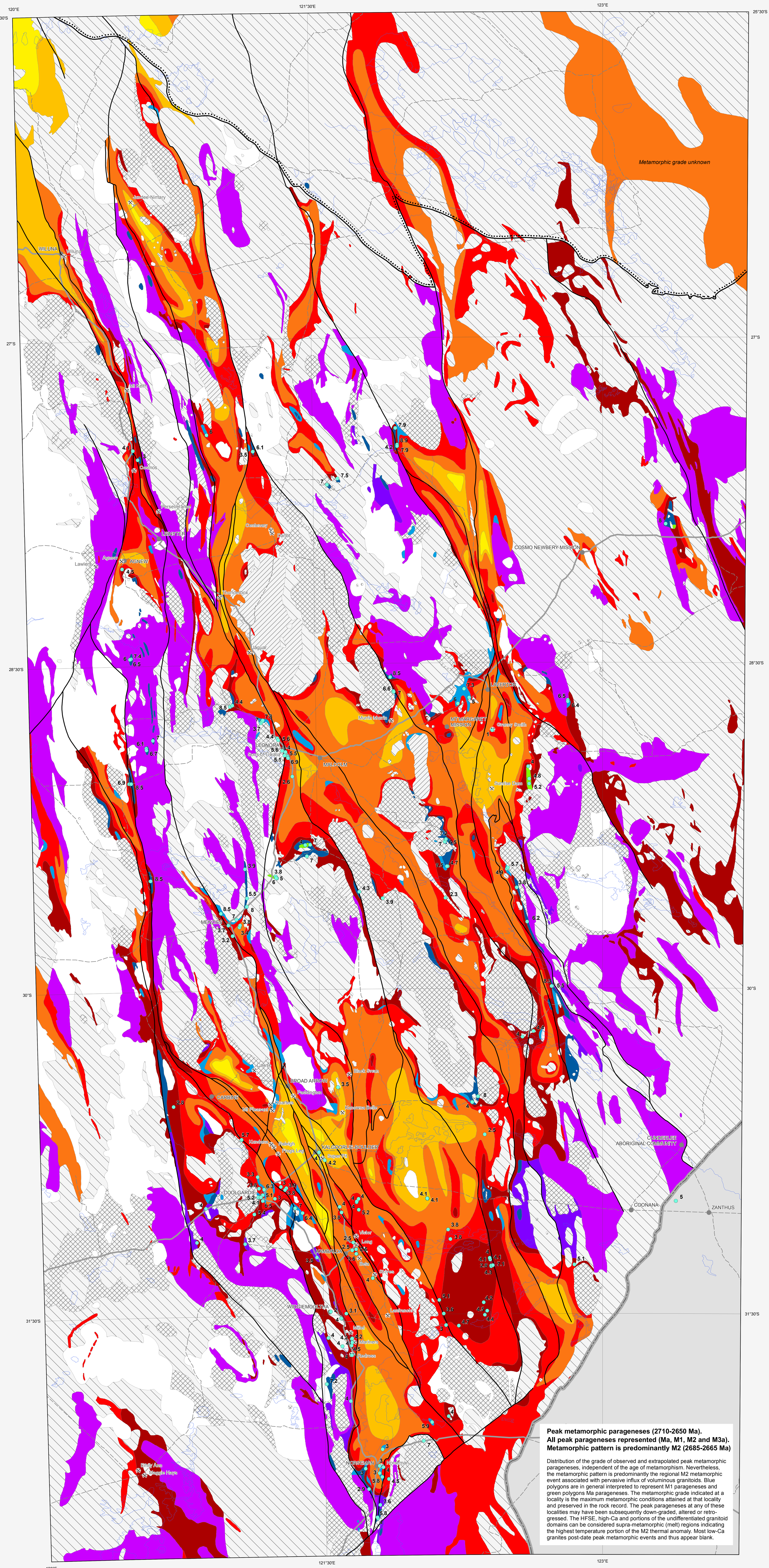
EAST YILGARN CRATON METAMORPHISM and STRAIN

PEAK METAMORPHISM



Peak metamorphic parageneses (2710-2650 Ma). All peak parageneses represented (Ma, M1, M2 and M3a). Metamorphic pattern is predominantly M2 (2685-2665 Ma)

Distribution of the grade of observed and extrapolated peak metamorphic parageneses, independent of the age of metamorphism. Nevertheless, the metamorphic pattern is predominantly the regional M2 metamorphic event associated with pervasive influx of voluminous granitoids. Blue polygons are in general interpreted to represent M1 parageneses and green polygons Ma parageneses. The metamorphic grade indicated at a locality is the maximum metamorphic conditions attained at that locality and preserved in the rock record. The peak parageneses at any of these localities may have been subsequently down-graded, altered or retro-gressed. The HFSE, high-Ca and portions of the undifferentiated granitoid domains can be considered supra-metamorphic (melt) regions indicating the highest temperature portion of the M2 thermal anomaly. Most low-Ca granites post-date peak metamorphic events and thus appear blank.

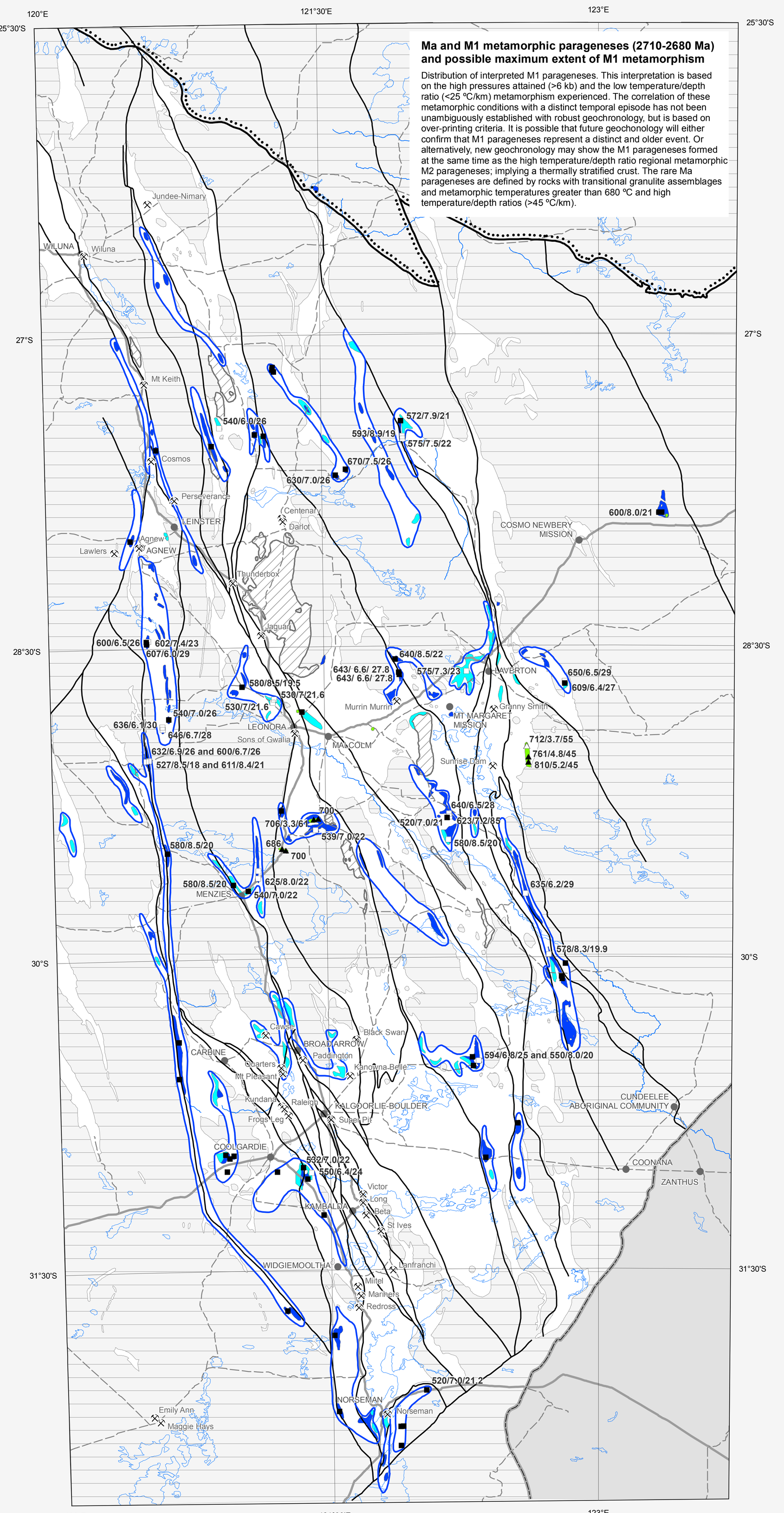
Scale 1:1 000 000

0 25 50 75 100 Kilometres

Universal Transverse Mercator Projection, Zone 51; Geocentric Datum of Australia 1994 (GDA 94)

- Post peak metamorphic rocks Low-Ca granite and some larger mafic granite and syenite bodies
- High-Ca granite (2685-2650 Ma): Supra-metamorphic heat source (~750 °C, few P constraints)
- High-field strength elements granite (2715-2675 Ma): Supra-metamorphic heat source (~750 °C, few P constraints)
- Undifferentiated granite, orthogneiss and deformed granite (~2685-2650 Ma): Supra-metamorphic heat source (~750 °C, few P constraints)
- Sub-greenschist facies (<320 °C) of medium pressure metamorphic series (30-50 °C/km)
- Lower greenschist facies (320-390 °C) of medium pressure metamorphic series (30-50 °C/km)
- Upper greenschist facies (390-450 °C) of medium pressure metamorphic series (30-50 °C/km)
- Lower amphibolite facies (450-520 °C) of medium pressure metamorphic series (30-50 °C/km)
- Middle amphibolite facies (520-620 °C) of medium pressure metamorphic series (30-50 °C/km)
- Upper amphibolite facies (620-700 °C) of medium pressure metamorphic series (30-50 °C/km)
- Undifferentiated amphibolite facies metamorphosed granite, typically gneissic (500-700 °C) of medium pressure metamorphic series (30-50 °C/km)
- Granulite and transitional granulite facies (>680 °C) of low pressure metamorphic series (40-60 °C/km)
- Lower amphibolite facies or epidote amphibolite facies (450-580 °C, >6 kb) of high pressure (<30 °C/km). Note that true epidote amphibolite conditions have not been confidently established in all localities
- Middle to upper amphibolite facies (580-700 °C, >6 kb) of high pressure metamorphic series (<30 °C/km)
- Major shear zones and faults
- Northern margin of Yilgarn Craton exposure
- Edge of Albany-Fraser Orogen
- 4.0 Peak metamorphic pressure in kb
- Mines
- Major roads
- Minor roads
- Towns
- Drainage
- Lakes

Ma and M1 METAMORPHISM



Ma and M1 metamorphic parageneses (2710-2680 Ma) and possible maximum extent of M1 metamorphism

Distribution of interpreted M1 parageneses. This interpretation is based on the high pressures attained (>6 kb) and the low temperature/depth ratio (<25 °C/km) metamorphism experienced. The correlation of these metamorphic conditions with a distinct temporal episode has not been unambiguously established with robust geochronology, but is based on over-printing criteria. It is possible that future geochonology will either confirm that M1 parageneses represent a distinct and older event. Or alternatively, new geochronology may show the M1 parageneses formed at the same time as the high temperature/depth ratio regional metamorphic M2 parageneses; implying a thermally stratified crust. The rare Ma parageneses are defined by rocks with transitional granulite assemblages and metamorphic temperatures greater than 680 °C and high temperature/depth ratios (>45 °C/km).

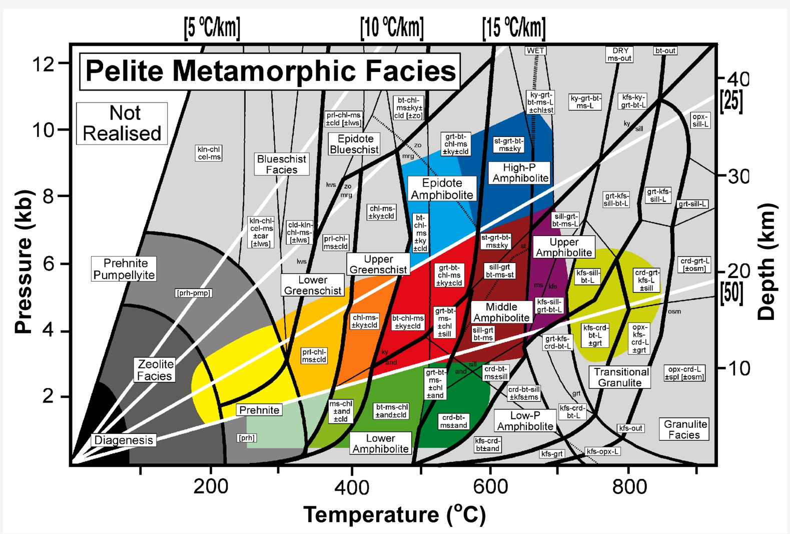
Scale 1: 2 000 000

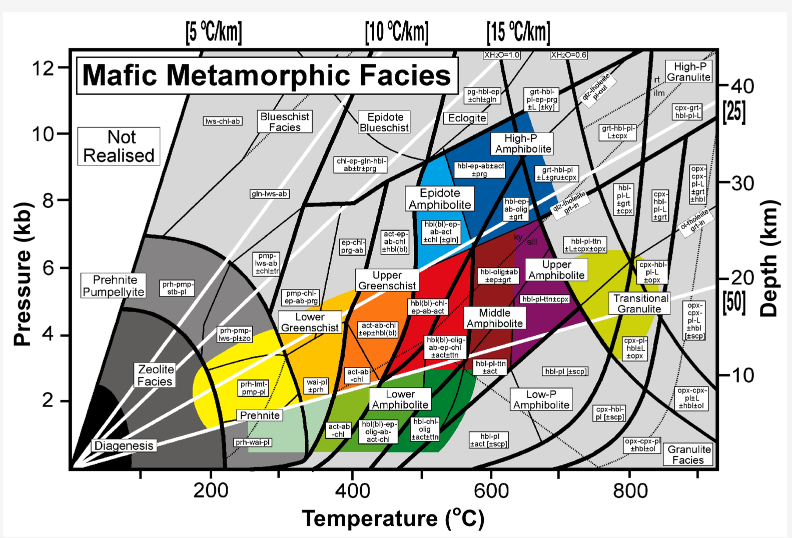
0 25 50 75 100 Kilometres

UTM Projection, Zone 51; GDA 94 Datum

- High-field strength elements granite (2715-2675 Ma): Supra-metamorphic heat source (~750 °C, few P constraints)
- All granitoids and gneiss collectively, based on edge of "greenstones"
- Outline of greenstones relative to granitoids
- Low- to very low-pressure (40-60 °C/km) granulite and transitional granulite facies (>680 °C)
- Medium-pressure (<30 °C/km) lower amphibolite facies or epidote amphibolite facies (450-580 °C, >6 kb). Note that true epidote amphibolite conditions have not been confidently established in all localities
- Medium-pressure (<30 °C/km) middle to upper amphibolite facies (580-700 °C, >6 kb)
- Outline of maximum plausible extent of M1 parageneses
- 500 / 4.0 / 45 Interpreted Ma parageneses; some with calculated temperature (°C), pressure (kb) and temperature/depth ratio (°C/km)
- 500 / 4.0 / 45 Interpreted Ma parageneses with documented isobaric cooling P-T path; some with calculated temperature (°C), pressure (kb) and temperature/depth ratio (°C/km)
- 500 / 4.0 / 45 Interpreted M1 parageneses; some with calculated temperature (°C), pressure (kb) and temperature/depth ratio (°C/km)
- 500 / 4.0 / 45 Interpreted M1 parageneses with documented clockwise P-T path with near isothermal decompression; some with calculated temperature (°C), pressure (kb) and temperature/depth ratio (°C/km)
- Major shear zones and faults
- Northern margin of Yilgarn Craton exposure
- Edge of Albany-Fraser Orogen
- Mines

Composite and quantitative PT petrogenetic grid (pelite, mafic) with diagnostic mineral fields. The different colour series indicate different temperature/depth ratios or thermal regimes. See Goscombe et al (2009) for details





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It is recommended that this map be referred to as: Goscombe B., Blewett R.S., 2009, *East Yilgarn Craton Metamorphism and Strain* (First Edition), 1:1,000,000 scale map, Geoscience Australia, Canberra. GeoCat # 69771; ISBN 978 1 921672 31 6

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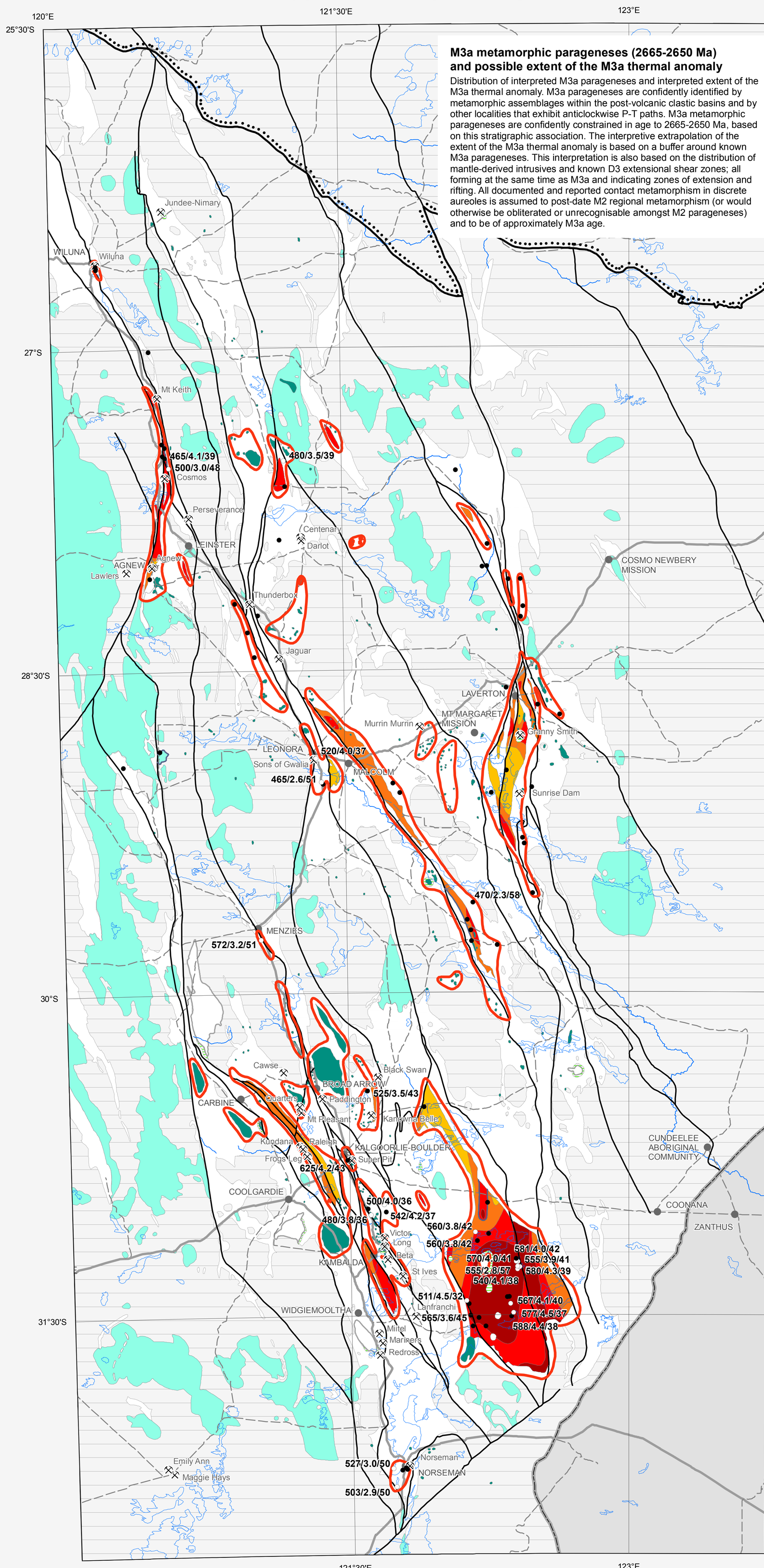
M3a METAMORPHISM



M3a metamorphic parageneses (2665-2650 Ma) and possible extent of the M3a thermal anomaly

Distribution of interpreted M3a parageneses and interpreted extent of the M3a thermal anomaly. M3a parageneses are confidently identified by metamorphic assemblages within the post-volcanic clastic basins and by other localities that exhibit anticlockwise P-T paths. M3a metamorphic parageneses are confidently constrained in age to 2665-2650 Ma, based on this stratigraphic association. The interpretive extrapolation of the extent of the M3a thermal anomaly is based on a buffer around known M3a parageneses. This interpretation is also based on the distribution of mantle-derived intrusives and known D3 extensional shear zones; all forming at the same time as M3a and indicating zones of extension and rifting. All documented and reported contact metamorphism in discrete aureoles is assumed to post-date M2 regional metamorphism (or would otherwise be obliterated or unrecognisable amongst M2 parageneses) and to be of approximately M3a age.

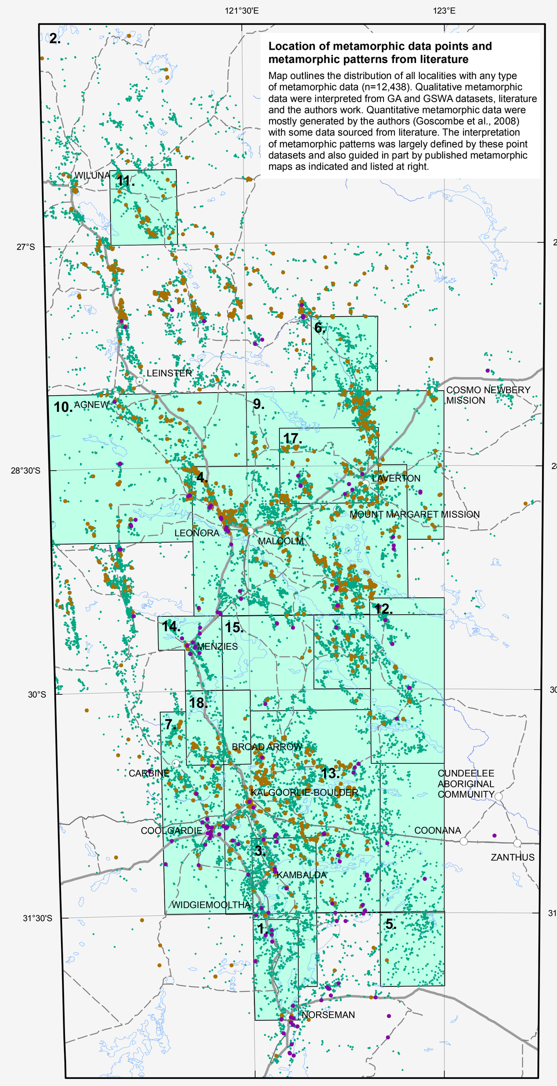
Scale 1: 2 000 000

0 25 50 75 100 Kilometres

UTM Projection, Zone 51; GDA 94 Datum

- Low-Ca granite (2655-2620 Ma): Supra-metamorphic heat source (~750 °C, 1-4 kb P constraints)
- Undifferentiated mantle-derived intrusives collectively: carbonatite, kimberlite, syenites, mafic granites and lamprophyres (2670-2650 Ma): Supra-metamorphic heat source (~750 °C, 1-4 kb P constraints)
- Selected undifferentiated granites with documented contact metamorphism
- All granitoids and gneiss collectively, based on edge of "greenstones"
- Outline of greenstones relative to granitoids
- Lower greenschist facies (320-390 °C) of medium pressure metamorphic series (30-50 °C/km)
- Upper greenschist facies (390-450 °C) of medium pressure metamorphic series (30-50 °C/km)
- Lower amphibolite facies (450-520 °C) of medium pressure metamorphic series (30-50 °C/km)
- Middle amphibolite facies (520-620 °C) of medium pressure metamorphic series (30-50 °C/km)
- Lower to middle amphibolite facies (450-600 °C) of low pressure metamorphic series (40-60 °C/km). Identified contact metamorphism
- Outline of interpreted extent of M3a thermal anomaly
- 500 / 4.0 / 45 Interpreted M3a parageneses; some with calculated temperature (°C), pressure (kb) and temperature/depth ratio (°C/km)
- 500 / 4.0 / 45 Interpreted M3a parageneses with documented anticlockwise P-T path; some with calculated temperature (°C), pressure (kb) and temperature/depth ratio (°C/km)
- Major shear zones and faults
- Northern margin of Yilgarn Craton exposure
- Edge of Albany-Fraser Orogen
- Mines

DATA SOURCES



Location of metamorphic data points and metamorphic patterns from literature

Map outlines the distribution of all localities with any type of metamorphic data (n=12,438). Qualitative metamorphic data were interpreted from GA and GSWA datasets, literature and the authors work. Quantitative metamorphic data were mostly generated by the authors (Goscombe et al., 2008) with some data sourced from literature. The interpretation of metamorphic patterns was largely defined by these point datasets and also guided in part by published metamorphic maps as indicated and listed at right.

Scale 1:3 000 000

0 50 100 150 200 Kilometres

UTM Projection, Zone 51; GDA 94 Datum

- 2. Outline of published metamorphic maps
- Localities with metamorphic data
- Localities with quantitative metamorphic data
- Localities with quantitative alteration data
- Major shear zones and faults
- Northern margin of Yilgarn Craton exposure
- Edge of Albany-Fraser Orogen

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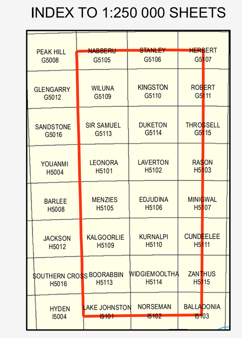

MAP LOCALITY

BULK STRAIN

Cumulative bulk strain (2810-2610 Ma): Qualitative Foliation Intensity Index (QFII)

Represents the cumulative bulk strain visible in the rock record. The strain pattern encompasses all different deformational episodes and represents the finite strain visible in the rock record. Temporal correlations of this strain distribution have been attempted in the accompanying Deformation Event Map (Appendix 2: Goscombe et al., 2009). Bulk strain has been qualitatively assigned from the intensity of the developed fabrics. The Qualitative Foliation Intensity Index (Goscombe & Gray, 2008) has been grouped into 6 categories and the distribution contoured assuming gradational transitions in bulk strain. In reality strain is not necessarily distributed as smoothly as the contoured pattern implies. In places there will be sudden transitions across many strain categories; these sharp contacts are smoothed by the contouring process but are nevertheless evident by the steep strain gradients represented.

Scale 1:1 000 000

0 25 50 75 100 Kilometres

Universal Transverse Mercator Projection, Zone 51; Geocentric Datum of Australia 1994 (GDA 94)

- QFII = 0, no reported strain
- QFII = 1 to 3, low strain, weak or spaced cleavage development
- QFII = 4, weak strain, foliations developed, weak schistosity and cleavage
- QFII = 5, moderate strain, gneissic fabric, strong grainshape fabric and moderate schistosity
- QFII = 6, high strain, strong foliation and schistosity
- QFII = 7 to 10, very high strain, intense schistosity, grain refinement fabrics and mylonites
- Major shear zones and faults
- Northern margin of Yilgarn Craton exposure
- Edge of Albany-Fraser Orogen
- Mines
- Towns
- Major roads
- Minor roads
- Drainage
- Lakes

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