaces muscovite & biotite, as well as plagioclase. Biotite & muscovite have variable grain sizes between 30–250µm and 50–100µm, respectively. However, most of the biotite grains are between 100–200µm. Quartz is commonly granoblastic & annealed. Minor sub-grain development has taken place within the larger grains and undulose extinction of grains is common. Small quartz grains have crystallized around larger ones, and around feldspar grains.	1985±14 Ma; most protolith 2028±5 Ma

	142911 *Bertibubba Supersuite (460034E 7167064N)*	Foliated porphyritic biotite monzogranite. This granite contains one pervasive foliation. This phase intrudes sample 142912 (Nelson, 1999).	Feldspar (50-65%), quartz (25-30%), biotite (10%), muscovite (2%), epidote (2%), & myrmekite. Accessory phases — titanite, minor opaques. Large 5-8mm long rectangular feldspar porphyroclasts composed of both k-feldspar and oligoclase-andesine are wrapped by intergrown biotite & muscovite, which are aligned in the foliation. Smaller feldspar grains also present. Biotite grains are commonly about 300µm long, with some as long as 600µm, & some as small as 80µm long. Small (c. 0.3mm) quartz grains are flattened in the foliation directly adjacent to the porphyroclasts; however, away from the feldspar porphyroclasts they form larger more equant grains. Epidote forms abundant small euhedral crystals that clump around biotite & small feldspar grains.	1961±3 Ma
	168946 *Bertibubba Supersuite (*433020E 7165590N)	Medium to coarse-grained, even-textured tonalite (foliated)	Plagioclase (40%), quartz (30%), microcline (20%), biotite (5-10%), muscovite (2-5%), & minor epidote with accessory zircon. Biotite and muscovite grains range in size between 50–600µm, and 20–100µm long, respectively. Foliation defined by biotite-richer zones where biotite is roughly aligned alternating with quartz-feldspar rich domains. Feldspar is locally replaced by sericite. Quartz is commonly recrystallised into grain free polygonal grains. Muscovite is not aligned in any foliation, and locally replaces biotite.	1961±6Ma
Glenburgh Terrane	*142924* *Moorarie Supersuite (*443590E 7204385N)	Fine- medium even-grained monzogranite. Intrudes monzogranite with 5cm mafic clots	Plagioclase (35%), microcline (20%), quartz (35%), muscovite (5%), and biotite (2–3%) with minor epidote, and sericite. Accessory phases — zircon, apatite. Fine crystals of epidote and sericite partially replace feldspar. Sericite also partially replaces biotite. Muscovite and biotite are randomly oriented throughout the rock. Muscovite is the most prominent mica in the sample, and is up to 500µm long; however, most grains are smaller (between 100–250µm long). Most biotite grains are between 50–200µm long. In places quartz forms elongate domains in which some of the quartz grains are flattened implying that they may represent foliation domains, within this otherwise massive, undeformed rock.	1827±14 Ma
	142926 Dalgaringa Supersuite (443290E 7199960N)	Biotite tonalite. Veined by fine-grained biotite monzogranite	Feldspar (60%), quartz (30%), biotite (10%), minor epidote, & sericite. Accessories — zircon, apatite & titanite. Biotite roughly aligned, defining foliation. Biotites mostly 50—250µm long. Larger biotite grains usually riddled with inclusions of zircon & titanite. Feldspar is mainly plagioclase consisting of andesine, and oligoclase-andesine, with minor (<5%) microcline.	2002±2Ma
	142932 Nardoo Granite (Dalgaringa Supersuite) (425750E 7187380N)	Porphyritic granodiorite. Intrudes deformed fine-grained tonalite gneiss and amphibolite of 'older' Dalgaringa Supersuite	Feldspar (45%), quartz (30%), biotite (10%), muscovite, sericite, & epidote. Accessories — zircon, titanite, & opaques. Biotite ranges in size from 100µm–1mm, and the larger biotites generally contain abundant small inclusions of opaques and zircon. Biotite occurs as aligned crystals in clumps throughout the rock, defining a foliation. Subordinate muscovite is also aligned in the foliation. Feldspar mostly comprises andesine–oligoclase, with subordinate k-feldspar and is locally sericitised.	1977±4 Ma
?	142933 Dalgaringa Supersuite (421290E 7189830N)	Biotite-orthopyroxene-clinopyroxene-andesine granulite; meta quartz diorite. Tectonically interleaved with felsic and mafic granodiorite of the Dalgaringa Supersuite	Plagioclase, clinopyroxene, biotite, and orthopyroxene Texture of the rock appears closer to rock was intruded under high-grade metamorphic conditions. Biotite is scattered throughout the sample and ranges in size from 100–600µm long. Inclusions of opaques are common within the biotite, mostly occurring aligned within cleavage planes. Small biotite grains appear aligned in a possible foliation, whilst the larger grains are randomly oriented throughout the rock.	1989±3Ma
	SO2/16A and	Arkosic, matrix-supported pebble to cobble	Quartz, sericite, muscovite, opaques and minor titanite and zircon. Large muscovites are of	*Not dated by*

	SO2/16C Mount James Formation (394252E 7217944N)	conglomerate. Most of the conglomerate clasts are composed of quartzite; however, locally derived clasts include politic rocks of the Moogie Metamorphics and felsic granite, and amphibolite. Unconformably overlies metasedimentary rocks of Moogie Metamorphics, which have been intruded by c. 1800Ma granite. To the south and north of this locality unconformably overlain by sedimentary rocks of the Edmund Group.	a detrital origin and is up to 1 mm long. Sericite or fine-grained muscovite grains are aligned parallel to a fabric which is parallel to bedding in the rock. These grains are locally tightly crenulated.	*SHRIMP;* <c. 1800Ma, > c.1600Ma
	CV–065	Metasedimentary schist from the Morressy Metamorphics.	Quartz, biotite, muscovite, feldspar, zircon, titanite, opaques. A quartz, biotite, muscovite schist in which the biotite forms very thin elongate minerals and defines the foliation in the rock. All the biotite appears to be oriented in the same way, ie. They all go to extinction at the same time. Dark pleochroic haloes in biotite have developed around zircon. Biotite ranges from 40µm–1mm, with most grains around 100µm long. Muscovite forms grains that are commonly up to 500µm long, with some only 50µm long and are both aligned roughly in the foliation, and cross-cut the foliation. However the grains that are not aligned in the foliation sometimes appear to be 'broken' up, or have been partially replaced by quartz and muscovite. Muscovite that replaces these larger grains are aligned in the foliation. So, there are 2 generations of muscovite present, one pre-foliation and one syn-folaition. Quartz is mostly recrystallised and polygonal throughout the rock.	

S2. Argon Data

Sample preparation and analytical procedure have been described in detail elsewhere (Occhipinti 2004; Reddy *et al.* 2004) so only a brief summary is presented here. ^{40}Ar/^{39}Ar analyses were conducted on muscovite and biotite using two different analytical approaches: Infrared laser total grain fusion and infrared laser step-heating. In both cases, samples were crushed and inclusion-free mica grains were selected after examination with a binocular microscope. Depending on grain size, single or multiple grain aliquots were used to ensure sufficient Ar for measurement. All samples were cleaned in methanol, then de-ionised water in an ultrasonic bath. Once dry, the samples were packed in aluminium foil and loaded into an aluminium package with other samples. The package was then Cd-shielded (0.4mm) and irradiated in the H5 position of the McMaster University Reactor, Hamilton, Canada for 90 hours. Biotite age standard Tinto B, with a K–Ar age of 409 Ma (Rex and Guise 1995) was placed at 5 mm intervals throughout the aluminium package to monitor the neutron flux gradient. Correction factors are as follows: (^{36}Ar/^{37}Ar)Ca = 0.000255, (^{39}Ar/^{37}Ar)Ca = 0.00065, and (^{40}Ar/^{39}Ar)K = 0.0015. Corrections for (^{38}Ar/^{39}Ar)K and (^{38}Cl/^{39}Ar)K were not undertaken because of the Proterozoic age and low Cl characteristics of the samples and the short amount of time between irradiation and the time of analyses.

Following irradiation, Ar was extracted using a CW–Nd–YAG laser, fired through a Merchantek computer-controlled X–Y–Z sample chamber stage and microscope system. A defocused 200μm beam (9.7-11 Amps for 120 seconds) was used for infrared laser analyses. Data were corrected for mass spectrometer discrimination and nuclear interference reactions. Errors quoted on the ^{40}Ar/^{39}Ar ages are 1σ, and ages were calculated using usual decay constants (Steiger and Jager 1977). J values are noted on the supplementary data tables. Background Ar levels were monitored prior to and after each analysis and the mean of the two blanks was used to correct each sample analysis. Ar data were corrected for mass spectrometer discrimination, ^{37}Ar decay, and ^{38}Ar decay.

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